H. BELKIN

FLUID INCLUSION RESEARCH

Edwin Roedder, *Editor*

Andrzej Kozlowski and Harvey E. Belkin,
Associate Editors

Volume 19
1986

Fluid Inclusion Research

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has been provided by the editor

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Volunteers Needed

The editors would appreciate any help that can be offered by the readers in issuing future volumes of Fluid Inclusion Research. Help is particularly needed in translation and in preparing abstracts on a regular basis from various segments of the literature. These jobs can be partitioned into as small units as desired; please contact any one of the editors at the above addresses. We are acutely aware of the inadequate coverage of the French literature, and would particularly welcome volunteers to make these items available to inclusion workers. On an informal basis, it would be most helpful if readers could send to the editors reprints or even just reference citations of pertinent literature. Such help is particularly useful to avoid missing obscure publications, such as theses, or ones in which the presence of inclusion data may not be obvious from title or abstract. If important papers have been missed in previous volumes, they also should be noted.

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Preface

This publication started in 1968 as an offshoot of the Commission on Ore-Forming Fluids in Inclusions (COFFI) of the International Association on the Genesis of Ore Deposits (IAGOD). However, the publication of these volumes is independently arranged and separately financed, solely by subscriptions, on a nonprofit basis. It was started with a loan, now repaid, from the International Union of Geological Sciences.

Its purpose is to provide entree to the world literature for the year with English abstracts or annotated citations of all items that either contain fluid inclusion data or are pertinent to some aspect of fluid inclusion work. This covers all types of fluid inclusions (aqueous, organic, silicate melt, sulfide melt, gas, etc.), causes and mechanisms of trapping (including various types of immiscibility), physical, chemical, and isotopic data, and data on experimental studies of systems pertinent to the interpretation of all types of phase changes occurring in inclusions, as well as to the sources and movement of such volatiles or fluids and their interactions with rocks. These data are generally given without editorial value judgements except in the case of obviously contradictory or obscure statements, where comments or "sic" are added in brackets. The extent of coverage varies in part as an inverse function of the availability of the original text to the average Western reader and in part as a direct function of the usefulness of the data. Items that are difficult to obtain, such as theses, may be covered in more detail than scientifically more important publications from readily available journals. Pertinent past and future meetings, and the resulting publications, are also listed.

Of the 376 items from Russian sources in this volume, over 200 of the abstracts were translated or abstracted by Associate Editor Kozłowski, David A. Brown (Broulee, Australia), D. Vitaliano (Bloomington, IN), I. Kulikov (Moscow, USSR), and S. Jaireth (Canberra, Australia). These translations represent an enormous contribution toward achieving the aims of Fluid Inclusion Research. There are 178 items from other foreign language sources (including 66 from the Chinese literature) and the English language literature for a total of 1589 abstracts, citations, or annotated citations, plus subject and locality indices.

Some cited items are listed as "Indexed under fluid inclusions." These items came from various computer searches but could not be looked up in time; they may involve only a trivial mention of fluid inclusions or they may be major items, since such distinctions are not normally made in computer data bases. Numerous persons and recent articles have suggested that with the rapid development of computerized data retrieval systems, bibliographical publications such as this one will soon be passé. While this seems to be the obvious wave of the future, and it is indeed marvelous to sit at a terminal and watch it spew out references galore, some serious reservations remain. First, it is necessary that the desired items be in the data base, and although the several extensive geological literature computer data bases have been consulted in assembling each of these volumes, none covers everything. Although each such search nets some items not previously found, most important, each produces only a small fraction of the entries found in any given volume of Fluid Inclusion Research. Second, and most important for a subject such as fluid inclusions, the data must be retrievable by applicable subject searches. A data base is only as good as the indexing that went into the entries, and herein lies the problem. Until all journal editors insist on key word lists from their authors, and consider the careful evaluation of the adequacy of this listing to be a major responsibility for author and editor alike, the quality of computer retrieval will be limited by the knowledge and care of the indexers. One needs only to make various subject searches of a computer data base that should pull out items from his own personal bibliography to realize how inadequate this indexing of geological data bases has been in the past.

Although each abstract is duly credited, I wish to acknowledge considerable help from Dr. M. Fleischer. Chemical Abstracts, of Columbus, Ohio, has most graciously permitted the use of a few of their copyrighted abstracts, as indicated by a CA number at the end of the abstract. Translations and other help have also been received from the following: C.E. Barker (Denver, CO); L. Baumann (Freiberg, GDR); R. Bodnar (Blacksburg, VA); J. Dubessy (Nancy, France); J. Ďurišová (Prague, ČSSR); C. Eastoe, (Tucson, AZ); K. Fuzikawa (Belo Horizonte, Brazil); J. Gieb (Marburg, FRG); J. Guha (Chicoutimi, Que.); J. Hedenquist (Taupo, N.Z.); E. Horn (Göttingen, FRG); G. Landis (Denver, CO); P. Lattanzi (Firenze, Italy); Li Binglun (Beijing, PRC); M.J. Logsdon (Denver, CO); Huan-Zhang Lu (Chicoutimi, Que.); K. Okano (Taupo, N.Z.); H.A. Stalder (Bern, Switz.); S. Takenouchi (Tokyo, Japan); and R. Thomas (Freiberg, DDR). Many other individuals, too numerous to list here, have helped by sending books, reprints, references, and abstracts. I am also indebted to Kevin W. Howard (U.S.G.S.) for library searches and, most particularly, to coeditors A. Kozłowski and H.E. Belkin. I thank Nancy Teed (U.S.G.S.) for the excellent typography.

To authors of pertinent articles that have been omitted or are misquoted here through haste, or through language difficulties, I extend my apologies and my request to have these things called to my attention; to authors whose original abstracts have been drastically shortened, edited, or revised, I offer a reminder that the following "abstracts" are not intended to be abstracts of the whole paper, but only that part most pertinent to inclusion workers. The obvious inconsistencies in citation, transliteration, abstracting, editing, cross-referencing, and indexing are strictly a result of lack of editorial time. The major shortcoming of this venture in the past has been the excessive lag time between the close of the literature year and publication. This can never be cut to zero, but has been greatly reduced. A necessary consequence of this accelerated publication schedule is an increase in the number of items in any volume from the previous year, simply because they were not available before the July 1 cutoff.

I will be glad to learn of unpublished translations of foreign language inclusion literature, and will also be glad to furnish photocopies of the original text of articles or abstracts that have not been translated, in exchange for partial or full translations for use in future issues. I would particularly like to receive abstracts from pertinent graduate theses and dissertations.

June 17, 1987 Edwin Roedder, Editor

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Past Meetings

The Seventh All-Union Conference on Thermobarogeochemistry was held in L'vov, USSR, September 1985. The abstracts were published in two volumes. Those of Volume 1 were printed in volume 18 (see Kalyuzhnyi, 1985); those of Volume 2 will be found in this volume.

An international symposium on Experimental Mineralogy and Geochemistry; Applications to Petrology and Ore Deposits, organized jointly by the mineralogical societies of Great Britain, France and Germany, was held April 17-19, 1986, in Nancy. Pertinent abstracts will be found in this volume.

The Sixth International Conference on Geochronology, Cosmochronology and Isotope Geology was held at Cambridge, UK, June 30 - July 4, 1986. Pertinent abstracts will be found in this volume.

The Forteenth General Meeting of the International Mineralogical Association was held 13-18 July, 1986, at Stanford University, Stanford, California, U.S.A. Pertinent abstracts will be found in this volume.

The Fifth International Symposium on Water-Rock Interaction was held in Reykjavik, Iceland, August 8-17, 1986. Pertinent abstracts will be found in this volume.

The Seventh IAGOD Symposium was held at Lulea, Sweden, August 18-22, 1986. Pertinent abstracts of the fluid inclusion session will be found in this volume.

The Third Short Course on Ore Microscopy and Fluid Inclusion Analysis was held by Washington State University, Dec. 1-3, 1986.

A meeting on Fluid Inclusion Studies: Advances in Metallogenesis and Exploration was held at University of Southampton, under the auspices of the Mineral Deposits Studies Group of the (British) Geological Society, 15-16 December, 1986. Abstracts of the 20 pertinent papers will be found in this volume.

The initial conference of American Current Research on Fluid Inclusions (ACROFI) was held January 5-7, 1987, at Socorro, NM. This is the American counterpart of the European group (ECRFI), which was established some years ago (see Past Meetings). ACROFI will meet every 2 years, approximately in alternation with those of ECRFI. The Socorro (first) meeting had 55 verbal papers, 20 posters, and 127 registrants, including 10 Canadians, 3 West Germans, and one each from Mexico, Sweden and Norway. Abstracts will be found in this volume.

The Ninth European Current Research on Fluid Inclusions (ECRFI) Symposium was held 4-6 May, 1987, at University of Oporto, Portugal. The meeting had 65 verbal papers, 11 posters and 173 registrants from 23 countries. Plans are to have papers from the symposium published in Bull. Minéralogie.

A meeting on stable isotope geochemistry of low-temperature fluids was held at the University of Saskatchewan, May 22-24, 1987.

A meeting on stratiform Mississippi Valley-type lead-zinc deposits was held at University of Southampton, 25-31 May, 1987; several fluid inclusion papers were presented.

A symposium on Raman Spectroscopy and Earth Sciences: Introduction and Applications was held October 16-17, 1986, in Paris. The 38 abstracts were published in Bull. Minéral., v. 109 Supplement, p. 59-70. Translations of the most pertinent abstracts will be found in this volume.

The Società Italiana di Mineralogia e Petrologia held a meeting in Siena, Italy, June 1986 on "The role of fluids in petrogenesis," followed by a short course on "Fluids and metamorphism." Papers from this meeting will be published in a special issue of Rendiconti della Società Italiana di Mineralogia e Petrologia.

Future Meetings

A 3-day fluid inclusion user school, sponsored jointly by Imperial College and the Applied Mineralogy Group, will be held in July 1987. For details contact Dr. A.H. Rankin, Department of Geology, Imperial College, London SW7 2BP, U.K.

The 22nd Annual Meeting of the Microbeam Analysis Society will be held July 13-17, 1987, in Kailua-Kona, Hawaii.

A meeting on "Fluid-rock interactions in the salt dome environment" will be held during the SEPM mid-year meeting in Austin, Texas, August 20-23, 1987.

The Third International Symposium on Observation of the Continental Crust through Drilling will be held September 7-10, 1987, in Mora and Orsa, Sweden. For details contact Stockholm Convention Bureau, Box 6911, S-102 39 Stockholm, Sweden.

The Fifth Meeting of the European Geological Societies on Orogeny, Magmatism and Metallogeny in Europe will be held October 6-9, 1987, in Dubrovnik, Yugoslovia. For details contact Secretariat MEGS 5, SAVA-Centre, POB 5, 11070 Beograd, Yugoslovia.

The Geothermal Research Society of Japan will hold their Annual Meeting in Morioka, Iwate-ken, Japan, on October 20-22, 1987. For details contact the Society c/o Geological Survey of Japan, 1-1-3 Higashi, Yatabe, Tsukuba, 305 Japan.

The Mineralogical Society of America will hold a short course on Thermodynamic Modelling of Geological Materials: Minerals, Fluids, Melts, at Phoenix, Arizona, October 22-25, 1987. For details, contact MSA at 1625 I Street, N.W., Suite 414, Washington, DC 20006.

An international symposium on petrogenesis and mineralization of granitoids will be held December 7-10, 1987, in Guangzhou, PRC. For details, contact symposium c/o Institute of Geochemistry, Academia Sinica, Guiyang, Guizhou Province, PRC.

A meeting on Mobility and concentration of base metals in sedimentary cover rocks: manifestations, mechanisms, prospection, will be held March 28-30, 1988, in Paris-Orleans. For details, contact J.F. Sureau, BRGM, BP 6009, 45060 Orleans Cedex, France.

The V.M. Goldschmidt Conference, marking the centennial year of his birth, will be held May 11-13, 1988, at Pennsylvania State University. For details, contact Goldschmidt Conference Coordinator, 410 Keller Building, The Pennsylvania State University, University Park, PA 16802.

A meeting Bicentennial Gold 88, on Gold and the Explorationist, will be held 16-20 May, 1988, in Melbourne, Australia.

An international symposium on geothermal energy will be held at Kumamoto and Beppu, Japan, November 10-14, 1988. For details, contact the Geothermal Research Society of Japan, c/o Geological Survey of Japan, 1-1-3 Higashi, Yatabe, Tsukuba, 305 Japan.

The International Association of Volcanology and Chemistry of the Earth's Interior will hold a scientific assembly in Santa Fe, New Mexico, June 25-July 1, 1989. For details, contact IAVCEI/1989, Protocol Office, Los Alamos National Lab., Mail Code P-366, Los Alamos, New Mexico 87545, USA.

The 6th International Symposium on Water-Rock Interaction will be held July 27-August 1, 1989, in Bath, UK. For details, contact Dr. W. Mike Edmunds, Scty.-Gen., British Geological Survey, Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire, OX10 8BB, UK.

The 15th General Meeting of the International Mineralog. Association will be held 12-17 July 1990, in Beijing, China.

Regional Representatives

The following series of Regional Representatives have been established to provide foci for coordination and exchange of information on inclusion activities, and to help assure complete coverage of the world literature by forwarding reprints or citations to the editors.

Africa: Prof. Dr. H.M. El Shatoury,
Prof. of Geology, Nuclear Materials
Corp., Atomic Energy Post Office,
Cairo, Egypt

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CH - 3000, Bern, Switzerland

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Abbreviations

The Cyrillic sequence, *а,б,в,г,д,е* is converted to abcdef. Other than the normal scientific and reference abbreviations, we use mainly the following:

dm	daughter mineral	T	temperature (°C)
dxl	daughter crystal	Td	temperature of decrepitation*
G	gas	Te	temperature of eutectic melting*
L	liquid	Th	temperature of homogenization*
V	vapor	Tm	temperature of melting*
P	primary	Tn	temperature of nucleation*
PS	pseudosecondary	Tt	temperature of trapping*
S	secondary	(...)	part of author's abstract omitted.

*For explanation, please see next page. Some papers use "Tf" for "temperature of formation" (i.e., Tt), others use it for "temperature of freezing," meaning Tm ice (or heating), and still others mean Tn ice (on cooling). A few use "Te" for "temperature of crystallization," meaning either Tn (on cooling) or Tm (on heating).

The original author's usage has been followed on the following:

GLI	gas liquid inclusion	Ka	thousand years
HC	hydrocarbon	My	million (10^6) years
ppb	parts per billion (10^9)	Ma	million (10^6) years
ppm	parts per million (10^6)	mybp	million years before present
µg/g	parts per million (10^6)	Ga	billion (10^9) years
%.	parts per thousand	XCO_2	mole fraction CO_2
ppt	parts per thousand	K	temperature Kelvin
per mil	parts per thousand	mg	milligram (10^{-3} g)
per mille	parts per thousand	µg	microgram (10^{-6} g)
%	parts per hundred	ng	nanogram (10^{-9} g)
percent	parts per hundred	J	joule
Ky	thousand years	KJ	kilojoule

The original author's usage has also been followed on <u>pressure</u>. Most use bars (≈ atm ≈ kg/cm^2), kilobars (kb or kbar), or megabars (Mbar), but others use pascals: 1 kPa = 10^3 Pa = 0.01 bar; 1 MPa = 10^6 Pa = 10 bar; 1 GPa = 10^9 Pa = 10^4 bar = 10 kbar. Still others use N/m^2 for newtons per square meter (10^5 N/m^2 = 1 bar).

Microthermometry Abbreviations

A concensus of fluid inclusion workers on usage of microthermometric terms was reached and first printed in Vol. 10 of COFFI (1977). It is suggested that if this terminology is used consistently in future papers, considerable ambiguity will be avoided. The details have been reprinted in each succeeding volume, and hence will be given here only in summary. (For ease of typewriting and typesetting, I suggest not using subscripts.)

Tt - The temperature of trapping, i.e., the temperature of formation of the inclusion. Thus Tt = Th if no pressure correction is needed.

Th - The temperature of homogenization. Unless otherwise indicated, this should refer to total homogenization. The phase into which homogenization occurs should also be stated as well (e.g., Th L or Th V). Where only the homogenization of a given pair of phases is meant, these should be designated, thus Th L-V, Th CO_2 L-V etc. The phase into which such homogenization occurs should also be stated as well, thus Th CO_2 L-V (V), or Th CO_2-H_2O (CO_2).

Tm - The temperature of melting. For ordinary water-rich inclusions, this may refer to the melting of ice, but ambiguity in this is all too common. The specific solid phase that melts (or dissolves) should always be designated. Thus Tm NaCl, Tm ice, Tm dms, Tm CO_2.

Te - The temperature of eutectic. This is the first recognizable formation of liquid on warming a completely crystalline inclusion; it is only an approximate or "practical" value at best, as traces of other components will always result in traces of melting at lower temperatures.

Tn - The temperature of nucleation of a given phase. This generally refers to nucleation on cooling, normally from a supercooled, metastable fluid. Thus Tn for an aqueous inclusion would be Tn ice, and formation of a bubble in a previously homogenized L-V inclusion would be Tn V.

Td - The temperature of decrepitation. This is used differently by various authors and cannot be defined exactly. Specific details on how such a temperature is determined, e.g., the start of decrepitation, the most rapid rise of decrepitation rate, the maximum number of impulses per unit increase in temperature, etc., will vary with the technique used and should be specified in each paper.

Eq. wt % NaCl - That quantity of NaCl that would yield the same Tm ice value. Sometimes incorrectly used for NaCl dm-bearing inclusions to signify total apparent NaCl content by combining measurements of size (or Tm) of NaCl dm and an assumption as to NaCl concentration of solution at room temperature.

Abstracts, Translated Abstracts, or Annotated Citations to World Literature, 1986

Caveats: Some items from previous years that were not available earlier are included; there will be more of such back date items in this and future issues, as a result of the faster publication schedule. Items for which a full English translation has become available during the year are included, even if the item was previously abstracted from the original foreign language. The first author's address is given as of the publication date only. Differences in the transliteration procedures that are used in various Western journals for Cyrillic author's or place names have resulted in different spellings of what is probably the same name (e.g., Petersil'e, Petersilie, and Petersilje; Ye vs E; ...iy vs ...ii, etc.). To avoid problems in the use of various bibliographic data bases, I have maintained such spellings as they appeared in the original publications. Similar problems occur with diacritic marks in author's names. (In alphabetizing here, these marks are ignored.) Even worse problems exist for Chinese names, which have been alphabetized here according to what I believe is the family name, regardless of the order of printing in the original.

AGOSTO, W.N., 1986, Lunar volatiles: More than meets the eye? (abst.): Lunar & Planetary Sci. XVIII, p. 3-4.

AINES, R.D. and ROSSMAN, G.R., 1986, Relationships between radiation damage and trace water in zircon, quartz, and topaz: Am. Min., v. 71, p. 1186-1193. First author at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125, USA.

The presence of trace amounts of water or hydroxide ion can dramatically affect the response of a mineral to radiation from both internal and external sources. In zircon, where radioactive decay of U causes structural damage (metamictization), water can enter the structure after a threshold of damage is reached and stabilize the metamict state by annealing local charge imbalance. Quartz crystals with both amethyst and citrine zones have molecular water in the citrine zones and dominantly hydroxide ion in the amethyst zones. This may be due to the reduction of the amethyst Fe(IV) color center by atomic H formed by radiolysis of the water. In topaz, special hydroxide sites correlate with the formation of a brown color center. The crystallographically identified hydroxyl on the (OH,F) site does not appear to be correlated with radiation damage. The mobility of H and the ease with which H-O species may be formed in silicates appear to explain much of the role of hydrous species in radiation-damage processes in minerals. These species occur in several charge states and many anneal local charge imbalance. The occurrence of trace amounts of water in even nominally anhydrous minerals makes this interaction common. (Authors' abstract)

AL, Y., WOLFSON, I. and ZENTILLI, M., 1986, Geological and fluid inclusion study of tin mineralization associated with the Wedgeport pluton, Yarmouth County, Nova Scotia: 1986 Colloquium of the Atlantic Geosci. Soc., Amherst, NS, Canada, Jan. 17-18, 1986, Maritime Sed. & Atlantic Geol., v. 22, no. 2, p. 175.

Indexed under fluid inclusions. (E.R.)

ALBINO, G.V., 1986, Sodium metasomatism and 'fenitization' along the Melones fault, Sierra Nevada foothills, California (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 524. Author at Dept. Geol., Univ. Western Ontario, London, Ontario, Canada N6A 5B7.

Intense Na metasomatism along the Melones Fault Zone, near Moccasin, California, has resulted in the development of fenite-like assemblages consisting of albite, riebeckite and aegerine accompanied by abundant sphene, minor chlorite, magnetite, hematite and pyrite. These parageneses are most common in fine-grained plagioclase- and hornblende-phyric dikes. The Na-enriched dikes contain as much as 11% Na_2O, compared to less than 5% in unaltered equivalents. Sodium appears to have been gained mostly at the expense of K_2O, CaO and SiO_2.

Pale blue to grey riebeckite occurs as bundles of very fine-grained needles pseudomorphous after igneous hornblende and along the margins of albite veins. Pale to bright green aegerine occurs as stout to elongate prisms intergrown with secondary albite, as replacements of hornblende phenocrysts and locally as rims on magnetite or hematite. Albite makes up the groundmass of the altered dikes and has replaced oligoclase phenocrysts. Quartz is absent in the riebeckite- and aegerine-bearing rocks. Altered dikes are commonly cut by veins, with open space-filling textures, consisting of albite and riebeckite, and less commonly, analcime and paragonite. Sodic scapolite is present locally, indicating that the metasomatizing fluids were, at least in part, quite saline.

Consideration of the stabilities of the alteration minerals indicates that the metasomatic fluids were undersaturated in silica with respect to quartz, were oxidized, alkaline and had large values of Na^+/K^+ and Na^+/Ca^+; the presence of sphene indicates that $X(CO_2)$ was low.

The time of alteration is constrained to be later than Nevadan deformation at 155 Ma and before formation of Mother Lode Au deposits at about 120 Ma. The source of the metasomatizing fluids is not known, but they do not appear to be related to alkaline magmatism. (Author's abstract)

ALDOUS, R.T.H., 1986, Copper-rich fluid inclusions in pyroxenes from the Guide Copper mine, a satellite intrusion of the Palabora igneous complex, South Africa: Econ. Geol., v. 81, p. 143-155. Author at Broken Hill Proprietary Co., P.O. Box 559, Camberwell, Victoria 3124, Australia.

A copper sulfide-bearing feldspathic pyroxenite diatreme at the abandoned Guide copper mine, 5 km northwest of the main Palabora complex, Transvaal Province, Republic of South Africa, contains euhedral cumulate pyroxenes with primary fluid inclusions. These inclusions contain an aqueous silicate liquid which on cooling crystallized pyroxene and K-feldspar, leaving a residual potassium and sodium bicarbonate-chloride brine highly charged with copper and sulfur. Some of the inclusions on heating show evidence of developing two immiscible liquids, which quenching suggests could be carbonate and silicate liquids. A residual aqueous component was also present in these inclusions when they cooled. From these primary inclusions and secondary aqueous inclusions representing just the copper-rich brine, it is possible to reconstruct a detailed cooling history of the diatreme which demonstrates that the copper sulfides were deposited from a residual hydrothermal fluid. (Author's abstract)

Dms reported include kalicinite(?), chalcopyrite, and sylvite. Other solid phases such as sphene and apatite may be captured. Diagrams showing sequential melting and immiscibility are presented. (E.R.)

ALEKHIN, Yu.V., KOLPANKOVA, N.N. and SOROKIN, V.I., 1985, Comparative characteristics of thermal waters and palaeohydrotherms which formed antimony ore mineralization: Abstracts of papers of the VI All-Union Volcanologic Symp., Petropavlovsk-Kamchatskiy, v. 3, p. 124-126 (in Russian).

Cited in Naumov, 1986 (this volume).

ALEKSANDROVA, N.I. and SOKOLOV, S.B., 1985, Variation in phase composition of inclusions as an indicator of heterogeneity in the pegmatite-forming systems, an example from beryl of mica pegmatites (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 13-14 (in Russian; translation by S. Jaireth). Authors at VIMS, Soviet Inst. Mineral Resources, Moscow, USSR.

Study of large crystals of blue beryl from pegmatite veins of the Mam mica-pegmatite deposits has revealed presence of two groups of syngenetic inclusions: 1) recrystallized melt inclusions of almost negative crystal shapes (inclusions are intensively flattened along 6-fold axis); 2) fluid inclusions of predominantly tabular shapes distributed parallel to each other along the long axis of the host crystal.

Melt inclusions are characterized by nonuniform phase composition manifested in variable ratio of isotropic and anisotropic solid phases and also in irregular distribution of gaseous phase. As a result, inclusions on heating to similar temperatures show different degrees of melting of entrapped material. After heating to 700-750°C for 6-8 hrs., in many such inclusions melt was seen along with solid phases. These failed to melt completely even ≤800-850°C, above which the crystal lost its transparency. Part of the unmelted solid phases had optical properties similar to the host beryl. Probably, recrystallized melt inclusions contain solids of different origin along with solid material of the host mineral deposited in the process of attainment of equilibrium by the inclusion cavity.

Groups of fluid inclusions are also marked by variable phase composition manifested in highly variable volume ratio of liquid and less dense fluid phase; sometimes one of the two phases is completely absent. It needs to be emphasized that signs of necking down have not been observed. Preliminary freezing studies (carried out by M.N. Candinov at the Institute of Mineral Resources) have revealed the presence of aqueous solution along with a mixture of liquid CO_2 and methane. Homogenization of inclusions occurred either into one of the above mentioned phases or with critical behavior. Th varies between 260 and 400°C. Inclusions which homogenize at the critical have Th varying between 285 to 320°C. Solid phase observed in some inclusions do not show any change even up to 550°C, and are probably xenogenic [i.e., solid inclusions].

Groups of fluid inclusions include one unusual type containing a liquid phase along with two separate less dense fluid phases. Freezing studies indicate that the less dense fluid is a mixture of different proportions of CO_2 and hydrocarbon (probably methane), leading to variation in Th of these less dense fluid phases. Complete homogenization of these inclusions occurs with critical behavior at 310 to 330°C.

Simultaneous entrapment of syngenetic inclusions of variable composition (recrystallized and fluid) and of mixed inclusions with intermediate composition (crytals + fluid) indicates that the pegmatite-forming system was heterogeneous, made up of two immiscible components - melt and coexisting fluid. Variable composition of recrystallized inclusions, revealed during their homogenization, and presence of xenogenic phases are indicators of heterogeneous state of the melt itself. Variable phase composition of fluid inclusions and difference in their state of final homogenization points suggests variation in the chemical composition of immiscible blebs separating from the melt. (Authors' abstract)

ALESHIN, V.G., BOGATIKOV, O.A., KONONOVA, V.A., NOVGORODOVA, M.I., SMEKHNOV, A.A., NOVIKOV, N.V. and NEMOSHKALENKO, V.V., 1986, Relics of reductive fluids trapped in native metals: Dokl. Akad. Nauk SSSR, v. 291, no. 4, p. 957-960 (in Russian). Authors at Inst. Geol. of Ore Deposits, Petrogr., Mineral. & Geochem. Acad. Sci. USSR, Moscow, USSR.

Studies of the native metals using Auger spectroscopy and secondary ion mass spectrometry indicated the composition of the metals and the volatile components, [as well as] certain of their compounds and functional groups. Electron Auger spectra and secondary ion mass spectra were obtained in the surface system LAS-3000. Auger spectroscopy has a sensitivity of the element detection (except of H_2 and He) 0.5-1 at. %, and secondary ion mass spectrometry detects all elements in the range 0.01-0.001 at. %. The specimens were grains of native copper (dia. ~100 µm) from the leucite-olivine-phlogopite picrites and a diamond [with a] face ca. 300 x 300 µm. Initial vacuum in the chamber was 10^{-10} torr, Auger spectra were excited by electrons with energy 3000 eV, specimen current was 0.02 µA, modulation amplitude 1.8 eV. Etching of the specimen surface was performed by Ar^+ ions, P Ar $5 \cdot 10^{-6}$ torr, beam energy 1500 eV, specimen current 2 µA. Secondary ion mass spectra were obtained by O^+ ions with energy 11.0 KeV, current of the secondary electrons and ions was equal 0.01 µA.

Analysis of the obtained Auger spectra proves that the grains of native copper are covered with a carbon film of a thickness of tens to hundreds of nm; also oxygen, sulfur and chlorine were found in this film. The secondary ion mass spectra indicated the surficial presence of hydrocarbons (lines of H^+ and CH^+ in positive ions and of H^-, CH^-, C_2^-, $C_2H_2^-$ in negative ions), and also of H, N, Li, Na, K, Mg, Ca, Al and Si. In one specimen the Auger spectroscopy indicated presence of the bivalent silicon. Also constantly present are B, S, Cl, F^- and HF^+. Spectra of diamond bear lines H, H_2 or D, N, O, Li, Na, K, Ca, Mg, Al, Si; F and OH are subordinate. Surficial layer of diamond is enriched in ^{6}Li, whereas deeper ^{7}Li is more abundant. The authors' interpretation is that all the elements and atom groups listed above are the traces of the reducing mineral-forming fluids, present at various stages of native element crystallization. (Abstract by A.K.)

ALIDODOV, B.A., 1985, Criteria for recognizing metamorphic-hydrothermal mineral-formation on the basis of gas-liquid inclusions (as exemplified in the gold deposits of Tadzhikistan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 109-110 (in Russian; translation by D.A. Brown). Author at State Pedagogical Inst. (DGPI), Dushanbe, USSR.

Gas-liquid inclusions (GLIs) in quartz and calcite have been examined from the gold-sulfide deposits of Tadzhikistan (Dzhilau, Taror, Gizhdarva, and Chore).

The study suggests that the deposits belong to the metamorphic-hydrothermal category. The criteria for such assignment include the following:

1) The uniformity of the morphology, phase composition, phase relations, and dimensions of the GLIs throughout the entire area.

2) Similarity in conditions of formation. The inclusions in the ore, both spatially and vertically have similar T and P (~150-450°C and 0.3-1.0 kbar), and composition and concentration of solutions (<20-25 wt %). Another criterion is the ubiquitous occurrence of CO_2, sometimes of high-density, not heterogenizing even during supercooling, which indicates high pressures, typical of the field of dynamothermal metamorphism.

3) The inclusions are identically distributed and have identical frequency in the minerals. Small dimensions especially indicate the relatively closed and equilibrium conditions of mineral-deposition, which is typical

mainly of metamorphic mineral-formation.

All these features reflect the conditions typical of regional metamorphic ore formation. In conjunction with other well-known geological criteria, they may be used to separate ores and minerals of metamorphic origin. (Abbreviated by E.R. from the author's abstract)

ALLISON, A.E., 1986, The geology of the Bajo El Durazno porphyry copper-gold prospect, Catamarca Province, Argentina: MS thesis, Univ. of Arizona.

The Bajo El Durazno prospect is a small, Au-rich porphyry Cu-type prospect located in Catamarca Province, northwest Argentina. It is associated with a small east-northeasterly elongated andesite porphyry stock emplaced at 8.7 m.y. into comagmatic and petrologically similar andesitic volcanic breccias. Concentric zones of hydrothermal alteration centered on the stock include early weak K-silicate alteration in the stock and adjacent wallrocks surrounded by an essentially coeval, weakly developed propylitic alteration zone. Well-banded magnetite ± quartz ± biotite veins are roughly coeval and coextensive with the earliest stages of potassium-silicate and propylitic alteration. Major Cu-Au mineralization with minor Ag and Mo developed during later stages of K-silicate alteration after the magnetite alteration event. The bulk of the mineralization occurs in quartz veins within the stock and its wallrocks near their mutual contact; supergene enrichment of Cu is not economically significant. Cu and Au grades are generally less than 0.4% and 1 ppm, respectively. The three early alteration assemblages were later overprinted by patchy areas of phyllic alteration consisting mainly of the assemblage sericite, quartz, pyrite, and anhydrite/gypsum. Irregular patches of weak to intense silicification are superimposed on all other alteration types.

A fluid inclusion study has revealed the presence of two hypersaline liquid-rich fluid inclusion types having salinities of 73.0-87.0 and 50.0-79.5 wt. % NaCl + KCl eq., respectively, a single low salinity liquid-rich inclusion type (6.6-8.0 wt. % NaCl eq.), and abundant vapor-rich inclusions. Hematite, anhydrite, and a variety of unidentified opaque and nonopaque minerals occur in many inclusions. Magnetite, K-silicate, and phyllic-silicic alteration in silicified zones formed between 310°C and 550°C and were the product of the less saline of the two hypersaline fluids; this fluid episodically boiled. Cu-Au mineralization in K-silicate rocks probably peaked at about 395°C. Fluid salinities and temperatures gradually decreased with time, and during later stages of alteration they also decreased with greater distance from the hot center of the system, perhaps as a result of dilution. Although proof is lacking, the two high salinity fluids and the low salinity vapor may be magmatic in origin, and the low salinity fluid may represent a late-stage influx of meteoric water that encroached on the waning magmatic hydrothermal system. A depth of formation of 1.6 kilometers is estimated for the presently exposed portion of the Bajo El Durazno prospect based on the fluid inclusion data. (From the author's abstract)

ALMAZÁN ESQUDEA, S.R., BUSTAMENTE GARCIA, J., RUBINOVICH KOGAN, R.E. and PATIÑO, M.P., 1985, Metallogenetic study of the El Aguacate vein, Murillos I, Ameca, Jalisco (Mexico): Geomimet, v. 135, p. 18-38 (in Spanish).

The El Aguacate vein is situated in latite-andesite pyroclastics, intruded by hypabyssal felsic to intermediate rocks. Carbonatization-silicification is the most important alteration.

Studies of fluid inclusions in calcite deposited following gold mineralization (stage four) indicate boiling fluids from the highly variable gas-liquid ratio, at 170-194°C, corresponding to a fluid depth of 85-115 meters. No minerals suitable for fluid inclusion study were encountered in [the main ore stage]. The gold and base metal sulfide mineralization is typical of epithermal deposits associated with subvolcanic intrusions. (From the authors' abstract, translated by θ. Landis)

ALVES, J.V. and FUZIKAWA, K., 1986, Recommended procedures in cryometry - Results of tests carried out under different conditions: XXXIV Brazilian Geol. Congress, Bull. No. 1 - Abstracts and short communications, p. 178-179, Goiania, Goias State (in Portuguese). Authors at NUCLEBRAS, Av. Uruguai, 531, Belo Horizonte-MG, 30.310, Brazil.

The Chaixmeca freezing/heating stage instruction booklet recommends the use of large working distance objectives to avoid damage during heating tests or perturbation of cryometric measurements. Thus objectives of 10x for larger inclusions and UMK50/0.60 (Leitz) for small ones are indicated. Nevertheless, there is no mention of the magnitude of errors that may be introduced when using objectives other than as specified, on making successive measurements that lead to an accumulation of ice on the stage or on intermittent slight freezing when approaching the phase change during the warming process. As the specified objectives are not readily available, successive measurements of CO_2 and H_2O triple points were performed using H20x, UMK-50 and 25x Leitz objectives in a Leitz Ortholux Pol II microscope.

The purity of CO_2 in the studied inclusion had previously been tested by Raman spectroscopy. Comparison of data obtained indicated the following results: the H20x objective gives values that are ~0.5°C and 0.2°C higher than the values obtained by UMK-50 objective for CO_2 and H_2O respectively; with the 25x one the results are ~7°C and 2.3°C lower, indicating the necessity of a calibration curve; the results with UMK-50 are the closest to the physical constants of these substances which are in agreement with the indications in the booklet. Furthermore the tests indicated that the accumulation of ice on the stage after several freezing runs causes a variation of T to lower values. This is quite evident for Tm ice. Intermittent freezing near a phase change T caused a lowering of 0.5°C. We conclude that only the UMK-50 or UTK-50 objectives are suitable for determination of the CO_2 triple point. For H_2O the accuracy of Tm ice is less important because small differences in salinity calculations usually are not critical for geological interpretations. Finally, intermittent freezing during warming process is not recommended and the accumulation of ice on the stage, which may become a problem in regions or periods of high humidity must be avoided. (Authors' abstract, translated by K. Fuzikawa)

AL-ZUBAIDI, A.O. and EL-MAHDY, O.R., 1986, Geology and fluid inclusions study of the Ablah fluorite deposit, Saudi Arabia (abst.): Terra Cognita, v. 6, no. 3, p. 508. Authors at Fac. of Earth Sci., King Abdulaziz Univ., P.O. Box 1744, Jeddah, Saudi Arabia.

The Ablah fluorite deposit is located in the southern part of the Arabian Shield, about 350 km southeast of Jeddah. It is the largest fluorite occurrence known in the Arabian Shield.

A later phase of magmatic activity resulted in the intrusion of a zoned pegmatite body. Gradual build up of pressure from below caused the fracturing and brecciation of the pegmatite and the development of a pipe composed of intensely brecciated fragments. Aqueous fluids and gases carrying fluorine, other volatiles, and some dissolved metals filled the fractures in the pipe and deposited initially quartz and then fluorite accompanied by a few sulphides. The close spatial association between the pegmatite, breccia, and fluorite pipe suggests a genetic affiliation with subsurface acid magma.

Fluid inclusions in fluorite and quartz samples are classified into two main types: A) vapor and aqueous liquid, and B) vapor, CO_2-rich liquid, and aqueous liquid. Microthermometric analyses of type A inclusions indicate 5.58 to 9.07 equiv. wt. % NaCl, whereas type B contain 5.1 to 10.45 equiv. wt. % NaCl, CO_2, and minor volatile components. Type B inclusions contain 90-95 mole % H_2O, 1.4 to 3.3 mole % NaCl, 3.25 to 8.39 mole % CO_2, and 0.04 to 0.33 mole % CH_4. Th for both types A and B ranges from 160 to 270°C, with its peak falling between 210 and 220°C. The chemical composition of the fluid inclusions indicates that the mineralizing solutions were mainly saline hydrothermal fluids. The fluorite pipe was emplaced at about 215°C at a maximum depth of 1.1 km. (From the authors' abstract)

AMUNDSEN, H.E.F., 1986, Coexisting carbonatitic, ultramafic and mafic melts in the lithosphere: Evidence from spinel lherzolite xenoliths, NW Spitsbergen (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 160-162. Author at Mineral.-Geol. Museum, Sars gt 1, 0562, Oslo 5, Norway.

Spinel lherzolite xenoliths contain quenched liquids representing three different origins: 1) Melts introduced into the lherzolite material shortly prior to or during eruption; 2) Melts formed by incipient fusion of the lherzolite assemblage (L_B*); 3) Trapped melts associated with amphibole ± apatite ± phlogopite.

Shortly prior to or during eruption, Ti, Na, K, P-rich basaltic melt (L_B) infiltrated the lherzolite material along cracks and grain boundaries. L_B locally carries abundant immiscible droplets of (H_2O + CO_2)-rich ultramafic silicate melt (L_U) and Mg-rich carbonatite melt (L_C). During quenching both L_U and L_C crystallized spherulitic ankerite + dolomite + magnesite, leaving a residual H_2O-rich ultramafic silicate melt.

Both L_U and L_C have much lower densities than L_B, and there is evidence of gravitational separation of immiscible liquids has occurred at depth both prior to and during the eruption. It seems unlikely that the assemblage of melts infiltrating the xenoliths could have migrated any significant distance without separating. This suggests the existence of a homogeneous "protomelt," which unmixed into immiscible $L_B + L_U + L_C$, at some stage during upwards migration. It seems likely that the host basalt at some stage originated by gravitational separation from an assemblage of melts similar to that infiltrating the xenoliths. The onset of immiscibility, and subsequent liquid fractionation, may be the prerequisite factor triggering explosive alkaline volcanism.

Major and minor elements and volatiles are strongly fractionated between the coexisting liquids: Ti, Al, Na, K, P are partitioned into L_B (or L_B*); Mg, Ni, H_2O ± CO_2 are partitioned into L_U; Mg, Fe, Ca, show variable partitioning into L_C. The strong partitioning of incompatible elements into L_U has important implications for storage and migration of Ni (and other siderophile elements ?) in the upper mantle. The existence of ultramafic melts, resembling high degrees of melting of residual mantle material, in apparent equilibrium with an amphibole lherzolite assemblage, puts a new perspective on interpretations of komatiites. Formation of such melts could be linked to relatively low-T processes in a (CO_2 + H_2O)-rich primitive mantle.

The NW Spitsbergen lherzolite xenoliths show that both carbonate-silicate and silicate-silicate immiscibility are important processes under upper mantle P/T-conditions, and suggest a genetic link between introduction of kimberlitic liquids in the upper mantle and the generation of carbonatites and alkaline basalts. (Abbreviated by E.R. from author's abstract; references deleted.)

ANDERSEN, Tom, 1986, Magmatic fluids in the Fen carbonatite complex, S.E. Norway: Evidence of mid-crustal fractionation from solid and fluid inclusions in apatite: Contrib. Mineral. Petrol., v. 93, p. 491-503. Author at Inst. Geol., Univ. Oslo, Box 1047, Blindern, N-0316 Oslo 3, Norway.

Three different types of carbonatite magma may be recognized in the Cambrian Fen complex, S.E. Norway: (1) Peralkaline calcite carbonatite magma derived from ijolitic magma; (2) Alkaline magnesian calcite carbonatite magma which yielded biotite-amphibole søvite and dolomite carbonatite; and (3) ferrocarbonatite liquids, related to (2) and/or to alkaline lamprophyre magma (damjernite). Apatite formed during the pre-emplacement evolution of (2) contains inclusions of calcite and dolomite, devitrified mafic silicate glass and aqueous fluid. All of these inclusions have a magmatic origin, and were trapped during a mid-crustal fractionation event ($P > 4$ kbars, $T > 625°C$), where apatite and carbonates precipitated from a carbonatite magma which coexisted with a mafic silicate melt. The fluid inclusions contain water, dissolved ionic species (mainly NaCl, with minor polyvalent metal salts) and in some cases CO_2. Two main groups of fluid inclusions are recognized: Type A: CO_2-bearing inclusions, of approximate molar composition $H_2O(88\text{-}90)$ CO(27-5) NaCl(5) ($d = 0.85\text{-}0.87$ g/cm^3). Type B: CO_2-free aqueous inclusions with salinities from 1 to 24 wt% $NaCl_{eq}$ and densities between 0.7 and 1.0 g/cm^3. More strongly saline type B inclusions (salinity ca. 35 wt%, $d = 1.0$ to 1.1 g/cm^3) contain solid halite at room temperature and occur in overgrowths on apatite. Type A inclusions probably contain the most primitive fluid, from which type B fluids have evolved during fractionation of the magmatic system. Type B inclusions define a continuous trend from low towards higher salinities and densities and formed as a result of cooling and partitioning of alkali chloride components in the carbonatite system into the fluid phase. Available petrological data on the carbonatites show that the fluid evolution in the Fen complex leads from a regime dominated by juvenile $CO_2 + H_2O$ fluids during the magmatic stage, to groundwater-derived aqueous fluids during post-magmatic reequilibration. (Author's abstract)

Raman studies also were used to verify dms of calcite, dolomite, and nahcolite; other dms include halite, sylvite, fluorite or villiaumite, and possible amphibole. (E.R.)

ANDERSON, A.A., SAHAGIAN, Dork and WARD, B.J., 1986, Bubble coalescence in basalt flows: Comparison of a numerical model with natural examples (abst.): EOS, v. 67, p. 409.

ANDREEV, G.V., 1986, Mineralogy and the conditions of synnyrite origin (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 45. Author at Geol. Inst., Ulan-Ude, 670015, USSR.

A new rock named synnyrite was found in the Synnyr plutonic plug in North TransBaikalia in the late sixties. The main minerals are orthoclase, kalsilite, nepheline, biotite and pyroxene.

The fine[sic] melt inclusions are found in the minerals of synnyrites and pseudo-leucitic syenites. Their Th are 1100-1050 in pseudo-leucite, 1250-1150 in pyroxene, 1080-1020 in nepheline. The P, determined by different methods, is 900-1300 atm. (From the author's abstract)

ANDREEV, G.V., BAZHEEV, Ye.D. and DUMNOV, Ye.P., 1985, Conditions of formation of certain volcanogenic hydrothermal deposits of the Western Transbaikalia: Sci. Session "Problems of metasomatosis and ore formation in Transbaikalia," Ulan-Ude; August 30-Sept. 1, 1983, p. 39-43, Novosibirsk (in Russian).

Cited in Naumov, 1986 (this volume).

ANDREW, C.J., 1986, Silvermines area, County Tipperary, Ireland, in Geology and genesis of mineral deposits in Ireland, C.J. Andrew et al., eds.: Irish Assoc. Econ. Geol., p. 377-417. Author at 31 Tower View, Trim, Co. Meath, Ireland.

In the Silvermines area Zn-Pb-Ba mineralization occurs within basal Carboniferous (Courceyan) transgressive siliciclastics and in the overlying carbonate sediments. Genetically, the Silvermines ore bodies are a classic example of the so-called sedimentary exhalative group of deposits. It is thought that metalliferous brines at ~220°C and salinities of 10-15 wt% NaCl eq. were derived from the Lower Palaeozoic basement and from the Old Red Sandstone Munster Basin clastics by convective mechanisms. These solutions rose up the basal root zone of the Silvermines Fault Zone, initially flushing green shaley fault-gouge material from the fracture system to be deposited on the sea floor as the footwall Green Shale to the upper ore bodies. At high levels within the dilatant fracture system the ascending brines encountered formational waters (c. 20°C, 25 wt% NaCl eq.) derived from Carboniferus seawater wherein mixing occurred with rapid and, possibly, locally explosive boiling, leading to the precipitation of the epigenetic lower ore zones. These lower zones are considered to be feeder zones to the upper ore body which is considered to be a sedimentary exhalative deposit. Brines debouched from WNW faults onto the sea floor and migrated gravitationally to palaeotopographic lows between the Waulsortian mudbanks. Within these dense brine acccumulations, beneath a halocline, the Fe-Ba sediments were precipitated, the distribution of the sulphate, carbonate and sulphide facies depending on the redox potential and activities of reduced sulphur and CO_2 in the local environments. Subsequent tectonism and brecciation created void spaces which were infilled by later solutions depositing galena and sphalerite. Examination of host-rock, cement, and sulphide mineralogical parageneses indicates a temporal evolution of the hydrothermal fluids migrating through and debouching from the fracture system. (From the author's abstract)

ANDREW, C.J. and POUSTIE, Anthony, 1986, Syndiagenetic or epigenetic mineralization - the evidence from the Tatestown zinc-lead prospect, Co. Meath, in Geology and genesis of mineral deposits in Ireland, C.J. Andrew et al., eds.: Irish Assoc. Econ. Geol., p. 281-296. First author at 31, Tower View, Trim, Co. Meath, Ireland.

Mineralization of sphalerite, galena, pyrite-marcasite and barite occurs as rhythmic colloform infill to fractures and voids and in interparticle porosity. Fluid inclusion studies suggest salinities of 10-12 eq. wt. % NaCl in the range of 140-190°C.

The Tatestown deposit was formed during early lithic diagenesis in a closed system; it is thus a syndiagenetic deposit. (From the authors' abstract)

ANDREYENKO, E.D. and SOLODOVA, Y.P., 1986, Inclusions in gemstones as typomorphic and diagnostic indicators, in Typomorphism of minerals and mineral associations, N.V. Petrovskaya, ed.,: Izd. Nauka, Moscow, p. 104-111 (in Russian).

ANDRIYANOVA, N.A., 1985, Temperatures of massive-sulfide mineral-formation in the Near-Orsk deposit (Northern Mugodzhary) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 115-116 (in Russian; translation by D.A. Brown). Author at Inst. Geol. Bashkirian Br., Acad. Sci. USSR, Ufa, USSR.

The massive-sulfide lode in the deposit consists of a single steeply-dipping lensoid body. The mineral assemblages in the ores are: sphalerite-pyrite, sphalerite-chalcopyrite-pyrrhotite, chalcopyrite-pyrite, etc. (Porotov et al., 1973). A zonation based on the thickness of the orebody and its dip has been identified in the various kinds of ores. Thus, ores with magnetite and pyrrhotite are located in the base of the lode, pyrite and chalcopyrite-pyrite ores occupy its central portion, and ores with sphalerite make up the hanging wall of the lode and wedge out along the strike and dip.

The translucent minerals, located within the orebody and in its hanging and footwalls have been studied in respect of Th and Td. Quartz, calcite, and gypsum have been analyzed. Their inclusions are P, mainly two-phase GLIs, and rarely all liquid water, and homogenize (P forms) into liquid. The dimensions of the inclusions are in thousandths, and rarely hundredths of a millimeter, with the gas phase occupying less than one-third of the volume of the vacuole.

It will be seen from the Table that Tf of the ores within the orebody diminishes upwards along the rise and from the base to the roof; a T zonation has been noted, in general conformable with the mineralogical zonation.

High mineral-formation Ts have been revealed in the zones of shearing, crumpling, and brecciation in the hanging wall, as the most weakened and favorable for the passage of solutions, although quite remote from the orebody. At the same time, in the samples located close to them in depth, but not tectonically disturbed, the inclusions are very small and homogenize at lower T.

In the gypsum, located along the rise of the orebody and in the peri-ore space, dehydration begins at 120-160°C, but the gas bubbles in the inclusions remain the same size, that is, homogenization, and consequently mineral-formation also, probably took place at temperatures greater than those assumed.

The temperatures of primary ore-formation in the Near-Orsk deposit are analogous to the Tf of the corresponding mineral associations in the chalcopyrite deposits of the South Urals (Uzel'ga, im. XIX Parts"ezd, and Podol'skoye). (Author's abstract)

Th and Td Determinations for the Near-Orsk chalcopyrite deposit

Position of relative orebody	Sampling Depth, m	Analzyed mineral	Mineral association according to M.I. Vakhrushev (1973)	Th Limits, °C	Td, °C
Footwall	350	quartz, calcite	pyritic (zone of dispersed pyrite segregation	90-236	26, 160, 215, 290, 365
Orebody	320 (base of lode)	quartz, calcite	chalcopyrite-pyrrhotite-magnetite-pyrite	131-346	
Orebody	500 390	quartz, calcite	chalcopyrite-pyrite	258-440 57-321	
	170	quartz, calcite	sphalerite-chalcopyrite-pyrite	130-259	60, 400
Orebody along dip	80	gypsum		123-163	
Hanging wall, zone of brecciation	360	quartz, calcite		116-378	
		gypsum			60, 170, 180, 220, 310, 330

ANFILOGOV, V.N. and BOBYLEV, I.B., 1985, Thermodynamic analysis of the dissolution of water in silicate liquids: Geokhimiya, no. 9, p. 1277-1285 (in Russian; translated in Geochem. Int'l., v., 23, no. 3, p. 1-9, 1986).

Authors at Inst. Geol. & Geochem., Urals Sci. Center, Acad. Sci. USSR, Sverdlovsk, USSR.

Abstract in Fluid Inclusion Research, v. 18, p. 10, 1985. (E.R.)

ANNELS, A.E., 1986, Ore genesis in the Zambia copperbelt, with particular reference to the northern sector of the Chambishi basin (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 41. Author at Dept. Min. Exploitation, Univ. College, Newport Road, Cardiff, Wales CF2 1TA.

The results of prelminiary studies of fluid inclusions and stable isotopes are reviewed. (From the author's abstract)

APODACA, L.E., WRONKIEWICZ, D.K. and NORMAN, D.I., 1986, Gas chemistry and paleo-flow ore solutions which mineralized the Cohiti, NM, epithermal Au deposit (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 528. Authors at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

The Cochiti (Bland) mining district is 1.4 to 6 Ma and is on the flank of the Jemez Caldera. Mineralization is irregularly distributed along quartz veins and Au grades in some shoots is >10 ppm. Fluid inclusion studies indicate boiling ore solutions, Th ranging from 240 to 310°C, and salinities of 0.5 to 3.5 wt.% NaCl. Bulk analyses of fluid inclusion volatiles by mass spectrometry indicate the principal gaseous species are CO_2, H_2S, H_2, CH_4, N_2, and C_2-C_8 organic compounds. Typically, H_2S values of inclusions in quartz from ore zones are 0.25 to 2 mole %, and values from non-mineralized veins are 0.002 to 0.003 mole %. Measured levels of H_2S and C_nH_n in excess of 1% in some sample were confirmed by microscopic observation. GC-MS analyses of organic species indicate up to 30 compounds; principal species are ethane, iso-butane, n-butane, propane, propene, pentane, cyclopentane, and hexane. Gas geothermometry indicates 300-340°C temperatures.

Paleo-flow of ore solutions was indicated by contouring fluid inclusion microthermometry data on longitudinal sections of veins. This suggests upwelling of 300°C fluids of 0.5 eq.wt.% salinity into cooler, more saline waters. Au mineralization is associated with 300°C fluids and closely spaced temperature contours, which were perhaps zones of fluid mixing. Geochemical calculations indicate the high H_2S, 300°C ore solutions could have transported up to several ppm Au. The data suggest the localized influx of these fluids was the major control on ore mineralization. Geochemical modeling indicates Au deposition over at least a 200 m vertical interval in response to boiling. Mixing of ore solutions with low pH surface waters would result in more localized Au shoots. (Authors' abstract)

ARAI, Shoji, 1986, "Iron meteorite paragenesis," a new group of mineral inclusions in diamond: N. Jb. Miner. Mh., v. 10, p. 463-466.

ARAKOV, Yu.V., RYSHKOV, M.M., 1985, Use of results of vacuum-decrepitometric and gas-chromatographic investigations of silica concretions for correlating the Mesozoic-Cenozoic deposits of the North Caucasus (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 256- 257 (In Russian; translation by Dorothy B. Vitaliano). Authors at Rostov State Univ., Rostov-on-the-Don, USSR.

The amount, temperature, and nature of gases evolved on heating concretions was used in connection with Td data to indicate similarity in structure and composition of the minerals, and hence similarity in conditions of formation. Concretions from various geologic age rocks yielded different compositions. (Abbreviated from authors' abstract by ER)

ARCHER, D.G., 1986, Enthalpy of dilution of aqueous sodium chloride from 76 to 225°C and aqueous dodecyltrimethylammonium bromide from 50 to 225°C: J. Solution Chem., v. 15, no. 9, p. 727-742.

ARESTOVA, N.A. and PUGIN, V.A., 1985, Distributions of Sr, Ba, Cu, Cr, V, Ni, and Co in basalt-rhyolite series as indicating their liquid-immiscibility origin: Geokhimiya, no. 7, p. 946-952 (in Russian; translated in Geochem. Int'l., v., 23, no. 1, p. 29-35, 1986). First author at Inst. Precambrian Geol. & Geochron., Acad. Sci. USSR, Leningrad, USSR.

Heavy-element distributions have been examined for three igneous complexes (Cortland in the USA, Skye in Britain, and Semch in Karelia), which are considered to have arisen via liquid immiscibility and magma mixing. In all three cases, there are identical trends in the element distributions, which are similar to those found for variolites and their components, which have been shown to be of liquid-immiscibility origin. The evidence confirms a liquid-immiscibility origin for these igneous complexes and makes the order of distributions of the elements more precise. (Authors' abstract)

AREVADZE, D.V. and JAROSHEVICH, V.Z., 1985, Role of deep-seated fluids in the formation of ore deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 31 (in Russian; translation by S. Jaireth). Authors at KIMS, Caucasus Inst. Mineral Resources, Tbilisi, USSR.

In earlier studies a meteoric source for most of the fluids in volcanic and shallow ore deposits was recognized.

Our studies on some volcanogenic deposits of this country and new data obtained by Japanese and American workers indicate that a significant role was played by deep-seated fluids during the productive stage of formation of these deposits. Role of meteoric water increases towards the closing stages, probably due to fall in the intensity of introduction of deep-seated fluids at the sites of ore deposition.

P in the system was frequently greater than hydrostatic, thus excluding dilution of deep-seated fluids by meteoric waters.

Oceanic water in fluid inclusions is very rare even in hydrothermal-sedimentary deposits. Probably, during metamorphism and/or hydrothermal transformation of ores, oceanic water is lost from the sediments.

Published data and our own studies indicate a significant role of deep-seated sulfur and carbon in the ore-forming system. (From the authors' abstract)

ÁRMANNSSON, Halldór, GÍSLASON, Gestur and TORFASON, Helgi, 1986, Surface exploration of the Theistareykir high-temperature geothermal area, Iceland, with special reference to the application of geochemical methods: Applied Geochem., v. 1, p. 47-64.

ARMBRUSTER, T.H., 1986, Channel occupancy, ordering and optical properties of cordierites (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 46. Author at Lab. Chem. Miner. Kristallogr., Univ. Bern, Freiestr. 3, CH-3012 Bern, Switzerland.

Cordierites which are nearly identical in [various] parameters may still show different optical properties due to varying amounts and ratios of multiple volatiles in the structural cavities. Most important in natural samples is the H_2O content. While the refractive indices increase with H_2O content, the optic axial angle decreases significantly and the birefringence increases slightly.

Volatiles with electron density distributions close to a sphere (e.g., noble gases) cause similar optical effects as water. Volatiles with anisotropic shape (e.g., rod-shaped molecules: CO_2, N_2) lead to an increased refractive index in the direction of preferred "rod alignment" and thus cause a high optic angle and birefringence. CO_2-rich cordierites are of special importance in granulite facies rocks. (From the author's abstract)

ARNE, D.C., CURTIS, L.W. and KISSIN, S.A., 1986, Internal zonation and genetic studies of the Nanisivik mine, Baffin Island, NWT (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 42. First author at Dept. Geol., Lakehead Univ., Thunder Bay, Ontario, P7B 5El, Canada.

Zn-Pb-Ag mineralization of Nanisivik, northwestern Baffin Island, is hosted by Upper Proterozoic dolostone. Fluid inclusions indicate that most mineralization took place over the range 150-210°C, from a brine containing 20-37 eq wt % $CaCl_2$. The sulfur isotopic cmpositions of main and late-stage pyrite crystals range from $\delta^{34}S$ = +27.4‰ to +28.0‰. Iron contents of sphalerite vary from 14 to 0 mole % FeS, correspond to well-developed color zoning and constrain the oxygen activity of the ore fluid to 10^{-46} to 10^{-41} at 200°C during sphalerite precipitation. Interbanded pyrite pseudomorphous after marcasite and sparry dolomite gangue indicate that the ore fluid fluctuated around pH = 5.0. Ore formation is modelled based on processes involving <u>in situ</u> reduction of sulfate to H_2S in a hot, metal-bearing brine by hydrocarbons liberated by the dissolution and replacement of carbonate wallrock. Banding is likely the result of repetitive sulfate reduction, metal precipitation and wallrock replacement in response to pulsatory influx of ore fluid. Textural and mineralogical variations probably resutled from slight variations in the oxidation state of the ore fluid and the availability of reduced sulfur. (From the authors' abstract)

ARNOLD, Michel, 1986, So-called metastable monophase aqueous fluid inclusions at room temperature: C.R. Acad. Sci. Paris, v. 303, Ser. II, no. 6, p. 459-461 (in French; English abstract). (See Translations)

ARNOLD, Michel and PARTIDA, E.G., 1986, Oxidizing properties of a boiling hydrothermal fluid: C.R. Acad. Sci. Paris, v. 303, Ser. II, no. 9, p. 817-820 (in French; English abstract).

In an upward moving, boiling hydrothermal fluid, fO_2 and fH_2 are controlled by the most sensitive chemical system (H_2O_l-H_2O_v-H_2-O_2) during cooling. Despite the initially reducing character of the water-rock system, the boiling fluid is able to oxidize the percolated rocks under stationary conditions. (Authors' abstract)

ARNOLD, Michel, PARTIDA, E.G. and BRACAMONTES, F.M., 1986, The sulphate-sulphide system: Evidences for a chemical and isotopic equilibrium at 300°C; geochemical implications: C.R. Acad. Sci. Paris, v. 303, Ser. II, no. 12, p. 1097-1099 (in French: English abstract).

In actual hydrothermal fluids, sulphate and sulphide aqueous species are in equilibrium under the prevailing conditions in the deep hot waters (~300°C, $m\Sigma S$ = 7.7 mM/kg H_2O). Freezing of equilibrium, at 290°C, may be related to boiling of water. In studied system, actual hydrothermal sulphur is clearly leached from sedimentary basement. (Authors' abstract)

ARNDT, N.T. and JENNER, G.A., 1986, Crustally contaminated komatiites and basalts from Kambalda, Western Australia: Chem. Geol., v. 56, p. 229-255. First author at Max-Planck-Inst. für Chem., Abteilung Geochem., D-6500 Mainz, FRG.

Interpretation of the magmatic evolution of the volcanic suite is complicated by the formation of felsic ocelli in the basalts. (From the authors' abstract)

ARRIBAS, A. 1986, Origin of uranium vein deposits in metasedimentary rocks: Fe mine, Salamanca (Spain), in Vein type uranium deposits, IAEA - TECDOC-361, p. 193-214 (in Spanish; English abstract). Author at Univ. de Salamanca, Salamanca, Spain.

The temperature and salinity of the fluid inclusions of the carbonates range from 230°C to less that 70°C, and from 0 to 25% NaCl equiv. respectively. (From the author's abstract)

ASH, J.P. and TYLER, N., 1986, A preliminary investigation of fluid inclusions in the Pilgrim's Rest Goldfield, eastern Transvaal: Econ. Geol. Research Unit Info. Cir. No. 180, 21 pp. First author at Dept. Geol. Sci., Univ. Texas, Austin, TX, USA.

The Pilgrim's Rest Goldfield encompasses a cluster of quartz-pyrite-gold veins that outcrop and subcrop over an area of 600 sq. km. in the eastern Transvaal. Most of the veins are found in the Malmani Dolomite of the 2200-m.y.-old Transvaal Supergroup; lesser numbers of veins crosscut the granitic basement or follow bedding in the Wolkberg and Pretoria Groups that underlie, and rest on, the Malmani Dolomite, respectively.

Six samples of vein quartz, two from vertical veins in the basement granite, two from strata-bound, bedded ore bodies ("reefs") in the dolomite, and two from stockworks that accompany the bedded reefs, were selected for fluid inclusion analysis. Pilgrim's Rest fluid inclusions are highly complex. Four principal types have been recognized. Type-1 inclusions are entirely aqueous; Type-2 contain mixtures of $CO_2 \pm H_2O \pm CH_4$; Type-3 are characterized by the presence of variable quantities of dm halite, sylvite, and anhydrite, in addition to liquid and vapor phases; Type-4 inclusions are nearly pure CO_2. The fluid inclusions are variable in density and composition. Inclusions containing high density, CO_2-rich fluids are ubiquitous. Aqueous inclusions exhibit moderate-to-high salinities.

T determinations indicate that the inclusions were trapped under a gradient of 100°C/km. Inclusions from quartz veins cutting basement granites homogenize between 300° and 400°C; inclusions from shallower, strata-bound reefs homogenize at 200°C. Each sample displays a range of Th and Td, suggesting that mineralization was probably a multiphase event. Preliminary geobarometry suggests depths-of-formation of 5.5-7.0 km. Pilgrim's Rest fluid inclusions are similar, in many respects, to those in Archean lode-gold deposits. (Authors' abstract)

See also Tyler, 1986 (this volume). (E.R.)

ASHIKHMINA, N.A., BOGATIKOV, O.A., LUBNIN, Ye.N., TOMASHOPOL'SKIY, Yu.Ya. and FRIKH-KHAR, D.I., 1985, Reduced elements inside mineral grains and glass of terrestrial magmatic rocks: Doklady Akad. Nauk SSSR, v. 280, no. 4, p. 1221-1224 (in Russian). First author at Inst. Geol. of Ore Deposits, Petrography, Mineral. & Geochem. of Acad. Sci. USSR, Moscow, USSR.

By Auger spectroscopy reduced forms of silicon (lower oxidation level than Si^{++} down to Si°) were found in augite from Cabo Verde, pyroxene from

Sikhote Alin' and from Anabar massif, and in glass from Tolbachik basalt. Pertinent to the redox regime of magmas. (A.K.)

ASLANJAN, S., 1985, Characteristics of vein quartz in some occurrences in SE Bulgaria: Sp. Bălg. Geol. d-vo, 1985, no. 2, p. 193-199 (in Russian; English summary).

The quartz veins in the area of Sakar Mts, Sveti Ilija Heights and the Balkin Mts (Măgliž) are of hydrothermal genesis and can be related to the Laramide and later stages of the geological development of SE Bulgaria. They are formed of low-T quartz, containing numerous gas-liquid inclusions. Most of the veins comprise over 99.5% SiO_2 and a relatively low content of trace elements. After a suitable technological treatment the quartz could be used as raw material for technical glass. (Author's summary)

ASTAKHOV, G.N., 1985, Thermobarogeochemical peculiarities of the South Osetian lead-zinc and barite deposits (Central Caucasus) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 102-103 (in Russian; translation by D.A. Brown). Author at Geol. Inst. Acad. Sci. Georgian SSR, Tbilisi, USSR.

Lead-zinc and barite deposits are widely distributed in the South Osetian ore region, located on the southern slopes of the Great Caucasus Range. The ore-bearing zones are here controlled by steeply-dipping, sublatitudinal and diagonal faults and are distributed in a Bajocian volcanogenic-sedimentary sequence, Upper Jurassic reefal limestones, and Cretaceous and Eocene sediments. The vertical range of lead-zinc mineralization (Kvaysa) is 1200 m, and its wedging-out in depth has not been observed. The barite veins in the Chord deposit have been exposed vertically over ~500 m, and wedging-out of the ore bodies has not so far been established.

Ore-precipitation in both kinds of deposits is believed to be polygenic. The productive mineral associations have arisen during two stages of ore formation: barite and subsequent polymetallic, which is positively correlated with S-isotope studies on the barites and sulfides. The mineralizing process took place over a T range of 300-70°C. Productive ore-deposition occurred in the mid-T range of 300-180°C.

Three structural-geochemical varieties of peri-ore haloes have been recognized in the Chord barite deposit: 1) haloes around barite commercial veins (Ba, Sr, Hg); 2) haloes, accompanying vein sulfide mineralization, and containing commercial barite mineralization (Pb, Zn, Cu, and Ag); and 3) haloes of redeposition of elements around commercial barite veins (Mn).

Along with the geochemical haloes, the Td survey has revealed intense "steaming-out" haloes which, in the form of subsymmetric selvages, outline the barite and lead-zinc ore bodies. The intensity of the "steaming-out" zones increases as one approaches the zones of productive mineralization. In the silicate rocks they are distributed over a distance of 70-100 m, and in the carbonates, 30-40 m.

The general-geological, mineralogical, isotope-geological, geochemical, and thermobarogeochemical data have enabled the author to work out firm recommedations for exploration and research into the barite and lead-zinc deposits of the concealed type. (From the author's abstract)

AUSBURN, K.E. and KISH, S.A., 1986, Rb/Sr isotope systematics applied to an ore-petrogenesis study of a Tertiary volcanic hosted epithermal Au-deposit: What can 87/86Sr data provide? (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 530.

AZADALIYEV, Dzh.A., KASHKAY, Ch.M, KURBANOV, N.A., RASHIDOVA, T.N., 1985, On the problem of an integrated approach to thermobarogeochemical investigations of the conditions of metasomatic mineralization (illustrated by several mineral deposits of Azerbaydzhan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 204-205 (In Russian; translation by Dorothy B. Vitaliano). Authors at Inst. Geol. Azerbaydzhan SSR, Baku, USSR.

The authors recommend a combination of methods: a) Th and Td of inclusions; b) thermodynamic calculation of the distribution of isomorphic components between coexisting minerals (phase correspondence, according to L. K. Perchuk); c) thermodynamic calculation of mineral stability fields; d) computer modeling according to the "Reaction model" program we developed.

The practical value of these investigations is determined by the fact that the particulars of the morphology, phase composition relationship and aggregate transformations of the inclusions in the minerals in a certain sense proved to be typomorphic of the pre-ore, syn-ore and post-ore metasomatites, and can be used as prospecting criteria. Cases were established where gas and liquid-gas inclusions were mainly typical of the minerals of pre-ore metasomatites; GLI and three-phase, of syn-ore; and liquid, of post-ore veinlets of quartz and calcite. The results obtained can be closely tied in with geological, mineralogic-geochemical and geophysical investigations and a feasible combination of criteria for prospecting for and predicting mineral deposits can be worked out. (Abbreviated by ER from the authors' abstract).

BABANSKIY, A.D., SOLOVOVA, I.P. and GLADKOV, N.G., 1985, Physico-chemical conditions of alteration of the ultrabasic nodules in the recent lavas of the volcano Chirinkotan: Abstracts of papers of the VI All-Union Volcanologic Symp., Petropavlovsk-Kamchatskiy, v. 2, p. 140-141 (in Russian).
Cited in Naumov, 1986 (this volume).

BABAYTSEV, O.V., VORTSEPNEV, V.V. and YEREMIN, R.A., 1984, Petrological peculiarities of the ore-bearing dike complexes of the Central Chukotka (Palyavaam Region), in Problems of the metallogeny of the North-East USSR, p. 37-43, Magadan (in Russian).
Cited in Naumov, 1986 (this volume).

BADA, Jeffrey, ZHAO, Meixun, ROACH, Mark and ZARE, Richard, 1986, Amino acids in K-T boundary sediments (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 531.

BAILEY, D.K., 1985, Fluids, melts, flowage and styles of eruption in alkaline ultramafic magmatism: Trans. Geol. Soc. S. Africa, v. 88, no. 2, 1985, p. 449-458.

BAINDURASHVILI, T.G., AREVADZE, D.V. and YAROSHEVICH, V.Z., 1985, Conditions of formation of and sources of material for the Lukhum deposit (Great Caucasus) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 101-102 (in Russian; translation by D.A. Brown). First author at Caucasian Inst. Min. Raw-Materials (KIMS), Tbilisi, USSR.

Antimony ores are common on the southern slopes of the Great Caucasus Range. The largest is the Lukhum deposit, where disseminated-arsenopyrite, vein and stockwork antimonite, and realgar-orpiment mineralization are combined in a single ore field.

Thermobarogeochemical studies have established that the formation of disseminated-arsenopyrite ores took place syngenetically with that of the calcite-quartz veins at >350°-240°C, from relatively highly-mineralized fluids with a significant amount of CO_2. Authigenic arsenopyrite dms have been fixed in the inclusions.

Quartz-calcite-antimonite ores precipitated at >300-160°C, whereas the quartz-calcite-realgar-orpiment ores were deposited at T >220-110°C.

The mineral-forming fluids during this stage of emplacement of the deposit were characterized by a Na-K-HCO_3-Cl composition with a salinity of <6 wt % NaCl equiv. Their specific peculiarity is the high CO_2 concentration, sometimes forming a separate phase. Pf (fluid pressure) varied from 20 to 50 MPa. Hydrothermal mineral-deposition ended with the formation of gangue quartz-calcite veinlets.

The principal sources of the components of the hydrothermal fluid, according to the H-isotopes in the water of the fluid inclusions, O- and C-isotopes in the carbonates, and also the S-isotopes in the sulfides, were deep-seated emanations (for H_2S and CO_2 in part and the country rocks (for CO_2). We could not estimate the water source owing to intense isotope-exchange of water with the surrounding carbonate rocks.

The high PT parameters of the ore-forming fluids in the Lukhum deposit place in doubt the assignment of this kind of deposit to the near-surface epithermal group. (From the authors' abstract)

BAKHANOVA, E.V., ANTIPOV, A.F. and VASHCHENKO, N.S., 1985, Fluid regime of gold deposit formation, and possibilities of it for exploration (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 43-44 (in Russian; translation by I.V. Kulikov). Authors at KazNIIMS, Alma-Ata, USSR.

With the help of chromatographic analysis (188 samples) in quartz from a certain vein gold-bearing deposit in central Kazakhstan, data were obtained on ratios between the main gases in the fluid consisting of H_2O, CO, H_2, CH_4 and N_2. The results show the maximum quantities of H_2 and CH_4 below 400 m depth; the nitrogen maximum (0.5-0.9 ml/g) at the depth of the highest levels in low temperature quartz. Hydrogen increases from north to south, with a maximum of 0.22 milliliter/gram at 250-450 m. The quantity of water stays roughly the same, giving an obscure minimum at the lower levels.

During the ore process the relations among components of the gas mixture were changing substantially; for solutions of earlier stages comparable quantities of N_2 and CO_2 were characteristic; for the stage of early sulfides the role of CH_4 was significantly strengthened; the productive period of mineral formation was marked by increased CO_2. Hydrogen increased with increase in Th. "K" values which characterize oxidation-reduction conditions of ore deposition, change from 0.006 to 0.3, i.e., its values are always less than 1.0, suggesting ore formation mainly under oxidizing conditions.

Some separate fluid components reveal significant correlation with gold content. H_2 contents in the range of 0.08-0.2 ml/g correspond to the regions of low gold. In the boundaries of the rich ore shoots at deeper levels the contents of hydrogen do not exceed 0.06 ml/g; and together with increase of hydrogen contents up to 0.3 ml/g, the gold content declines. Contents of CO and CH_4 correspond positively with regions of low gold content. Some interesting regularity was observed in localization of rich ores in regions of 0.03 ml/g content of CH_4. With increase of water content in quartz the gold content declines. Characteristically, poor ores occur in regions of 7 and more ml/g of water.

The results obtained in the distribution pattern of fluid components in productive associations spreading to greater depth, and also their positive correlation with gold contents permit not only placing limits on ore-bearing regions but also permit use of these data in forecasting ore shoots. (Authors' abstract)

BAKHANOVA, Ye.V., 1985, Use of thermobarogeochemical data in prospecting for and appraising gold mineralization (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 249-250 (In Russian; translation by Dorothy B. Vitaliano). Author at KazNIIMS, Alma-Ata, USSR.

Integrated thermobarogeochemical investigations were made on two gold-quartz deposits in Southern Kazakhstan, as a result of which, in addition to estimating the main P-T conditions of formation of the deposits, the state and the composition of the mineralizing medium, it seems possible to use these data as direct and indirect criteria in prospecting and evaluating Au mineralization.

By analysing the T conditions of formation of the deposits by the Th method it was established that the productive stage was formed in a medium T range (320-200°C), which was stable for a long period encompassing several successive Au-bearing associations. Most of the Au was deposited in a still lower T range, 285-200°C. Hence the medium T interval of mineralization can be considered a prospecting-assessment criterion for finding productive Au mineralization. Another parameter is the establishment of the T gradients of zoning (10-12°C per 100 m). In estimating depth, having measurements of T of the productive stage, the use of T gradients provides the possibility of determining the vertical scope of mineralization.

Study of Td of quartz showed that crowding of the T isolines of the beginning of decrepitation coincides spatially with traces of the lines of intersection of faults, and this fact makes it possible to map individual faults in the volume of the ore field and make a spatial correlation of the structural framework of the deposit. Comparative analysis of the distribution of parameters of decrepitation with mineralization shows that the T of the beginning and end and main maximum of Td correlate positively with the regions of occurrence of high-grade ores. Other things being equal, a sharp change in morphology of the T field is most favorable. High values of total intensity of decrepitation indicate the possibility of the appearance of "blind" mineralization of fourth order (more than 50 arbitrary units).

Investigations based on determination of the content of bound and pellicular water in samples of rocks and minerals make it possible to determine the relative filling of GLI and their concentration in the investigated bodies in a given volume, which is especially important in studying systems carrying ultramicroscopic inclusions. The investigations made it possible to ascertain the nature of the positive correlation between the water content in GLI and productivity (based on Au content) of the quartz. The optimal water content for the ore columns of levels II and III (20-50 arb. units) is 0.6-0.8%.

Comparison of data on the chemistry of the solutions (predominance of Cl, alkalies, Na > K in the productive stage, etc.) in the inclusions in minerals of these deposits in Southern Kazakhstan with analogous data on other quartz vein Au deposits in Kazakhstan, the Urals and other provinces of the Soviet Union makes it possible to assign them to the hypabyssal. This permits a formational division of the bodies.

Thus these thermobarogeochemical investigations [are useful] in prospecting and appraising gold deposits. (From the author's abstract)

BAKUMENKO, I.T., 1986a Peculiarities of magmatic ore formation in granite pegmatites (according to data of inclusion study) (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 48. Author at Inst. Geol. & Geophys., Sib. Branch Acad. Sci. USSR, Novosibirsk, 630090, USSR.

Thermobaric and fluid modes of granite pegmatite formation have been reconstructed by the study of crystallized melt and associated magmatic fluid inclusions. Granite pegmatites of two types connected with rest magmas of granite massifs and anatectic melts obtained at metamorphism have been studied with O.N. Kosukhin and V.P. Chupin (1,2).

Among chamber pegmatites of rest origin the crystallization of weakly mineralized small non-industrial bodies is characterized by the highest T (>650° C). Magmatic zones of pegmatites of useful ore formation are of low T. Topaz- and quartz-bearing pegmatites poor in fluorine form at 650-600° C, and those rich in fluorine with piezoquartz and fluorite form at 600-550° C. A magmatic final T of "miarolitic" pegmatites, intermediate between rare-metal and chamber ones, with colored tourmalines is even lower (down to 520-500° C). Irrespective of absolute values, a T difference between the beginning of peripheral aplitic zone crystallization and the termination of crystallization of rest magmas in central pegmatoid-block zones and cavities of magmatic step is constant (about 50-80° C). The crystallization T ranges are much wider in external zones than in internal ones.

According to the measurement by V.P. Chupin (2), among the pegmatites of anatectic origin the pegmatite formations connected with granulitic facies metamorphism are characterized by the highest T (>820° C), and micaceous pegmatites are of the lowest T (640° C). Other pegmatites of amphibolite facies occupy an intermediate position.

An increase in fluid P in melts crystallized at lower T is typical of both rest and anatectic pegmatites. Water predominates in the fluid of rest chamber pegmatites, its content varying from 3 to 10 wt% at a fluid P of 0.8-1 to 4-5 kbar. The melt crystallization T decreased further in miarolitic pegmatites in the result of accumulation of fluxing components. Water P in this case is lower than in chamber pegmatites, and CO_2 content in fluid is somewhat higher, which is typical only of high-T varieties of chamber pegmatites. In contrast to rest magmas, those of anatectite-pegmatite crystallize under more high-P conditions (5-9 kbar) and contain carbon dioxide in a higher concentration up to its predomination in high-T melts. (Author's abstract)

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1. I.T. Bakumenko Magmatic stage of granite pegmatite formation (according to data of inclusion study). Mineralogicheskii Zhurnal. N 5, 1983, p. 62-71, "Naukova Dumka," Kiev.
2. O.N. Kosukhin, I.T. Bakumenko, V.P. Chupin Magmatic stage of granite pegmatite formation. Trudy IGiG, vyp. 476, "Nauka," Siberian Branch Acad. Sci. USSR, Novosibirsk, 1984, p. 136.

BAKUMENKO, I.T., 1986b Processes of magmatic petrogenesis based on the data from studies of inclusions of mineral-forming media: Geologiya i Geofizika, no. 7, p. 125-133 (in Russian). Author at Inst. Geol. & Geophys. of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

New data on Th of melt inclusions confirmed and completed the opinion on the high-T (up to 1350-1400°C) and "dry" nature of basic and intermediate magma of the trap, andesite, alkaline-basalt formations and ophiolite series at the sub-liquidus stage of crystallization, on the leading role of CO_2 in their volatiles, and on the mantle origin of these magmas, especially the andesitic ones in the calc-alkaline series of island arcs. Even high T

(>1450°C) are pertinent to the sub-liquidus crystallization of hyperbasites (peridotites, meymechites and picrites); such melts bear very dense CO_2 (up to 1.2 g/cm^3) indicating high P (10-13 kbar). Within the ranges of the Pacific "igneous ring" the differentiation of these melts leads to a major T decrease (down to 960°C), appearance of appreciable amounts of water, and crystallization of hornblende. Water may come from mantle sources and/or from the pore solutions of the subducting rocks. When melt immiscibility (silicate-silicate or other) in the magmatic system is suggested, it is necessary to prove the equilibrium of the coexisting phases, because disequilibrium coexistence is possible and very common. Carbonatites crystallize from a melt which is the product of differentiation of the alkaline-peridotitic melt (T >1450°C) by crystallization of olivine, pyroxene and melilite. In the moment of crystallization of nepheline and early apatite (1100-1000°C) the melt becomes alkaline and rich in water and salts. Generation of granitic melts during the direct thermal action of basite magmas may cause the formation of both low-T (to 640°C) and high-T (above 1200°C) acid melt fractions, depending on the amount of water in the country rocks, depth of the process and other factors. The detection of the acid residual products in inclusions in minerals of andesites and andesite-basalts formed by intravacuole differentiation indicates a possible genetic connection between acid and basic magmas in the andesite formations. Continental granitoid magmas are generated in the granulite and eclogite facies under the presence of CO_2, N_2, CH_4 and minor water, but in the amphibole facies, with the presence of H_2O as the prevailing volatile. The amount of H_2O dissolved in magmas varies strongly, thus separation of water phase may occur either due to decompression or due to differentiation of the water-saturated melt. Pegmatites rarely form under conditions of sharp decompression of the intruding granitoid magmas but frequently form when water can accumulate in magma originally containing ≥4 wt. % H_2O. PH_2O in the remnant chambers may achieve 4-5 kbar, exceeding the lithostatic P. When decompression is relatively quick, aplites form instead of pegmatites. "Boiling" of melts leads to formation of inclusions of H_2O (or other volatiles) coeval with magmatic ones. Hypabyssal granite-porphyries or granites, "screened" from the surface, may bear gas vugs formed in water-poor magmas at elevated temperatures (>900 or >1000°C). Deeper granitoid massifs bear pegmatites formed from the melt containing up to 10 wt. % H_2O at low T (down to 550-540°C) and under high PH_2O (4-5 kbar). Total T decrease during crystallization of most of the chamber pegmatites, from the beginning of their formation to the end of their magmatic stage, is small and equals 50-80°C. All the most important zones of the chamber pegmatites, including the "apographic," pegmatoid and blocky zones formed during the magmatic stage of pegmatite formation. Weakly mineralized chamber pegmatites formed at high T (750-660°C), those with topaz and piezoquartz at 650-600°C and those with optical fluorite and piezoquartz at 600-550°C. The lowest T (<550°C) are typical of the rare-metal chamber pegmatites. Anatectic pegmatites formed at higher T (>820°C) and P of fluid up to 9 kbar; sometimes anatectic H_2O-rich melts formed muscovite pegmatites at T down to 640°C. (Abstract by A.K.)

BAKUMENKO, I.T., BAZAROVA, T.Yu., VAVILOV, M.A., KRASOV, N.F., MOTORINA, I.V., PANINA, L.I., POLIVEEV, A.G. and CHUPIN, V.P., 1985, Peculiarities of differentiation of the basaltoid magmas derived from the data of the complex studies of inclusions in minerals: Abstracts of papers of the VI All-Union Volcanologic Symp., Petropavlovsk-Kamchatskiy, v. 2, p. 143-145 (in Russian).

Cited in Naumov, 1986 (this volume).

BALLARD, Sanford, III and POLLACK, H.N., 1986, Present-day heat flow and thermobarometry of ancient diamonds: Implications for diversion of heat by Archean cratons (abst.): EOS, v. 67, p. 1183.

BALLHAUS, C.G., 1986, Fluid phases and platinum mineralization in the Bushveld Complex, South Africa: Mitt. Osterr. Minerlog. Gesell., v. 131, p. 105-108 (in German).

See next item and five papers by Ballhaus (± coauthors) in Fluid Inclusion Research, v. 18, p. 22-26, 1985. (E.R.)

BALLHAUS, C.G. and STUMPFL, E.F., 1985, Fluid-melt inclusions in the Merensky and Bastard Reef, western Bushveld Complex, South Africa, and their significance for platinum mineralization (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 18-19. First author at Inst. Mineral. & Petrol., Mining Univ. Leoben, A-8700, Leoben, Austria.

See five papers by Ballhaus (± coauthors) in Fluid Inclusion Research, v. 18, p. 22-26. (E.R.)

BALLHAUS, C.G. and STUMPFL, E.F., 1986, Sulfide and platinum mineralization in the Merensky Reef: Evidence from hydrous silicates and fluid inclusions: Contrib. Mineral. Petrol., v. 94, p. 193-204. Authors at Inst. Min. & Petrol., Mining Univ., A-8700 Leoben, Austria.

See five papers by Ballhaus (± coauthors) in Fluid Inclusion Research, v. 18, p. 22-26. (E.R.)

BANNIKOVA, L.A. and RYZHENKO, B.N., 1984, Carbon and sulfur isotope ratios in the products of redox reactions under hydrothermal conditions (in the system CH_4-Na_2SO_4-NaCl-H_2O): Geokhimiya, 1984, no. 9, p. 1268-1282 (in Russian; translated in Geochem. Int'l., v. 22, no. 2, p. 99- , 1985).

Abstract in Fluid Inclusion Research, v. 17, 1984, p. 15-16. (E.R.)

BANSHCHIKOVA, I.V. and OVCHINNIKOV, L.N., 1985, Thermobarogeochemistry of the metamorphic complexes in the section of the Kola superdeep borehole (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 199-200 (in Russian; translation by Dorothy B. Vitaliano). Authors at IMGRE, Inst. Min., Geochem. & Cryst. of Rare Elements, Acad. Sci. USSR, Moscow, USSR.

Systematic thermobarogeochemical investigations were made of microinclusions in various metamorphic parageneses of the rocks of the Archean Kola complex and of the Middle Proterozoic Pechenga complex.

The main rock varieties of the Kola gneiss-migmatite complex (1150-6835 m) -- paleosomes of gneisses and amphibolites -- are characterized by interstitial inclusions of superdense salt-water fluids. Syn-Kola migmatite-granites contain crystallized inclusions with Th >830°C; the migmatite-plagiopegmatites contain crystal-fluid inclusions with T_h 810-675°C and inclusions of liquid CO_2 with a specific volume ≤0.98 cm^3/g.

The mineral parageneses of the rocks of the zonally metamorphosed Pechenga complex (6835-0 m) are characterized by inclusions of aqueous solutions of complex salt composition, varying in concentration and phase state down the section. Th of the inclusions from the parageneses of the prehnite-pumpellyite facies (0-1400 m) fall in the 190-340°C interval; epidote-chlorite facies (1400-2600 m), at 340-455°C; and biotite-actinolite facies (2600-4563 m), at 455-560°C. The paleotemperature gradient varies down the section from 100 to 55°/km.

Early retrograde parageneses of the rocks of the Pechenga complex (1285-4250 m) contain multiphase inclusions of Na-K-Cl-HCO_3 composition with Th 260-460°C.

Post-Pechenga porphyritic granites (9558 m) are characterized by crystalline inclusions, the Th of which reaches 845°C for the early phases of emplacement and 820°C for the later, and the specific volumes of the liquid CO_2 in the accompanying inclusions are 1.02 and 0.92 cm^3/g, respectively.

The late retrograde parageneses of the rocks of the Kola and Pechenga complexes contain multiphase inclusions of NaCl solutions with Th of 250-380°C.

Deposition of bituminous matter in the interstices of the minerals from zones of cataclasis, related to late faults, are closely associated with inclusions of bitumen-hydrogen-hydrocarbon solutions.

Experimental study of the inclusions in rocks and vein formations in the section of the Kola superdeep borehole made it possible to reconstruct the evolution of the PT conditions and fluid regime of metamorphism, ultrametamorphism and metasomatic processes. Three major periods in the development of these processes during the formation of the Pechenga structure and development of its basement were brought out. (From the authors' abstract)

BARABAS, A.H., 1986, The significance of hydrothermal rectorite in the Cala Abajo porphyry copper deposit, Puerto Rico (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 50. Author at Dept. Geol., MS 24 California State Univ., Fresno, Fresno, CA 93740.

Rectorite, a regularly interstratified smectite-white mica, is widespread both in the hydrothermally altered, low-potassium tonalite host of the Cala Abajo porphyry copper deposit (Rio Vivi district, west central Puerto Rico) and in nearby altered wall rocks of similar bulk composition. At room T, both two-phase aqueous fluids and saturated brines occur in fluid inclusions (Types I and II, respectively). For Type I inclusions Th are typically 310-340°C and salinities are 2.4 to 8.6 wt. % equiv. NaCl. For Type II inclusions, Tm NaCl, which range from 270 to greater than 600°C, are generally greater than Th (230-310°C). The corresponding salinities (36 to greater than 77 wt. % NaCl equiv.) for Type II inclusions indicate that suspended halite crystals were present during trapping. Trapping T of 320-385°C are inferred from Tm NaCl measurements for those Type II inclusions believed to have trapped brine without halite. P of 70-535 bars correspond with these Ts. If the T of rectorite stability is coincident with that of pyrophyllite, as most occurrences suggest, the isochores for the Type I inclusions suggest trapping at maximum T of 310-360°C and P of 50-570 bars. Although their relative ages are not known, the P-T conditions appear to have been similar for the trapping of both Type I and II fluids. (From the author's abstract)

BARANOV, E.N., KARPUKHINA, V.S. and NAUMOV, V.M., 1985, The paleotemperature zonation of the massive copper-sulfide deposits of the Verkhneural'sk ore region (south Urals) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 74-76 (in Russian; translation by D.A. Brown). First author at GEOKHI AN SSSR, Moscow, USSR.

Clarification of the temperature conditions of massive-sulfide ore-genesis remains a complex problem. This results both from the polygenic and polychronic nature of the massive-sulfide deposits, and also from the significant difficulties in studying massive-sulfide ores. [In our studies of] the massive copper-sulfide deposits of the Verkhneural'sk (Upper Ural) ore region, [we concentrated on the] temperature changes of the paleohydrothermal systems of the orebodies and geochemical haloes, [based on Th measurements].

In the haloes, we examined secondary inclusions in the quartz phenocrysts of acid volcanics, and in the ores, we studied inclusions in quartz, barite, and carbonates (distinction between primary and secondary was difficult). The inclusions were small (≤10 μm, and rarely more). Two-phase and single-phase (aqueous) inclusions predominate, and three-phase types with carbon dioxide are less common. The rare multiphase inclusions [have trapped] a solid phase, and are not highly-concentrated, as earlier believed (Polenkov et al., 1981). The concentration of the solutions in them, as in the two-phase inclusions, does not (according to cryometric data) exceed 5 wt% NaCl equiv.

During the analysis of the change in Th in space, data on the highest-temperature inclusions were primarily taken into account. This enabled us to establish a regularly-directed change in temperatures and to construct a model of the paleotemperature zonation of the deposits examined (Uzel'ga, Chebach'ye, and Molodezhnoye). A feature of these models is the lateral type of zonation (with separation of central linear zones of high temperatures - 250-370°C, which define the ore-conduits), and the marked fall in temperature during passage into the broad flank zones (190-150°C). The paleotemperature gradient in the transition zone reaches 100-150°C/100 m, whereas within the flank zones it decreases to 20-10°C/100 m. So far no regularly-trending change in temperature with depth has been established. Only in the transition from the sub-ore metasomatites into the ores is a sudden drop in temperature of 100-150°C usually identified. However, in the orebodies, and sometimes also in the rocks overlying them, local zones of high temperatures may be revealed.

Substantially gaseous inclusions, with carbon dioxide, are found mainly in the ore-conduit zones. They homogenize into the gas phase at the same T as the two-phase inclusions. Their appearance points to effervescence of the hydrothermal solutions during approach to the zone of ore-deposition. The pressures in the Uzel'ga deposit amount to 620-970 bars.

The reliability of the paleotemperature models obtained is emphasized by the distinct spatial contiguity between the T and geochemical zonation of the haloes: the inner zones of the geochemical haloes are characterized by higher T, and the frontal zones, by lower. This opens up the possibility of carrying out paleotemperature reconstructions of the ore-forming systems based on the lithogeochemical haloes.

The established paleotemperature zonation of the deposits reflects the overall duration of their ore-forming systems and does not contradict the hypotheses concerning the predominance of the hydrothermal-sedimentary method of their formation. (Authors' abstract)

BARANOV, E.N., KNYAZEVA, S.N. and SUSHCHEVSKAYA, T.M., 1985, The gases of inclusions in the aureoles of the chalcopyrite deposits of the Upper Ural ore district (southern Urals) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 152-153 (in Russian; translation by Dorothy B. Vitaliano). Authors at Vernad. Inst. Geochem. & Anal. Chem., USSR Acad. Sci., Moscow, USSR.

A study was made of the gas component of secondary inclusions in quartz phenocrysts from the acid volcanics containing the chalcopyrite deposits of the Upper Ural ore district. The gas-liquid inclusions in the quartz of the volcanics were produced in connection with hydrothermal activity and record thermobarogeochemical aureoles. The purpose of the investigation was to bring out the details of the variation in composition of the gases in the inclusions in the aureoles and to assess the possibilities of using them to characterize the paleohydrotherms and in prospecting for concealed mineralization.

Analysis of the gas phase (with determination of CO_2, CO, CH_4, H_2) and of the amount of H_2O in the inclusions in the quartz was carried out on a

"Khrom-41" chromatograph. In preparation for the analyses, monomineralic samples of quartz were treated by boiling in HCl and then, to eliminate the possible effect of organic matter, in acetonitrile. The inclusions were decrepitated thermally at temperatures of 150-500°C, with preliminary heating of the samples to 150°C to remove low-temperature inclusions. Metasomatic quartz was not analyzed, as a result of the constant fine impurities of sulfides and sericite in it. The results obtained were interpreted taking into account data on the structure and composition of lithogeochemical aureoles.

In the composition of the inclusions, water is always sharply predominant, always constituting more than 90% of the total amount of gases. Among the other gases, CO_2 usually predominates -- up to 50-60% of their volume. CO and N_2 are always present -- up to 30%, rarely more. CH_4 was identified in only half the samples studied. H_2 is virtually absent.

The overall gas content, including water, varies from 0.02 to 3 mg/g quartz, being higher in the zones near the ore and decreasing with distance from the deposits. It reaches maximum values in the zones of ore channels near the ore bodies. On the whole, the overall gas content is clearly correlated with the intensity of the lithochemical aureoles, with their total metal content. The concentration of dissolved gases in the inclusions is in inverse proportion, nearly hyperbolic, to the toal gas content of the quartz.

The composition of the gas phase of the inclusions varies systematically in the structure of the aureoles around the ores. This is expressed primarily in an increase in the relative proportion of reduced forms of carbon (low CO_2/CH_4 and also CO_2/CO ratios in zones of ore-conducting channels). Correspondingly, the amount of CO_2 in quartz in the flank and supra-ore zones of the aureoles increases (with Th of 190-150°C).

Differences in composition of the inclusions in the aureoles of the individual deposits were ascertained. In the aureoles of the Molodezhnoye and Chebach'ya deposits, which occur in the lower ore level of the district, CH_4 is always present in the inclusions and the CO_2/CH_4 molar ratio is less than 1.0, while in the aureoles of the Uzel'ga deposit, the ore bodies of which are localized in the upper and lower levels, CH_4 is found only in the zone of the ore channel near the ore bodies and the CO_2/CH_4 ratio is >2.0.

The data on gas composition offer the possiblity of estimating the redox potential of the pyrite-bearing solutions and tracing its variation in the paleohydrothermal ore-forming system. To use them in prospecting for concealed pyrite mineralization is premature, as the overall gas content and variation in composition of the gases in the inclusions are closely correlated with the parameters of the lithogeochemical aureoles. The advantages of the latter in solving practical problems, on the basis of criteria with greater prospecting information content and economic feasibility, are obvious. (Authors' abstract)

BARANOV, E.N., SCHTEINBERG, A.D. and KARPUKHINA, V.S., 1986, Genetical model and prognosis of deep-seated massive sulfide ore deposits, Verkhneuralsky area, southern Urals, U.S.S.R. (topic 9) (abst.): Abstracts of Posters, VII IAGOD Meeting, Lulea, Sweden, 18-22 Aug., 1986 (unpaginated). Authors at USSR Acd. Sci., Moscow, USSR.

The Verkhneuralsky ore deposits are located within Middle Devonian volcanic suites represented by highly differentiated formations of contasting rock types. The ancient volcanic edifices are well preserved. Almost all ore deposits are deep-seated. The deposits are associated with three upper levels of basaltic-rhyolitic rhythmic volcanic suites and are located in linear zones approximately coaxial with basaltic ridges and valleys, the latter being covered by acidic volcanic products. The ore bodies are classified as hydrothermal-sedimentary in origin, forming peculiar sulfide "hills" as well as filling depressions above the ore-transporting structures. The ore fluid temperatures are estimated as 370-390°C. Zones of fluid boiling are located below the ore bodies. (From the authors' abstract)

BARANOVA, N.N., 1986, Fluid inclusions in minerals of gold-bearing ore deposits: Ore element and hydrogen sulfide content (abst.): Terra Cognita, v. 6, no. 3, p. 508. Author at V.I. Vernadsky Inst. of Geochem., USSR Acad. Sci., Moscow, USSR.

Fluid inclusions in quartz from gold-bearing ore deposits of three types of ore formations (gold-sulfide, gold-rare metal, gold-silver) have been investigated. The concentration of gold and antimony was determined by neutron activation, and sulfide ion content was obtained using an ion-selective electrode.

It was found that in the evolution of hydrothermal solutions the gold content varies from 10^{-7} M up to 10^{-4} M, the sulfide ion concentration from 10^{-4} M up to 0.1 M, and the maximum content of antimony found was 0.6 M.

According to the interpretation of published data on the determination of Fe, Cu, As, Mn, Sb, Ag, Ni, Bi, Sn, W and Mo content in fluid inclusions in ore minerals, these concentrations fall within the range of 10^{-3} M to 10^{-2} M, sometimes up to 0.1 M. Iron, manganese, and occasionally arsenic and antimony could be considered as main components of hydrothermal systems. All these ore minerals are close associates of gold.

Direct correlation of sulfide ion and antimony content with gold concentration in fluid inclusions in quartz from the gold-sulfide ore formation associated with rich antimony mineralization was established. Thus, it was assumed that hydrosulfide and heteropolynuclear complex compounds of Au and Sb could be regarded as dominant gold-bearing species of hydrothermal solutions forming the ore deposits of this type. Hydroxychloride and chloride gold-bearing complex compounds are suggested as the most probable species of ore-bearing solutions of gold-rare metal and gold-silver ore formations.

Geochemical behavior of gold along with the ore mineral stabilities of a number of ore elements at 300°P(tot) = 1 kbar, S(tot) = 10^{-2} M, Cl = 1 M was investigated. The data on gold content of the hydrothermal solutions, complex coumpound formation, average values of carbon, hydrogen, nitrogen and sulfur concentration in fluid inclusions in quartz from gold-bearing ore deposits were also taken into account. Redox reactions involving C, H, N, S and other polyvalent elements are proposed as the dominant factor of geochemical behavior of gold in the hydrothermal process. The deposition of ore minerals of gold-sulfide, gold-rare metal and gold-quartz-bearing ore formations corresponds to the hydrogen fugacity of CO_2-CH_4 at C(tot) = 3-4 M. Mineral assemblages of near surface gold-bearing ore deposits are presumably formed under moderately oxidizing conditions as determined by the conversion of hydrogen sulfide to HS^- or even to SO_4^{2-}. (Author's abstract)

BARANOVA, N.N. and KOL'TSOV, A.B., 1985, On the behavior of gold in hydrothermal processes on the basis of new data on fluid inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 39-40 (in Russian; translation by I. Kulikov). First author at GEOKHI, Moscow, USSR.

On the basis of 1) experimental determinations by the authors on the Au and Ag concentrations in solutions of fluid inclusions in quartz of some gold-bearing deposits; 2) literature data on concentrations of Fe, Cu, As, Sb, Ag, Ni, Bi, Sn, W and Mo in inclusion solutions (the minerals of which most often associate with gold); and 3) comparisons of the latter with experimental results on solubility studies of basic mineral forms of these metals in Cl- and H_2S-solutions at parameters which correspond to the conditions of inclusion formation, the following was shown: 1) in high-temperature solutions, which correspond to the conditions of hydrothermal transport of above listed ore components their contents are of n·0.001-n·0.01 mole/liter, and sometimes up to n·0.1 mole/l; 2) iron and manganese by their concentrations serve as macro-components of hydrothermal systems, and in some cases one can add to them As and Sb; and 3) the level of gold is 10^{-7}-10^{-4} mole/l.

Analysis of fO_2-pH diagrams for gold plotted with regard to data of its concentration in hydrothermal solution and data on complexes, for 300°C, 1 kbar, ΣS 10^{-2} and ΣCl 1 mole/l, and concentrations of C, H, N and S in various forms brought to average value found in fluid inclusions in quartz in gold deposits, together with regions of mineral stabilities of the above metals, showed that the role of oxidation-reduction reactions of elements with changing valence is of major importance in the hydrothermal process.

In the region of oxygen fugacity determined by the pair CO_2-CH_4 (carbon buffer, ΣC 3-4 mole/kg H_2O) the stable minerals are arsenopyrite, chalcopyrite, antimonite, bithmuthinite, and argentite, which are characteristic of gold-sulfide, gold-rare metal and gold-quartz types of deposits; gold concentration in these conditions reached 10^{-6}-10^{-5} mole/l. Reactions of $H_2S \rightarrow HSO_4^-$ or SO_4^{2-} are observed. The role of the carbon buffer is greater than that of the nitrogen buffer during the deposition of gold. (From the authors' abstract)

BARANOVA, N.N. and KOL'TSOV, A.B., 1986, On the influence of ore and volatile components of hydrothermal solution on the process of transport and deposition of gold (based on the fluid inclusions' study): Geokhimiya, 1986, no. 6, p. 739-750 (in Russian; English abstract).

Based on analysis of data on concentrations of Au, Fe, Cu, Sb, Ag, Mn, As, Bi, Ni, Sn, W, and Mo in the fluid inclusions as well as on experimental study of the solubility of the main mineral forms of deposition of these metals at the conditions close to formation of the inclusions it was determined that in the field of the hydrothermal transport a concentration of ore components is n·0.001 M to n·0.01 M [and] sometimes to n·0.1 M. Level of gold content lies within 10^{-7} to 10^{-4} M. A significant role of redox interactions with participation of elements of variable valence has been shown. The quantitative estimation of participation of various forms of volatile components of the fluid (C, H, S, N) in formation of gold mineralization has been given. (Authors' abstract)

BARBIERI, M., BELKIN, H.E., CHELINI, W., DE VIVO, B., LIMA, A. and TOLOMEO, L., 1986, Fluid inclusions and Sr isotopes from Mofete 1 and San Vito 1 geothermal wells, Phlegrean Fields, Campania, Italy (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, Reykjavik, Iceland, August 8-17, 1986, p. 33-36. First author at Dipart. di Sci. della Terra, Citta Univ., P.le A. Moro 5, 00100 Roma, Italy.

Primary, pseudosecondary, and secondary fluid inclusions amenable for freezing and heating microthermometry occur in calcite occupying microvugs and filling thin fractures, in subhedral quartz crystals, and in K-feldspar set in a fine-grained matrix. The fluid inclusions can be classified into the following types (all aqueous): A--two-phase [L (liquid) + V (vapor)], liquid-rich; B--two-phase (L + V), vapor-rich; and C--multiphase (L + V + daughter crystals), liquid-rich. Table 2 summarizes the results of the microthermometric measurements. Although observed in almost all the studied levels, type B was measured successfully only in a few cases (Table 2). Type C was observed only twice in Mofete 1 at 928 m but was common in San Vito 1 at 2676 m. Although clathrates were not observed, a measured in-hole CO_2 pressure of 26 bars in Mofete 1 (1989 m) suggests that some CO_2 exists in the trapped fluids. Type B inclusions cogenetic with type A were measured from Mofete 1 at 928 and 1299 m and from San Vito 1 at 1715 and 2676 m. They have characteristics that strongly suggest that they represent the trapping of the vapor phase of a boiling fluid. The small inclusion size and poor optical quality of the samples limited the determination of the final melting point of ice (Tm-ice) and especially the eutectic temperature (Te). However, when observed, the Te (-50 to -40°C) suggests the presence of other cations (at least Ca). The results from both Mofete 1 and San Vito 1 show a consistent pattern of homogenization temperatures (Th) coincident with present in-hole temperatures. Both Th and in-hole temperatures fall slightly below the boiling point with depth curve for pure water. Considering we are dealing with a complex soluiton (CO_2 plus various dissolved salts), the exact position of the appropriate boiling point with depth is unknown. The average salinity of the trapped fluids is ~3.6 wt% NaCl equivalent for Mofete 1 and San Vito 1 wells (except hypersaline solutions at San Vito 1 at 2676 m). This overall picture agrees with the present fluid systematics found by drilling. In summary, the fluid inclusion data for San Vito 1 and Mofete 1 reflects the present thermal regime and fluid characteristics, suggesting that the host minerals are relatively recent and(or) that the geothermal field has remained stable during the later stges of Phlegran Fields evolution. (From the authors' text)

BARGAR, K.E., FOURNIER, R.O. and THEODORE, T.G., 1986, Reply on "Particles in fluid inclusions from Yellowstone National Park - bacteria?" [Barger et al., Fluid Inclusion Research, v. 18, p. 27]: Geology, v. 14, p. 90-91. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

A reply to Glen, 1986 (this volume). (E.R.)

BARKER, Colin and SMITH, M.P., 1986, Mass spectrometric determination of gases in individual fluid inclusions in natural minerals: Anal. Chem., v. 58, no. 7, p. 1330-1333. First author at Amoco Prod. Co. Res. Center, Box 591, Tulsa, OK 74102.

Fluid inclusions in minerals provide a source of geologically significant fluids. We have developed a new computerized mass spectrometric technique for analyzing volatiles in individual inclusions. The inclusions are opened by decrepitation in vacuum, and the computer recognizes the abrupt rise in P and controls the mass spectrometer. This scans continuously from 1 to 65 amu every 25 ms, which is within the time constraints of a bursting inclusion. The peak height for each mass in each mass spectrum is measured and stored along with the background data. Data are reduced after analysis. Each mass number is assigned its own attenuation factor by the computer in a preliminary analysis. This permits the determination of trace components down to 1 part in 10,000. With this system it is possible to analyze up to 225 inclusions in 1 h using a 10-mg sample of quartz, calcite, plagioclase, pyroxene, galena, or other mineral. (Authors' abstract)

BARKER, C.E., CRYSDALE, B.L. and PAWLEWICZ, M.J., 1986, The relationship between vitrinite reflectance, metamorphic grade, and temperature in the Cerro Prieto, Salton Sea, and East Mesa geothermal systems, Salton Trough, United States and Mexico: U.S. Geol. Survey Bull. 1578, Chapter 8, p. 83-95. Authors at U.S. Geol. Survey, Box 25046, MS 921, Denver, CO 80225.

The vitrinite reflectance of sedimentary organic matter in the Cerro

Prieto, Salton Sea, and East Mesa geothermal systems was found to be strongly related to measured borehole temperature. Vitrinite reflectance was used to estimate the maximum temperature (T_{max}) to which rocks in these systems had been exposed because other methods of estimating T_{max} and thermal history reconstruction showed that these systems are now at maximum temperature. Vitrinite reflectance has an advantage over some inorganic-based geothermometers because the temperature of the borehole can usually be estimated at any depth, giving a continuous thermal record throughout the system. By comparison, an estimation of T_{max} from changes in mineral assemblages (metamorphic grade) was found to be relatively insensitive. Metamorphic grade is defined as the existence of a particular assemblage of index minerals; however, these assemblages have been found to react or persist over wide temperature ranges; thus, metamorphic grade is only a crude geothermometer.

The degree of inaccuracy possible in estimating T_{max} using metamorphic grade is illustrated by a short-term thermal event at a depth of 1,300 m in a borehole in the Cerro Prieto field, Mexico. This thermal event induced a reequilibration of oxygen isotopes and formed high-temperature fluid inclusions in veins and host rock. Vitrinite reflectance increased in the rock, and fission tracks in detrital apatite were completely annealed, indicating a T_{max} of 250°-300°C. Metamorphic grade, as estimated by an assemblage change of smectite + kaolinite to illite + chlorite, suggests a T_{max} of only 150°-180°C.

The wide temperature range over which certain mineral assemblages can form and (or) persist indicates that metamorphic grade is less accurate than vitrinite reflectance in estimating T_{max}. (Authors' abstract)

BARKER, C.E. and HALLEY, R.B., 1986, Fluid inclusion, stable isotope, and vitrinite reflectance evidence for the thermal history of the Bone Spring Limestone, southern Guadalupe Mountains, Texas, *in* Gautier, D.L., 1986, Roles of organic matter in sediment diagenesis: Soc. Econ. Paleontol. & Mineralogists, Spec. Publ. 38, 203 pp, p. 189-203. Authors at U.S. Geol. Survey, Box 25046, Denver, CO 80225, USA.

The Permian (Leonardian) Bone Spring Limestone is a significant oil reservoir rock in the Delaware Basin of west Texas and southern New Mexico. Analysis of fluid inclusions trapped in fracture-filling cements, oxygen isotope composition of the cements, and thermal maturity measurements of host rock provide a detailed record of the thermal and fluid history for this area of the western Delaware Basin. Although these cements have petrographically distinct multiple zones, Th of oil fluid inclusions and $\delta^{18}O$ data divide these cements into two (early and late) groups. Early cements have $\delta^{18}O$ near 0‰ and contain dull-blue fluorescent oil inclusions whose Th is mainly between 55°C and 90°C. The late cements occur in fractures that crosscut the early cements and are strongly oriented subparallel to the local structures formed during the Laramide orogeny and Basin and Range uplift. The late cements have $\delta^{18}O$ between -8% and -9‰ and contain sparse oil inclusions similar to those in the early cement. P fluid inclusions in the late cements have a Th mainly between 90°C and 135°C. Petrographic observations suggest that overlap in Th between early and late cements is due to: (1) incorporation of fragments of early cements into crosscutting late cements; (2) local neomorphism of early calcite along margins of late calcite; and (3) formation of S inclusions (some distinguished by yellow fluorescence) during uplift and exposure.

When interpreted through burial history reconstruction, Th and $\delta^{18}O$ data suggest that oil migrated relatively early while this rock was about 55°C to 75°C. These T were attained at near maximum burial depth of 1-2 km (estimated 30°C/km paleogradient) at the end of the Permian. The average Th values of P inclusions of about 110°C are consistent with maximum T of ca. 120°C interpreted from a mean vitrinite reflectance (Rm) of 0.7%, suggesting that the late cements record the maximum T attained in the rock. The change in $\delta^{18}O$ of about 8‰ from the early to late cement is nearly that expected from the difference in Th between these cements. Although maximum burial depth was reached near the end of the Permian, maximum T was not recorded until geothermal gradients apparently increased in the Tertiary. The evidence for this higher geothermal gradient is recorded in cements from fractures formed during early Tertiary deformation.

Calculations from calcite/water fractionation relations and Th indicate that early calcite cement precipitated from water that had $\delta^{18}O$ of about +9‰ and later cements precipitated from water of about +7.5‰. These values are typical for waters remaining after intense evaporation of for deep basin brines. T determinations are associated with sufficient error that both cement generations may have been precipitated from the same water, and cement isotopic differences may have resulted solely from T changes. (Authors' abstract)

BARKER, C.E. and WOOD, Teresa, 1986, Notes on cathodolumnescence microscopy using the Technosyn stage, and a bibliography of applied cathodoluminescence: U.S. Geol. Survey Open-File Rept. 86-85, 35 pp.

BARLEY, M.E., GROVES, D.I., HO, S.E. and PHILLIPS, G.N., 1986, Archaean and Tertiary volcanic-hosted gold mineralization: Similarities and contrasts, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 1-6. First author at Dept. Geol., Univ. Western Australia.

Archaean greenstone-hosted and Tertiary epithermal gold deposits show significant differences in structural control, wallrock alteration and mineralogical zonation. Archaean deposits are i) sited in structures typical of the ductile-brittle transition, ii) have great vertical extent but limited vertical zonation, and iii) are dominated by Fe-sulphides, K-mica, albite and carbonates, whereas Tertiary epithermal deposits are i) sited in the near-surface environment in brittle structures, ii) have limited vertical extent but well-developed vertical zonation, and iii) are dominated by argillic alteration, silicification and propylitization. Despite these differences, the deposits are remarkably similar in ore mineralogy and metal associations, particularly the high Au/base-metal ratios relative to crustal values. Both deposit types appear to have been deposited from low salinity, H_2O-CO_2 fluids carrying gold and other metals as reduced sulphur complexes.

The contrasts in deposit form, alteration styles and mineralogical zonation can be readily explained by the depth and mechanisms of ore deposition. Gold was deposited in Archaean gold deposits largely as a result of reactions between deep-crustal metamorphic fluids and hot, ductile wallrocks. In epithermal gold deposits, gold was deposited as a result of boiling and fluid mixing in near-surface, brittle host rocks. (Authors' abstract)

BARNES, S.J., 1986, The distribution of chromium among orthopyroxene, spinel and silicate liquid at atmospheric pressure: Geochimica Cosmo. Acta, v. 50, p. 1889-1909.

BARROS, J.C., 1986, Fluid inclusions, genetic models and exploration stategies for emerald deposits: Cases from Brazil (abst.): Terra Cognita, v. 6, no. 3, p. 509. Author at Univ. de Brasilia, 70910 Brasilia, Brazil.

In the "Centre-West Region" of Brazil, the Precambrian has recently been identified as belonging to the lower ultramafic schistose units of an extensive Archean greenstone belt containing emerald mineralization.

Fluid inclusions, occurring in emerald from ferroan phlogopite, talc-schist and quartz and feldspar matrices, attain a size of 470 µm. They are classified into 5 types, according to their chemical composition. Type "C" accounts for 70% of the total population and is CO_2-rich, with CO_2 gas predominating over CO_2 liquid. Type "G" inclusions are very rare and contain trapped silicate melt, interpreted as devitrified glass, in a quartz matrix. Thermometric studies show a wide range of salinities, from 0.9 to 37 equiv. wt. % NaCl. Te freezing data and daughter mineral melting indicate that the fluids are enriched in NaCl, KCl, $MgCl_2$, and CH_4, and contain abundant CO_2 (7.20 mole %). This liquid has a density averaging 0.75 gm/cm^3. The wide range of Th is attributable to different pulses of fluid resulting in multi-stages of beryl formation. The shallow depth of deposit formation has favored sudden P release resulting in rapid variations in P-T conditions. The high T inclusions indicate that the early fluid had a discontinuous line of descent due to immiscibility, effervescence and/or boiling. At a later stage and at lower T and P, there is a roughly continuous line of descent. A genetic model, involving pneumatolytic-hydrothermal stages and based on field and fluid inclusion data, is proposed. (From the author's abstract)

BARTON, M.D., 1986, Phase equilibria and thermodynamic properties of minerals in the $BeO-Al_2O_3-SiO_2-H_2O$ (BASH) system, with petrologic applications: Am. Mineral., v. 71, p. 377-300.

BARTOSHINSKIY, Z.V., BEKESHA, S.N., VINNICHENKO, T.C., KALYUZHNYY, V.A., SVOREN', I.M., 1985, Gas impurities in diamonds from the deposits of Yakutia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 229-230. (In Russian; translation by Dorothy B. Vitaliano). Authors at Leningrad State Univ., IGGGI Akad. Sci. Ukrainian SSR, USSR.

Despite their exceptional importance for clarifying problems related to the origin of this mineral under mantle conditions of our planet, data on the volatile substances in natural diamonds are very scarce at present, and concern only individual samples from foreign deposits.

Study of volatile impurities in diamonds from the Yakutian deposits, which we were the first to carry out, was accomplished using special apparatus consisting of a heater connected to a mass spectrometer. The investigations were made as the samples were heated to 1600°K; the gases liberated from the crystals at about 1000, 1300 and 1600°K were analyzed.

Diamonds from the Mir and Sytykan pipes and placers in the basin of the Anabar R. were studied; all the samples were devoid of visible cracks and solid inclusions and were carefully purified before the analysis. The diamonds from the Mir pipe were octahedra with sheaf-like striations, those from the Sytykan pipe were multifaceted combinations of the octahedron and rhombododecahedron with sheaf-like and hackly striations on {110}, and those from the placers were cryptolaminated dodecahedrons and dark-colored individuals of cubic habit. With the exception of the last, all the stones were colorless and highly transparent.

During the investigations, H_2O, N_2, CH_4, CO, CO_2, C_2H_6 and C_3H_8 were found in the diamonds; the ratios between the volumes of these differed essentially at different T. The table gives the results of mass-spectrometric investigations of the gaseous substances liberated from the crystals when they were heated to about 1000°K. In all cases the commonest components were N_2, CO and water, the volumetric amounts of which (like the others) underwent substantial variations in the different deposits and varieties.

Both the foreign and the Yakutian diamond deposits contain various hydrocarbons, the formation of which is little dependent on T, just as in the case of water, CO and CO_2. Whereas the place of the last two components in the reactions forming diamond (for instance, by the Boudoir reaction) seems obvious, the role of hydrocarbons still awaits explanation. One thing is certain: the volatile components in natural diamonds are relicts of the diamond-forming fluid medium, preserved in very tiny voids, microcracks, and along dislocations and other defects of the diamond crystal lattice. It also is possible that some of the volatile components detected mass spectrometrically were formed on the surface of the catalyst crystal from individual liberated atoms and radicals, by means of various chemical reactions.

Further investigations in the field of study of volatiles in natural diamonds will open up greater possibilities both in the matter of deciphering the processes of their formation in the upper mantle and in correlating the concentrations of these components with various particulars of the mineral containing them. (From the authors' abstract)

Table

Volatile Components	Content, vol.%			
	Mir pipe	Sytykan pipe	Placer in Anabar basin	
			Cryptolamellar dodecahedrons	dark-colored cubes
H_2	28.10	2.19	9.42	7.91
N_2	50.94	34.47	55.63	17.21
H_2O	8.46	16.07	-	51.97
CO	-	27.30	17.83	12.20
CO_2	9.29	2.23	3.42	6.05
CH_4	3.21	13.44	8.84	3.70
C_2H_6	-	3.52	3.01	0.45
C_3H_8	-	0.78	1.85	0.51

BASHAM, I.R. and MATOS DIAS, J.M., 1986, Uranium veins in Portugal, in Vein type uranium deposits, IAEA - TECDOC-361, p. 159-168. First author at British Geol. Survey, Edinburg, Scotland.

Vein-type U deposits in Portugal demonstrate a broad temporal and physical spectrum from intragranitic hydrothermal jasper-type veins formed at moderately high T, through lower T quartz veins and peribatholithic disseminated mineralization of 'Iberian-type,' to undoubted supergene enrichments in surface-related planar traps such as weathered basic dikes. All appear to be in close spatial relationship to 'fertile' Hercynian granites in which uraninite of low Th content is the main contributor to the enriched U levels. The availability of this large source of labile U, a pervasive fracture network and a series of tectonic and intrusive events which could generate hydrothermal circulation, allow several alternative genetic models for the mineralization. It now appears that the classic hydrothermal pitchblende veins within the granite are most likely of late-Hercynian age. (From the authors' abstract)

Fluid inclusion data from sericitized zones, and from fluorite and sphalerite showed formation T of 200-250°C. (E.R.)

BARSUKOV, V.L., DURASOVA, N.A., KOVALENKO, N.I., RYABCHIKOV, I.D. and RYZHENKO, B.N., 1986, Oxygen fugacities and the behavior of tin in melts and supercritical solutions (abst.): Terra Cognita, v. 6, no. 3, p. 526.

BAUMANN, L., LEEDER, O. and WEBER, W., 1985, The position of platform activation (arcogenesis) in plate tectonics and its metallogenetic importance (exemplified by the North Atlantic-West European lithospheric area), in K.H. Wolf, ed., Handbook of strata-bound and stratiform ore deposits, Part IV, Vol. 12, General studies: Amsterdam Elsevier Sci. Pub., p. 409-460.

Includes a highly complex "representation of liquation in natural melt systems" (Fig. 20, p. 433). (E.R.)

BAYHURST, G.K. and JANECKY, D.R., 1986, Metal compositions of Mauna Loa sublimate (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 537.

BAZHEYEV, Ye.D. and ISHKOV, Yu.M., 1985, Variation in salt composition and content of ore components in hydrothermal solutions of different stages in wolframite deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 149-150 (in Russian; translation by Dorothy B. Vitaliano). Authors at Geochem. Inst. of Buryat-Mongol Affiliate of USSR Acad. Sci., Ulan-Ude, USSR.

As a result of study of the interrelationships of hydrothermal veinlets of different composition with one another and with magmatic formations of different age, the temporal relationships between individual mineral parageneses in the wolframite deposits of Transbaikalia and Central Kazakhstan were established. Later, on the basis of ontogenetic criteria, the order of crystallization of the ore and gangue minerals constituting a given paragenesis (quartz, wolframite, fluorite) was established, and also different generations of the same mineral were distinguished. The determination, as a result of those investigations, of "pre-ore," "syn-ore" and "post-ore" quartz (or fluorite), and subsequent individual study of primary gas-liquid inclusions in crystals of different generations, served as the basis for ascertaining the composition of the hydrothermal solutions at different stages of the process. This was manifested practically in the fact that so far as possible, only those inclusions whose trapping time relative to the stage of massive ore deposition was predetermined as a result of detailed mineralogical investigations were subjected to thermo- and cryometric and laser-spectral study.

Evolution of solutions in the formation of quartz-hübnerite veins (Dzhida ore field)

[Sample type]	Stage	Th, °C	Te, °C	Cs %	CW g/l*	C_{Mu} g/l*
Vein filling	Ore	260-215	-31.6...-29.1	20.4-18.4	125	112
	Post-ore	170-125	-29.3...-28.8	2.4- 0.2	not det. (<3.3)	not det. (<0.006)
Wall-rock meta-somatite	Pre-ore	390-295	-29.7	24.8-23.1	no data	
	Ore	260-230	-31.6...-30.2	20.0	22	98
	Post-ore	185-165	-34.6...-29.6	4.0- 3.0	(<17)	4

Notes: Cs = composition of "special" salt component (fluoroborate?).
[*CW and C_{Mu} are not defined - Ed.]

That study made it possible to establish that in the course of development of the hydrothermal process, the qualitative composition of the solutions varied only slightly: at all stages halogens (chlorine and fluorine) were the main [anions] of the W-bearing solutions; sometimes B was present. The concentration of a certain salt component, "special" for each deposit, which shows a distinct correlation with the concentration of the ore-forming elements, is of principal value, not the concentration of all the components. After massive ore deposition the content of ores and of the "special" component in the solutions drops sharply (table).

Taking into account the aforementioned correlation and the high concentration of the "special" component (in this case fluoroborate?) in the solutions of the pre-ore stage, it can be said with a great amount of confidence that the solutions which produced the wall-rock alteration contained a substantial number of ore-forming elements.

The regularities brought out make it possible to estimate, during exploration, the productivity of veins along individual sections (including barren ones) on the basis of study of inclusions in minerals. The use of laser-spectral microanalysis of the liquid phase of individual gas-liquid inclusions opens up the possibility of determining the prospects of wall-rock metasomatites even in the prospecting stage, on the basis of inclusions of solutions of the pre-ore stage. (Authors' abstract)

BAZRAFSHAN, Khosrow, 1986, Geology and geochemistry of Hermosa District deposits, Sierra County, New Mexico (abst.): New Mexico Geol., v. 8, no. 3, p. 68. Author at Geosci. Dept., New Mexico Inst. of Mining & Tech., Socorro, NM 87801.

The results of thermometric and gas analyses of fluid inclusions show that these deposits are shallow-seated, boiling epithermal deposits. A mineralization temperature of 240-280°C and salinity range of 0-9 eq. wt.% NaCl have been obtained from the fluid inclusion analyses. The results of gas analyses show that, besides water, the ore-forming fluids in the inclusions also contain small amounts of He, H_2, CO_2, H_2S, CH_4, and some other organic compounds. Based on all geochemical and geological data, it can be concluded that these deposits are the result of igneous heat that was injected into a sedimentary rock-fluid system, and a convective cell was established in the sedimentary fluids. These fluids dissolved rock components at high T and deposited them at lower T. (From the author's abstract)

BEANE, R.E., WILKINS, Joe, Jr. and HEIDRICK, T.L., 1986, A geochemical model for gold mineralization in the detachment fault environment (abst.): Ariz. Geol. Soc. Digest, v. 16, p. 222. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48106.

See Wilkins, Beane, and Heidrick, 1986, this volume. (E.R.)

BEARD, J.S. and DAY, H.W., 1986, Origin of gabbro pegmatite in the Smartville intrusive complex, northern Sierra Nevada, California: Am. Min., v. 71, p. 1085-1099. First author at Dept. Min. Sci., Nat'l. Museum of Natural History, Smithsonian Inst., Washington, DC 20560, USA.

We propose that the pegmatites formed from a mafic intercumulus melt in the presence of a fluid phase.

Fluid inclusions in plagioclase appear to be associated preferentially with the alteration in the pegmatites. Hence, either a fluid phase was present locally during pegmatite crystallization and cooling, or fluids migrated preferentially through the podiform pegmatites as they cooled. (From the authors' abstract and text)

BEATY, D.W., CUNNINGHAM, C.G., RYE, R.O., STEVEN, T.A. and GONZALEZ-URIEN, Eliseo, 1986, Geology and geochemistry of the Deer Trail Pb-Zn-Ag-Au-Cu manto deposits, Marysvale district, west-central Utah: Econ. Geol., v. 81, p. 1932-1952. First author at 13939 West Cedar Place, Golden, CO 80401.

The principle sulfide depostis exposed in the Deer Trail mine, Marysvale district, west-central Utah, form a semicontinuous group of elongated strata-bound Pb-Zn-Ag-Au-Cu bodies (mantos) [replacing] carbonate beds. Fluid inclusions in main-stage sphalerite homogenize at 250° to 300°C with salinities ranging from near zero to 17 to 22 equiv wt % NaCl. The inclusions locally contain liquid CO_2 and show evidence of boiling. T based on $\delta^{34}S$ sphalerite-galena values range from 245° to 267°C. The $\delta D(H_2O)$ and $\delta^{18}O(H_2O)$ values of the hydrothermal fluids determined from isotopic analyses of quartz and inclusion fluids in fluorite, quartz, and sphalerite range from -131 to -75 per mil and -20.3 to -2.2 per mil, respectively, and correlate with inclusion salinities, T of deposition, and position of the host mineral in the paragenesis. The deposit formed during the interaction of two types of heated aqueous fluids: a high-salinity, probably magmatic and a dilute meteoric fluid. Magmatic water was significant during main-stage base metal mineralization but was replaced almost entirely by meteoric water in the late stages of the paragenesis. (From the authors' abstract)

BEATY, D.W., LYNCH, W.C. and SOLOMON, G.C., 1986, Origin of the ore deposits at Gilman, Colorado; oxygen and hydrogen isotopic constraints (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 537.

BEATY, D.W., NAESER, C.W. and LYNCH, W.C., 1986, Geology and significance of the auriferous manto deposits at Tennessee Pass, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 537. First author at Noranda Explor., Box 15638, Denver, CO 80215.

The numerous small manto deposits at Tennessee Pass, Colo., hosted in the easterly-dipping Leadville Dolomite, crop out over 7 km of strike, and average about 13 ppm Au. The ores are heavily oxidized, but at one time consisted of semi-massive pyrite, fine-grained quartz, zeolites, and native gold. Fluid inclusions in quartz indicate a deposition temperature of about 200°C. Strong igneous affinities are indicated by oxygen isotopes ($\delta^{18}O$(fluid) = +3 to +6), sulfur isotopes ($\delta^{34}S$(pyrite) = +1 to +4), and trace elements (high As, Sb, Hg). A large area of argillic and phyllic alteration (T = 300°C) affects Laramide intrusive rocks 3 km east of Tennessee Pass. Fission-track geochronology indicates a major paleothermal anomaly (40-42 Ma) around this alteration center, which is interpreted to reflect a buried porphyry stock.

These relations show elements of similarity with the major nearby manto districts of Leadville and Gilman. In the center of the system, the hydrothermal flux was dominantly vertical, resulting in moderate to high temperature veining and pervasive alteration (similar to Leadville). Although the Paleozoic carbonates do not crop out in this area, deep drilling within the paleo-thermal anomaly has intersected unoxidized gold-rich mantos similar (but deposited at higher temperature) to those found in outcrop. Lateral to that, confined up-dip fluid flow resulted in few veins, stratigraphically controlled alteration (similar to Gilman) and deposition of the Tennessee Pass epithermal replacement deposits. This area thus appears to represent a partially exhumed, highly auriferous, manto-type system. (Authors' abstract)

BEBOUT, G.E., 1986, High P/T fluid flow during subduction zone metamorphism: Catalina schist terrane, Santa Catalina Island, CA (abst.): GSA Abstracts with Programs, v. 18, p. 538.

BEBOUT, G.E. and CARLSON, W.D., 1986, Fluid evolution and transport during metamorphism: Evidence from the Llano Uplift, Texas: Contrib. Mineral. Petrol., v. 92, p. 518-529. First author at Dept. Earth & Space Sci., Univ. California at Los Angeles, Los Angeles, CA 90024, USA.

A field, petrologic and stable isotopic investigation of the marbles and calc-silicates of the 1.15 b.y. Valley Spring Gneiss documents the dilution of internally evolved CO_2-rich fluids by externally derived aqueous fluids introduced along channelways. (From the authors' abstract)

BECK, C.W., 1986, Spectroscopic investigations of amber: Applied Spectroscopy Reviews, v. 22, no. 1, p. 57-110.

An extensive review (>200 references) on all aspects of the subject. Of pertinence to any studies of the fluid and gas inclusions found in amber. (E.R.)

BECKER, R.H. and PEPIN, T.O., 1986, Mars, Earth and SNC meteorites: The noble gas-nitrogen connnection (abst.): Terra Cognita, v. 6, no. 2, p. 102. Authors at Physics Dept., Univ. Minnesota, Minneapolis, MN 55455, USA.

Noble gas contents and nitrogen isotope ratios in glass inclusions of the antarctic shergottite EETA 79001 are far higher than in the surrounding lithology and reflect the presence of a gas component which may be presumed to have been trapped during glass formation. (From the authors' abstract)

BECKETT, J.R., 1986, The origin of calcium-, aluminium-rich inclusions from carbonaceous chondrites: An experimental study: Ph.D. dissertation, Univ. of Chicago.

BEHR, C.B. and NORMAN, D.I., 1986, Geochemical analyses of epithermal ore fluids: St. Cloud-U.S. Treasury vein system, Chloride district, Sierra County, New Mexico (abst.): GSA Abstracts with Programs, v. 18, p. 538. Authors at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Vein mineralization is structurally controlled and hosted primarily by Tertiary volcanic rocks. Base-metal ores predominate at lower levels, grading into silver, then gold ores with increasing elevation. Fluid inclusion studies indicate boiling occurred within the ore zones with salinities of 0 to 3 eq. wt.% NaCl and Th of 220 to 270°C.

Bulk analyses of fluid inclusion volatiles by mass spectrometry of surface samples along 1.5 km of vein outcrop, and from ore shoots, reveals increasing levels of gaseous species with elevation in mineralized zones and high amounts in unmineralized quartz up to 100 m above ore shoots (e.g., total gaseous species at depth are about 0.27 mole % and up to 2.45 mole % above ore shoots). Anomalous inclusion gases above ore zones indicate hidden ore shoots and suggest applications to exploration. Principal gases are H_2, N_2, H_2S, CH_4, and C_2C_8[sic; probably C_2H_8 meant] organic compounds. H_2S levels are approximately 0.01 mole % in all analyses and principal C_2C_8[sic] organic species are benzene, n-butane, propane, and toulene.

Microscopic observations correlate high percentages of vapor-filled inclusions with the increased amounts of gaseous species in inclusions observed at high levels in the system. The data indicate progressive depletion of volatiles from a boiling ore-fluid and that the fluids mineralizing the ore shoots experienced a different boiling history. Modeling of depositional processes based on the analytical data, and assuming an open, boiling system, explains the over 200 m vertical extent of ore deposition and the observed mineral zonations. (Authors' abstract)

BEHR, H.J. and DILL, Harald, 1986, Ore mineralization and fluid migration in the mid-European orogenic thrust belt: Preliminary studies for the Continental Deep Drilling Program (abst.): Abstracts of Posters, VII IAGOD Meeting, Lulea, Sweden, 18-22 Aug., 1986 (unpaginated). Authors at Continental Deep Drilling Program, Niedersächsisches Landesamt für Bodenforschung, Hannover, FRG.

Sn, W, and U were concentrated in late Variscan S-type granites as a result of prograding differentiation. At about 290 Ma, these elements were remobilized, leading to the formation of uranium oxide, scheelite, wolframite, and cassiterite in veins near the granite bodies. This remobilization occurred via high-temperature (up to 450°C), low-salinity solutions. Conversely, barite-fluorite veins, most widespread at the periphery of the basement of the Permo-Triassic embayments, originated from high-salinity brines under ore moderate temperatures (150-180°C). They were generated during the waning stages of thrust activity, when graben-like troughs were formed at the thrust front. Deeply circulating solutions (Ca-Na-(K-Mg)-Cl) removed Ba, F, and Sr from the enclosing wall rock and the clastic rocks covering the deeply eroded basement. Via convective circulation, these brines accumulated in faults cutting the basement. Radiometric dating show that these ores were deposited from the Permian through the Early Liassic. (From the authors' abstract)

BELEVTSEV, Ya.N., STRYGIN, A.I., BELEVTSEV, R.Ya. and TERESHCHENKO, S.I., 1985, Thermobarometric and petrographic characteristics of the Precambrian rocks of the Belorussian-Baltic region (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 196-197 (in Russian; translation by Dorothy B. Vitaliano). Authors at IGFM, Acad. Sci. Ukrainian SSR, Kiev, USSR.

As a result of thermobarometric investigations of gas-liquid inclusions and high-density CO_2 inclusions and their aggregate state in the Precambrian ferruginous quartzite, and ores of the Belorussian-Baltic region, the rocks were subjected to regional metamorphism of epidote-amphibolite to granulite facies, and the original substrate was sedimentary silty-pelitic sandy deposits, rich in ferruginous and carbonate material in individual regions. (Abbreviated by E.R. from the authors' abstract)

BELKIN, H.E., CAVARRETTA, G., DE VIVO, B. and TECCE, F., 1986, New data on fluid inclusions in recent hydrothermal minerals in the Sabatine area (abst.): CNR Gruppo Naz. Volcanol. Annual Mtg., Roma (in Italian).

BELKIN, H.E., CHELINI, W., DE VIVO, B. and LATTANZI, P., 1986, Fluid inclusions in hydrothermal minerals from Mofete 2, Mofete 5 and San Vito 3 geothermal wells, Phlegrean Fields, Campania, Italy, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 7-12. First author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092, USA.

A fluid inclusion study of the Mofete 2, Mofete 5, and San Vito 3 geothermal wells, Phlegrean Fields, Campania, Italy, indicates that the hydrothermal minerals were formed by aqueous fluids that were moderately saline to hypersaline and at least, in part, boiling. Three types of P fluid inclusions were found in hydrothermal K-feldspar, quartz, calcite, and epidote: A) two-phase (liquid + vapor), liquid-rich with a wide range of salinity, B) two-phase (liquid + vapor), vapor-rich with low salinity, and C) three-phase (liquid + vapor + NaCl dxl crystal(s)), liquid-rich. Results of microthermometric and crushing studies are reported for eleven drill core samples taken from the lower portions of the three wells. The fluid inclusion salinity values for Mofete 5 and Mofete 2 reflect the hypersaline and saline fluids, respectively, that were found by drilling. Fluid inclusion Th for Mofete 2 and San Vito 3 generally increase with depth and correspond to the down-hole extrapolated T. Th for Mofete 5 are higher than the down-hole extrapolated T. Crushing studies reveal the presence of gas (CO_2?) under P (>1 atm.) in inclusions from all studied samples. (Authors' abstract)

BELKIN, H.E., DE VIVO, B., BECCALUVA, L. and MACCIOTTA, G., 1986, Fluid inclusion and chemical studies of spinel peridotite xenoliths from Sardinia

(Italy) (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 54. First author at MS 959, U.S. Geol. Survey, Reston, VA 22092, USA.

Spinel peridotite xenoliths commonly occur in Pliocene-Quarternary alkaline to subalkaline volcanic rocks that crop out in Sardinia (Italy). A study of their fluid inclusions and mineral and whole-rock chemistry has been used to place constraints on their origin and history of ascent. Fluid inclusions have been examined by microthermometric techniques using a CHAIXMECA heating and freezing stage; XRF and microprobe analyses have been performed on the xenoliths and constituent minerals, respectively.

Fluid inclusions containing essentially pure CO$_2$ and various proportions of silicate glass have been found in orthopyroxene, clinopyroxene and olivine and represent the trapping of two immiscible fluids. Most of these inclusions are S because they occupy healed fractures that sometimes crosscut each other and also cross grain boundaries. A few high density inclusions appear to be P but show partial decrepitation phenomena. Th of vapor (V) and liquid (L) CO$_2$ ranges from -40° to +31°C (95% Th V + L → L; 5% Th V + L → V) and yields a CO$_2$ density that ranges from 1.11 to 0.18 g/cm^3. Most densities are between 0.60 and 0.80 g/cm^3. The frozen inclusions melt in a very narrow range with an equilibrium melting T = ~-56.6°C; this suggests essentially pure CO$_2$. If a trapping T of 1000°C for a pure CO$_2$ system is assumed, the trapping P would be between 0.5 kb and 10 kb. For an average media (rock or magma) density of 2.8 g/cm^3, the inclusions would be trapped at depths from 2 km (0.18 g/cm^3 CO$_2$) to 37 km (1.11 g/cm^3 CO$_2$). The CO$_2$ fluid inclusions represent a separate volatile phase ascending with the magma that was continuously trapped (along with silicate melt) by intragranular fracturing. Although the inclusions appear to show a continuum from high to low CO$_2$ density, the mode represents trapping at 9 to 17 km and may indicate a common fracturing event during ascent. Another cluster of inclusions with densities equivalent to trapping at 2 to 3 km may represent residence in a shallow magma reservoir. (From the authors' abstract)

BELKIN, H.E. and TECCE, Francesca, 1986, Hydrothermal phlogopite from the SH2 well, Sabatini volcanic district, Latium, Italy: Fluid inclusions and chemistry (abst.): GSA Abstracts with Programs, v. 18, p. 538. First author at U.S. Geol. Survey, MS 959, Reston, VA 22092

The SH2 deep well (2,498.7 m) was drilled in 1982-1983 by an ENEL-AGIP Joint Venture as an exploratory hole to assess the geothermal potential of the area north of Bracciano Lake, Latium, Italy. Drill-cutting samples from a thermometamorphic-metasomatic zone (1,140-2,498.7 m) contain anhydrite ± phlogopite. Euhedral to subhedral phlogopite (C2/m,1M) crystals, 0.5 to 2 mm, commonly are zoned (as viewed $\perp$ to (001)). The crystals contain solid inclusions of anhydrite and apatite and primary fluid inclusions (FI). Two-phase (liquid + vapor) liquid-rich inclusions and multiphase (liquid + vapor + daughter crystals) liquid-rich inclusions yield a range of temperature of homogenization (Th) (190 to 295°C) that is similar to the Th of FI in the associated anhydrite and the measured down-hole well temperature. This similarity indicates that the phlogopites are hydrothermal and that they have been formed by the geothermal fluids. FI freezing studies show a variable fluid salinity (0 - 8 wt.% NaCl equivalent) and that the fluid also contains at least Ca^{2+}.

The phlogopites (analyzed $\perp$(001) by electron microprobe) are nearly endmember; FeT/(FeT + Mg) = 0.02 to 0.1, and Al^{IV}/11 oxygens = 1.0 to 1.35. F, BaO and TiO$_2$ range from 2.4 to 5.0 wt.%, 0 to 3.8 wt.%, and 0.1 to 0.89 wt.%, respectively. Simple dark and light zones, either core or rim, usually are separated by sharp boundaries. The darker zones usually contain fluid inclusions and are Fe-rich. The light zones can have more or less

F, BaO, or TiO_2 than the dark zones.

The variation of fluid inclusion salinities, the phlogopite zoning, and the chemistry of the zoning suggest that different fluids and varying conditions were operative in this geothermal system. (Authors' abstract)

BELLO, R.M.S., SCHULTZ-GUETLER, R.A. and VALARELLI, J.V., 1986, Influence of Al_2O_3 on the opx-cpx geothermometer samples from Surubim, Bahia: Anais da Acad. Brasileira de Ciencias, v. 58, no. 1, p. 164 (in Portuguese).

Indexed under fluid inclusions. (E.R.)

BELONOZHKO, A.B. and SHMULOVICH, K.I., 1986, Study of dense fluid in micropores by the molecular dynamics technique: Geokhimia, 1986, no. 11, p. 1523-1534 (in Russian; English abstract).

Pertinent(?) to the problem of the degree of representativeness of fluid trapped in small inclusions. (E.R.)

BELYANIN, V.S. and GRIGOR'EVA, T.V., 1986, Thermodynamic analysis of solubility of magnetite in the high-temperature aqueous solutions: Geokhimiya, 1986, no. 10, p. 1443-1451 (in Russian; English abstract).

BENEŠOVÁ, Z., ČADEK, J. and CHRT, J., 1986, Fluorite mineralization in the Bohemian Massif, in A.D. Shcheglov, ed., Geology and genesis of fluorite deposits: Far East Sci. Center of Acad. USSR, Vladivostok, p. 38-43 (in Russian).

Fluorite vein deposits of Mesozoic age which predominate in the Bohemian Massif were formed from highly concentrated saline brines in the range 130-230°C. Fluorite is accompanied by quartz, hematite, and feldspar in the higher T stage, by pyrite, calcite and sulphates in the lower T stage. Another type of fluorite deposit represented by the Teplice and Jílové deposits in northern Bohemia is of Tertiary and Quaternary age. Fluorite deposits form stratabound bodies in Cretaceous rocks. Fluorite was deposited from low to medium concentration solutions rich in F, below 160°C. Fluorite had been found as a minor constituent of Variscan Sn-W deposits of the Krušné hory Mountains and Slavkovský les Mountains. It was formed from saline brines at about 350-400°C. (Authors' abstract, translated by J. Ďurišová)

BENY, C., TOURAY J.C. and DARDENNE, M., 1986, Characterization by Raman spectroscopy of carbonates in the calcite family: Application to the determination of solid phases in fluid inclusions (abst.): Bull. Minéral., v. 109 Suppl., p. 60 (in French). First author at GIS BRGM-CNRS, 1A rue de la Férollerie, 45071 Orléans Cedex, France.

Identification of solid phases and dms in fluid inclusions is based, in general, on optical and microthermometric arguments and morphological and qualitative chemical data obtained by electron diffraction, but this is a destructive technique. In certain cases, Raman spectroscopy permits the direct determination of solids enclosed within inclusions in minerals. In this respect, calcite is one of the phases that has more commonly been identified so far by this method. In the case where other carbonates of the same family might be present, it would be useful to have a listing of reference data to permit mineralogical identification.

The purpose of this communication is to provide a table of characteristic frequencies, taking into consideration literature data, and especially to report new results obtained using this table to identify a rhombohedral carbonate occurring as a dm in P fluid inclusions in topaz.

We have studied 3 P inclusions in topaz from pegmatites in Serra de Mesa (Goías, Brazil). The inclusions contain an aqueous phase, a rim of liquid CO_2, and a CO_2 vapor bubble. Two solids are present. The first, having an acicular crystal form, produces a Raman spectrum which, at the present time, cannot be interpreted. The second, of rhombohedral shape, gave a spectrum showing the peaks characteristic of rhodochrosite. This thus provides a direct method of estimating the [minimum] amount of Mn in hydrothermal solutions.

In conclusion, if one takes into consideration all of the peaks in their Raman spectrum, it is easy to distinguish between different carbonates corresponding to the pure end members in the calcite family.

With respect to solid solutions, we expect, a priori, to find intermediate characteristics. Recent data of Bischoff et al. shows that this is very much the case. High-precision measurements are always necessary to estimate compositional errors with respect to calcite containing up to 15-20 mole % $MgCO_3$. Comparable studies must be undertaken on the other solid solutions, in particular the system siderite-rhodocrosite, in order to better evaluate the limits of using Raman spectroscopy in micromineralogy.

Thus, the proposed method has been used to distinguish between the various carbonates in a nondestructive manner, which no other method of microanalysis permits. (Authors' abstract, translated by R.J. Bodnar)

Editor's note: Similar abstract, in English, in Georaman-86, Special meeting Soc. Franc. de Min. et de Crist., Paris, 16-17 Oct., 1986.

BERDNIKOV, N.V., 1985, The Symposium "Thermobarogeochemistry of endogenic processes," Blagoveshchensk, Sept. 14-15, 1984: "Tikhookeanskaya Geologiya," no. 2, p. 120 (in Russian).

Cited in Naumov, 1986 (this volume).

BERDNIKOV, N.V., and KARSAKOV, L.P., 1985, Monitoring the fluid regime of metamorphism on the basis of inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 187-189 (In Russian; translation by Dorothy B. Vitaliano). Authors at Far Eastern Sci. Center of the USSR Acad. Sci., Khabarovsk, USSR.

Two possible origins of metamorphogenic inclusions are discussed: by trapping of batches of the mineralizing fluid by the crystal, and by coalescence of impurities of the fluid components contained in voids and dislocations in the structure of a mineral being formed. Nor is a "mixed" variant ruled out, where the trapped inclusions are the centers to which intrastructural impurities are attracted. The authors believe inclusions in metamorphogenic minerals can be formed by both processes. The distinction is very important in thermobarogeochemical investigations of metamorphism, as they carry different information.

Whereas the trapped inclusions probably contain fluid of the bulk composition, microinclusions from different minerals (formed by coalescence) may contain fluid of different composition due to the selective character of adsorption of fluid components by faces of different composition. Moreover, there may be microinclusions of different composition in the very same mineral, as its different faces have different surface energy.

Mixed variants, containing material from both processes, apparently are not very likely in nature, inasmuch as migration of fluid inclusions in solid silicates requires considerable temperature gradients, which are lacking in a deep metamorphic system.

Thus the generations of "trapped" inclusions carry the main and most reliable information on the fluid regime of metamorphism. (Abbreviated by ER from the authors' abstract).

BERDNIKOV, N.V., TOMILENKO, A.A. and KARSAKOV, L.P., 1985, Evolution of fluid regime of metamorphism and ultrametamorphism in the eastern part of the Bureya massif: Doklady Akad. Nauk SSSR, v. 285, no. 2, p. 439-441 (in Russian). First author at Inst. of Tectonics & Geophysics of Far-East Sci. Center of Acad. Sci. USSR, Khabarovsk, USSR.

Basement of the Bureya massif consists mostly of granitoids with fragments of blocks of various metamorphic complexes (diaphthorite gneisses and granulites of the amphibolite facies and zonally metamorphosed schist complex). Samples for inclusion studies were taken from garnet-cordierite-biotite-fibrolite gneisses of the Taskakh series from the upper Bureya River, leucosomes of injection migmatites from the Isa River basin and biotite granites from the region of the Nora River. Garnet-biotite thermometer gave T of metamorphism equal 650°C.

Quartz from gneiss bears inclusions filled mostly by CO_2-CH_4 fluid. P and PS inclusions contain mainly CH_4 fluid, later ones (PS and S) mainly CO_2 fluid. P inclusions of pure CH_4 are rare, some of them crystallize at T <-182.5°C, proving purity of methane; their Th ranges from -131 to -103.5°C and indicates methane specific volume from 2.67 to 3.8 cm^3/g. Th of pure CO_2 S inclusions vary from -17 to -16°C, specific volume of CO_2 0.92 to 1.25 cm^3/g. Most fluid inclusions in quartz of gneiss contains limited amount of water. One PS inclusion contained methane-carbon dioxide mixture under critical conditions; evolution of this filling may be described as follows (S = solid):

$$S\ CO_2 + L\ CH_4 + G(CH_4 + CO_2) \xrightarrow{-120°C} S\ CO_2 + G(CH_4 + CO_2) \xrightarrow{-61°C} L(CO_2 + CH_4) + G(CO_2 + CH_4) \xrightarrow{Tcr\ =\ -56°C} \text{fluid}\ (CO_2 + CH_4).$$

Migmatite leucosomes bear CO_2-H_2O and rare crystallized melt inclusions; Th of the latter is in ranges 640-660°C; crystallized melt inclusions in quartz of biotite granites gave practically the same Th (640-680°C); fluid inclusions in granites have essentially aqueous composition. Thus, at 650°C P of trapping of CH_4 inclusions was $3.6\text{-}5.6 \cdot 10^8$ Pa, and for CO_2 inclusions $3.1\text{-}5.7 \cdot 10^8$ Pa. Early metamorphic fluid was reducing and next it changed properties to oxidized. (Abstract by A.K.)

BERG, G.W., 1986, Evidence for carbonate in the mantle: Nature, v. 324, p. 50-51. Author at Geol. Dept., Univ. Port Elizabeth, PO Box 1600, Port Elizabeth 6000, South Africa.

The presence of primary carbonate in kimberlite magmas, which erupt to the Earth's surface from depths of ≥150 km, carrying with them the rare elemental form of carbon, diamond, is evidence for a reservoir of carbon in the Earth's mantle. Hypotheses about the form in which this carbon is stored were largely speculative until laboratory experiments established that at depths of ≥50 km carbon can be incorporated in the solid carbonates, dolomite ($CaMg(CO_3)_2$) and magnesite ($MgCO_3$). However, only one instance of minute inclusions of dolomite in a sample of rock from the mantle has ever been recorded, despite 25 years of intensive study of these rocks. Here I report the presence of hitherto undescribed brucite/calcite intergrowths ($Mg(OH)_2/CaCO_3$) in mantle-derived xenoliths which occur in the diamond-bearing volcanic kimberlite pipes of Kimberley, South Africa. These intergrowths could reflect the presence of relatively abundant dolomite in the mantle. They seem to have been overlooked to date because of their fine textures and susceptibility to replacement by secondary serpentine. (Author's abstract)

BERNARD, Alain and LE GUERN, Francois, 1986, Condensation of volatile elements in high-temperature gases of Mount St. Helens: J. Volcan. & Geotherm. Res., v. 28, p. 91-105.

BERNARD, L.J., 1986, Gold deposition within an "acid-sulfate" hot spring type system (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 6. Author at Dept. Geol., Univ. College, Swansea.

A Tertiary, gold-rich acid-sulfate hot spring system is found on the southern periphery of the El Indio gold-silver-copper mine, in the Andes of north-central Chile. Within this area, known as the Tambo mine, typical features of a hot spring system are expressed as bedded sulfates, sulfate sinters, explosion breccias and native sulfur. Deeper in the system are the more important hydrothermal breccias and veins that host the gold mineralization. Within both these structures gold is directly associated with strongly silicified, rhyolite tuff, wall rock contacts and the main gangue mineral, barite. Other gangue minerals are the sulfates alunite and jarosite and to a lesser extent oxides of tellurium and iron. Studying this assemblage on a S.E.M. has revealed gold is not only found as concentrations in its native state, in the silicified fragments and in barite, but also finely disseminated throughout the barite crystals. Alunite also crystallized concurrently within this gold-rich assemblage. It is hypothesized that this assemblage formed as ascending fluids rich in gold and barium mixed with near surface acid-sulfate waters. (Author's abstract)

BERNDT, M.E., BECK, W. and SEYFRIED, W.E., Jr., 1986, Hydrothermal alteration of basalt: Effect of high temperature Ca fixation on Sr isotope systematics (abst.): EOS, v. 67, p. 392.

BERZINA, A.I., SOTNIKOV, V.I., OSORGIN, N.Yu., Fomina, L.N., 1985, (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 233-234. (In Russian; translation by Dorothy B. Vitaliano). Authors at Inst. Geol. Geophys., Siberian Branch, USSR Acad. Sci., Novosibirsk USSR.

In essentially Mo deposits, e.g. the Sorskoye deposit (Kuznets Alatau), the ore mineralization is related to the development of silica- and alkali-rich granites and granite porphyries. Of the volatile components, F is critical and had the greatest effect on the development of the endogenetic process and primarily on liquation phenomena in the magma. This is supported by the coexistence of melt and high-T fluids (up to 600-730°C). Fluids rich in F produced extensive K-feldspathization and albitization of the granitoids, and of the veins of the first stage of mineralization spatially related to them. HF, an insignificant content of N_2 and the absence of CO_2 are recorded in the gas phase of the inclusions. Fluorides occur among the dms. The formation of the ore veins and breccias of the second stage of mineralization is related to fluids, essentially meteoric, in which CO_2 and N_2 predominated.

The Kal'makyr deposit (Central Asia) and the Kharmagtay prospect (Mongolia) were used as examples of the essentially Cu deposits. The mineralization is spatially related to stocks and dikes of grandiorite porphyry and diorite porphyry. The high-T fluids consist of melt-solutions of essentially chloride composition, in which the salt concentration reaches 50-60%. The role of CO_2 and N_2 increased abruptly in the formation of the ore veinlets.

Cu-Mo deposits controlled by small bodies of porphyritic rocks of intermediate composition and high alkalinity are characterized by moderate activities of halides against a background of high activity of water and CO_2. The deposits differ in both content and ratios of H_2O and CO_2. Wide scatter of these values is also observed within individual deposits. The largest Cu-Mo deposits in Mongolia, Erdenetuin-Obo and Tsagan-Suburga, are characterized by high gas contents and a wide scatter of values within each deposit. A general increase in gas content in the order: host granitoid -- porphyries of the ore complex -- K-feldspathized rocks is established. The aplite-granites and seriticitized rocks contain the least gases.

In the granitoids of the ore complex, high H_2O/CO_2 ratios compared to the host rocks are observed. The proportion of H_2O is still higher in the K-feldspathized rocks, and CO_2 increases abruptly in the sericitized rocks.

Data on the composition of the gases of fluid inclusions in quartz, zircon and apatite, and also data of chromatographic analysis of the rocks of the ore-bearing magmatic complexes, their host granitoids and hydrothermally altered rocks, indicate the complexity of the evolution of the composition of the volatile components in the endogenetic process in Cu-Mo deposits. The relationship between the volatile components in the fluids at different stages and phases of the process was governed primarily by the ratio of juvenile and meteoric components and degassing phenomena under conditions of relatively good permeability of the medium. (From the authors' abstract)

BERZINA, A.P., KURODA, I., SOTNIKOV, V.I. and ILLARIONOVA, E.N., 1986, Sources of fluids in copper-molybdenum occurrences of the Mongolian People's Republic (according to the data of the study of hydrogen isotope composition): Akad. Nauk SSSR, Sibirskoe Otdelenie, Geologiia i Geofizika, 1986, no. 3, p. 71-81 (in Russian; English abstract).

On the basis of the analysis of hydrogen isotope composition of minerals and the rocks of Cu-Mo occurrences of Mongolia it was established that meteoric waters took a substantial part in magmatic and ore-metasomatic processes. It is especially characteristic of well developed tectonic zones, which represent the major water-saturated structures. Out of these structures and in tectonically less developed zones where poor mineralization occurs, the magmatic formations of enclosing plutons are characterized by the values δD which correspond to primary-magmatic waters. Within the zones of ore accumulation which differ in long and complex magmatism development, the meteoric component is marked in all magmatic formations. The role of juvenile water is larger in the making ore-bearing magmatic complex and formation of metasomatites which genetically and in time stand close to this complex. (Authors' abstract)

BETHKE, C.M., 1986, Hydrologic constraints on the genesis of the Upper Mississippi Valley mineral district from Illinois Basin brines: Econ. Geol., v. 81, no. 2, p. 233-249.

BEYER, R.P. and STAPLES, B.R., 1986, Pitzer-Debye-Hückel limiting slopes for water from 0 to 350°C and from saturation to 1 kbar: J. Solution Chem., v. 15, no. 9, p. 749-764. First author at Univ. Washington, Seattle, WA.

Using internationally recognized critical evaluations for the dielectric constant of water by Uematsu and Franck and the thermodynamic surface of water by Haar, Gallagher, and Kell, the Bureau of Mines presents values for the Pitzer-Debye-Hückel limiting slopes for osmotic coefficients, apparent molal enthalpies, apparent molal heat capacities, apparent molal volumes, molal compressibilities, and apparent molal expansivities from 0 to 350°C and from saturation to 1 kbar. (Authors' abstract)

BINDE, Gisela, 1986, Contribution to mineralogy, geology and genesis of cassiterites: Freiberger Forschungsheft C 411, 60 pp. - Leipzig: VEB Deutscher Verlag für Grundstoffindustrie 1986 (in German; English abstract).

Investigations of mineral inclusions in cassiterites from the Erzgebirge Mountains and from some other deposits showed that only a part of the solid mineral inclusions in cassiterite are exsolutions. Pregenetic and postgenetic inclusions occur as well as inclusions taken over from neighboring rocks. Most trace elements of cassiterite are also bound in inclusions. Some trace elements cause a dark coloration of the cassiterite and an increase of density. (Author's abstract)

BINNS, P.R. and BODNAR, R.J., 1986, Decrepitation behavior of fluid inclusions in quartz at one atmosphere confining pressure (abst.): EOS, v. 67, p. 399. First author at Chevron Oil Field Res. Co., P.O. Box 446, La Habra, CA 90631.

One of the basic assumptions upon which fluid inclusion geothermobarometry is based is that the inclusion volume has remained constant since the time of trapping. Geologic observations and results of numerous laboratory studies, however, suggest that during basin subsidence and during retrograde metamorphism volumes of early-formed inclusions may increase in response to large differences between the internal P in the inclusion and the lower confining P, thus invalidating microthermometric data obtained from these inclusions. In order to better understand the conditions under which reequilibration occurs in nature, and to evaluate the relative importance of various factors which control decrepitation behavior, we have determined the internal P required to decrepitate synthetic inclusions of known composition, and of various sizes and shapes, in natural quartz.

Except for mechanical properties of the host mineral, the single most important factor controlling the amount of internal pressure required to decrepitate a fluid inclusion in quartz is the size of the inclusion. Of considerably less importance is the inclusion shape. The relationship between internal P required to cause decrepitation and the size and shape of an inclusion is given by:

$$P(int) = 2525 - 162X - 58.5X^2 + 36Y$$

where P(int) is the internal P (in bars), X is the $\log_{10}$ of the inclusion volume (in μm^3), and Y is a variable describing the inclusion shape; Y varies from zero for an extremely irregularly shaped inclusion to ten for a regularly shaped inclusion having a spherical or negative crystal morphology.

To investigate the effect of time on decrepitation behavior, two samples were placed in a furnace and maintained at a T such that the internal P in the inclusions was between 400 and 700 bars. Sixteen inclusions in these samples have been monitored at regular intervals. Of the sixteen inclusions, one decrepitated during the first 24 hours, a second began stretching after 1744 hours, and a third decrepitated after 5621 hours. The remaining thirteen inclusions have maintained their original Th, even though they have been held at an internal P 400-700 bars above the confining P for over 7500 hours (these experiments are continuing at the present time). (Authors' abstract)

BISCHOFF, J.L. and ROSENBAUER, R.J. and PITZER, K.S., 1986, The system NaCl-H_2O: Relations of vapor-liquid near the critical temperature of water and of vapor-liquid-halite from 300° to 500°C: Geochimica Cosmo. Acta, v. 50, p. 1437-1444. First author at U.S. Geol. Survey, Menlo Park, CA 94025, USA.

Vapor-liquid relations (P-T-x) for the system NaCl-H_2O were determined experimentally at T spanning the critical T of water (Tc), the lowest T in the system at which critical behavior occurs. In addition, vapor-liquid-halite P-T-x(vapor) relations were determined from 300° to 500°C. Results show that at 373.0°C, immediately below Tc, the vapor side of the isothermal vapor-liquid P-x boundary has a shape quite different from that previously conceived. The NaCl content of the vapor increases with P in a smooth manner from the P of the three-phase assemblage (135 bars, 0.0029% NaCl) to a P just below that of the vapor P of pure water (0.012% NaCl at 184 bars). Above this P the boundary abruptly reverses and projects asymptotically to 0% NaCl in a beak-like shape at 218 bars, the vapor P of pure water. At 375.5°, slightly above Tc, the asymptote disappears, and is replaced by a rounded nose. At progressively higher T, the nose disappears and by 380°C the familiar symmetrical bell-shaped curve predominates with the critical point defined by the top of the bell. The P-T curve of the three-phase assemblage determined in the present study is in agreement with previous workers. The NaCl content of the three-phase vapor, however, is much higher than some literature values at T above 410°C. (Authors' abstract)

BITSOJEV, K.B., IVANOV, P.A. and PAL'MOVA, L.G., 1985, The behavior of vacuole water and CO_2 during dynamometamorphism of vein quartz from one of the gold-ore regions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 63 (in Russian; translation by I.V. Kulikov). Authors at MGRI, Moscow, USSR.

Quartz from one of the gold-ore deposits of gold-quartz low-sulfide type was studied by gas chromatography. Quartz veins with economic content of gold were formed according to the studies from alkaline-carbonic acid solutions with significant variations in CO_2 content: 7-42 mole CO_2/kg of H_2O. It should be stressed that gold-productive hydrothermal solutions differed from the solutions forming barren quartz veins, by higher average content of CO_2: 25.5 mole CO_2/kg of H_2O, and 17.5 mole/kg accordingly.

Dynamometamorphism changes structural characteristics and the distribution of fluid inclusions in vein quartz. P inclusions were eliminated from the places of quartz granulation and metamorpic inclusions formed as a result. During intensive granulation the number of fluid inclusions decreases sharply, both in gold-bearing, and barren quartz. Finally, in metamorphosed quartz the quantity of water and CO_2 decreases. (From the authors' abstract)

BLANK, J.G., DELANEY, J.R. and DES MARAIS, D.J., 1986, Carbon in basaltic glass from the Juan de Fuca Ridge (abst.): EOS, v. 67, no. 44, p. 1253. First author at Univ. Washington, Sch. Oceanography, WB-10, Seattle, WA 98195.

Basaltic glass from 20 locations along the Juan de Fuca Ridge axis were measured for carbon abundance and stable isotopic composition using a 3-step combustion procedure. Values for the high-temperature (650-1200°C) interval range from 39 to 146 ppm C (± 10 ppm) and $\delta^{13}C$(PDB) = -4.8 to -9.2‰ (± 0.5‰). Most samples contain less than one percent vesicles. There is no apparent correlation between the degree of vesiculation and carbon concentration or isotopic composition.

Uncrushed glasses are supersaturated with respect to Harris' (1981) CO_2-solubility curve determined from natural samples. Carbon concentration does not increase with depth. Samples analyzed after crushing to remove vesicle carbon are also supersaturated when compared to existing solubility curves. Glasses may not have equilibrated before quenching. Alternatively, previously-determined CO_2-solubility curves may be incorrect.

Isotopic fractionation between carbon dissolved in glass and isotopically-heavier vesicle carbon varies from 4.1 to 4.9‰, comparable to experimentally-determined values (Javoy et al., 1978).

Variation in carbon concentration and isotopic composition agree with predicted Rayleigh fractionation curves. A lack of systematic variation along the JdF ridge axis may reflect local transport and degassing histories of magmas which are decoupled from processes occurring at greater depths. (Authors' abstract)

BLOOMSTEIN, E.I., 1986, Ammonia alteration is a geochemical link in gold deposits of the Carlin-Midas Belt (abst.): J. Explor. Geochem., v. 25, nos. 1-2, p. 239.

BOBROV, A.A., ROSIKHINA, A.I. and SIVORONOV, A.A., 1985, Physicochemical conditions of petrogenesis of the Lower Precambrian plagiogranitoids of the Central Dnieper area, according to data of mineral thermobarometry (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 194-195 (in Russian; translation by Dorothy B. Vitaliano). Authors at Novomoskovskaya GRE PGO "Yuzhkrgeologiya," USSR.

Plagiogranites developed in the Central Dnieper granite-greenstone region take part in the make-up of the Auly and Central Dnieper formational complexes. Supercrustal and ultrametagenic plagiogneisses and plagiogranite-gneisses are related to the former, and also metatonalites. Bodies of tonalite-plagiogranite having all the signs of intrusive formations are related to the latter, younger, complex.

The ultrametamorphogenic plagiogranitoids of the Auly complex are associated with magmatites of two genetic types: anatectic and metasomatic. As a result of study of inclusions of the mineralizing medium in quartz, the main PT parameters and fluid regime of migmatization of both types were established.

In the quartz of the migmatites, the composition of which is close to the eutectic, swarms of inclusions of crystallized melt with a Th of 680-720°C were found.

Study of PS and S inclusions made it possible to ascertain the direction of evolution of the T, P and composition of the fluids liberated in the crystallization of anatectic melts, and also the physicochemical conditions of migmatization of non-anatectic (metasomatic) type. It turned out that the composition of the fluids changed in increments, but with a clearly expressed general tendency toward linear change as the T and P decreased, from water-CO_2 in the initial stages of crystallization to highly concentrated sodium chloride and slightly concentrated essentially aqueous in the final stages. That trend of transformation of the fluid medium of post-magmetic mineralization is confirmed by the results of study of the corresponding morphogenetic types of inclusions.

The fluid medium of migmatization of non-anatectic type consisted of a complex system of homogeneous CO_2-salt solutions with a T of 530-635°C. A sharp drop in P in the mineral-forming system, denoting the beginning of the regressive stage of metamorphism, led to heterogenization of the high-T homogeneous CO_2-salt fluid and its splitting up into CO_2-water and water-salt components.

Th of inclusions of crystallized melt in the quartz of tonalites of the tonalite-plagiogranite formation occurred at 945-980°C, and in apatite from the same tonalites, at 1150-1170°C. The tonalite melt was characterized by low partial P of water and apparently was formed during palingenesis of the lower parts of continental crust in the final stages of formation of the greenstone belts. (Authors' abstract)

BODNAR, R.J., 1986, Fluid inclusion characteristics of skarns and limestone-hosted precious metals deposits associated with intrusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 545. Author at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Skarn and other limestone-hosted precious metal deposits associated with intrusions form over a wide range of physical and chemical conditions, as evidenced by the variability in characteristics of fluid inclusions from these deposits. Inclusions in skarn deposits are similar to those from related epizonal silicic plutons, reflecting the close association between igneous activity and skarn formation. Early (pre-ore) skarn formation is accomplished by high temperature (>450°C), low to moderate salinity, low density fluids of magmatic origin, and at pressures equal to or slightly above lithostatic. The CO_2 content of these fluids is generally ≤10 mole %. As these systems evolve to lower pressure and temperature conditions, fluid immiscibility generates a high salinity aqueous brine coexisting with a CO_2-rich vapor phase. Many of the resulting halite-bearing inclusions homogenize by halite dissolution, indicating that fluid immiscibility occurred at relatively low pressures and close to the liquidus in the H_2O-NaCl system. Sulfide deposition is generally associated with these later immiscible fluids, at temperatures of ~250-450°C. Gold deposition occurs late in the paragenesis of these systems, from low salinity (<15 wt.%), moderate temperature (250-350°C) fluids of probable meteoric origin.

Limestone-replacement and manto-type silver deposits contain fluid inclusions similar to those found in the later stages of "typical" skarn deposits. Fluid immiscibility is common as evidenced by coexisting vapor-rich and halite-bearing inclusions, and the CO_2 content of the fluids varies widely from deposit to deposit, ranging from undetectable amounts to >10-20 mole %. High-salinity inclusions from these deposits often contain sylvite, anhydrite, numerous opaque minerals and other unidentified phases in addition to halite, and commonly homogenize by halite-dissolution, consistent with a relatively low pressure environment of formation. Homogenization temperatures range from ~250-450°C, and the majority of silver mineralization is associated with inclusions which homogenize at the low temperature end of this range. (Author's abstract)

BODNAR, R.J., 1986, Review of A Practical Guide to Fluid Inclusion Studies, T.J. Shepherd, A.H. Rankin and D.H.M., Alderton, 239 pp.: Econ. Geol., v. 81, p. 493-494. Author at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

See Shepherd et al., 1985, Fluid Inclusion Research--Proceedings of COFFI, v. 18, p. 373, 1985. (E.R.)

BODNAR, R.J., 1986, Volumetric properties of H_2O-NaCl solutions from 100-900°C, 1-5 kbar and X(NaCl) = 0.0-1.0 (abst.): EOS, v. 67, p. 399. Author at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Mean molar volumes of H_2O-NaCl mixtures having compositions of 30, 50 and 70 wt.% NaCl were determined over the range 100-900°C and 1-5 kbar using an internally heated pressure vessel equipped with a bellows-type volumometer system. These data were combined with other experimental PVT data for pure H_2O, pure NaCl, and H_2O-NaCl solutions and regressed to generate a single empirical equation relating the mean molar volume (V, in $cm^3 \cdot mole^{-1}$) to the T, P and composition-dependent variables X, Y and Z. The resulting 64 term empirical equation predicts the mean molar volumes of H_2O-NaCl mixtures with an accuracy of a few percent or better over the range 100-900°C, 1-5 kbar and X(NaCl) = 0.0-1.0, and is valid in the single fluid phase field as well as in the two fluid phase fields liquid plus vapor and liquid plus halite. This equation can thus be used to calculate isochores and pressure corrections for fluid inclusions which homogenize either to the liquid or vapor phases, or by halite dissolution.

Partial molar volumes of NaCl and H_2O in H_2O-NaCl solutions over the range 100-900°C, 1-5 kbar and X(NaCl) = 0.0-1.0 were calculated from the derivative of the volume equation with respect to mole fraction NaCl, using the slope-intercept technique. Partial molar volumes of H_2O exhibit relatively little variation over the entire PTX range, whereas the partial molar volume of NaCl varies by more than three orders of magnitude. At high T, low P and low salinities, partial molar volumes of NaCl are large, negative numbers, reaching values of -1000 to -3000 $cm^3 \cdot mole^{-1}$ at 700-900°C, 1 kbar and infinite dilution. Such large, negative partial molar volumes reflect the ability of small quantities of NaCl to significantly collapse the water structure at high T and low P. With increasing salinity, the partial molar volume of NaCl becomes less negative and approaches a constant positive value at high salinities that is essentially independent of T and P. (From the author's abstract)

BODNAR, R.J. and STERNER, S.M., 1986, Determination of the volumetric properties of H_2O-CO_2 fluids at 600°C and 3 kbar using synthetic fluid inclusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 545. Authors at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Synthetic fluid inclusions provide a relatively simple method for determining PVTX properties of fluids over a wide range of PTX conditions because (1) they trap a representative sample of the fluid present at formation conditions, (2) maintain this fluid during quenching to ambient conditions and (3) represent isochoric systems. Using synthetic fluid inclusions, volumetric properties of H_2O-CO_2 fluids have been determined at 600°C and 3 kbars for compositions ranging from pure H_2O to 75 mole % CO_2. The molar volume of pure H_2O inclusions was obtained from the measured homogenization temperature and the known relationship between temperature and molar volume of H_2O along the liquid-vapor curve. This molar volume is the same as the molar volume of H_2O at the trapping conditions, because inclusions represent isochoric systems. The molar volume of the CO_2-rich portion of H_2O-CO_2 inclusions was determined from the homogenization temperature of the CO_2-rich phases in the inclusions and known PVT relations for CO_2 along the solvus. The molar volume of the H_2O-rich portion of the inclusion at this same temperature and pressure was obtained from the Steam Tables. The total molar volume of the inclusion was then calculated from the known bulk composition of the inclusion and the molar volumes of the individual phases in the inclusion using a series of mass and volume balance equations, and this value is the same as the molar volume of the H_2O-CO_2 fluid at formation conditions.

The molar volume of pure H_2O at 600°C and 3 kbar determined from synthetic fluid inclusions (26.1 cm^3/mole) is identical, within experimental error, to previously published values. The molar volume of H_2O-CO_2 mixtures increases with increasing CO_2 content, but at a continuously decreasing rate, and the measured data points project smoothly to the previously determined value for the molar volume of pure CO_2 at 600°C and 3 kbar (54 cm^3/

mole). Excess volumes of mixing calculated from these data show a positive deviation from ideality at low $X(CO_2)$, and the magnitude of V^{xs} decreases as $X(CO_2)$ increases above ~25 mole % CO_2. For $X(CO_2)>0.5$, $V^{xs} \approx 0$ and the fluid behave ideally. (Authors' abstract)

BOGDANOVSKIY, V.G., On peculiarities of inclusions of mineral-forming media in quartz of rocks of the Khetolamba and Chupa Archean complexes in the Northen Karelia (Chupa-Loukh region), in "Lithosphere: problems of geology and environment protection," Moscow, p. 20 (in Russian).

Cited in Naumov, 1986 (this volume).

BOGGS, R.C., 1986, Miarolitic cavity and pegmatite mineralogy of Eocene anorogenic granite plutons in the northwestern, U.S.A. (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 58.

BOGOCH, Ron, MAGARITZ, Mordeckai and MICHARD, Annie, 1986, Dolomite of possible mantle origin, southeast Sinai: Chem. Geol., v. 56, p. 281-288. First author at Geol. Survey of Israel, Jerusalem 95 501, Israel.

Dolomite and breunnerite occur in large amounts as veins and tabular bodies in association with the Tarr albitite within late Precambrian greenschist-facies metamorphics of southeast Sinai. Isotopic data for the dolomite (mean $\delta^{18}O = +6.9‰$; mean $\delta^{13}C = -8.1‰$; mean $\delta D = -65‰$; mean $\varepsilon_{Nd} = +3.4$; mean $^{87}Sr/^{86}Sr = 0.70422$), together with their low incompatible-element and high transition-metal contents, suggest that the dolomite derived from a mantle source. The isotopic composition of the breunnerite indicates contamination by metamorphic water during the replacement phase of the dolomite by the breunnerite. (Authors' abstract)

BOHLEN, S.R., 1986, Geobarometry and pressure-temperature-time paths of granulites (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 58.

BOHLKE, J.K.F.P., 1986, Local wall rock control of alteration and mineralization reactions along discordant gold quartz veins, Alleghany, California: PhD dissertation, Univ. California, Berkeley. (Quoted from Newsletter, Int'l. Liaison Group on Gold Mineralization, no. 4, p. 39, April 1987.)

The gold deposits of Alleghany, California, are typical of epigenetic gold-bearing systems in Archean to Phanerozoic metamorphic terranes worldwide. Detailed analyses of alteration haloes in serpentine, mafic amphibolite, and granite wall rocks at Alleghany indicate that widely contrasting deposit types, ranging from fuchsite-carbonate schists to pyrite-albitites, resulted when different wall rocks interacted with a common but exotic CO_2-rich hydrothermal vein fluid. Patterns of element redistribution within haloes and among lithologic units suggest a complex process involving fluid flow along vein fractures and diffusion (± infiltration) normal to the veins. Wall rocks locally controlled both the directions and magnitudes of chemical fluxes across vein walls.

Vein fluids at constant T and P, with relatively constant ratios of $Na^+/K^+/H^+$ and $CO_2/H_2S/H_2$, were capable of contrasting ("divergent") reactions in proximal alteration zones because the wall rocks controlled the Al(Cr + Fe + Mg) and Fe/Mg ratios[sic], and component activities, of hydrothermal mineral solid solutions. Thus, pyrite and albite were stable with respect to the relatively pure siderite and K-mica that occur sparingly in proximal granite zones, but they were not stable with respect to the relatively impure siderite and K-mica that characterize proximal serpentinite zones.

Calculated reaction coefficients for H^+, H_2, and H_2S suggest that different wall rocks at different stages of alteration may have inhibited or promoted Au precipitation. The distribution of Au, and its calculated solubility, are consistent with its having been precipitated from $Au(HS)_2^-$ complexes at least in part in response to dolomitization of serpentinite (fluid acidification) and pyritization of granite (fluid desulfidation and reduction). "Stratabound" disseminated ore bodies were identified in a variety of other host rocks with higher than average Fe/Mg ratios, where pyrite was stable with respect to intermediate magnesite-siderite.

It is proposed that externally derived CO_2-bearing vein fluids approached partial equilibrium with buffering alteration assemblages in the average, or dominant, rocks along their flow paths. Contrasting reactions then produced simpler but radically different proximal assemblages when the fluids encountered chemically extreme rocks. This analysis is believed to explain much of the diversity in the mineralogy and chemistry of gold deposits in heterogeneous metamorphic terranes, while maintaining a simple genetic classification based on the distinctive chemistry of the hydrothermal fluids. (Author's abstract)

BÖHLKE, J.K. and KISTLER, R.W., 1986, Rb-Sr, K-Ar, and stable isotope evidence for the ages and sources of fluid components of gold-bearing quartz veins in the northern Sierra Nevada foothills metamorphic belt, California: Econ. Geol., v. 81, p. 296-322. First author at Dept. Geol. & Geophys., Univ. California, Berkeley, CA 94720.

CO_2-bearing fluids responsible for metasomatism and much of the vein mica, carbonate, albite, and quartz deposition in several northern mines were isotopically heavy ($\delta^{18}O \approx 8$-14‰; δD between about -10 and -50‰) and do not resemble seawater, magmatic, or meteoric waters. Metasomatic and vein-filling mica, dolomite, magnesite, and quartz in altered ultramafic rocks generally formed from fluids with similar Sr and O isotope ratios at a given locality. Consistent quartz-mica $\delta^{18}O$ fractionations ($\Delta^{18}O(Q\text{-}M) =$ 4.5-4.9‰) from various localities imply uniform equilibration T, probably between 300° and 350°C. On a local (mine) scale, fluids responsible for both carbonate alteration of mafic and ultramafic wall rocks and albitic alteration of felsic and pelitic rocks had similar Sr isotope ratios.

Systematic geographic variations in both Sr and O isotopes can be rationalized by assuming extensive fluid interaction with rocks similar to the ones that are exposed within a few kilometers of the veins, but the ultimate sources of the fluids, and of Au and other constituents, may be independent of these. Isotopically lighter (meteoric?) fluids deposited some late quartz overgrowths and occupied S fluid inclusions in earlier vein quartz. (From the authors' abstract)

BOLAND, J.N., 1986, Precipitation mechanisms of metallic particles in olivine (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 59.

BOLAND, J.N. and DUBA, A.G., 1986, An electron microscope study of the stability field and degree of nonstoichiometry in olivine: J. Geophys. Research, v. 91, no. B5, p. 4711-4722. First author at Div. Geomechanics, CSIRO, Mt. Waverly, Victoria, Australia.

The stability of San Carlos olivine (Fo 90.5) relative to changes in oxygen fugacity at 1300°C has been determined studying the microstructural changes in single crystals using transmission and analytical electron microscopy. The first detectable metallic phase, heterogeneously nucleated along dislocations within (100) and (001) subboundaries, had a composition $Ni_{65}Fe_{35}$ equilibrated with a CO/CO_2 gas mixture having an oxygen fugacity fO_2 of $10^{-5.6}$ Pa. Although the (100) subboundaries contained a high density of dislocations with Burgers vector [100], the nucleation sites were restricted to [010] and [001] dislocations: a result consistent with the theory of heterogeneous nucleation along dislocations. Under the reducing conditions of an fO_2 of 10^{-12} Pa, a forsteritic olivine is produced at the gas-mineral interface with a high density of metallic precipitates ($Fe_{96}Ni_4$) homogeneously nucleated in the olivine. Nonstoichiometry of the olivine was inferred from the absence of any additional silica-rich phases. The nonstoichiometry was analyzed in terms of possible crystalline defect structures, especially vacancies, assuming no evaporative losses from the surface except an oxygen exchange reaction. On the basis of the model proposed, the highly reduced olivine would contain an excess of SiO_2 ($X(SiO_2)$ = 0.355 compared with a stoichiometric value of 0.333) from the surface to a depth of several micrometers. (Authors' abstract)

Pertinent to the interpretation of melt inclusions in olivine. (E.R.)

BONHOMME, M.G., VIVIER, Gérard, VITTOZ, Pascal, HUCK, K.-H. and BUHMANN, Dieter, 1986, Clays associated with the fluorite-barite mineralization at Oberwolfach, FRG: Mineralogy, REE geochemistry and K-Ar ages (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 22 (in French). First author at Inst. Dolomieuy et U.A. CNRS, 38031, F. Grenoble.

The fluorite-barite deposit mined at Oberwolfach, Black Forest, FRG, has been the subject of numerous studies reviewed by Huck (1984) who studied the distribution and geochemistry of the ore. Clays associated with different tectonic events and episodes of mineralization have been sampled. Mineralogical study shows that the clays consist exclusively of illite (frequent) and kaolinite (rare). According to their crystallinity index the illites formed under diagenetic conditions, which is consistent with Th of fluid inclusions of 140° to less than 70°C. Illites in the fault zone are anchimetamorphic. Chemically, one of the green illites is peculiar in that it has a low Ti content (TiO_2 <0.8%) whereas it is rich in Cr (Cr_2O_3 = 2.19-2.40%) and Ni (NiO = 0.10-0.20%) (Bonhomme et al., 1983). Using REE distributions, it is possible to distinguish clays from different localities and generations (Moller et al., 1982). The following K-Ar ages were measured: illites in the fault zones: 207 Ma; illites and kaolinite from the mineralization : 142-156 Ma; illites in the altered country rocks: 233-262 Ma; low Ti, high Cr and Ni illites: 185-196 Ma. On the basis of these K-Ar ages the formation and deformation history of the ore deposits can be reconstructed. (Authors' abstract, translated by R. Kreulen)

BONI, Maria, 1986a, Pb-Zn-Ba ore deposits in the Sardinian Cambrian: A comparison with the Irish Carboniferous, in Geology and genesis of mineral deposits in Ireland, C.J. Andrew et al., eds.: Irish Assoc. Econ. Geol., p. 677-684. Author at Dipart. Sci. dela Terra, Univ. Napoli, Largo S. Marcellino 10, 80138 Napoli, Italy.

Uses literature data on fluid inclusions. (E.R.)

BONI, Maria, 1986b, The Permo-Triassic vein and paleokarst ores in southwest Sardinia: Contribution of fluid inclusion studies to their genesis and paleoenvironment: Mineral. Deposita, v. 21, p. 53-62, Author at Dipart. di Sci. della Terra dell'Univ. di Napoli, Largo S. Marcellino, 10 80138 Napoli, Italy.

The results suggest that the fluids associated with mineralization are within the range normally recorded for Mississippi Valley-type deposits elsewhere in the world, both for Th (from below 60°C to 130°C for quartz, calcite, barite and dolomite, higher for fluorite) and salinities (5-24 equiv. wt% NaCl). High levels of $CaCl_2$ are also present in the fluids. Similar T and salinities are shown by the dolomitic alteration of the karsified Cambrian limestones, which are the host rocks of the studied ore deposits, indicative of a common origin for both the alteration and mineralization. (From the author's abstract)

BORDONSKIY, G.S., KRENDELEV, F.P. and POLYAKOV, S.V., 1985, Gaseous inclusions in lake ice and the radiobrightness temperature of the ice cover: Geologiya i Geofizika, no. 9, p. 66-73 (in Russian).

Cited in Naumov, 1986 (this volume).

BORIANI, A., KOVALENKO, V.I., NAUMOV, V.B. and SOLOVOVA, I.P., 1986, New data on Pantelleria magmatic rock origin based on melt inclusions: Italian Soc. Mineral. and Petrology, Seminar on Role of fluids in petrogenesis, Siena, 3-4 June, 1986, [Program and Abstracts], p. 28. First author at Dipart. di Sci. della Terra, Univ. di Milano, Italy.

The island of Pantelleria is a classical example of acidic agpaitic rocks named pantellerites that were described by Daly at the eve of our century. The origin of pantellerites is often interpreted in terms of fractional crystallization of hawaiitic magma, but not all is quite clear in this problem. Melt inclusions in all members of the rock series in question are considered as a clue to genetic interrelations.

Th of P melt inclusions was measured. The data indicate the existence of marked variations in crystallization temperatures as follows: 1185°-1175° for hawaiites (olivine, plagioclase), 1160°-1020° for high-alumina trachytes (olivine, pyroxene, anorthoclase), 880°-830° for agpaitic trachytes (anorthoclase) and 985°-810° for pantelerites, pumices and ignimbrites (pyroxene, anorthoclase, quartz).

For the first time such unusual P melt inclusions were observed in the anorthoclases of pantellerites, pumices and ignimbrites. They consist of poorly crystallized glass, dense fluid represented by gas bubbles (9-18% vol.) and aqueous solution (82-91% vol.). The latter consists mainly of chlorides (Te <-22°) of high concentration (14-28.5 wt.% eq. NaCl) and high density (0.85-1.10 g/cm^3). These data are in good agreement with microprobe determination of chlorine content in residual and homogeneized melt (glass) inclusions in anorthoclase and quartz. The chlorine content in homogeneized melts is found to vary from 0.97 to 0.69 wt.%, the mean value being 0.80 wt.% (11 analyses). The residual melts are characterized by 0.87 to 0.36 wt.% of chlorine, the mean value being 0.69 wt.% (11 analyses).

Th measurements of the fluid phase (166°-305°) was used in calculations of fluid pressure that results extremely high (2.6-4.3 Kbar) at 550°. These data along with the volumetric measurements of fluid in melt inclusions (4.9-8.4 % vol.) allowed to obtain first data on water content of pantelleritic melt. The latter is found as great as 7.7-12.4 % wt. at certain stages of phenocryst crystallization.

The obtained data are considered as evidence of the important role of the fluid phase, namely H_2O, in the formation the magmatic rocks of Pantelleria. (Authors' abstract)

BORISENKO, A.S., BOROVNIKOV, A.A. and PAVLOVA, G.G., 1985, The physicochemical parameters for the formation of the siderite-sulphosalt veins in the Delyun-Yustyd trough (NW Mongolia) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 117-118 (in Russian; translation by D.A. Brown). First author at Inst. Geol. & Geophys., Sib. Div. Acad. Sci. USSR, Novosibirsk, USSR.

1. Siderite-sulfosalt veins are widely developed within the Delyun-

Yustyd late Paleozoic trough, [which is] filled with a thick sequence of Devonian volcanic-sedimentary and terrigenous deposits. They are the products of four phases of hydrothermal activity: quartz-siderite (siderite, quartz, barite, hematite, and chalcopyrite), aresenopyrite-löllingite (arsenopyrite, löllingite, pyrite, chalcopyrite, and pyrrhotite), sulfosalt (tetrahedrite, bournonite, chalcostibite, zinkenite, semseyite, antimonite, and horobetsuite [intermediate between stibnite and bismuthinite]), and late sulfide (chalcopyrite, galena, sphalerite, bismuthinite, and bismuth). The siderite-sulfosalt mineralization was associated in time with the Mesozoic stage of tectonomagmatic activity in the region.

2. Quartz, siderite, calcite, and barite from the veins contain GLIs ($L(H_2O) + G$, $L(H_2O) + L(CO_2 + CH_4) + G$, $L(H_2O) + NaCl + G$, and $L(CO_2 + CH_4) + G$). Th of inclusions in quartz-I and -II (quartz-siderite phase) are respectively 80-135° and 70-180°C, in barite <60°, and in siderite 70-115°C. In the sulfosalt phase, Th = ~90-230°C, whereas in calcite from the late sulfide phase it is ~60-80°C. A marked Th rise has been observed between the early quartz-siderite phase and the sulfosalt phase, and then it gradually falls towards the concluding sulfide phase. This points to a wave-like T change during the hydrothermal process. The vertical T-gradient during the formation of the veins was 70-110°/km (quartz-siderite phase). Pressure reached 120-600 bars (CO_2 inclusions in quartz of the quartz-siderite phase). The mineral-forming solutions were marked by heterogenization, as indicated by the presence of gaseous CO_2 or CH_4-CO_2 inclusions along with the primary GLIs ($L(H_2O) + G$, and $L(H_2O) + NaCl + G$).

3. According to cryometry, there is a predominance of NaCl and $CaCl_2$ in the mineral-forming solutions, their ratio varying from 1.5:1 to 20:1, and their total concentration from 25-31 wt % (quartz-siderite phase) to 15-12 wt % (late-sulfide phase). Numerous GLIs have been noted in quartz from the quartz-siderite phase, with composition varying from CO_2 (Tm CO_2 = -57 - -58°C, and Th = -35 - +15°C) to essentially CH_4 (Th CH_4 = -100 - -105°C, and Tm CO_2 = -81°C).

4. Hence, the siderite-sulfosalt veins here belong to typical low-T (<250°C) hydrothermal formations, which involved the participation of heterogeneous highly-concentrated chloride solutions, with a separate high-density gas phase. The appearance of CH_4 in the gas phase of the mineral-forming solutions was probably associated with the breakdown of organic matter in the Upper Devonian black-slate sediments, which surround the siderite-sulfosalt veins. (From the authors' abstract)

BORISENKO, A.S., OBOLENSKIY, A.A. and LEBEDEV, V.I., 1985a Essential features of the generalized genetic model of epithermal silver deposits: Genetic models of endogenic ore formation: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 3, p. 99-100 (in Russian). Cited in Naumov, 1986 (this volume).

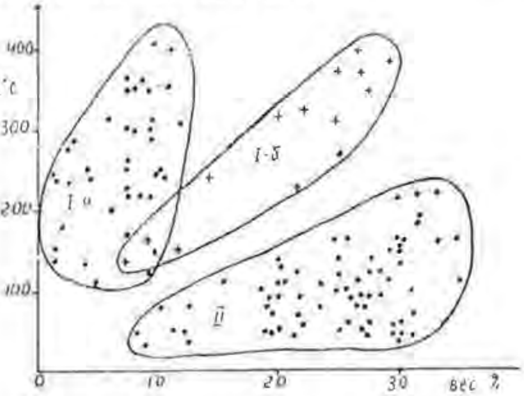
BORISENKO, A.S., OBOLENSKII, A.A. and LEBEDEV, V.I., 1985b Mineral-forming solutions of hydrothermal silver deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 68-70 (in Russian; translation by I.V. Kulikov). Authors at IGiG SO AN SSSR, Novosibirsk, USSR.

1. Hydrothermal silver deposits are of two genetic types: volcanic-hydrothermal and magmatic (epithermal magmatic). The deposits of Au-Ag and Ag-Sn ore types belong to the first type, and epithermal deposits of Ag-As and Ag-sulfosalts types belong to the second type, as well as some of the Ag-Pb type.

2. Volcanic-hydrothermal silver deposits are medium to low thermal formations, formed over a wide range of temperature, from 400-450° to 100-

150°C, and pressure, from n·10 to 300-400 bar (Lyakhov, 1968; Goncharov and Sidorov, 1979). The main productive associations formed at 250-150°C. The ore-forming processes took place in near-surface conditions at high vertical temperature gradients (8-35°/100 m), with steplike changes in T between the stages, and with an active role of meteoric water. Mineral-forming solutions usually were of low concentrations (1-12 wt%), and of chloride or chloride-bicarbonate composition (see field 1-a on figure). K/Na ratios in the solutions is 1-0.2. In rare cases polyphase inclusions were discovered in the minerals of these deposits, containing halite and sylvite (salinity >25 wt%) (field 1-b). High concentrations of CO_2 are not characteristic in mineral-forming solutions of volcanic-hydrothermal silver deposits.

3. The deposits of Ag-arsenide and Ag-sulfosalts ore types (southern Siberia, middle Asia, Canada, GDR, Czechoslovakia) are typical low-temperature formations. They formed at <250°C (Ag-arsenide at 40-180°C; Ag-sulfosalts 50-230°C), at P 100-600 bar, and low vertical T gradients (7-12°C/100 m). Mineral-forming solutions of this type of silver deposits everywhere are characterized by rather high concentrations of dissolved components (up to 35 wt%, field 2 on the fig.), in the composition of which $CaCl_2$ and NaCl prevail. Less abundant are KCl, $MgCl_2$, Br^-, I^-, and NH_4^+. K/Na ratio is 0.4-0.08. Contrary to Ag-arsenide type, CO_2, and sometimes CO_2 + CH_4, are constantly present in the Ag-sulfosalts type of deposits. These gases form secluded high density gas inclusions. An active role in formation of this type of silver deposits was played by exogenic chloride brines of saline depositions. (From the author's abstract)



BORODENKO, Yu.A., KATRICH, N.P. and TIMAN, B.L., 1985, Dependence of the critical rate of gas inclusion formation in leucosapphire crystals on the melt layer thickness during horizontal zonal melting and directed growth: Kristallografiya, v. 20, no. 2, p. 407-408 (in Russian). See Translations.

BORODENKO, Yu.A., KATRICH, N.P. and TIMAN, B.L., 1986, Formation of gas inclusions during the growth of leucosapphire single crystals by directional crystallization: Izv. Akad. Nauk SSSR, Neorg. Mater., v. 22, no. 1, p. 169-171 (in Russian; translated in Inorg. Mater., v. 22, no. 1, p. 149-xxx, 1986)

A highly mathematical treatment. (E.R.)

BORODENKO, Yu.A., TIMAN, B.L. and MEL'NIKOVA, A.M., 1986, Gas inclusions in sapphire upon horizontal, directional crystallization: Inorganic Materials, v. 22, no. 7, p. 980-983.

BOTKUNOV, A.I., GARANIN, V.K., KROT, A.N., KUDRYAVTSEVA, G.P. and MATSYUK, S.S., 1985, Primary hydrocarbon inclusions in garnets from kimberlite pipes "Mir" and "Sputnik": Doklady Akad. Nauk SSSR, v. 280, no. 2, p. 468-473 (in Russian). Author's institution not specified.

Three varieties of garnets from the Yakutian kimberlite pipes "Mir" and "Sputnik," were studied for fluid inclusions: 1) low Mg, higher Fe, low Ca; 2) high Mg, lower Fe, high Ca; 3) intermediate between 1 and 2 Mg and Fe, and high Ca. Garnets which contained fluid inclusions have chemical composition close to garnets from websterite and lherzolite nodules, sometimes to garnets from eclogites and to certain garnet inclusions in diamond from the "Mir" pipe. Garnets are "saturated" [the authors' expression] by numerous inclusions with maximum size 200 µm. P polyphase inclusions of organic matter are very abundant. Spectrum of luminescence in monochromatic light λ_0 = 488 nm (source - argon laser) of one inclusion was identical to luminescence spectrum of oil from the Saxtysh deposit. Several types of organic inclusions were distinguished: 1. G (L?) 5-10% + yellow-brownish hydrocarbon (HC) L 70-95% + colorless birefringent organic phases <1%. "G" phase frequently occurs in several bubbles in one inclusion without forming a single "bubble." On heating "G" phase dissolves in L HC at 308-320°C and solid organic phases slowly dissolve in L HC. Total homogenization was not achieved because at ~350°C inclusions decrepitate. 2. One or several "G" bubbles + yellow-brownish L, 3. "G" bubble, up to 50 vol.% + colorless L, 4. "G" bubble up to 50 vol.% + colorless L + isotropic crystals, up to 2 vol.% + anisotropic crystals ± up to 1 vol.% of graphite(?). All types of inclusions may be found in one garnet grain, also decrepitated inclusions are common, indicating the sharp P decrease on magma ascent. Evaluation of T of garnet formation by the garnet-pyroxene thermometer gives the value ~1000°C. Identification of HC leached by n-hexane and chloroform was performed by low-T spectrofluorimetry and IR spectroscopy. By IR spectra there were found absorption bands of CH_2- and CH_3-groups, chains of (CH_2)-n groups and bands of complex ethers and carbonyl. Polycyclic aromatic HC fraction (% of the total fraction) comprised homologues of naphthalene 75-95, homologues of phenantrene 3-23, pyrene 2-4, 3,4-benzenepyrene nil to 0.1 and 1,12 bezenepyrilene nil to 0.4. Authors suggest that similar HC might be the source of carbon for diamond crystallization. (Abstract by A.K.)

BOTRYAKOV, G.V., 1985, Effect of fluid conditions during evolution of acidic melts on the composition and metallogenic specialization of volcanic rocks (as illustrated by the Eastern Sikhote-Alin volcanic belt): Vulkanog. Vulkanog.-Osad. Porody Dal'nego Vostoka, 1985, p. 21-30 (in Russian).

The Late Cretaceous acidic effusive rocks (ignimbrites) of the title volcanic belt are of 2 types: in type 1, the phenocrysts are dominantly K-feldspar, with plagioclase subordinate, whereas type 2 effusives have plagioclase, biotite, and hornblende as phenocrysts. Based on Th of melt (glass) inclusions in quartz (Q), the Q in the type 1 effusives crystallized at higher T (1240-1280°) than the Q in the type 2 rocks (1040-1160°) and has higher CO_2 content. During the Late Cretaceous volcanism in the region, the fluid regime evolved from CO_2-rich (type 1) to F-H_2O-rich (type 2) effusives. (From C.A. 106: 141295u)

BOTTRELL, S.H., 1986a The origin of the gold mineralization of the Dolgellau district, North Wales: The chemistry and role of fluids: Ph.D. dissertation, Univ. East Anglia.

The mineralized veins of the Dolgellau Gold Belt, their host shales (the Clogau Shales and Maentwrog Formation) and the underlyng Cambrian/Pre-Cambrian sequence of the Harlech Dome with its associated igneous rocks have all been studied by a combination of geochemical, fluid inclusion and stable isotope techniques. This has enabled the characterization of the fluids associated with the metamorphic and mineralizing events in the Dome and estimation of the P-T conditions of these events.

Fluid inclusion studies show the metamorpic fluid in the "Lower Formations" (those below the Clogau Shale) to be an aqueous Na-K-Cl brine while in the Clogau Shales it is an immiscible pair of CH_4-H_2O fluids with Na-K-Cl dissolved in the aqueous-rich phase. This implies that conditions were far more reducing in the Clogau Shales during metamorphism due to the presence of graphite in the shale. Geothermometry and geobarometry using the immiscible fluid pair in the Clogau Shales gives metamorphic conditions of 300-365°C, 3.0-3.3 kb. The mineralized-vein inclusions also contain an immiscible CH_4-H_2O pair which yield conditions for the mineralizing event of 245-320°C, 1.6 kb at the maximum T. Both metamorphic and mineralized vein samples show late-stage calcic and weakly saline aqueous inclusions.

Oxygen isotopes show widespread resetting of carbonate and mica minerals, probably an effect of the late stage fluids noted above, while quartz retains a metamorphic value. Isotopic T estimates for metamorphic and mineralizing conditions are consistent with those from fluid inclusions.

On the basis of the fluid inclusion evidence a model has been proposed for the genesis of the ores of the Gold Belt. This model postulates that an oxidized metamorphic fluid from the Lower Formations was introduced into the Clogau Shale. Here it underwent reaction with its new host and became more reduced as some of the introduced water reacted with graphite in the shale to produce methane with consequent deposition of the ores. The stable isotope data and theoretical consideration of the fluid inclusion and geochemical data all support this model. They also suggest that a basic/ultrabasic igneous lithology was the source of the gold-mineralizing fluid. (Author's abstract)

BOTTRELL, S.H., 1986b, Implications of stable isotope studies for the genesis of the ores of the Dolgellau gold belt (abst.): ICOG VI Meeting, Cambridge, Terra Cognita, v. 6, pt. 2, p. 230.

See previous item. (E.R.)

BOTTRELL, S.H., SHEPHERD, T.J. and YARDLEY, B.W.D., 1986, Fluid rock interaction and controls on ore genesis in the Dolgellau gold belt, North Wales (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 69-72. First author at Dept. Earth Sci., Univ. Leeds, Leeds LS2 9JT, UK.

Microthermometric analysis of fluid inclusions in quartz veins has been used to characterize the compositions of fluids associated with both mineralized and regional metamorphic veins in the Harlech Dome. In addition mass spectrometric analyses have been made of bulk inclusion fluids and used to estimate the compositions of the inclusion fields. A model of ore genesis based on fluid inclusion data has been tested by the application of fluid phase and fluid-mineral equilibrium calculations. Calculations have been made of both solvent and solute composition. The results of these calculations have been used to assess the importance of various chemical factors in controlling the deposition and localization of the gold ores. (From the authors' text)

See previous item.

BOTTRELL, S.H., SHEPHERD, T.J., YARDLEY, B.W.D. and DUBESSY, J., 1986, A fluid inclusion model for the genesis of the ores of the Dolgellau Gold Belt, North Wales (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 6. First author at Dept. Earth Sci., Univ. Leeds, Leeds, LS2 9JT, UK.

The Dolgellau Gold Belt comprises a group of SW-NE trending quartz-veins in uplift-related faults on the south and east flanks of the Harlech Dome. Where they cross the graphitic Clogau Shales many of the veins are auriferous. One vein, at the Clogau-St. Davids mine, accounts for almost the entire gold production of the area. This work presents a detailed fluid inclusion study of this vein and others in the area and develops a model for the genesis of the gold ores.

Microthermometric analysis of fluid inclusions in quartz veins has been used to characterize the compositions of fluids associated with both mineralized and regional metamorphic veins. In addition, mass spectrometric analyses of bulk inclusion compositions and Raman analyses of individual inclusions have been used to constrain fluid compositions. Metamorphic veins in graphitic units contain aqueous immiscible CH_4-H_2O fluids whilst veins in nongraphitic units contain aqueous inclusion fluids. The mineralized veins at Clogau-St. Davids have a more complex assemblage of inclusion fluids with both aqueous CH_4-H_2O inclusions and high salinity inclusions with dxl. All the vein types contain similar late-stage inclusion populations, which are discounted from a role in ore genesis.

The inclusion assemblage in the mineralized veins is interpreted as the result of interaction of an aqueous fluid (the metamorphic fluid from units below the Clogau Shale) with graphite in the wall rocks to the vein. The consequences of this model for the mineralizing process are discussed. (Authors' abstract) See previous item.

BOUDAL, Christian, 1986, Petrology of Popocatepetl volcano (abst.): Int'l. Volcan. Congress, Auckland, N. Z, Abstracts, p. 138. Author at Centre de Recherches Volcanol., Univ. Clermont II - 5, Rue Kessler 63038 Clermont-Ferrand, France.

The calc-alkaline series of Popocatepetl volcano is characterized by andesitic and dacitic products. The contrast of temperature between the upper and lower parts of the reservoir is about 100 to 170°C [from melt inclusions?]. Unmixed vitrous inclusions in plagioclases suggest water saturated conditions at the top of the reservoir, contrasting with undersaturated magma at a deeper level where the pyroxenes crystallize. Water content of magma is estimated at 3%. (From the author's abstract)

BOUDREAU, A.E. and McCALLUM, I.S., 1986, Hydrothermal transport of the PGE, an alternative model for the formation of stratabound PGE deposits in layered intrusions (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 60-61. Authors at Dept. Geol. Sci., AJ-20, Univ. Washington, Seattle, WA 98195.

Several lines of evidence suggest that the stratabound platinum-group element (PGE)-rich zones of the Bushveld and Stillwater Complexes, which are characterized by unusually coarse textures, relatively abundant halogen-bearing and hydrous phases, a variety of exotic minerals (e.g., graphite) and, in the case of the Merensky Reef, high temperature fluid inclusions, are the result of fluid transport of the PGE: 1) The secondary dunites/hortonolites of the Bushveld Complex, which are generally thought to have been the result of recrystallization by hot, silica-poor fluids, contain the highest reported grades of PGE in rocks from the Complex, and illustrate that late-stage fluids can remobilize and concentrate the PGE, particularly Pt and Pd. 2) Volcanic condensates from Hawaii are known to be unusually enriched in the noble metals. 3) Ultramafic rocks, which make up the footwall of the ore zones, typically have higher PGE abundances than do basaltic or more silicic rock types. If the PGE, particularly Pt and Pd, were initially present primarily with interstitial sulfides in the ultramafic footwall rocks, then they could be readily transported by late-stage fluids migrating through the crystal pile.

The high Cl content of halogen-bearing phases from the PGE zones of both the Stillwater and Bushveld Complexes suggests that Cl is the dominant complexing agent for the PGE.

We suggest that Cl-rich aqueous fluids exsolving during the solidification of the cumulus pile incorporated the PGE and base metals, which may have been originally preconcentrated in minor interstitial sulfide phases during the initial formation of the cumulate sequence. Horizons marked by major lithologic discontinuities due to influxes of more primitive magma are likely statigraphic traps to the upward migration of these fluids, as they may define a horizon above which the cumulate sequence has not yet reached vapor saturation. Fluids reaching this horizon must redissolve and cause partial melting and/or recrystallization of existing cumulates, and can result in the precipitation of the PGE-sulfides. A variety of features, e.g., rounded and embayed cumulus plagioclase grains associated with the J-M Reef, are consistent with this interpretation. (From the authors' abstract)

BOUDREAU, A.E. and McCALLUM, I.S., 1986, Investigations of the Stillwater Complex: III. The Picket Pin Pt/Pd deposit: Econ. Geol., v. 81, p. 1953-1975. Authors at Dept. Geol. Sci., AJ-20, Univ. Washington, Seattle, WA 98195.

Calculated fluid compositions in equilibrium with the observed mineral assemblage show that these fluids were silica and alkali rich and that HCl and HF were important fluid species. (From the authors' abstract)

Many S inclusions in interstitial quartz in anorthosite have dxl NaCl(?) or rutile(?) and/or carbonate(?) Th ranges from 200 to 500°C, consistent with the greenschist facies metamorphism which has affected the rocks. (From the authors' text)

BOUDREAU, A.E., MATHEZ, E.A. and McCALLUM, I.S., 1986a Composition of apatite and biotite from the Stillwater and Bushveld Complexes. Part II: Lunar Plan. Sci. XVII, p. 72-73. Authors at Dept. Geol. Sci., AJ-20, Univ. Washington, Seattle, WA 98195.

The data strongly suggest that the minor and trace elements (i.e., sulfur, alkalis, PGE and REE) may be substantially redistributed within the crystal pile by migrating Cl-rich fluids. (From the authors' abstract)

BOUDREAU, A.E., MATHEZ, E.A. and McCALLUM, I.S., 1986b The role of Cl-rich fluids in the Stillwater Complex (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 47. Authors at Dept. Geol. Sci., AJ-20, Univ. Washington, Seattle, WA 98195, USA.

Biotite and apatite from the J-M Reef of the Stillwater Complex and the Merensky Reef of the Bushveld Complex are enriched in Cl relative to those from other parts of the same intrusions and to non-ore-bearing intrusions such as the Skaergaard Intrusion. These and other observations imply that Cl-rich fluids were concentrated within the ore zones. (From the authors' abstract) See next item.

BOUDREAU, A.E., MATHEZ, E.A. and McCALLUM, I.S., 1986c Halogen geochemistry of the Stillwater and Bushveld Complexes: Evidence for transport of the platinum-group elements by Cl-rich fluids: J. Petrology, v. 27, p. 967-986. Authors at Dept. Geol. Sci., AJ-20, Univ. Washington, Seattle, WA 98195.

Compositional data on apatite, phlogopite, and amphibole indicate that the high-T hydrothermal fluids which affected the lower portions of the Stillwater and Bushveld Complexes were Cl-rich. Apatites from the platinum-group element (PGE) ore zones from both complexes are enriched in Cl relative to other cumulus and noncumulus apatites in these intrusions and to apatites from the Skaergaard and Kiglapait Intrusions and the Great Dyke. Apatites from all five intrusions can be grouped into three distinct compositional fields: (a) Cumulus apatites are essentially fluorapatites with molar $Cl/(Cl + OH + F) < 0{\cdot}03$; (b) noncumulus apatites, with the exception of those from the PGE ore zones of the Stillwater and Bushveld Complexes, have $Cl/(Cl + OH + F) < 0{\cdot}20$; (c) Cl-rich apatites associated with PGE-rich zones have $Cl/(Cl + OH + F)$ between $0{\cdot}45$ and $1{\cdot}0$. The REE content of noncumulus and Cl-rich apatites also show a positive correlation with Cl concentration. It is argued that because Cl is less soluble in silicate melts than F and because melts with extremely high Cl/F ratios are unknown, the Cl-rich apatites equilibrated with Cl-rich hydrothermal fluids exsolved during solidification of the cumulate sequence.

The Cl, F, and OH contents of phlogopites and amphiboles are more variable. Compositional heterogeneity is due to crystal-chemical controls on halogen contents, variation in the halogen content of the original melt/fluid phase and subsolidus re-equilibration during cooling with both surrounding mineral phases and low T fluids. However, both the Stillwater and Bushveld phlogopites are enriched in Cl compared to those from the Skaergaard and Kiglapait Intrusions.

The compositions of coexisting minerals from the Pt deposit of Olivine-Bearing Subzone I of the Stillwater Complex are used to compute a fluid composition. The fluid is rich in alkalis and Fe as well as HCl, and the solution composition is consistent with fluid compositions deduced for the PGE-bearing secondary hortonolite pipes of the Bushveld Complex. The high (Pt + Pd)/Ir ratios of these deposits are also consistent with a hydrothermal origin, as both Pt and Pd are more soluble in Cl-complexing fluids than Ir. (Authors' abstract) See previous item.

BOULTER, C.A. and GLOVER, J.E., 1986, Chert with relict hopper moulds from Rocklea Dome, Pilbara Craton, western Australia: An Archean halite-bearing evaporite: Geology, v. 14, p. 128-131.

BOURCIER, W.L., 1986, A computer program for calculation of fluid inclusion phase equilibria in the system H_2O-NaCl-CO_2-CH_4-H_2S with applications to Mississippi Valley-type ore deposits (abst.): EOS, v. 67, no. 44, p. 1258. Author at Earth Sci. Dept., Lawrence Livermore Nat'l. Lab., Livermore, CA 94550.

A FORTRAN computer program for calculating fluid inclusion phase equilibria in predominantly aqueous fluid inclusions in the system H_2O-NaCl-CO_2-CH_4-H_2S is described. The necessary phase equilibrium data were obtained from solubility measurements of CO_2, CH_4, and H_2S in NaCl solutions. Densities of the H_2O-NaCl-gas aqueous phase are calculated using densities of pure NaCl solutions and molar volume data for the constituent gases. Gas fugacities and compressibility factors are calculated using a modified Bendict-Webb-Rubin (BWR) equation of state. The Lewis rule for gas mixing is used to model the gas mixtures, i.e., interactions between unlike gases are assumed ideal, all other interactions are non-ideal.

The program is valid for systems having up to 5-10 mole % total gas contents, temperatures up to 400°C, salinities up to 6 molal NaCl, and pressures up to about 2.0 kb. It thus covers the range of conditions of formation of many epithermal ore deposits and diagenetic processes. Application of the program to the problem of origin of Mississippi Valley-type (MVT) ore deposits will be discussed using measured gas contents and phase relations of fluid inclusions in dolomites and sphalerites from four MVT districts. Preliminary results for fluid inclusions from deposits from east Tennessee, western Newfoundland, the Tri-State area, and the upper

Mississippi Valley district gave pressures of homogenization of 200-400 bars and, therefore, minimum depths of 2-4 kilometers, assuming an hydrostatic pressure gradient. These depths of formation are much greater than those estimated with other methods. (Author's abstract)

BOWERS, T.S., 1986, The geochemical consequences of H_2O-CO_2 fluid immiscibility on ore deposition; a reaction path approach (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 548. Author at Dept. Earth, Atmos. & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

The effects of fluid immiscibility on mineral equilibria and ore deposition can be calculated by incorporation of a modified Redlich-Kwong activity model for H_2O and CO_2 from Bowers and Helgeson (1983) into the EQ3/6 chemical equilibria and mass transfer computer code (Wolery, 1978, 1979, 1983). The computer model generates a reaction path for the special case of a fluid passing through a pressure gradient at 250°C where the vapor phase produced when the fluid begins to boil leaves the system and is not considered to interact further with the rock. A sample fluid in equilibrium with quartz at 2 Kb, containing 5, 3, and 0.5 ppm of Cu, Pb and Zn, respectively, at pH = 4.5 and with 15 mole % CO_2 intersects the H_2O-CO_2 solvus at 250°C when the pressure drops to 1500 bars. The onset of fluid immiscibility results in an increase in pH and the formation of a quartz-calcite vein containing approximately 1% by weight chalcocite, galena and sphalerite. No interaction of the fluid with wallrock was considered. In contrast, a fluid of similar composition but containing only 5 mole % CO_2 will not intersect the H_2O-CO_2 solvus until 350 bars. Although calcite precipitates prior to the onset of phase separation in this case, its production rate increases as the fluid begins to boil. Initial deposition of metal sulfides is spread over a large pressure range rather than represented at a sharp front as in the first example. This technique shows potential for modeling ore deposits where fluid inclusion evidence suggests that the initiation of ore deposition is contemporaneous with the onset of fluid immiscibility, and where sufficient chemical or mineralogical information is present to constrain the initial composition of the fluid. (Author's abstract)

BOWERS, T.S., CAMPBELL, A.C. and EDMOND, J.M., 1986, Factors controlling the chemistry of vent fluids at 21°N and 13°N, East Pacific Rise (abst.): EOS, v. 67, p. 392.

BOWMAN, J.R., 1986, Groundwater influx coupled with the transition from lithostatic to hydrostatic fluid pressure during contact skarn development (abst.): EOS, v. 67, p. 272.

BOWMAN, J.R., PARRY, W.T., KROPP, W.P. and KRUER, S.A., 1986, Isotopic evolution of hydrothermal solutions in the Bingham Canyon, Utah, porphyry copper system (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 549. Authors at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

Over 150 stable (H, O) isotope analyses have been made on quartz veins and altered igneous rock from the early potassic and propylitic alteration and later sericitic and argillic alteration in the Bingham Canyon porphyry Cu deposit. Fluid inclusion data from vein quartz associated with the early alteration indicate that, on average, temperatures and fluid pressures decrease continuously outward from the center of potassic alteration into the peripheral propylitic alteration, with the following typical values: central potassic core (600°C, 800 bars); middle transition zone (450°C, 500 bars); outer propylitic zone (350°C, 200 bars). The degree of oxygen-isotope exchange between veins and igneous rock matrix correlates with increasing T, intensity of alteration, and abundance of quartz veins. Calculated $\delta^{18}O$ and δD values of hydrothermal fluids range from 5.1, -41 permil in the outer propylitic zone to 6.8, -67 permil in the center of the potassic zone (core), and exhibit a systematic and continuous trend of ^{18}O-enrichment and D-depletion with increasing T toward the innermost potassic core. This trend is inconsistent with progressive influx of local meteoric water (δD = -90 to -105 permil). The observed trend can be interpreted in one of two ways: 1) Mixing of magmatic water with progressively larger portions of D-enriched formation water outward from the potassic core; 2) Isotopic exchange of water from a single source (likely meteoric water) with the Bingham stock at variable T and low (<0.02) water (W)/rock (R) ratios (atomic oxygen). Temperatures required to reproduce the calculated oxygen and hydrogen isotopic compositions of the alteration fluids in each zone by fluid-rock isotopic exchange are in reasonable agreement with those inferred from fluid inclusion and oxygen-isotope thermometry. The low W/R ratios required by the second alternative imply deep, high T circulation and isotopic exchange of the alteration fluids, with subsequent focusing upward into the presently exposed levels of potassic and propylitic alteration. Later stage sericitic and argillic alteration fluids are depleted in both ^{18}O and D (-80 to -97 permil), indicating these stages were dominated by local meteoric water. This later meteoric-hydrothermal system apparently involved shallower circulation at higher W/R ratios. (Authors' abstract)

BOWMAN, J.R., PARRY, W.T., KROPP, W.P. and KRUER, S.A., 1986, Isotopic evolution of hydrothermal solutions in the Bingham Canyon, Utah, porphyry copper system (abst.): Terra Cognita, v. 6, no. 2, p. 212.See previous item.

BOYD, F.R., GURNEY, J.J. and RICHARDSON, S.H., 1985, Evidence for a 150-200-km thick Archaean lithosphere from diamond inclusion thermobarometry: Nature, v. 315, no. 6018, p. 387-389. First author at Geophys. Lab., Carnegie Inst. of Washington, Washington, DC 20008, DC.

Occurrences of diamondiferous kimberlites in southern Africa are concentrated within the boundaries of the Kaapvaal craton where crustal rocks are as old as 3500 Myr. Garnet inclusions from diamonds that erupted in the Finsch kimberlite and kimberlites of the Kimberley group, situated in the southern part of the craton, have Rb/Sr and Sm/Nd model ages of 3200-3300 Myr. These kimerlites were erupted ~100 Myr ago; thus the diamonds are xenocrysts. The localization of diamond-bearing kimberlites in the craton and the eruption of Archaean diamonds in late Cretaceous time are evidence that these diamonds crystallized and were immobilized in a root extending to depths of 150-200 km. Our applications of thermobarometry to silicate inclusions in the diamonds suggest that ambient temperatures at those depths 3000 Myr ago were 900-1200°C, similar to the range predicted from present-day heat flow. (Authors' abstract)

BOYD, S.R., SEAL, M., MATTEY, D.P., MENDELSSOHN, M.J., MILLEDGE, H.J. and PILLINGER, C.T., 1986, Zoned diamonds: Records of mantle volatile activity (abst.): Terra Cognita, v. 6, no. 2, p. 191.

BRADLEY, M.A., 1986, Vein mineralogy, paragenesis, and fluid inclusion study of the Silver district, La Paz County, Arizona: Arizona Geol. Soc. Digest, v. 16, p. 457-459. Author at Dept. Geosci., The Univ. Arizona, Tucson, AZ. (See also Ariz. Geol. Digest, v. 16, 1986, p. 457-459.)

The primary mineralization can be summarized as follows: Stage I - deposition of massive black calcite, fluorite, and quartz with minor barite;

virtually all sulfide and most Ag deposited; Stage II - brief stage of banded quartz-calcite deposition, with accessory fluorite; minor Ag values in Ag-bearing Mg oxides; and Stage III - massive white barite, with intergrown quartz and calcite; much hematite and Mg oxide content but no Ag values.

Fluid-inclusion measurements were made from over 40 doubly polished thin sections of fluorite, calcite, and quartz, representing all three stage of mineralization. The mean Th for fluorite was 153.5°C. Calcite measurements from Stage I mineralization show a consistent south-to-north trend of decreasing T, from means of 164°C-174°C at the Red Cloud, Black Rock, and Princess-Hamburg mines to below 138°C at the Clip mine. Stage III Th are fairly consistent at 128°C. Salinity measurements made from Tm observations are more constant, with a total variation from 18 wt% in the south to 14.5 wt% in the north.

The evidence from gangue mineral zonation, sulfide occurrences, and fluid-inclusion data indicates that the mineralizing solutions entered the district from the south and migrated north along major fault zones, in the process losing T and precipitating calcite and fluorite. Increases in pH and fO_2, as evidenced by the change from fluorite- to barite-dominated assemblages, were probably generated by boiling and by reaction with hematite-rich wall rocks. The salinity values are high in terms of "normal" epithermal systems, but coincide well with precious-metal epithermal systems. (From the author's abstract)

BRADSHAW, Alvin and SCHLEICHER, K.E., 1986, An empirical equation of state for pure water in the oceanographic region of temperature and pressure determined from direct measurements: J. Chem. Eng. Data, v. 31, p. 189-194.

BRAND, Paul, 1986, A thermodynamic consideration on using glass inclusions in rhyolitic quartzes for thermometry: Freiberger Forschungshefte, v. C402, p. 104-111 (in German). Author at the Bergakademie Freiberg, Sec. Chemie, 9200 Freiberg/Sa., GDR.

The thermodynamic changes in state of a magma during its ascent and the condition and changes of the glass inclusions in quartz crystals formed from such magma were considered according to the model system water-acidic silicate melt, using the results on melt inclusions in rhyolitic quartzes obtained by Thomas and Blankenburg, 1986. It was shown by thermodynamic estimations that adiabatic degassing of a hydrous acidic magma is not connected with a temperature lowering of about 200 K as outlined by Thomas and Blankenburg. On the basis of thermodynamic considerations the cooling of the magma from 1050°C to 830°C, as indicated by the existence of two (or three) types of melt inclusions in the quartz samples, can essentially be traced back to heat transfer to the wall rock during magma ascent. (Abstract courtesy R. Thomas)

BRANTLEY, S.L., CRANE, S.R., CRERAR, D.A., HELLMANN, Roland and STALLARD, Robert, 1986, Dissolution at dislocation etch pits in quartz: Geochimica Cosmo. Acta, v. 50, p. 2349-2361. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802, USA.

Of pertinence to the formation of inclusions by etching followed by growth. (E.R.)

BRANTLEY, S.L., CRERAR, D.A. and EVANS, Brian, 1986, Rates and mechanisms of porosity reduction in quartz: Implications for fluid flow in rocks (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 79-82. First author at Dept. Geol. Sci., Princeton Univ., Princeton, NJ 08544.

Continued next page.

We have shown that two solution-transfer processes in quartz, crack-healing and pressure-sintering, are quite fast, and can be measured in the laboratory time frame. This implies that these porosity-reducing processes should happen quickly even at quite low temperatures. Fluid flow in hot rocks must be either confined to relatively large flow channels, or must occur as discrete pulses of high-pressured ($P_f > P_c$) fluid followed by a fluid pressure decrease and surface area/water mass ratio decrease. This A/M decrease could be several orders of magnitude if large fractures replace small microcracks. The time necessary for rock-water chemical, thermal, and isotopic equilibration will vary drastically with this A/M ratio. (From the authors' Conclusions)

BRATHWAITE, R.L., McKAY, D.F. and HENDERSON, S., 1986, The Martha Hill gold-silver deposit, Waihi, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 19-23. First author at New Zealand Geol. Survey, Lower Hutt, New Zealand.

The large gold-silver-base metal sulphide-quartz vein system at Martha Hill is hosted by hydrothermally altered quartz-bearing andesites of Miocene age. The alteration is characterized by propylitic assemblages, with strong silicification accompanied by adularia and illite bounding the quartz veins. K-Ar dates on wall rock adularia indicate that the veins formed about 7.2 Ma ago. Several stages of vein filling are recognized; the main ore stage comprised crustiform banded quartz veins carrying pyrite, sphalerite, galena, chalcopyrite, acanthite and electrum. Fluid inclusion data indicate that the mineralization was deposited mainly in the T range of 220-270°C. The vein system forms a complex graben structure, and a strong tectonic control is shown by repeated fracturing and vein filling along two main fault/fracture orientations. A tectonic-hydrothermal model is invoked in which a fault/fracture system has acted as a tectonic valve on a hydrothermal fluid reservoir. (Authors' abstract)

Salinities were 0.2 to 4.0 eq. wt. % NaCl, the range presumably caused by CO_2; some evidence of boiling was noted. (E.R.)

BRATUS', M.D., MAMCHUR, G.P., IVANIV, I.N., SUDOVTSEV, V.F. and YARYNYCH, O.A., 1984, Isotope composition of carbon of the carbonate breccias of the western slope of the Ukrainian Shield: Mineralog. Sbornik., v. 38, no. 2, p. 87-89 (in Russian).

Cited in Naumov, 1986 (this volume).

BRATUS', M.D. and VYNAR, U.N., 1986, 7th All-Union Conference on Thermobarometry and Geochemistry of Ore-Forming Fluids: Geokhimiya, 1986, no. 9, p. 1370-1372 (in Russian).

A review of the conference. Abstracts from the first volume of abstracts are in Fluid Inclusion Research, v. 18, and those of the second volume are in this volume. (E.R.)

BREARLEY, Mark and BOETTCHER, Art, 1986, The effect of CO_2 on the viscosity of liquid silicates at high pressure (abst.): EOS, v. 67, no. 44, p. 1275.

BREDEHOEFT, J.D. and INGEBRITSEN, S.E., 1986, Mantle degassing and the generation of high pore pressure (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 549-550. Authors at U.S. Geol. Survey, Water Resources Div., Menlo Park, CA 94025.

A number of investigators have argued that the mantle is continuing to degas both juvenile and recycled volatiles. The fluids being degassed probably include H_2O, CO_2, CH_4, N_2 and H_2. There is a general consensus that CO_2 is one of the dominant gases being released from the mantle.

Barnes, Irwin and White (1984) mapped the worldwide distribution of CO_2 springs and showed that they occurred in areas which correspond with the major zones of seismicity. Irwin and Barnes (1980) suggested that CO_2 migrating upward through the crust could generate high pore pressures. The purpose of this investigation is to test the feasibility of this hypothesis. We have simulated the simultaneous transport of CO_2 and heat at mid-crustal depths and examined the permeability at which the current estimates of the flux of CO_2 from the mantle would generate pore pressure approaching lithostatic. The simulation is not as well constrained as one would like because of the lack of high temperature and pressure data on the physical parameters which describe CO_2, i.e., density and viscosity as functions of temperature and pressure. The results suggest that mantle degassing as a mechanism for generating high pore pressure requires permeabilities that are low; however, they are not unrealistically low. Mantle degassing may be an important mechanism to generate high pore pressure in the lower and mid crust. (Authors' abstract)

BREY, G.P. and KOGARKO, L., 1986, Solubility of CO_2 in kimberlitic and carbonatitic melts (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 163. First author at Max-Planck-Inst. Chem., Saarstrasse 23, D-6500 Mainz, FRG.

The solubility of CO_2 was measured as a function of pressure at liquidus temperatures in complex kimberlitic, olivine melilititic and carbonatitic compositions. Carbonatitic melts generated at depth in a peridotitic mantle with CO_2 as the only volatile species will, on ascent, immediately crystallize periclase, become SiO_2-rich by fractional crystallization and cannot reach the earth's surface. This is only possible in the additional presence of H_2O since water expands the stability of silicate towards carbonatitic compositions. (From the authors' abstract)

BRICE, J.C., 1986, Crystal Growth Processes: Glasgow, Blackie, 298 pp.
Includes minor discussion of inclusion formation. (E.R.)

BROMAN, C., 1986, Fluid inclusion evidence on the genesis of the sulfide deposits in the Skellefte district, Sweden (abst.): Terra Cognita, v. 6, no. 3, p. 509. Author at Dept. Geol., Univ. Stockholm, S-106 91 Stockholm, Sweden.

The sulfide deposits in the Skellefte district, northern Sweden, are enclosed in Proterozoic marine volcanic-sedimentary rock sequences. All rocks have been tectonically deformed and metamorphosed to greenschist facies. The mineralizations occur as massive Fe-Zn-Cu sulfide ore bodies that are underlain by stringers of Fe-Cu sulfides. The host rocks in the vicinity of the stringers have been hydrothermally altered to sericite or chlorite schists. The ores are interpreted to have formed by volcanic-exhalative processes in a subduction-related environment.

Fluid inclusion studies support the proposed genetic model of ore formation. An early generation of aqueous two-phase (liquid and vapor) inclusions that are suggested to be pre-metamorphic in origin are found in ore samples across the whole Skellefte district. This inclusion type indicates that ore formation took place in non-boiling Ca-Na-Cl solutions with a total salinity of 4 ± 2 equiv. wt. % NaCl. Two stages of mineral formation are distinguished at 210°C and 295°C, respectively.

Local recrystallization processes in relation to or after the regional metamorphism are documented by later (secondary) generations of fluid inclusions.

(1) CO_2-(with a moderate density) and CH_4-bearing inclusions that were observed only within rehealed microfractures in quartz.

(2) Aqueous two-phase (l + v) inclusions that demonstrate low Th (80-200°C) and contain complex salt (Ca-Mg-Na-Li?-Cl) mixtures. (Author's abstract)

BROOKS, J.W., LARSON, P.B. and O'NEIL, J.R., 1986, Paragenesis and fluid characteristics of the Mammoth Revenue vein, Platoro Caldera, San Juan Mountains, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 550. First author at Dept. Geol., Washington State Univ., Pullman, WA 99163.

The Mammoth Revenue vein, located in the Platoro mining district, San Juan Mountains, Colorado, contains base and precious metal mineralization in a multiply brecciated quartz vein. The three main states of mineralization, from earliest to latest, are: 1) base metal sulfides, 2) silver sulfosalts with silver-rich electrum (Au:Ag approximately 1:1), and 3) gold-silver tellurides with gold-rich electrum (Au:Ag approximately 3:1). All fluid inclusions in barren and mineralized vein quartz are simple two phase inclusions (liquid and vapor) and yield homogenization temperatures of 200° to 350°C. Examination of the fluid inclusions indicate that there was boiling of the hydrothermal fluid only during base metal deposition (approximately 320°C). Salinity of hydrothermal fluids was less than 3.4 weight per cent equivalent NaCl for all quartz analyzed. $\delta^{18}O$ values of altered host volcanic rocks range from +4.0 to +6.2 per mil and vein quartz $\delta^{18}O$ values range from +6.3 to +9.3 per mil. The calculated $\delta^{18}O$ values of fluid in equilibrium with the quartz range from +1.0 to -6.3 per mil. Preliminary δD values range from -130 to -113 per mil. Quartz codeposited with base metal mineralization yields the highest calculated $\delta^{18}O$ value for any ore depositing fluid. The calculated $\delta^{18}O$ value of the fluid that deposited the earliest, barren quartz (-2.9 per mil) is lower than that of the fluid that deposited the base metals. These data suggest that the base metal mineralization was due to mixing of two distinct fluids: magmatic and meteoric. Later sulfosalt and telluride mineralization (calculated $\delta^{18}O$ values of -3.9 and -6.3 per mil, respectively) indicate increasing domination by meteoric water in the hydrothermal fluid during subsequent stages of vein evolution. (Authors' abstract)

BROWN, E.T., EDMOND, J.M., CAMPBELL, A.C., MEASURES, C.I., BOWERS, T.S. and PALMER, M.R., 1986, Preliminary report on metal chemistry of Salton Sea drilling project hydrothermal fluids (abst.): EOS, v. 67, no. 44, p. 1256. Authors at Dept. Earth, Atmos. & Planet. Sci., M.I.T., Cambridge, MA 02139.

Hydrothermal fluids from the first flow test of the Salton Sea Scientific Drilling Project have been analyzed for a number of minor elements. These fluids have a pre-flash chloride content of 4.3 M/kg. This Cl is derived from evaporite deposits within the sediment filled Salton Trough and has a profound effect on the metal content of these fluids. Many metals have solution concentrations 100-1000 X higher than in vent waters from ridge crest hydrothermal vents at 21°N. Those elements that show a thousand fold enrichment include: As - 2 uM, Ag - 30 uM and Pb - ~1 mM. Elements such as Co - 40 uM, Zn - 10 mM and Cd - 30 uM display a 100 fold increase over 21°N. Copper is only 3-5 times higher. The pH of the Salton Sea fluids ranges from 5.2 to 5.4, two orders of magnitude higher than at 21°N. This shows the importance of Cl as a solubilizing agent in these fluids. (Authors' abstract)

BROWN, G.E., Jr. and EWING, R.C., 1986, Introduction to the Jahns Memorial Issue: Am. Mineral., v. 71, p. 233-238. First author at Dept. Geol., Stanford Univ., Stanford, CA 94305.

A brief review of the contents of this issue, which contains 30 contributions on granite pegmatites. (E.R.)

BROWN, P.E., Fluid inclusions, fluids and lode gold ores, Wabigoon Subprovince, NW Ontario, Canada (extended abstr.): Extended Absts., Geocongress '86, Johannesburg, South Africa, p. 279-282. Author at Dept. Geol., Univ. Wisconsin, Madison, WI 53706, USA.

Eighteen samples containing CO_2 inclusions were studied. Volume % CO_2 was <40(1), 40-80(4), and >80(13). Th CO_2 L-V [presumably in liquid] range from -21 to +31°C; pressure (based on CO_2 isochores modified for CH_4 contents), and T of 300-450°C, range 3-5 kb. (E.R.)

BROWN, P.E. and AHMED, G.A., 1986, A petrographic and fluid inclusion comparison of silver-poor and silver-rich zinc-lead ores, N.E. Washington State: Mineral. Deposita, v. 21, no. 2, p. 156-163. First author at Dept. Geol. & Geophysics, Univ. Wisconsin, Madison, WI 53706.

Many of the zinc-lead deposits of NE Washington State are poorly known examples of Mississippi Valley Type (MVT) mineralization. This study compares inclusion fluids from the Josephine Breccia ores with the later cross-cutting sulfide-bearing quartz veins. The breccia ores are cemented mainly by open space fillings of dolomite, sphalerite, quartz, galena, jasperoid and calcite. Replacement is of minor importance. Ore and gangue deposition occurred over the range 150-250°C with most of the temperatures less than 200°C. The aqueous brines typically contain 17-23 equivalent weight percent NaCl with often substantial amounts of Ca and/or Mg chlorides. Homogenization temperatures do not delineate any cooling or paragenetic sequence. The cross-cutting vein quartz contains CO_2-rich inclusions with overall densities usually less than 0.7 g/cc and homogenization temperatures from 250-325°C. Sulfur isotope analyses yield two populations with the quartz vein ores being lighter (<13 per mil CDT) than the average for the conformable ores. The later veins are not remobilized MVT sulfides but represent a separate, high-silver period of mineralization. (Authors' abstract)

BROWN, P.E. and LAMB, W.M., 1986, Mixing of H_2O-CO_2 in fluid inclusions; geochemistry and Archean gold deposits: Geochimica Cosmo. Acta, v. 50, p. 847-852. Authors at Dept. Gel. & Geophys., Univ. Wisconsin, Madison, WI 53706, USA.

A modified Redlich-Kwong (MRK) equation of state for H_2O and CO_2 was used to calculate bulk molar volumes, mole fractions and CO_2 densities for mixed volatile fluid inclusions. The results allow very useful P-T diagrams to be constructed (for fixed CO_2 density) and contoured with volume percent CO_2 observed in the laboratory. These diagrams permit rapid qualitative or quantitative determination of the P-T path for a bulk inclusion isochore above the solvus in the system H_2O-CO_2 (± NaCl). The calculations suggest peak metamorphic P of 3-5 kb for some Archean greenstone gold deposits. Insights gained from this work may require reinterpretation of P estimates in published fluid inclusion studies. (Authors' abstract)

BRYZGALIN, O.V., 1985, Estimating dissociation constants in the supercritical region for some strong electrolytes from an electrostatic model: Geokhimiya, no. 8, p. 1184-1195 (in Russian; translated in Geochem. Int'l., v., 23, no. 2, p. 84-95, 1986).

BUCHHORN, I.J., 1986, Geology and mineralization of the Wagon Pass prospect, Napier Range, Lennard Shelf, Western Australia: Proc. Commonwealth Mining & Metal. Congr., Australia, 13th, Perth, Australia 1986, v. 2, p. 163-172.

Indexed under fluid inclusions. (E.R.)

BUELTER, D.P. and GUILLEMETE, R.N., 1986, Trace element distribution in epigenetic dolomite associated with lead-zinc mineralization of the Viburnum Trend, southeast Missouri (abst.): Symp. on the Bonneterre Formation (Cambrian), southeastern Missouri, May 1 and 2, 1986, Univ. of Missouri-Rolla, Rolla, MO [Abstracts], p. 6.

BUISSON, G. and LEBLANC, 1986, Gold in mantle peridotites from Upper Proterozoic ophiolites in Arabia, Mali and Morocco (abst.): Terra Cognita, v. 6, no. 3, p. 534-535. Authors at Centre Géol. & Géophys., U.S.T.L., 34060 Montpellier, France.

An Upper Mantle connection has been suggested for many Archean gold deposits related to carbonatized komatiites. Similar gold mineralization and alteration mineralogy are known in gold-bearing listwaenites (i.e., carbonatized ultramafic rocks) in mantle-derived ultramafic massifs from various ophiolite complexes. Isotope investigations indicate a probable mantle source for the carbon of the carbonates. Fluid inclusions from the carbonates and quartz of listwaenites contain heterogeneous CO_2-H_2O-CH_4 fluids and indicate moderate T of crystallization (150-250° C). The REE patterns show a strong LREE enrichment in the carbonatized material and correspond reasonably to an hydrothermal process of carbonate metaomatism. (From the authors' abstract)

BUKUROV, G.S., 1986, Derivation of an eutectic equation and its use for the thermodynamic analysis of magmatic melt crystallization: Dokl. Akad. Nauk SSSR, v. 290, no. 3, p. 706-709 (in Russian). Author at Central-Kazakhstan Sec. of Geol. Inst. Acad. Sci. of Kazakh SSR, Karaganda, USSR.

The paper presents a simplified eutectic equation for a two-component system, tabular values for calculations and application of this equation to the Skaergaard intrusion. (A.K.)

BULANOVA, G.P., 1986, Compositional evolution of syngenetic inclusions of ultrabasic association in Yakutian diamonds (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 371-373. Author at Inst. Geol., Yakut Br., Siberian Dept., USSR Acad. Sci.

Reports an inclusion of magnesite in diamond. (E.R.)

Note - this same volume contains many other abstracts dealing with solid inclusions in diamond, not listed here. (E.R.)

BULNAEV, K.B., 1985, Conditions of formation and location of the fluorine-rare-earth ore mineralization: Geologiya Rudn. Metorozhd., no. 2, p. 28-38 (in Russian).

Cited in Naumov, 1986 (this volume).

BULNAEV, K.B. and BAZHEEV, Ye.D., 1985, On genesis of the fluorite mineralization in the upper part of the Uda River (Western Transbaikalia): Geologiya Rudn. Metorozhd., no. 6, p. 102-108 (in Russian).

Cited in Naumov, 1986 (this volume).

BUNDTZEN, T.K. and SMITH, T.E., 1986, Late Precambrian metallization in the Kantishna-Fairbanks mineral belt, central Alaska (abst.): Terra Cognita, v. 6, no. 3, p. 543. Authors at Alaska Div. Geol. & Geophys. Surveys, 794 Univ. Ave., Basement Fairbanks, AK 99701, USA.

Fluid inclusion data and detailed petrographic examinations indicate at least three temperature levels of sulfide-gold deposition in the vein deposits with a total T range of 150°C to 400°C. Sulfur isotopic compositions ($\delta^{34}S$ values) from polymetallic veins in both mineralized areas in the mineral belt range from -2.0 to +5.0;* volcanigenic massive sulfides show $\delta^{34}S$ values from +9.0 to +14.0. Lead isotope values of galena from both stratabound and vein deposits in the Kantishna and Fairbanks deposits are radiogenic and cluster near the end of a single stage growth curve, similar to values from continental rift environments. (From the authors' abstract) * ‰?

BURCHARDT, Immo, 1986, On some questions as to the genesis of "Vulkanit-Achaten": Z. Geol. Wiss., Berlin, v. 14, no. 4, p. 459-471 (in German; English Summary). Author at VEB Geologische Forschung und Erkundung Halle, 4030 Halle, Köthener Strasse 34, GDR.

Contrary to the concept of genesis held by Blankenburg,* to obtain volcanic agates from melted chert-xenoliths, arguments are offered, which indicate [lithophysae?] a genesis of agates in degassed vesicles of volcanic rocks and degassed vesicles of rhyolite globe-structures by hydrothermal solutions in course of geyser activity. (Authors' summary)

*[See Blankenburg et al., 1983, and Thomas and Blankenburg, 1981, both in Fluid Inclusion Research, v. 16, 1983. E.R.]

BURLINSON, K.G. and MACKIE, A.W., 1986, Geology and fluid inclusion decrepitation studies at the Arltunga gold field, N.T. (abst.): Eighth Australian Geol. Conv., Geol. Soc, of Australia, "Earth Resources in Time and Space," Feb. 16-21, 1986, Flinders Univ., Adelaide, Abstracts, no. 15, p. 35-36. First author at Burlinson Geochem. Svcs. Pty. Ltd., Darwin.

This study investigated the usage of decrepitation analyses in discriminating between mineralized and barren quartz veins in a structurally and metamorphically complex area.

The Au mineralization occurs in pyritic quartz veins infilling tension gash structures and aligned fractures which formed during the intense folding events. It is suggested that the Au was hydrothermally leached from older volcanic assemblages of the basement complex by fluids associated with the greenschist facies retrograde metamorphic event at 335-310 m.y. (Alice Springs Orogeny) and deposited in these structurally favorable sites.

Twenty quartz samples from 13 veins, both mineralized and barren, were collected and analyzed by decrepitation using the BGS 04 decrepitometer. The results show that there are 4 distinct types of quartz veins. The most obvious difference between the decrepigrams is the presence or absence of a decrepitation peak at a low T, near 250°C. Microscope observations of thin sections of 9 of the samples show that this decrepitation peak is caused by the presence of a population of CO_2-rich fluid inclusions. In these the internal P causes decrepitation at T which may often be lower than the Th.

The 9 samples showing such a low T peak also have intense additional peaks at 450°C and 580°C, the latter peak being related to the alpha-beta phase inversion of the quartz structure. These samples are all closely spatially related to the old Au workings.

A second group of 6 has similar decrepigrams to the above group, but lacks the peak at 250°C. These samples came from small old workings which were probably sub-economic.

The third group of 4 has decrepigrams with only very few counts overall and which are bimodal with peaks at about 500°C and 580°C. These samples are remote from old workings and are probably barren.

The remaining sample shows only a single decrepitation peak at the quartz inversion T of 580°C. This sample was also from a barren background area, remote from old workings.

The decrepitation results clearly discriminate between different types of quartz which cannot easily be distinguished by hand specimen examination. As there are vast numbers of fluid inclusions per gram of rock (often some

10^9) the method is more reliable than the analysis of trace constituents in distinguishing between quartz types, which may be inhomogenously distributed. In addition, the technique is not affected by leaching during weathering and is little influenced by sampling error problems, in distinct contrast to the problems of using chemical analyses of trace constituents.

The Arltunga results show a close relationship between the presence of low-T decrepitation peaks caused by CO_2-rich fluid inclusions and the occurrence of Au mineralization. This relationship has also been reported from the Pine Creek Area, N.T., and is also known to occur in the Kalgoorlie area, W.A., and the Timmins district, Ontario, Canada. It is of considerable interest that the technique is applicable in this structurally and metamorphically complex region although it must be remembered that the Au mineralization is probably one of the latest events in the area. (From the authors' abstract)

BURNHAM, C.W. and NEKVASIL, Hanna, 1986, Equilibrium properties of granite pegmatite magmas: Am. Mineral., v. 71, p. 239-263. First author at Dept. Geosci., Pennsylvania State Univ., University Park, PA 16802.

Includes discussion of the effects of H_2O, Cl, F, and B. (E.R.)

BURNHAM, C.W. and POST, J.E., 1986, Positional disorder of cavity and channel cations in mineral structures: Influence of local framework cation configurations (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 65.

Possibly of pertinence if such cations migrate into fluid inclusions. (E.R.)

BURROWS, D.R., WOOD, P.C. and SPOONER, E.T.C., 1986, Carbon isotope evidence for a magmatic origin for Archaean gold-quartz vein ore deposits: Nature, v. 321, p. 851-854. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

Archaean gold-quartz vein/shear zone systems constitute one of the most important types of gold ore deposit; however, their origin is controversial. Here we discuss newly obtained $\delta^{13}C(PDB)$ values for carbonate associated with the second largest such system in the world (Hollinger-McIntyre, Superior Province, Canada), together with values for fourteen other Au-mineralized locations in the Timmins area and for the largest such system in the world (Golden Mile, Western Australia). All of the data are statistically identical to the $\delta^{13}C$ values, reported here, of proven magmatic carbonate recently found in Au- and W-enriched MoS_2 mineralization in the Mink Lake sodic granodiorite stock, northwest Ontario. The $\delta^{13}C$ values appear to exclude greenschist-amphibolite facies metamorphic processes, a widely accepted genetic alternative, and granulite facies processes. We conclude that currently available carbon isotope data suggest that the H_2O-CO_2 fluid which deposited this type of Archaean Au mineralization was magmatically derived. (Authors' abstract)

BYERS, C.D., GARCIA, M.O. and MUENOW, D.W., 1986, Volatiles in basaltic glasses from the East Pacific Rise at 21°N: Implications for MORB sources and submarine lava flow morphology: Earth & Planet. Sci. Letters, v. 79, p. 9-20. First author at Chem. Dept. & Hawaii Inst. Geophys., Univ. Hawaii, Honolulu, HI 96822, USA.

Pillow-rim glasses from a suite of moderately evolved lavas erupted along the axis of the East Pacific Rise (EPR) at 21°N were analyzed by high-temperature mass spectrometry for volatile content. Concentrations of H_2O, F and Cl in the 21°N glasses are low and correlate inversely with Mg# yielding well-defined trends. These and other geochemical data indicate derivation of the 21°N glasses from similar parental magmas produced from a highly depleted, nearly homogeneous source. Total volatile, H_2O, F and

S contents are lower and CO_2 content is somewhat higher in these samples than in previously analyzed Mid-Atlantic Ridge (MAR) glasses. 21°N glasses are similar in volatile content to glasses from the Galapagos Spreading Center (GSC) at 95°W except in Cl (lower) and CO_2 (higher). Unlike most MAR and GSC glasses, CO_2 is the dominant volatile in all of the 21°N glasses with Mg# >62. All of the EPR and GSC glasses contain reduced carbon species (CO and CH_4), unlike most previously analyzed MAR samples. These data indicate that sources for mid-ocean ridge basalts are extremely volatile-poor (<0.10 wt.%) and are probably dominantly reduced (below quartz-fayalite-magnetite buffer).

Sheet flow and pillow basalts contain identical volatile contents. Thus, volatile abundance is not a factor controlling flow morphology. Extrusion rate and/or surface topography are probably the most important factors influencing flow morphology in submarine basalts. H_2O-release patterns are however related to flow morphology. Mass pyrograms for sheet flow and pillow basalt glasses both show bimodal H_2O-release behavior at the same temperatures (800°C and 1000°C ± 50°C). However, the dominant H_2O-release peak for sheet flow glasses is at the lower temperature; for pillow-rim glasses it is at the higher temperature. Infrared spectroscopic studies indicate that H_2O in these glasses is present only as hydroxyl groups. Thus, the cause of differences in the bimodal H_2O-release and how it is related to flow morphology is unclear. (Authors' abstract)

CABRI, L.J., 1986, A third issue [of Econ. Geology] devoted to platinum deposits: Econ. Geol., v. 81, no. 5, p. 1045- .

This issue (#5) of Economic Geology is devoted to platinum deposits, and hence contains several items on sulfide-silicate immiscibility. (E.R.)

ČADEK, J. and MALKOVSKÝ, M., 1986, Fluorite in the vicinity of Teplice Spa, Bohemia - A new type of fluorite deposit (abst.): Terra Cognita, v. 6, no. 3, p. 514. Authors at Geol. Survey, Malostranske Namesti 19, 11821 Prague 1, Czechoslovakia.

A new type of fluorite occurrence with large regional distribution was discovered. Fluorite formed during a young mineralization stage connected with emersion of thermal springs. It occurs in association with barite, pyrite, galena, uranium oxide, limonite, siderite and calcite. The temperature of fluorite formation, based on fluid inclusion studies, is well below 100°C, probably below 70°C. The isotopic study of vein carbonates in the thermal area provides a temperature of crystallization of 52.7°C, i.e., approximately 10°C higher than the temperature of the present-day springs in the area. (From the authors' abstract)

CALDERONI, G., FERRINI, V., GARBARINO, C., MASI, U., NICOLETTI, M. and PADALINO, G., 1985, Geochemistry of the fluorite and barite vein mineralization from Monte Genis (Sardinia, Italy): Mineral. Petrogr. Acta, v. 29, p. 13-23.

Contains D-isotope analyses of fluid inclusions in fluorite and barite. (P. Lattanzi)

CAMERON, R.G., 1986, Mineralized fractures and lineaments, Macksville region, northern NSW (abst.): Eighth Australian Geol. Conv., Geol. Soc. of Australia, "Earth Resources in Time and Space," Feb. 16-21, 1986, Flinders Univ., Adelaide, Abstracts, no. 15, p. 37-38. Author at Geol. Survey New South Wales, Sydney.

The Sb veins probably formed at T similar to the filling T (ranging from 100°C to 250°C) in the veins of the Hillgrove Sb field near Armidale. This range is within the T range of metamorphic waters and it is suggested that these veins probably formed from metamorphic waters rather than from igneously derived hydrothermal fluids. No plutons occur in the Taylors Arm and Munga Creek areas. Metal ratios for the Sb veins show relatively higher abundances of Ag and base metals in the western part of the Taylors Arm district, possibly suggesting formation at slightly higher T than those further east and southeast - but there are no fluid inclusion data to support this idea. (From the author's abstract)

CAMPBELL, A.C., EDMOND, J.M., BOWERS, T.S. and KHADEM, M., 1986, Temporal and areal variations in the chemistry of oceanic vent fluids: 13°N, 21°N and Guaymas Basin (abst.): EOS, v. 67, p. 391-392.

CAMPBELL, A.R. and ROBINSON-COOK, Sylveen, 1986, Fluid inclusion microthermometry in coexisting wolframite and quartz (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 556. Authors at Dept. Geosci., New Mexico Tech., Socorro, NM 87801.

Although wolframite is opaque to visible light, it is transparent to near infrared radiation. Using infrared microscopy, fluid inclusions were observed in wolframite from four deposits: Victorio Mountains, New Mexico; Panasqueira, Portugal; San Cristobal, Peru; and Black Pine, Montana. Microthermometric data from inclusions in wolframite of each deposit is compared to those from intimately associated quartz, presumed to be cogenetic.

At Victorio Mountains inclusions in wolframite contain less CO_2 and have higher Th (280-380°C) than those in associated quartz (Th = 140-320°C). Th could not be measured at Panasqueira as the wolframite became opaque upon heating, however the wolframite inclusions salinities (8-13 wt% NaCl) are slightly higher than those of quartz (5-10 wt%). Also at Panasqueira vapor-rich inclusions found in wolframite have been reported only in the quartz which occurs in the wolframite stage of mineralization (Kelly and Rye, 1979). Th measurements from coexisting wolframite and quartz at San Cristobal (qtz = 230-350°C, wolf = 250-340°C) and Black Pine (qtz 250-280°C, wolf = 210-280°C) are each in agreement.

Previous studies have often assumed that inclusion measurements from quartz represent depositional conditions of wolframite. The data presented here document that coexisting wolframite and quartz may yield discrepant conditions of formation and suggest that caution should be exercised when making this assumption. (Authors' abstract)

CANDELA, P.A., 1986a Mass transfer in magmatic-hydrothermal systems: The effect of vapor evolution on oxygen fugacity (abst.): EOS, v. 67, p. 389.

CANDELA, P.A., 1986b The evolution of aqueous vapor from silicate melts: Effect on oxygen fugacity: Geochimica Cosmo. Acta, v. 50, p. 1205-1211. Author at Dept. Geol., Univ. Maryland, College Park, MD 20742, USA.

In low-iron systems such as the high silica rhyolitic magmas associated with Climax-type porphyry molybdenum systems, high oxygen fugacities may be obtained. (From the author's abstract)

CANDELA, P.A., 1986c, Toward a thermodynamic model for the halogens in magmatic systems: An application to melt-vapor-apatite equilibria: Chem. Geol., v. 57, p. 289-301. Author at Lab. Min. Deposits Res., Dept. Geol., Univ. Maryland, College Park, MD 20742, USA.

Equations have been derived which yield trends in the concentration of chlorine, fluorine and water in apatite during the crystallization of a magma. The model includes a quasichemical formulation for the halogens in silicate melts, the formulation of the partitioning of chlorine, fluorine and hydroxyl between apatite and a silicate melt as two independent exchange constants, and an explicit statement of mass balance in apatite. This model predicts that the F:Cl:OH ratio in a crystallizing apatite remains approximately constant in a vapor-undersaturated system, even though their concentration in the magma is increasing. Attempts to explain such trends using Nernst partition coefficients yield erroneous conclusions, and exemplify the failure of these simple partition coefficients. When a vapor phase is evolved, the Cl/F ratio in the apatite decreases sharply because Cl is partitioned strongly into the aqueous fluid while F is not. Such trends in the chemistry of apatite have been reported in the literature. When coupled with textural data, these heretofore unexplained trends in apatite chemistry may be used as indicators of vapor evolution in felsic igneous systems. (Author's abstract)

CANDELA, P.A. and HOLLAND, H.D., 1986, A mass transfer model for copper and molybdenum in magmatic hydrothermal systems: The origin of porphyry-type ore deposits: Econ. Geol., v. 81, no. 1., p. 1-19. First author at Dept. Geol., Univ. Maryland, College Park, MD 20742.

Equations have been derived which model element partitioning between silicate melts, aqueous fluids, and crystalline phases during crystallization. These equations can be used to calculate the efficiency of removal of elements from magmas into aqueous fluids as a function of (1) the bulk solid-liquid partition coefficient of these elements; (2) the initial and saturation water concentrations in the melt (which together determine the amount of melt crystallized before water saturation); and (3) the chlorine concentration of the melt (in the case of chlorine-complexed cations).

The efficiency with which copper and molybdenum can be removed from silicate melts, E(Cu) and E(Mo), respectively, has been calculated. Based on geologic data, copper is modeled as a compatible element and molybdenum is modeled as an incompatible element. Under these conditions the ratio E(Mo)/E(Cu) increases as the initial water concentration of the melt decreases for a given depth of vapor evolution and a given Cl/H_2O ratio and increases as the depth of vapor evolution increases for a given Cl/H_2O ratio and a given initial water concentration of the melt.

Cu is concentrated so efficiently into a moderately to highly saline aqueous phase that liquid-vapor extraction seems to be a reasonable process to account for the concentration of Cu in porphyry Cu deposits. Efficient extraction of Cu results when aqueous fluids are evolved early in the crystallization of the intrusion. The value of D(Mo) is small relative to D(Cu) at moderate to high chloride concentrations, and the extraction of Mo from the melts into aqueous fluids therefore tends to be less efficient. However, vapor-liquid partitioning can extract the requisite quantities of Mo from granitic melts of batholitic size if Mo acts as an incompatible element and if the water content of the magma at water saturation is on the order of several weight percent. (Authors' abstract)

CAO, Junchen, 1985, A preliminary discussion on classification and some geochemical features of stratabound fluorite deposits in China: Geol. & Prospecting, v. 21, no. 7, p. 8-14 (in Chinese).

Apparently contains inclusion data (p. 10-11). (E.R.)

CARAPEZZA, M., GURRIERI, S., NUCCIO, P.M. and VALENZA, M., 1984, CO_2 and H_2S concentrations in the atmosphere at the Solfatara of Pozzuoli: Bull. Volcanol., v. 47, no. 2, p. 287-293 (published 1986). Authors at Inst. Mineral., Petrogr., e Geochimica, Univ. di Palermo, Palermo, Italy.

The CO_2 and H_2S concentration in the Solfatara atmosphere has been measured. The concentrations of both gases are higher nearby the more active areas and decrease away from them. A sharp horizontal and vertical gradient of the CO_2 content has been recognized.

Such gradient is assumed to result from a diffusion of gas from the ground to the atmosphere.

The total output of CO_2 has been computed based on a turbulent diffusion model. The obtained value is in good agreement with previously observed values (Italiano et al., 1984).

The feasibility of monitoring the atmosphere of Solfatara for either gas hazard and surveillance of volcanic activity has also been evaluated. (Authors' abstract)

CARLSON, S.C., WANG, H.F., KOWALLIS, B.J., BONNER, B.P. and HEARD, H.C., 1986, Thermal stress microfracturing of three granites (abst.): EOS, v. 67, p. 373.

CARMICHAEL, D.M., 1986, Chemographic expansion of mixed-volatile equilibria in P-T space (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 52. Author at Dept. Geol. Sci., Queen's Univ., Kingston Ontario, K7L 3N6, Canada.

Deals mainly with system CO_2-H_2O. (E.R.)

CARMICHAEL, I.S.E. and GHIORSO, M.S., 1986, Oxidation-reduction relations in basic magma: A case for homogeneous equilibria: Earth & Planet. Sci. Letters., v. 78, p. 200-210.

CARTEN, R.B., 1986, Sodium-calcium metasomatism: Chemical, temporal, and spatial relationships at the Yerington, Nevada, porphyry copper deposit: Econ. Geol., v. 81, p. 1495-1519. Author at AMAX, Alloy Div., Henderson Mine, P.O. Box 38, Empire, CO 80438.

Phase equilibria and geologic reconstruction of depth of emplacement suggest that temperatures during early sodic-calcic alteration were limited to the range of 360° to 480°C at pressures between 300 and 800 bars. Late sodic alteration took place at similar pressures but at temperatures less than 360°C. (From the author's abstract)

CASQUET, C., 1986, C-O-H-N fluids in quartz segregations from a major ductile shear zone: The Berzosa fault, Spanish Central System: J. Metamorphic Geol., v. 4, p. 117-130. Author at Dept. Petrol., Univ. Complutense de Madrid, 28040 Madrid, Spain.

Fluid inclusions in selected quartz segregations across the Berzosa shear zone have been studied by microthermometric methods as well as, in some instances, by Raman analysis. Host rocks are medium-grade staurolite schists and sillimanite gneisses.

Three types of inclusions have been found, which in a time sequence are: $CO_2 \pm H_2O$; H_2O + salt (B-type); and $N_2 + CH_4$. Three types of B inclusion may be distinguished in turn, depending on whether they were trapped during an earlier dynamic-recovery phase (B_2-type), or were trapped apparently along with $N_2 + CH_4$ inclusions from a heterogeneous fluid (B_3-type).

Considerations from isochores confirm that $CO_2 \pm H_2O$ inclusions were trapped during late-peak and high-T retrograde metamorphic conditions (in the range 650-500°C and 5-2 kbar), whilst $N_2 + CH_4$ inclusions, along with the B_3-type of inclusions, formed at low-pressures (<1 kbar) and temperatures (<300°C). B_2-type inclusions were trapped chronologically between these two in a period in which strong inverse lateral thermal gradients developed in the zone. Inferred P-T paths for the area are convex to the

T-axis. (From the author's abstract)

CASSEDANNE, J.-P. and BARROS, J.-C., 1986, Some emerald deposits of Goiás: Rev. Gemm. a.f.g., v. 88, p. 9127 (in French).

At Porangatu, emeralds occur in and near bodies of phlogopite schist formed when fluids associated with Proterozoic pegmatites reacted with Archean komatiites. Fluid inclusions up to 470 μ long are characteristic of dark emeralds. Negative crystal forms, elongate parallel to the c-axis, are common. Most inclusions (70%) are rich in CO_2; others contain aqueous solutions (some with halite and sylvite as daughter minerals), or vapor. Salinities range from 2 to 28.5% (NaCl?). Temperatures of formation range from 350°-630°C and pressures from 0.4 to 0.7 kbar. (Abstract [fluid inclusion data only] prepared from text in French by C.J. Eastoe)

Note: Data in photo caption (Tm NaCl = 315°C) seem inconsistent with upper salinity limit (28.5%) in text. (C.J.E.)

CATHELINEAU, Michel, 1986, The hydrothermal alkali metasomatism effects on granitic rocks: Quartz dissolution and related subsolidus changes: J. Petrology, v. 27, Pt. 4, p. 945-965. Author at Centre de Recherches sur la Géol. de l'Uranium, BP 23, 54501 Vandoeuvre les Nancy Cedex, France.

Contains a short discussion (p. 958-959) of literature and some new data on inclusions involved in subsolidus alteration of granites. (E.R.)

CATHELINEAU, Michel, MARIGNAC, Christian and PUXEDDU, Mariano, 1986, Early stage of hydrothermal metamorphism at temperatures or 325°-600°C in the deepest part of the Larderello geothermal field (Italy) (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 100-103. First author at Centre de Recherches sur la Géol. de l'Uranium, Nancy, France.

Five types of fluid inclusions in recrystallized quartz crystals have been identified. Type 1). The oldest fluids are CO_2-CH_4-rich vapors with variable CO_2/CH_4 ratios (CO_2 melting point of -58° to -59.6°C; clathrates melting between +2° and +13.5°C) and likely traces of H_2S (some melting between -70° and -90°C). Densities and salinities are variable with Tm ice between -4° and -9°C in a complex system. Very low Te (-60°C) suggest the presence of NaCl-$CaCl_2$. Three-phase CO_2-rich inclusions were also found. The high CO_2 and CH_4 contents could be related to the metamorphic environment of the host rock mainly represented by graphite-rich metapelites and metapsammite. Two different brines with very high salinities are ubiquitous. In one sample the CO_2, CH_4-rich fluids (Type 1) seem to pre-date the brines. Type 2). Inclusions of one brine show two daughter minerals, NaCl and perhaps $CaCl_2$, with Th >540°C. The same type of brine shows a lower Th = 325°-355°C in a sample from a greater distance from the heat source. These temperatures are comparable with present day in-hole measured temperatures and with Th measured by Belkin et al. (1985) for the late stage of hydrothermal metamorphism (stage 2). Type 3). The other brine is present in fluid inclusions where halite is the only daughter mineral (Tm ice from -38° to -42°C, Tm NaCl at 185°-215°C). Th values (>560°C) are very high and in perfect agreement with those obtained from mineralogical data and particularly from the two-feldspar geothermometer. The slightly different Th values for the two brines, coexisting in the same sample, suggest a likely origin of brine 2) from boiling of brine 3). Only in one sample two other types of fluid inclusions were found: type 4), i.e., H_2O vapor represented by two-phase inclusions with high salinities (Tm ice frm -18° to -25°C) and high Th (>540°C), and type 5), similar to type 4) but with lower salinities (Tm ice from -5° to -10°C) and lower Th (430°-530°C). The very high salinities of these inclusions rule out the origin of their vapor from boiling of the brines previously described. A more likely explanation could be a mixing between an older brine still trapped in higher levels with low-salinity vapors produced by boiling of a more recent and deeper brine. The deepening of the brines could be a consequence of a downward shifting of the isotherms due to the monotonic and slow cooling of the field. Vapor 5) probably represents a more recent product of mixing that began with vapor 4), as indicated by increasingly dilute compositions.

From the preliminary data here presented it is difficult to ascertain the origin and nature of the different fluids and particularly of the brines 2) and 3). The presence of $CaCl_2$, instead of KCl together with NaCl a daughter mineral, recall the Na-Ca-Cl brines of Mississippi Valley deposits and oil fields. Two different hypotheses can be proposed to explain the high calcium content of the Larderello fluid inclusions. 1) The Larderello deep hydrothermal fluids of stage 1 partly derived by heating of marine waters penetrated in the basement through a major deep fracture system during Mio-Pliocene transgression before the emplacement of the Alpine granite. 2) The widespread occurrence of carbonates of Ca-silicates in the metamorphic basement exert a prevalent influence on the composition of deep and shallow hydrothermal fluids, as confirmed by the prevalence of Ca-silicates among the hydrothermal minerals at Larderello.

On the whole the data presented in this paper indicate the appearance, in a deep hydrothermal circuit, of magmatic fluids whose chemical composition is strongly modified by the bulk composition of the wall rock. (From the authors' abstract)

CATHELINEAU, Michel and NIEVA, David, 1986, Geothermometry of hydrothermal alteration in the Los Azufres geothermal system: Significance of fluid inclusions data (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 104-107. First author at Centre de Recherches sur la Géol. de l'Uranium, Vandoeuvre, France.

Approximately 400 inclusions from hydrothermal calcite, anhydrite and quartz have been studied. They are mostly aqueous with low salinities. P and S inclusions were not distinguished clearly. Th increases from the shallowest levels to the deepest. Temperatures of trapping would not exceed the measured Th of [by?] more than 5-10°C. There is an unexpected wide range (≃ 60°C) of temperatures in the deepest levels. Most fluid inclusions exhibit very low salinities (around 0.9-1.5% eq. wt. NaCl) but some of them are characterized by higher salinities varying from 2 to 7% eq-wt-NaCl. The plot of salinities versus Th shows two different trends:

1) varying salinities at nearly constant temperature may indicate a dilution process between two fluids of different salinities.

2) the horizontal trend of Th at constant salinity may represent the general cooling of the field.

3) fluids characterized by lower temperatures around 280°C may be considered either as fluids infiltrated from the upper levels, or as more recent fluids (temperatures in agreement with the actual ones). (From the authors' text)

CATHELINEAU, M., OLIVER, R., NIEVA, D. and GARFIAS, A., 1985, Mineralogy and distribution of hydrothermal mineral zones in Los Azufres (Mexico) geothermal field: Geothermics, v. 14, no. 1, p. 49-57. First author at Centre de Recherches sur las Geol. de l'Uranium, Vandoeuvre, France.

The general features of the geometry of Los Azufres reservoir have been defined through the mapping of hydrothermal mineral alteration zones. Hydrothermal alteration has been studied in cuttings and drill cores from most of the active wells. X-ray diffraction microprobe analysis and classical optical methods have been employed for the identification of primary and authigenic minerals in fresh and altered samples. Observed patterns of alteration have been correlated with T and patterns of fluid circulation. The resulting model depicts a body of geothermal fluid at depth, which ascends and discharges through two main fracture systems. These two circulation zones are characterized by concentric aureoles of increasing hydrothermal alteration towards quasivertical axes. The overall pattern could be described as a dome structure produced by the abnormal thermal gradient, distorted by the effects of active upward circulation of the fluids. (Authors' abstract)

CATTALANI, S. and WILLIAMS-JONES, A.E., 1986a Aqueous- and CO_2-CH_4-N_2-bearing fluid inclusions at the St. Robert Ag-W-Bi deposit, Eastern Townships, Quebec (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 53. Authors at Dept. Geol. Sci., McGill Univ., Montreal, Quebec, H3A 2A7, Canada.

Ag, W, Bi, Pb, Zn mineralization occurs in three major high level quartz vein sets at St. Robert, Eastern Townships, Quebec. These vein sets include an early, discordant Ag-bearing set in the south, and later concordant but separate W and Bi-bearing sets in the center and north respectively. Concordant granodioritic, and later discordant lamprophyric dike swarms are associated with the deposit. The presence of a central thermal metamorphic aureole measuring 2.5 km by 400 m indicates a larger intrusive stock at depth. A fault-controlled alteration halo of proximal argillic and distal phyllic facies overprints the aureole.

Microthermometric data on fluid inclusions in quartz, scheelite, sphalerite, and calcite indicate that early fluids were of low-salinity, and contained highly variable proportions of CO_2 and H_2O (XCO_2 = 0.3-1.0). Later, post-mineralization fluids also had low salinity but contained no CO_2. Th data indicate Tt of 200°C for the early fluids, and 150 to 200°C for the later fluids. Analysis of the early fluid inclusions using a laser Raman microprobe shows that CH_4 and N_2 are major components of the CO_2 phase. It is proposed that the data are consistent with heterogeneous entrapment of immiscible phases under low, largely hydrostatic P conditions. Mineralization is interpreted to have occurred as a result of the effervescence of a C-O-H-N phase from hydrothermal fluids that were initially acid and meteoric in origin. (Authors' abstract)

CATTALANI, Sergio and WILLIAMS-JONES, A.E., 1986b Geological and fluid inclusion studies at the Saint-Robert Ag, W, Bi deposit, Eastern Townships, Quebec, in Current Research, Part A, Geol. Survey of Canada, Paper 86-1A, p. 365-374. First author at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec H3A 2A7.

Ag-W mineralization at Saint-Robert-Bellarmin Eastern Townships, Quebec, occurs in high level quartz veins. These veins comprise an early, discordant Ag-bearing set in the south and later concordant W and Bi-bearing sets in the center and north respectively. The deposit is associated with granodioritic and lamprophyric dike swarms. A 2.5 km x 400 m thermal metamorphic aureole indicates a larger intrusive stock at depth. The aureole is overprinted by fault-controlled alteration of proximal argillic and distal phyllic facies. Early, low salinity, liquid H_2O-liquid CO_2-vapor CO_2, and later, low salinity, post-ore, aqueous fluids are trapped as inclusions in quartz. Th data indicate that the early CO_2-bearing fluids were trapped at ~200°C, and the later aqueous fluids between 150-200°C. Highly variable CO_2 contents in the early fluid suggest heterogeneous entrapment of immiscible CO_2-rich and H_2O-rich phases. Mineralization is attributed to CO_2 effervescence from initially acid meteoric solutions. (Authors' abstract)

CAULFIELD, J.B.D., DIXON, P.R., RYE, D.M. and LeHURAY, A.P., 1986, Structural and textural evidence for the timing of Zn + Pb + Ba mineralization in central Ireland: Review and update (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 560. First author at Dept. Geol. & Geophys., Yale Univ., P.O. Box 6666, New Haven, CT 06511.

Large deposits of Zn + Pb + Ba in Ireland are mainly stratabound and associated with synsedimentary normal faults. They are hosted by a narrow range of unmetamorphosed Mississippian carbonates deposited shortly after incursion of an epicontinental sea. Styles of mineralization have been compared to both SEDEX [and] MVT deposits. Large scale dateable structural features unequivocably tightly constrain the timing of the onset of mineralization which was penecontemporaneous with sedimentation. Ore zones at Silvermines have been brecciated by synsedimentary slumping; at Tatestown they are offset by a fault that was active during and shortly after mineralization; at Navan, a major angular unconformity overlain by only a slightly younger sediments, truncates five ore lenses. Petrographic studies show that mineralization started prior to compaction of the lithifying carbonates. Sulfides at Tatestown are cut by fine scale structures developed during compaction. Sulfides are the first minerals that infill primary stromatactic cavities at Ballinalack. In most of the deposits, drilling has shown that there are related minor shows of sulfides in the underlying low metamorphic grade strata. The absence of any significant sedimentary basin and the high temperatures (>180°C) of the ore-stage fluids (measured from fluid inclusions and sulfur isotope fractionation temperatures) preclude models invoking derivation of metalliferous fluids by basin-brine expulsion or by shallow ground water flow from adjacent highlands. The heterogeneity of sulfur isotope ratios (-42 to +14‰) regionally, suggest that sulfur was derived locally. A variety of precipitation mechanisms are allowed. Fluids expelled during marine transgression related to extension were opportunistic. Ensuing deposits represent local geology and chemistry superimposed on larger scale regional events. (Authors' abstract)

CAULFIELD, J.B.D., LeHURAY, A.P. and RYE, D.M., 1986, A review of lead and sulphur isotope investigations of Irish sediment-hosted base metal deposits with new data from the Keel, Ballinalack, Moyvoughly and Tatestown deposits, in Geology and genesis of mineral deposits in Ireland, C.J. Andrew et al., eds.: Irish Assoc. Econ. Geol., p. 591-615. First author at Dept. Geol. & Geophys., Yale Univ., P.O. Box 666, New Haven, CT 06511, USA.

In addition to citation of various literature studies, the authors report (p. 595) P inclusions in sphalerite had Th 117-123°C and salinities of 17-22 eq. wt% NaCl. (E.R.)

CAVARRETTA, G., DE VIVO, B. and TECCE, F., 1985, Studies on high-enthalpy fluids in the subvolcanic environment: The SH2 geothermal well in the Sabatini area: CNR Gruppo Naz. Vulcanol., Boll. 1985, p. 41-52 (ext. abstr.) (in Italian).

CAVARRETTA, Giuseppe and PUXEDDU, Mariano, 1986, Tourmalines in hydrothermal mineral assemblages from Larderello geothermal field (Italy) (extended abst.): Fifth Int'l. Symp. on Water-Rock Interaction, Extended Abstracts, Reykjavik, Iceland, Aug. 8-17, 1986, p. 108-111.

CERCONE, K.R. and LOHMANN, K.C., 1986, Diagenetic history of the Union 8 pinnacle reef (Middle Silurian), northern Michigan, USA, in Reef Diagenesis, J.H. Schroeder and B.H. Purser, eds.: Springer-Verlag, Berlin, p. 381-398. First author at Indiana Univ. of Pennsylvania, Dept. Geosci., 114 Walsh Hall, Indiana, PA 15705, USA.

Th values of >180°C for early void-filling calcite are believed to result from "entrapment of methane or carbon dioxide, or by leakage and contamination of the liquid phase due to aquathermal pressuring" (p. 390). Some very low "initial melting temperatures"(as low as -62°C) are recorded in late fracture-filling calcite. (E.R.)

ČERNÝ, P., FRYER, B.J., LONGSTAFFE, F.J. and TAMMEMAGI, H.Y, 1986, The Archean Lac du Bonnet batholith, Manitoba: Igneous history, metamorphic effects, and fluid overprinting (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 72. First author at Dept. Geol. Sci., Univ. Manitoba, Winnipeg, MB R3T 2N2 Canada.

Extensive porphyroblastesis of K-feldspar in the biotite granite is accompanied by remarkable disturbance of $\delta^{18}O$ (+6.6 - +11.0), depletion in LREE and HREE (at constant Eu), T, Zr, Hf, Th, and P, and slight enrichment in K and Ga. Major components and Rb-Sr isotopic ratios are not affected. Massive flow of CO_2-rich aqueous fluids channelled along zones of weakness appears to be responsible. (From the authors' abstract)

CHALOKWU, C.I. and GRANT, N.K., 1986, The composition and petrologic significance of the trapped intercumulus liquid in the Partridge River intrusion (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 561.

CHAMBERLAIN, S.C., DOSSERT, W.P. and SIEGEL, D.I., 1986, A new paragenesis and new localities for witherite: Canadian Mineralogist, v. 24, p. 79-90. First author at Inst. Sensory Res., Syracuse Univ., Syracuse, NY 13210, USA.

These data suggest that this witherite formed as the result of sulfate reduction and methane fermentation by bacteria in anoxic groundwaters. (From the authors' abstract)

CHANGKAKOTI, A., MORTON, R.D. and GRAY, J., 1986, Hydrothermal environments during the genesis of silver deposits in the Northwest Territories of Canada: Evidence from fluid inclusions: Mineral. Deposita, v. 21, p. 63-69. First author at Dept. Geol., Univ. Alberta, Edmonton, Canada.

The Ag-Ni-Co-Bi-As-U veins in the Northwest Territories of Canada are hosted by volcano-sedimentary and intrusive rocks of the Great Bear Batholithic Complex. Fluid inclusion data from the gangue minerals of the veins suggest a wide range in salinity and T for the hydrothermal fluids. The salinities of the fluids range from about 15 to 25 wt.% NaCl equiv. Th ranges from 150° to 250°C for stage I fluids; 220° to 480°C for stage II fluids; 250° to 350°C for stage III fluids; 150° to 250°C for stage IV fluids and 90° to 250°C for stage V fluids. The coexistence of liquid-rich and vapor-rich inclusions in stages II and III minerals suggest that the hydrothermal fluids were boiling or effervescing. The coexistence of saturated and unsaturated inclusions in stages II and III minerals may be due to effervescence of a less saline fluid, whilst for stages IV and V it may be due to mixing of a highly saline fluid with a less saline fluid, or due to alternation of hydrostatic and lithostatic P at the time of trapping of the inclusions. (Authors' abstract)

CHANGKAKOTI, A., MORTON, R.D., GRAY, J. and YONGE, C.J., 1986, Oxygen, hydrogen, and carbon isotopic studies of the Great Bear Lake silver deposits, Northwest Territories: Can. J. Earth Sci., v. 23, p. 1463-1469. First author at Dept. Geol., Univ. Alberta, Edmonton, Alta., Canada T6G 2E3.

The native-silver-bearing deposits of the Great Bear Lake region occur within two separate domains, namely the Echo Bay sector and the Camsell River sector. In all these deposits, native silver occurs in veins, associated with a wide range of Ni-, Co-, and Fe-arsenides, Cu-, Fe-, Ni-, and Co-sulfides, and pitchblende in gangues of quartz, calcite, dolomite, siderite, rhodochrosite, and fluorite. The host rocks of the veins are for the most part Aphebian volcano-sedimentary roof pendants within the Great Bear batholitic complex. The carbonates (calcite, dolomite, siderite, and rhodochrosite) show a wide range of $\delta^{18}O$ (6.8 to 22.5‰, SMOW) and $\delta^{13}C$ (-2.7 to -13.3‰, PDB) values. A single analysis of quartz gave a $\delta^{18}O$ value of 16.54‰ (SMOW). The δD of water in fluid inclusions in quartz, dolomite, and calcite shows a range from -62.2 to -98.5‰ (SMOW). The δD of present-day meteoric waters from the region shows a range of -146.5 to -165.2‰ (SMOW). The $\delta^{18}O$ of the hydrothermal fluids (0.47 to 9.12‰, SMOW) was calculated from the $\delta^{18}O$ values of the quartz, calcite, and dolomite belonging to different paragenetic sequences. The $\delta^{13}C$ of carbon (-2.8 to -8.6‰, PDB) in the hydrothermal fluid was calculated from the $\delta^{13}C$ values of the calcites. The oxygen, carbon, and hydrogen isotopic values indicate that in the early stages of mineralization, magmatic water and carbon from a magmatic source were predominant. During the late stages of mineralization, the influence of meteoric water became more pronounced. (Authors' abstract)

CHAO, Jing, HALL, K.R., MARSH, K.N. and WILHOIT, R.C., 1986, Thermodynamic properties of key organic oxygen compounds in the carbon range C_1 to C_4. Part 2. Ideal gas properties: J. Phys. Chem. Ref. Data, v. 15, no. 4, p. 1369-1436.

CHAPMAN, J.B., 1986, Potential mixing of fluids between evaporite strata in the Delaware Basin, New Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 562. Author at Environmental Evaluation Group, P.O. Box 968, Santa Fe, NM 87503.

In the northern part of the Permian Delaware Basin, a 600 meter thick sequence of salt beds, the Salado Formation, is sandwiched between two formations consisting of anhydrite and salt with minor carbonates. The Castile Formation, underlying the Salado, contains large pockets of pressurized brine, which have been variously proposed to consist of remnant Permian seawater, gypsum dehydration water, and introduced water (post-Permian). Groundwater above the Salado in the Rustler Formation has a clear meteoric origin, though the age of the water is under debate. The stable isotopic compositions provide evidence of fluid mixing between ground water in the Rustler, fluid inclusions in the Salado, and brine in the Castile reservoirs (Fig. 1). An increase in both oxygen-18 and deuterium is evident with depth below land surface. The timing and mechanism of the interpreted mixing event are unknown, but could be related to either slow movement of water through the Salado aquitard or to a major salt recrystallization event. (Author's abstract)

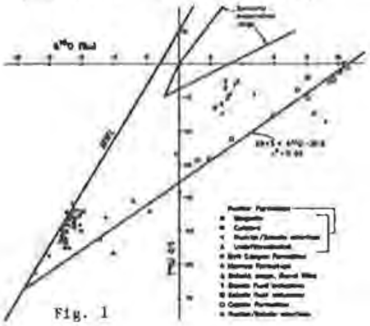


Fig. 1

CHAREF, A., 1986, Nature and role of fluid phases associated with Pb-Zn mineralizations and their metallogenic consequences: Fluid inclusions and isotopes (H, C, O, S, Pb) studies of Malines (France), Jbel Hallouf-Sidi Bou Aouane and Fedj-el-Adoum (Tunisia) mines: Doctoral thesis, I.N.P.L., Nancy, 303 pp. (in French; English abstract).

These three carbonate-shale hosted Pb-Zn ore deposits were studied to determine the source and nature of the fluids, sulphur and metals. These ore deposits were selected to include the very young (Plio-quaternary) karstic deposit of Jbel Hallouf-Sidi Bou Aouane and to compare it with the much older deposit of Malines whose stratiform mineralization could be Cambrian. In addition, Fedj-el-Adoum was chosen to represent a diapir-related deposit. Both Fedj-el-Adoum and Malines also represent examples of polyphase mineralization - stratiform, karstic, massive, and/or vein. The three ore deposits are directly or indirectly related to either a basin or sedimentary formations.

At Jbel Hallouf, model isotopic T are 10 to 25°C. The fluid was of meteoric origin and contained CO_2. During CO_2 degassing processes, travertine type carbonates ($\delta^{13}C > 4$) were precipitated with sulphides. Before surfacing as a spring the waters passed through an anaerobic zone where they leached reduced sulphur and metals from the sedimentary formations.

At Malines karstic mineralization (K-I) was also at a relatively low temperature (model isotopic temperatures are <70°C). However the nature of the fluids which transported the reduced sulphur and metals were probably different. It is proposed that these waters came from the Triassic sediments above together with a surface meteoric water contribution. Another mineralization event was superimposed which in the karsts is called K-II and in the fissures in the Cambrian dolomites is termed F. It is suggested that sulphur and metals of the K-II and F mineralizations were transported with the formation waters at temperatures of about 150°C. These saline fluids probably originated in the Rhone basin. It is proposed that these fluids were released aperiodically. Between the pulsations of warm fluids cold meteoric waters entered the deposition sites. The Rhone basin was probably also the source of the later CO_2 and hydrocarbon bearing fluids which precipitated the geodic barites.

The systematic nature and coherence of the microthermometric and Raman microspectrometric measurements on fluid inclusions in barite indicate that the data can be interpreted in terms of the V-X properties of the fluids at the time of their trapping. These valuable thermodynamic data imply that the impermeable Triassic marls were responsible for retaining the fluids in the underlying zone at P greater than lithostatic until these strata became fractured.

At Fedj-el-Adoum, there are two different types of mineralization associated with the diapir. The bedded mineralization formed at about 110°C with $\delta^{34}S$ between 29.8 and 11.7‰. The fluids are interpreted to be of formation water origin and that they transported the metals (Zn > Pb) and reduced sulphur. The later massive mineralization with $\delta^{34}S$ between -4.8 and -13.1 and T ~70°C involved bacterial reduction of Triassic sulphate from the diapir. Organic matter was intimately associated with the reactions and its oxidation probably contributed water (organic water) to the fluids. (From the author's abstract)

CHAREF, Abdelkrim, SHEPPARD, S.M.F. and MICHARD, Annie, 1986, Pb-Zn mineralization associated with diapirism: Fluid inclusion and stable isotope (H, C, O, S, Pb) evidence for the origin and evolution of the fluids at Fedj-el-Adoum, Tunisa (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 563. Authors at CRPG, B.P. 20, Vandoeuvre, France.

Three principal types of Pb-Zn mineralization occur in the contact zone to a saliferous diapir and its surrounding Cretaceous limestones. Combined fluid inclusion and stable isotope studies have shown that (1) for first generation bedded and vein ore, saline fluids (18-23 wt % equiv. NaCl; 130-100°C) with δD ~ -60, δ18-O ~ 13, containing CO_2, N_2 and hydrocarbons, precipitated sulfides (Zn > Pb) with δ34-S ~ 12 to 30, (2) for first generation massive ore and second generation bedded and vein ore equally saline fluids at ~ 70°C with δD ~ -110 and δ18-O ~ 10 precipitated calcite with δ13-C ~ -16 and sulfides (Pb > Zn) with δ34-S ~ -13 to -5, and (3) low temperature (<50°C) meteoric waters with δD ~ -20 introduced a final generation of calcite (δ13-C ~ -1). Pb-isotope compositions of (1) and (2) ores imply different sources for metals. For (1) fluids are interpreted to be formation waters which transported metals and reduced S from Jurassic to Cretaceous sediments in nearby basin. Sulfide S originated from bacterial reduction fo sulfate S in sediments before deep burial. For (2) fluids are considered to contain a major organic water component, possibly generated during a simplified overall reaction of type:

$$1.5[C_{12}H_{26}] + 8CaSO_4 \rightarrow 8H_2O + 8H_2S + 8CaCO_3 + 10[CH_{0.7}]$$

where much of hydrogen was derived from organic constituents, such as petroleum, durial [during?] bacterial sulfate reduction reactions using diapir sulfate (cap-rock type reactions). Two or more sources of fluid, sulfur and metals are required for ore deposit. The later (2) mineralization was not therefore formed by reworking (1) mineralization. (Authors' abstract)

CHARLES, R.W., VIDALE BUDEN, R.J. and GOFF, Fraser, 1986, An interpretation of the alteration assemblages at Sulphur Springs, Valles Caldera, New Mexico: J. Geophys. Res., v. 91, no. B2, p. 1887-1898.

CHATURVEDI, Lokesh, 1984, Occurrence of gases in the Salado Formation: Environmental Evaluation Group, Environ. Improvement Div., Health & Environ. Dept., State of New Mexico, 77 pp.

Gas blowouts involving fatalities during potash mining at the Kerr-McGee mine near Carlsbad were investigated. The gases extracted from salt (from WIPP-DOE-177, 1983) were mainly N_2, with <11% O_2 and <7.8 CH_4. (E.R.)

CHAUSSIDON, M. and SHEPPARD, S.M.F., 1986, Isotopic study (H, C, O, S) and evidence for sea water-magma interaction at 13°N, EPR (abst.): Terra Cognita, v. 6, no. 2, p. 213.

CHAVEZ, W.X., Jr., 1986, Geologic characteristics of volcanic-hosted "manto-type" Cu(-Ag) deposits, Coastal Range, northern Chile: The Mantos Blancos district as a type example (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 563. Author at Dept. Mining & Geol. Engrg., New Mexico Tech., Socorro, NM 87801.

Volcanic-hosted, disseminated and fracture-controlled copper sulfide ores of the Mantos Blancos district characterize epigenetic "manto-type" deposits in and adjacent to the Coastal Range of northern Chile. Hypogene ore mineral assemblages are characterized by low sulfur:metal ratios and the presence of specular hematite and calcite. Ore zones are stratiform yet only locally stratabound, and display complex zoning from central bornite + digenite + chalcocite ± cv mineralization enclosed by a bornite + chalcopyrite zone, and ultimately an outermost chalcopyrite + pyrite ± galena fringe. Specularite and red, fine-grained hematite are widespread mineralization products and in part represent iron liberated from previously-formed ore sulfides during late, hypogene ore formation which resulted in the generation of dg + cc ± cv ore. Studies on liquid-rich, two-phase calcite-hosted fluid inclusions yield uncorrected Th values from 80 to 115°C; freezing point depressions range from -16 to -44°C and "first melting" temperatures cluster around -50°C. These data are interpreted in terms of the model $CaCl_2$-NaCl-H_2O system and suggest the fluids were dense, highly saline, $CaCl_2$-rich brines with salinities exceeding 30 wt% dissolved salts and $CaCl_2$:NaCl weight ratios in excess of 3:1. There is no evidence of boiling. Sulfur isotope data with $\delta^{34}S$ values near zero are consistent with, though do not conclusively demonstrate, a magmatic sulfur origin.

Alteration is characterized by Na metasomatism and locally intense chloritization and carbonatization of originally subalkaline, continental to submarine intermediate to felsic volcanic rocks. Field and laboratory observations suggest ore genesis may be related to late stage subvolcanic activity and intrusion of shallow, felsic to intermediate sills and dikes, or, alternatively, to fluids generated during burial metamorphism of the Mantos Blancos volcanic sequence. (Author's abstract)

CHEANG, K.K., WENNER, D.B. and STUCKLESS, J.S., 1985, Oxygen isotope studies of hydrothermal alteration and uranium migration in the Granite Mountains, Wyoming, U.S.A., in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 33-40.

CHEILLETZ, A., 1986, Epigenesis versus syngenesis: A contribution to the debate based on the stratiform tungsten skarn mineralizations of Djebel Aouam (Central Morocco) (abst.): Terra Cognita, v. 6, no. 3, p. 519. Author at CRPG, BP 20, 545 01 Vandoeuvre, Les Nancy Cédex, France.

The recent discovery of stratiform tungsten skarn mineralizations in the polymetallic W-Pb-Zn-Ag Djebel Aouam district, Central Morocco, provides an opportunity to test epigenetic and syngenetic concepts. These mineralizations can be interpreted as stratiform skarn occurrences developed by metasomatic replacement of barren calc-silicate layers.

Fluid inclusion studies as well as silicate and scheelite electron microprobe analyses allow the calculation of the physico-chemical parameters during reaction between percolating fluids and calc-silicate layers. The stratiform mineralized skarn, which exhibits a diablastic texture defined by an intergrowth of quartz, Mg-biotite, actinolite, pure scheelite, apatite and ilmenite, developed at T = 570°C-600°C, P(total) = 1.8 kb, $fO_2 < 10^{-19}$b, $fS_2 = 10^{-4}$b and involves moderately saline fluid circulations.

The development of stratiform skarn mineralization occurs away from the granitic contact. REE analyses of scheelite crystals and highly mineralized zones do not show any correlation with outcropping Djebel Aouam granitic stocks but might suggest some relation with an evolved late acidic magma. The stratiform tungsten skarn mineralization appears enveloped by a huge biotitic stockwork-like alteration halo similar to a Cu-porphyry wall-rock alteration zone. (From the author's abstract)

CHEN, Anfu and ZHAO, Hongbo, 1986, Fluid inclusion study of the Xiazhuang uranium deposit: Geochimica, 1986, no. 2, p. 174-182 (in Chinese; English abstract). Authors at Beijing Inst. of Uranium Geol.

The Xiazhuang U deposit is located on the northeastern flank of a granite pluton (142-183 m.y.) in South China. There are several fault zones and crushed belts in the mining area. The most important ore-bearing structures are the silicified fracture zones extending in the NNE direction, the other group of faults extend in the EW direction, filling [a] lamprophyre dike.

Fluid inclusions in pre-mineralization quartz generally contain CO_2.

Fluid inclusions in fluorite formed at the mineralization stage, if boiled, contain dm NaCl, KCl and $CaCO_3$.

Hydrothermal T are estimated to be 100°-300°C, P = 20-500 atm, and salinities 16-30 wt.%. The isotopic compositions of fluid inclusions are as follows: $\delta D = -54$ to -88‰ (SMOW), $\delta^{18}O(H_2O) = -2.97$ to 8.85‰ (SMOW), and $\delta^{13}C = -6.99$ to 7.89‰ (PDB). The $\delta^{34}S$ values of pyrite are -3.40 to -15.32‰.

The hydrothermal solutions are characteristic of meteoric waters. The U in the hydrothermal solutions may be transported in the form of carbon uranyl complexes $[UO_2\ (CO_3)_2^{-2}\ UO_2\ (CO)_3^{-4}]$. The conditions of pitchblende precipitation are: T = 160°-250°C, P = 20-60 atm., and boiling hydrothermal solutions. (Authors' abstract)

CHEN, Dexing, ZHOU, Leyao and LI, Fanglin, 1986, The study of physico-chemical conditions of mineralization of Ag-Pb ore deposit in Yindongzi, Shaanxi Province: Earth Sci., v. 11, p. 367-374 (in Chinese; English abstract). Authors at Wuhan College of Geol., Wuhan 430074, China.

By use of thermodynamics and fluid inclusions, the physico-chemical conditions of mineralization have been studied in this paper. Based on the physicochemical conditions (temperature, pressure, pH value, Eh value, sulfur fugacity, oxygen fugacity and salinity) obtained, the authors suggest that the mineralization was controlled by two major factors: the addition of reducing sulfur and the increase of pH value. It is suggested that the mineralization took place in a reducing environment. (Authors' abstract)

CHEN, J., 1986, Experimental study on solubility of cassiterite in the presence of charcoal: Geol. Rev., v. 32, no. 3, p. 287-294 (in Chinese; English abstract). Author at Dept. Geol., Nanjing Univ.

Under the condition of the presence of charcoal, the solubility of cassiterite in chloride solution can be increased by a factor of 1000. (From the author's abstract)

CHEN, Miyang and JIANG, Zhiyu, 1986, The isotopic characteristics of the two type lead-zinc ore deposits in northern Guangdong, South China (abst.): Terra Cognita, v. 6, no. 2, p. 230. Authors at Res. Inst. of Geol. for Mineral Resources, CNNC, Guilin, China.

In Dabaoshan, it is proved [that] the ore-forming hydrothermal fluid is a mixture of magmatic water, thermal brine and meteoric water according to the D from mineral inclusions and ^{18}O from gange minerals.

In Fankou, the main components of the ore-forming fluid are meteoric water. (From the authors' abstract)

CHEN, Xianpei and GAO, Jiyuan, 1986, Thermal water sedimentology and Pb-Zn-barite deposits (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 57-58. Authors at Inst. Geochem., Acad. Sinica, Guiyang, Guizhou, China.

The central part of Guangxi Autonomous Region is located in a platform which was consolidated in Caledonian orogeny. Stratiform barite deposits (SB) and vein Pb-Zn-barite deposits (VB) occur in the rift basin in Devonian system which is the cover of the platform, and these two deposit types are of economic importance. Composition of the SB is very [simple]. In the radiospherical barite which is located in the outside of the eye shape structure fluid inclusions are very rare and very tiny, their Th is ~140°C, and the [fluid] is SO_4-Cl-Na-K. The $\delta^{34}S$ values of the barite is about +29‰. SB is associated with stratiform Mn, V, Mo mineralization, however, the VB occurs in clusters containing base metal veins (PV), base metal-barite veins (VB) and single barite veins (VB). The ore veins show zonality in horizontal and vertical directions. The horizontal zoning of the barite vein cluster is PV, VB, MVB from deep fault controlling the rift basin to outside, and the vertical zoning displays its feature in extended depth of the ore veins (PV: 350 m, VB: 200-300 m, MVB: 100 m), mineralization T (VB: 184-220°C, MVB: 103-190°C), mineral composition and country rock alteration, etc. The $\delta^{34}S$ values of VB barite are 19-30‰ (average 26.5), MVB is about 23-26‰ (average 25.1‰), which is similar to the values of stratiform deposits. The [fluid] in the MVB barite is SO_4-Cl-Na-K as well. VB and SB are different in the form of expression of the same mineralization. We think that the traditional classification dividing barite deposits into stratiform and vein deposits is not satisfactory, because in nature [these are similar]; we consider them together and propose a stratiform-vein type deposit which is typical representation of thermal water mineralization. (From the authors' abstract)

CHEN, Yinhan, 1986, On the formation conditions of porphyry Cu-Mo polymetallic deposits in the Xiaosigou district: Geochimica, no. 3, p. 211-224 (in Chinese; English abstract). Author at Inst. Chem. & Mining Geol., Ministry of Chem. Industry, PRC.

The host rock body consists of quartz-diorite-porphyry (marginal facies), granodiorite-porphyry (intermediate facies) and granite-porphyry (central facies). The petrographic facies are asymmetrically spread. The formation T of the rock body ranges from 890° to 800°C, the P from 330-380 atm, and the depth from about 1.5 to 2 km. Mineralization was controlled by the N-E contact zone and adjacent fault structures. Mo-mineralization occurs in the granite-porphyry with strong potash-replacement. Cu-Mo-mineralization is distributed in the inner contact zone of the rock body, and the wallrock is K-silicified granite porphyry. Cu-pyrite-mineralization is recognized in skarn and serpentinite. Pb-Zn ore veins occur in marblized limestones. Rock and mineral analyses, fluid inclusion studies and high T-P experiments indicate that extensive precipitation of Cu and pyrite took place at T = 290°-250°C, and P = 330-380 atm and that of copper at T = 400°-310° and P = 330-380 atm. Precipitation of Pb and Zn was followed by the transformation of hydrothermal solutions from alkaline to intermediate with decreasing T. (Author's abstract)

CHEN, Yinhan and YAN, Yongheng, 1986, A study on the crystal growth conditions of fluorite from Pingquan: Acta Mineralogica Sinica, v. 6, no. 2, p. 167-173 (in Chinese; English abstract). Authors at Inst. Geol. & Mineral Resources, Hebei, PRC.

Fluid inclusion study of fluorite from Pingquan indicates that formation temperatures of the five crystal-growth zones from the bottom upwards range from 132° to 100°C, and pressures from 24 to 16 bar. The salinity of fluids varies from 10.4 to 6.14 (wt%), the density from 1.04 to 0.995 cm^3/g[sic], and the Eh ≈ -0.26 - -0.27 V. The ore-forming medium is weakly acidic.

In our study, we have found colloidal inclusions, which consist of gel (outer crust) and colloform (inter core). The existence of colloidal [colloform?] inclusions suggests that colloform [colloids?] has a role to play in moderate-low temperature hydrothermal mineralization. (Authors' abstract)

CHEN, Zhen, 1986, The genesis of the Tongshanling "interformational skarn type" polymetallic deposit: Mineral Deposits, v. 5, no. 2(16), p. 36-43, 13 (in Chinese; English abstract).

Indexed under fluid inclusions. (E.R.)

CHEN, Zhizhong, PENG, Genyong, QUI, Shaoping, QUI, Zhaoyun and WEI, Ruoou, 1986, The genesis of W deposit at Damingshan, Guangi: Geol. & Prospecting, v. 22, no. 5, p. 13-19 (in Chinese).

Includes data on fluid inclusion, ^{18}O, ^{34}S, and D. (E.R.)

CHEREPANOV, A.N. and SHARAPOV, V.N., 1986, Thermodynamic conditions of retrograde boiling phenomenon of cotectic magmas in intrusive chambers: Dokl. Akad. Nauk SSSR, v. 291, no. 4, p. 953-956 (in Russian). (See Translations.)

CHIVAS, A.R., BARNES, I., EVANS, W.C., LUPTON, J.E. and STONE, J.O., 1986, Liquid carbon dioxide of magmatic origin and its role in volcanic eruptions (abst.): Terra Cognita, v. 6, no. 2, p. 257.

CHIVAS, A.R. and O'NEIL, J.R., 1985, Koloula, Guadalcanal: A porphyry copper with initial very high-temperature alteration drowned in sea water (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 21. First author at Res. Sch. of Earth Sci., G.P.O. Box 4, Canberra, A.C.T., 2601, Australia.

The Koloula Igneous Complex (age 4.5 to 1.5 Ma) on the island of Guadalcanal, Solomon Islands, comprises 26 intrusive phases from olivine pyroxenite to trondhjemite dykes. Porphyry copper mineralization is associated spatially and temporally with several relatively late-stage porphyritic tonalite bodies. There are two main centers of hydrothermal alteration and mineralization. The earlier, A system, consists of an inner potassic zone surrounded by peripheral propylitic alteration. The innermost zone contains alkali feldspar-quartz-magnetite-actinolite ± pyroxene (salite) veinlets. The presence here of hydrothermal pyroxene is unique among the described porphyry systems (other than in associated skarns). Both fluid inclusions and Δ^{18} quartz-magnetite (6.4 per mil), indicate a temperature of ~725°C.

The isotopic composition of unaltered rock-forming primary biotite and hornblende establish the δD-δ^{18}O composition of magmatic water during mineralization at Koloula. Early high-temperature quartz veining was precipitated from magmatic water (T = 650-725°C; δ^{18}O(calc.) = 7.2 per mil, whereas peripheral A-system quartz veins formed with a high component of non-magmatic water (T = 250°C from fluid inclusions; δ^{18}O(calc.) = 0).

Although an early magmatic-water component was present within the later B system, it became dominated by the abundant development of sericite that preserves an isotopic signature consistent with the influx of ocean water (T = 350°C; δ^{18}O(calc.) = 0 to 2.5; δD(calc.) = -8 to -25). Independent evidence for an oceanic formation is also available from field relationships and ^{87}Sr/^{86}Sr. Late-stage carbonate veins (δ^{13}C = -1 to 2.3), typically devoid of mineralization were probably derived from dissolution of Miocene limestone or from dissolved oceanic bicarbonate. A calcite-pyrite-sphalerite veinlet, with δ^{13}C calcite = -2.4, may have a small component of magmatic carbon. (Authors' abstract)

CHIZHIK, O.Le., KHAKIMOV, A.Kh., 1985, Physicochemical conditions of formation of emerald and accessory beryl in micaites (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 214-215 (In Russian; translation by Dorothy B. Vitaliano). Authors at Central G/E, "Tsentrkvartssamotsvety", Moscow, USSR.

Comparative analysis of P inclusions was made on a deposit of micaite type, where 3 generations of accessory beryl and emerald appear.

Analysis of the results of the investigations on beryl show that this mineral (including emerald) is ubiquitous, formed over the whole T range of mineralization (500-240°C). Beryl-I is characterized by the presence of essentially gas, gas-liquid and multiphase inclusions, with Th (G) or Th (L) of 470 to 380°C. Beryl-II contains only GLI, Th of 240-360°C. The inclusions in beryl-II differ from those in beryl-I in the high density of the solutions, much lower Th and absence of a solid phase. In beryl-III both liquid-gas and gas-liquid inclusions are found. as in beryl-I, they contain a solid phase and have Th (L) or Th (G) at high T, from 380 to 500°C. In contrast to beryl-I, the inclusions in beryl-III contain a substantial amount of CO_2 (up to 25%). The inclusions in emerald are similar to those in beryl-II in their parameters, but in contrast to the latter, CO_2 is almost always present, and the upper limit of the Th of the inclusions is much higher (430°C).

The results of chemical analysis of aqueous extracts show that all the beryl varieties analyzed on the basis of inclusions contain cations K, Na, Li, Ca, and Mg, and anions Cl, F, SO_2 and HCO_3. However, the relative concentrations of these components are not the same in the solutions investigated. Inclusions in beryls-I and -II contain relatively high K, Mg, and Cl and minimal Na, F and HCO_3.

Inclusions in beryl-III and emerald show an appreciable increase in concentrations of Na, Li, F and HCO-3 and relatively low K, Mg and Cl.

This material, together with geological and mineralogical data, make it possible to point out the following"

1. The emerald-beryl mineralization in the deposit studied occurred in two stages. Beryl I and II crystallized in the first stage, beryl III and emerald in the second. After these stages of mineralization there occurred powerful tectonic movements, leading to the renewal of the mineral formations of stage I.

2. Emerald crystallized in stage II, which corresponded in character to the stage of acid leaching. The main components of the mineralizing solutions of this stage are Na, Li, F and HCO_3. CO_2 was the main gaseous component of this stage.

3. Beryl-III is paragenetic with emerald; its aureole is always much wider than that of emerald, due to which the finding of beryl-III is of great prospecting importance as an indirect criterion in evaluating the emerald potential of ore bodies (Authors' abstract).

CHOI, S.G., PARK, N.Y. and PARK, S.W., 1986, Gold-silver mineralization of Taechang-Boryeon and Geumwang mines in northeastern Chungcheong provinces: J. Korean Inst. Mining Geol., v. 19, Spec. Iss., p. 193-206 (in Korean; English abstract).

A number of auriferous veins occur in the Precambrian metamorphic terrain from Chungju to Mugeug district. These Au(-Ag) deposits consist mainly of the fissure-filling quartz veins intruding the Precambrian gneiss or schist and Jurassic or Cretaceous granite, and can be divided into two mineralization epochs, (a) Au-rich veins related to Daebo igneous activity, and (b) Au-Ag veins related to Bulgugsa igneous activity.

The auriferous quartz veins of Taechang and Boryeon mines associated with late Jurassic igneous activity are massive in character, and show simple mineral assemblages and low Ag/Au ratio in the ores, representing a single mineralization system. The ore minerals are predominantly quartz containing minor or trace amounts of pyrrhotite, sphalerite, galena, pyrite, chalcopyrite and electrum. Electrum is closely associated with pyrrhotite and has from 61.4 to 78.5 atomic % Au. Fluid inclusion data suggest that ore minerals were deposited between 238 and 390°C from CO_2-rich fluids.

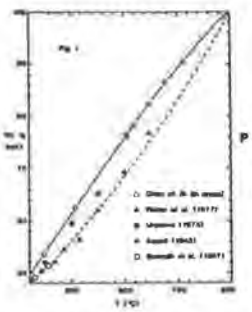
The Au and/or Ag-bearing quartz veins of Geumwang mine related to middle Cretaceous igneous activity are characterized by a multistage history, and diverse mineral assemblages with a high Ag/Au ratio in the ores.

The ores of Geumwang mine have two contrasting mineral assemblages (1) pyrite + galena + sphalerite + arsenopyrite + electrum + argentite, representing the higher Au mineralization, and (2) pyrite + chalcopyrite + galena + sphalerite + arsenopyrite + silver sulfosalts + electrum + native silver + argentite, representing the higher Ag mineralization. Electrum is closely associated with pyrite and has from 11.2 to 49.9 atomic % Au. The depositional environment during the higher Au mineralization can be estimated as the range of both T and fS_2, T = 200 ~ 300°C, $\log f(S_2) = 10^{-10} \sim 10^{-15}$. The higher Ag mineralization may be interpreted to have formed a range of falling T (150 ~ 200°C) and low fS_2 ($10^{-15} \sim 10^{-18}$). These T data are consistent with Th of fluid inclusions in quartz. Thus, the Au veins related to the Daebo igneous activity may be formed at higher T and P than the Au-Ag veins associated with the Bulgugsa igneous activity. (From the authors' abstract)

CHOU, I-Ming, 1986, Redetermination of phase equilibrium properties in the system $NaCl-H_2O$ to 1000°C and 1500 bars (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 77. Author at 959 National Center, U.S. Geol. Survey, Reston, VA 22092, USA.

Phase equilibria in the system $NaCl-H_2O$ were recently determined by Bodnar and others (1) to 1000°C and 1500 bars using synthetic fluid inclusions formed by healing fractures in quartz in the presence of the two coexisting fluids at various P and T. In that study, salinities of the vapor-saturated liquids at P and T were determined by using the measured T of halite dissolution [Tm NaCl] in the halite-bearing inclusions in each sample and by using the halite solubility equation in (2). As figure 1 shows, the extrapolation in (2) to higher T (dashed line) considerably underestimates the solubility of halite, and the recent data (3) (solid line in fig. 1) require a modification of the phase diagram reported in (1).

The new phase diagram (fig. 2) is considerably different from that



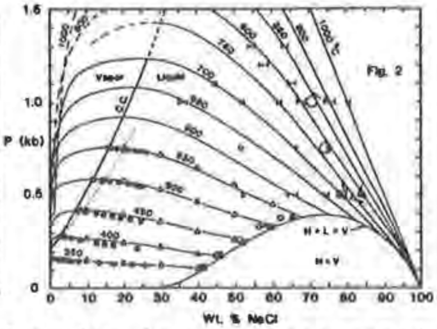


Fig. 1. Solubilities of halite in vapor-saturated liquids determined at T >420°C. The solid and dashed lines are based on the equations given in (3) and (2), respectively.

Fig. 2. Isothermal (P-X) projections of the coexisting phases in the system $NaCl-H_2O$ obtained from redetermination of the synthetic fluid inclusion data (1) (horizontal bars and open circles) and data from the literature. The horizontal bars are at the contoured T; the open circles indicate data at intermediate T, the size of the symbols representing compositional range. The critical curve (C.C.) and its dashed extrapolation is from (6). The dotted curve is the critical curve from (7). The halite solubility curve (H + L + V) is constructed from the P-T data of (6) and the T-X data of (3). Also shown are the liquid composition data from (6) (solid circles and squares) and from (4), (7) and (8) (triangles). The squares and solid triangles are for halite-saturated liquids at 350°, 400°, 450°, 500° and 550°C.

given in (1). In this modification, a correction of 7°C for the systematic error in [Tm NaCl] reported in (1) was applied, and the halite solubility equations in (3) and (2) were used for [Tm NaCl] greater than 430°C and less than 430°C, respectively. The new phase diagram not only minimizes the discrepancy between the data given in (4) and in (1) at 550°C (see fig. 2) but also provides satisfactory explanations for the peculiar DTA signals at higher T and at P below 500 bars, including the sharp reversal in the dP/dT slope of the "halte liquidus" and the "peak-splitting" phenomenon (figs. 7, 8 in (5)). This revision is quite significant for the interpretation of the high-T fluid inclusion data.

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(1) Bodnar, B.J., et al. (1985), Geochim. et Cosmochim. Acta, 49, 1861-1873. (2) Potter, R.W., II, et al. (1977), J. Research U.S. Geol. Survey, 5, no. 3, 389-395. (3) Chou, I.M., et al. (in press), Abstr. in EOS for 1986 Spring AGU. (4) Urusova, M.A. (1975), Russian J. Inorganic Chem., 20, 1717-1721. (5) Gunter, W.D., et al. (1983), Geochim. et Cosmochim. Acta, 47, 863-873. (6) Sourirajan, S., and Kennedy, G.C. (1962), Am. Jour. Sci., 260, 115-141. (7) Urusova, M.A. (1974), Russian J. Inorganic Chem., 19, 450-454. (8) Urusova, M.A., and Ravich, M.I. (1971), Russian J. Inorganic Chem., 16, 1534-1535. (9) Keevil, N.B. (1942), Am. Chem. Soc. Jour., 64, 841-850. (10) Benrath, A., et al. (1937), Zeitschr. Anorg. u. Allg. Chemie, 231, 285-297. (Author's abstract)

CHOU, I-Ming, 1986, Solubilities of sylvite along the three-phase curve in the binary system KCl-H_2O (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 564. Author at U.S. Geol. Survey, Reston, VA 22092.

As a part of the phase relation studies in the system NaCl-KCl-H_2O at high P and T, solubilities of sylvite along the three-phase curve in the system KCl-H_2O were determined by using a method that had been successfully applied to determine the solubilities of halite along the three-phase curve in the system NaCl-H_2O (Chou et al., 1986, EOS, 67, p. 408). In P-T space, sylvite liquidus isopleths determined by differential thermal analysis (DTA) are linear above 500 bars (Chou, 1982, GSA, Abstr. with Progr., 14, p. 463); at lower pressures, the deviation of the onset temperatures of the first DTA peaks in isobaric cooling scans from the extrapolation of the linear isopleths results from inhomogeneity of the samples, as Chou et al. (ibid.) described for the similar case in the system NaCl-H_2O. The intersections of these extrapolated linear isopleths with the three-phase curve define the solubilities of sylvite along that curve. Values are given in the table, in which pressures are estimated from the data of Benedict (1939, J. Geol., 47, p. 252) and Keevil (1942, J. Am. Chem. Soc., 64, p. 841).

These sylvite solubilities can be represented by the equation: Wt. % KCl (± 0.19) = $12.194 + 0.15557\,T - 5.407 \times 10^{-5}\,T^2$, where $438 < T < 770$°C. They are about 3 to 4 wt.% higher in KCl than those reported by Keevil (ibid.) and Benrath et al. (1937, Zeit. anorg. allgem. Chemn., 231, p. 285). These discrepancies, as the similar case in the system NaCl-H_2O, demonstrates (Chou, in press, the 14th IMA Abstr. with Progr., 1986), may yield considerable differences in implied P-T-X conditions when sylvite solubility data are used to interpret synthetic fluid inclusion data in the system KCl-H_2O. (Author's abstract)

Wt. % KCl	P(bars)	T(°C)
70.10	161	438
78.65	218-219	523
84.09	224-227	577
89.37	207	635
94.72	130	700
100.00	1	770

CHOU, I-Ming, GUNTER, W.E. and PITZER, K.S., 1986, Halite liquidus and the compositions of halite- and gas-saturated liquids in the system NaCl-H_2O above 450°C (abst.): EOS, v. 67, p. 408. First author at MS 959, USGS, Reston, VA 22092.

Isobaric cooling scans in differential thermal analysis of the halite liquidus show that the isopleths of the halite liquidus projected on the P-T surface are linear above - 0.5 kb with steep positive slopes; at lower P the slopes of these isopleths become negative, and the isopleths intersect the halite-liquid-vapor three-phase curve at shallow angles (Gunter et al., Geochim. Cosmochim. Acta, 47, p. 863, 1983). We believe that the reversal of these isopleth slopes is caused by the inhomogeneity of the samples during the cooling scans at lower P; samples originally in the liquid-vapor two-phase region failed to homogenize as they passed through the narrow liquid region on cooling before precipitating halite. Any inhomogeneity in the sample causes part of the sample to become more concentrated than the bulk composition and halite will therefore precipitate at high T than the true liquidus T.

On the other hand, samples at P $\geq$0.5 kb were in the liquid region and were homogeneous during entire cooling scans before precipitating halite; their halite liquidus T should be within 3°C of the true values, taking the supercooling effect into account. In P-T space, linear extrapolation of the halite-liquidus isopleths at these P to the three-phase curve provides information on the compositions of the liquids saturated with both halite and vapor. These liquid compositions can be represented by: wt. % NaCl (±0.2) = $19.39 - 0.0364\ t + 3.553 \times 10^{-4}\ t^2 - 2.298 \times 10^{-7}\ t^3$, where $447 \leq t \leq 800$°C. These liquids are ~7 wt. % higher in NaCl than those reported by Keevil (Amer. Chem. Soc. J., 64, p. 841, 1942) at T near 600°C and are near his values when extrapolated to ~400°C. (Authors' abstract)

CHOU, I.-M. and PHAN, L.D., 1986, Solubility relations in the system potassium chloride-ferrous chloride-water between 25 and 75°C at 1 atm: J. Chem. Eng. Data, v. 31, p. 154-156.

CHRISTIANSEN, E.H. and LEE, D.E., 1986, Fluorine and chlorine in granitoids from the Basin and Range province, western United States: Econ. Geol., v. 81, p. 1484-1494. First author at Dept. Geol., Brigham Young Univ., Provo, UT 84602.

Analysis of fluorine and chlorine in 228 samples of granitoids from the Basin and Range province of the western United States suggests that at least three types of granitoids can be distinguished: (1) fluorine-poor granitoids of the northwestern Great Basin (mean F = 0.041 wt.%, maximum = 0.11 wt.%) intrude a variety of allochthonous oceanic or island-arc terranes that were probably accreted to North America during the Paleozoic and Mesozoic eras; (2) fluorine-rich Precambrian granites generated during "anorogenic" magmatism of Proterozoic age in the southwestern United States (mean F = 0.118 wt %, maximum = 0.35 wt %); and (3) a large group of granitoids with moderate fluorine contents (mean F = 0.053 wt %, maximum = 0.13 wt %). This last group consists of granitoids of the eastern Great Basin and the southern Basin and Range province that occur throughout the autochthonous continental terrane of the western United States. These differences in fluorine concentration do not appear to be the result of regional differences in the degree of magma evolution. Instead, this variability is attributed to magma contamination by, or generation from, a comparatively fluorine-rich reservoir in the continental crust underlying the southern and eastern portions of the Basin and Range province and to the absence of this reservoir in the northeastern Great Basin. This interpretation is consistent with the geologically established boundaries of the "exotic" terranes and with the Sr and Nd isotope compositions of rocks from these regions. Chlorine contents (mean Cl = 0.013 wt %, range = 0.005-0.050 wt %) show no regional differences and are uniformly low in these granitoid rocks. (Authors' abstract)

CHRISTIE, A.B. and BRATHWAITE, R.L., 1986a A comparison of epithermal mineralization in the Hauraki goldfield and the geothermal systems of the Taupo volcanic zone, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 25-30. Authors at N.Z. Geol. Survey, Lower Hutt, New Zealand.

The fossil epithermal systems in the Hauraki Goldfield are similar to those presently active in the Taupo Volcanic Zone in terms of broad geological setting, temperature and chemical composition of the fluid, and wall rock alteration mineralogy. However, the economically important Au-Ag mineralization of the Hauraki Goldfield occurs as large steeply dipping quartz veins in andesite, whereas subsurface mineralization in the modern geothermal systems occurs in thin veinlets and cavities, mainly in rhyolitic rocks, but to a lesser extent also in greywacke and andesite. Subtle, but perhaps significant differences are noted in the chemistry of the mineralizing fluids; the Hauraki fluids may have been slightly more concentrated and therefore carried greater quantities of metals in solution. Also the generally lower concentration of iron in their sphalerites and absence of pyrrhotite, compared to its more common occurrence in the geothermal systems, suggest that they had higher sulphur and oxygen fugacities than the present geothermal fluids. The fossil geothermal system at Ohakuri contains precious metal mineralization and is similar to some rhyolite hosted deposits in the Hauraki Goldfield. (Authors' abstract)

Most fluid inclusion data from published references. (E.R.)

CHRISTIE, A.B. and BRATHWAITE, R.L., 1986b, Epithermal gold-silver and porphyry copper deposits of the Hauraki goldfield - A review: Monograph Ser. on Mineral Deposits, v. 26, p. 129-145: Berlin-Stuttgart, Gebrüder Borntraeger.

This is the full paper corresponding to previous abstract. (E.R.)

CHU, Xuelei, CHEN, Jinshi and WANG, Shouxin, 1986, Fractionation mechanism of sulfur isotope and physicochemical conditions of alteration and ore formation in Louhe iron deposit, Anhui (China): Dizhi Kexue, 1986, no. 3, p. 276-289 (in Chinese).

Indexed under fluid inclusions. (E.R.)

CLARK, A.H., PEARCE, T.H., ROEDER, P.L. and WOLFSON, I., 1986, Oscillatory zoning and other microstructures in magmatic olivine and augite: Nomarski interference contrast observations on etched polished surfaces: Am. Mineral., v. 71, p. 734-741. Authors at Dept. Geol. Sci., Queen's Univ., Kingston, Ontario K7L 3N6, Canada.

Nomarski imaging of HCl-etched surfaces of olivines in basalts from three widely separated localities unexpectedly reveals delicate oscillatory zoning. (From the authors' abstract)

Of pertinence to study of the origin of melt inclusions in these minerals. (E.R.)

CLARK, J.R. and WILLIAMS-JONES, A.E., 1986a Geology and genesis of epithermal gold-barite mineralization, Verrenass deposit, Toodoggone district, B.C. (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 57. Authors at Dept. Geol. Sci., McGill Univ., Montreal, Quebec H3A 2A7, Canada.

Verrenass mineralization is an example of a unique class of barite-gold deposits. Fluid inclusions in barite homogenize between 180-200°C, and have salinities of 3.0 wt.% NaCl equiv. Evidence of boiling has not been observed. (From the authors' abstract)

CLARK, J.R. and WILLIAMS-JONES, A.E., 1986b Geochemistry of recent precipitates in wells of the Cerro Prieto geothermal field, Mexico, and implications for epithermal precious and base metal mineralization (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 57.

CLARK, T.C., VAN WYK, E., 1985, Inspection and classification of fluid inclusions within kimberlites and mantle-derived xenoliths: Petros, [Natal Univ., Durban, S.A.], v. 12, p. 9-12.

Olivine macrocrysts found within kimberlites and their mantle-derived xenoliths, contain inclusions that appear to be rich in carbon dioxide. Using the Chaixmeca heating-freezing stage and the Raman spectrometer to analyze these inclusions, it is possible to obtain a temperature of homogenization, from which the fluid density, fluid composition and temperature of decrepitation[sic] can be determined. The temperature of decrepitation aids in the estimation of the maximum temperature of crystal formation. This data provides a better understanding of the physico-chemical conditions operating in the upper mantle. (Authors' abstract)

CLARKE, Michael, 1986, Hydrothermal geochemistry of silver-gold vein formation in the Tayoltita mine and San Dimas mining district, Durango and Sinaloa, Mexico: PhD dissertation, Univ. Arizona.

The San Dimas mining district, including the Tayoltita mine, is a Tertiary Ag-Au epithermal vein system deposited in a calc-alkaline volcanic pile. Hydrothermal alteration and vein formation is temporally related to a granite batholith intruded into the volcanics. Alteration mineralogy in andesites is compatible with a hydrothermal flow model in which heated water rises through the batholith, cools to 260°C, and flows out into the volcanics. In the process, aNa^+/aH^+, aK^+/aH^+, aCa^{++}/a^2H^+, $aSO_4^=.a^2H^+$, and aH_2S increase; aAl^{+++}/a^3H^+ decreases; and aFe^{++}/a^2H^+ remains constant, all relative to original fluid conditions in the andesites. Lateral elongation of Ag:Au ratio zoning plotted on vertical projections of veins is interpreted to reflect hydrothermal fluid flow principally in a horizontal direction during ore deposition.

Quartz vein-filling accompanied by chlorite, calcite, rhodonite, and adularia, is widest in a vertical interval ~500 to 1,000 meters below the original surface. Pyrite is widely distributed, but Ag minerals, electrum, and base-metal sulfides are restricted to the upper portion of the vertical interval of veining in a zone termed the ore horizon. Paragenetic relationships among vein minerals of the Cinco Senores vein in the Tayoltita mine indicate that aH_2S decreased; aCu^+/aH^+, aAg^+/aH^+, and aAu^+/aH^+ increased; and aFe^{++}/a^2H^+ and $aSO_4^=.a^2H^+$ remained nearly constant during the initial stage of ore deposition.

Fluid inclusion studies of quartz from the Cinco Senores vein indicate that ore deposited at an average T of 260°C from boiling fluids of apparent salinities ranging from 0.15 to 0-.3 m NaCl eq. The greater apparent salinities probably reflect dissolved gases as well as chloride salts. Correlation of Ag:Au ratios in deposited vein with Tm ice in fluid inclusions suggests that evolution of ore fluids in space was accompanied by both increase in deposited Ag:Au ratios and decline in fluid solute concentration. Correlation of Tm ice with paragenetic age of associated quartz suggests that vein-depositing hydrothermal fluids evolved in both space and time from relatively concentrated to dilute conditions. Both boiling and mixing could have caused this decline in solute concentration. (Author's abstract)

CLAYTON, J.L. and BOSTICK, N.H., 1986, Temperature effects on kerogen and on molecular and isotopic composition of organic matter in Pierre Shale near an igneous dike: Org. Geochem., v. 10, p. 135-143.

CLEMENS, J.D., HOLLOWAY, J.R. and WHITE, A.J.R., 1986, Origin of an A-type granite: Experimental constraints: Am. Mineral., v. 71, p. 317-324.

CLIFTON, C.G., 1986, Primary gas dispersion halos in disseminated gold deposits: Examples from Nevada and California (abst.): J. Geochem. Explor., v. 25, p. 259. Author at Exploration Res. Labs., 131 NW 4th Street, Box 200, Corvallis, OR 97330, USA.

All hydrothermal systems contain significant amounts of volatiles, either as dissolved aqueous species, as free gaseous species, or both. As hydrothermal solutions traverse or permeate a rock mass, gases are "deposited" in the rock in several ways, including: adsorption onto alteration phyllosilicates (clays and micas), entrapment in vugs, and encapsulation in fluid inclusions. The gases are easily liberated from wallrock material by heating and are identified by gas chromatography/mass spectrometry. Primary gas dispersion halos occur as anomalous concentrations of individual gases (H_2S, SO_2, CO_2, etc.) or as groups of gases (total hydrocarbons, total sulfur gases, etc.). (From the author's abstract)

CLINE, J.S., 1986a, A fluid inclusion and alteration study of the 16 to 1 epithermal Ag-Au deposit, Esmeralda County, Nevada (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 566. Author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

Study of fluid inclusions and wall rock alteration in the volcanic-hosted 16-1 vein deposit indicates precious metals deposited in response to temperature decrease resulting from fluid mixing and boiling. Fluid inclusion properties indicate temperatures and salinities ranged from 145° to 225°C and from 3.5 to 11.5 wt% NaCl equiv., respectively. Inclusions associated with sulfide mineralization vary from 180° to 200°C and 8.4 to 10.6 wt% NaCl equiv. Temperatures and salinities decrease consistently with elevation and decline an average of 40°C and 1.4 wt% NaCl equiv. over an elevation increase of 130 meters. Th versus Tf diagrams reveal clustered temperatures and salinities associated with base metals in deeper levels, and variable homogenization and freezing temperatures in upper levels. This variability reflects increased fluid mixing and boiling (Hedenquist and Henley 1985), and is coincident with increased precious metal abundances in the upper levels. Inclusion crushing experiments reveal variable CO_2 contents and indicate locations of boiled and unboiled fluids.

Observed enthalpy-chloride relationships (after Fournier 1979) are consistent with mixing of deep hydrothermal fluids and near-surface, low salinity, 67°C fluids. Mixing is the principal mechanism indicated for temperature reduction throughout the system with increased influence of boiling in upper levels.

Fracturing and open space filling are the most important wall rock changes produced by the hydrothermal event; metasomatism is minor. Alteration zoning is typical of that observed in active geothermal systems. Chlorite, epidote, and pyrite are spatially related to deep andesites; adularia and calcite formed at all levels in response to boiling and related pH increases; nontronite formed in high level, low temperature environments. No acid alteration assemblage is present. (Author's abstract)

CLINE, J.S., 1986b, The Sixteen-to-One epithermal silver-gold deposit, Esmeralda County, Nevada: A wall rock alteration and fluid inclusion study: MS thesis, Univ. Arizona.

Fluid inclusion and wall rock alteration data from the Sixteen-to-One deposit indicate precious metals precipitated in response to T decrease resulting from fluid mixing and boiling. Fluid T and salinities varied from 145° to 225°C and from 3.5 to 11.5 wt% NaCl eq., respectively; fluids decrease an average of 40°C and 1.4 wt% NaCl eq. over an elevation increase of 130 meters. Th and salinities become more variable in upper levels coincident with increased precious metal abundances. Fluids contained variable amounts of CO_2.

Fracturing and open space filling are the most important wall rock changes produced by the hydrothermal event; metasomatism is minor. Vein-controlled alteration minerals include primarily quartz with lesser calcite, chlorite, pyrite, adularia, epidote, and montmorillonite, and trace white micas; zoning is typical of that present in active geothermal systems. Observed enthalpy-chloride relationships are consistent with mixing of deep, 225°C fluids and shallow, 93°C fluids. (Author's abstract)

CLOCCHIATTI, Roberto and METRICH, Nicole, 1986, Refilling and mineralogical disequilibrium in etnean lavas: The "Monte Frumento delle Concazze" eruption: C.R. Acad. Sci. Paris, v. 303, Ser. II, no. 12, p. 1117-1122 (in French; English abstract).

Scoriae from Monte Frumento delle Concazze are the result of a nonhomogeneous mixing between hawaiitic and basaltic lavas. Minerals which characterize the hawaiitic products, as salitic pyroxene (Wo45 Fs13-15), olivine (Fo75), labradorite and titanomagnetite, are resorbed and melt inclusions decrepitated. These features point out an increasing of the temperature with the ascent of a new basaltic magma. Later, minerals crystallize again with more magnesian compositions (diopsidic pyroxene, Fo80-84) which indicate a thermal stabilization in the system. (Authors' abstract)

CLOCCHIATTI, Roberto and NATIVEL, Pierre, 1986, Hydrothermal origin and P-T conditions of formation of quartz phenocrysts in Plaine des Sables, Piton de la Fournaise Volcano (Reunion Island, Indian Ocean): C.R. Acad. Sci. Paris, v. 302, Ser. II, no. 20, p. 1231-1236 (in French; English abstract).

Quartz phenocrysts in Plaine des Sables contain numerous fluid inclusions with aqueous fillings that testify a hydrothermal process which has affected recent lavas of Piton de la Fournaise at the place named Plateau des Basaltes. The advanced stage in hydrothermal process of the host rock, the relatively high temperatures inferred from a study of the inclusions, the low water pressures and the slight salinity of the fluid are indications that tend to prove that this place can be regarded as a potential geothermic target. (Authors' abstract)

CLUZEL, D. and GUILLOUX, L., 1986, Hydrothermal character of the Shaba Cu-Co-U mineralization (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 58. Fist author at Lab. Géol. Dynamique, Univ. d'Orléans, 45046 Orleans Cedex, France.

In spite of the retrograde alteration indicated by the presence of argillaceous minerals (e.g., kaolinite after kyanite: chlorite after phlogopite), most mineralogical associations derive from regional hydrothermal alteration, with T ranging from 300 to 350°C, and P(T) ranging between 1 and 2 kbar. These minimum conditions were estimated by the study of the extent of Na-K and Si-Al substitutions, the measurement of the crystallinity index of the aluminous potassic micas, and the study of fluid inclusions.

The occurrence of and geological relationships between the stratiform Cu-Co-U mineralization and Al-Mg-K host sediments suggest that the genesis of the sulfides is closely related to processes responsible for the formation of host-rock minerals at shallow depths in playa environments. A hydrothermal process involving intra- and extrasedimentary Cu-Co-Cl-enriched water is an obvious explanation for the data. On the basis of the geothermal system, the sediment-hosted stratiform Cu-Co-U deposits of Shaba appear to correspond to incipient stratabound sulfide deposits overprinted by hydrothermal and diagenetic processes. Regional metamorphism has modified the initial features of the host sediments, forming new mineralogical assemblages. (From the authors' abstract)

COCIRTA, Constantin, 1986, Mafic microgranular enclaves of Bono massif (Northern Sardinia). Petrogenetic significance of complex plagioclases and their inclusions: C.R. Acad. Sc. Paris, v. 302, Ser. II, no. 7, p. 441-446 (in French; English abstract).

Mineralogical and chemical studies have been carried out on the complex plagioclases and their inclusions in Bono enclaves [nodules?]. A genetic model is proposed for the "sieve like" texture plagioclase crystallized during the junction and the beginning of mixing of two magmas (acid and basic). (Author's abstract)

COCKER, M.D. and PRIDE, D.E., 1986, Evolution of Au-Ag-Pb-Zn-Cu-Mo mineralization in the Breckenridge mining district, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 567. First author at 2009 Lambert Ct., Plano, TX 75075.

Au-Ag-Pb-Zn-Cu-Mo mineralization in the near-surface environment of the Breckenridge district is related to small (300-700 m diam.) intrusive complexes that were generated by a large (40 km^2), concealed, post-Eocene stock. The stock is defined by an EW positive aeromagnetic anomaly, and it was emplaced into NNW-striking late Paleozoic to late Mesozoic sedimentary rocks and Eocene monzonite and quartz latite sills. Exposed intrusive complexes contain a variety of hydrothermal breccias, plus rhyodacite to rhyolite intrusions. Vertical flow-banding fiamme textures, and "upward-fanning" suggest that some of the complexes vented to the surface.

Doming during intrusion of the stock produced radial and concentric fractures in the overlying rocks. These fractures controlled the orientations of major veins and dikes, the location of large-scale stockwork vein sets, and the loci of intrusion of the small intrusive complexes, as well as present drainage patterns.

Several hydrothermal circulation systems were produced by heating of the country rocks during intrusion of the stock and associated complexes. Initial heating was recorded as biotite hornfels and calc-silicate skarn. Early mineralization within hydrothermal breccias, stockwork vein sets, and skarns was dominated by high temperature (210-480°C), highly saline (35-65% total salt), boiling magmatic-rich fluids that deposited native gold, chalcopyrite, molybdenite, pyrrhotite, magnetite, galenobismutite, Ag-bearing galena, and Fe-rich sphalerite, plus quartz. Quartz-sericite and chlorite-epidote-carbonate alteration overprinted the early thermal event. As the hydrothermal systems cooled (370-180°C), less saline (3-13% total salt) fluids with an increasingly meteoric signature deposited veins of Ag-rich galena, Fe-rich sphalerite, and Au-bearing pyrite, plus carbonates. (Authors' abstract)

COLE, D.R. and DRUMMOND, S.E., 1986, The effect of transport and boiling on Ag/Au ratios in hydrothermal solutions: A preliminary assessment and possible implications for the formation of epithermal precious-metal ore deposits: J. Geochem. Explor., v. 25, p. 45-80. Authors at Geosci. Group, Chem. Div., Oak Ridge Nat'l. Lab., Oak Ridge, TN 37831, USA.

A thermodynamic model has been used to quantify the effects of transport and deposition on the gold and silver contents, Ag/Au ratios and $\Sigma CO_2/\Sigma H_2S$ ratios in boiling hydrothermal solutoins. Boiling is singled out because the majority of the precious-metal vein deposits studied exhibit some evidence of two-phase behavior.

The transport calculations indicate that the low Ag/Au ratios (<1) in solution result from conditions dominated by low T ($\leq$250°C), low Cl^- (0.1 m), moderate to high pH ($\geq$5) and ΣH_2S ($\geq 10^{-3}$ m), and high $\Sigma H_2S/\Sigma SO_4$ ratios ($>10^5$). At these conditions, argentite is the most stable silver phase and gold is transported dominantly as $Au(HS)_2^-$. The $AuCl_2^-$ complex dominates at high T ($\geq$250°C), high Cl^- (1.0 m), low ΣH_2S ($<10^{-3}$ m), low to moderate pH ($\leq$5), and low $\Sigma H_2S/\Sigma SO_4$ ratios ($<10^5$). These conditions favor high Ag/Au ratios in solution (>1) and generally native silver as the most stable silver phase. The overall frequency distibution of the Ag/Au ratios in solution exhibits many similarities with patterns given for natural epithermal vein deposits. Collectively, these distributions display a pronounced mode between Ag/Au values of 10 and 100.

The depth at which boiling commences becomes shallower with either decreasing T and/or CO_2 concentration for a constant salinity. Solutions with the highest initial gas concentrations will tend to deposit gold and silver over the greatest vertical distances, and produce deposits with lower ore grades. The model also predicts the presence of more intense zones of gold and silver enrichment near the top of the boiling interval which may be analogous to the very high-grade bonanza ore observed in many precious metal vein deposits. However, the low magnitude of these enrichments during a single boiling event suggest that many volumes of a boiling fluid passing through a given volume of rock are required in order for ore grades in the mineralized boiling zone to reach levels typical of most epithermal deposits.

During the boiling process, the Ag/Au ratios remain relatively constant except near the top of the boiling interval where abrupt changes are observed. Significant increases in Ag/Au ratios are associated with systems that have moderate to high T, high Cl^-, low ΣH_2S, low to moderate pH, and hihg $\Sigma CO_2/\Sigma H_2S$ ratios. Conversely, a drop in the Ag/Au ratios near the top of the boiling zone accompanies systems with low T, low Cl^-, moderate to high pH, high ΣH_2S and low $\Sigma CO_2/\Sigma H_2S$ ratios. The frequency distribution of the boiling Ag/Au ratios is very similar to both the transport histogram and the histograms for natural vein deposits. The Ag/Au mode of 10 to 100 is preserved, and the overall range of values is basically the same (10^{-3} to 10^3). (Authors' abstract)

CONGDON, Roger and NASH, W.P., 1986, Differentiation of high-fluorine rhyolite, Honeycomb Hills, Utah (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 80.

CONNAUGHTON, L.M., HERSHEY, J.P. and MILLERO, F.J., 1986, PVT properties of concentrated aqueous electrolytes: V. Densities and apparent molal volumes of the four major sea salts from dilute solution to saturation and from 0 to 100°C: J. Solution Chem., v. 15, no. 12, p. 989-1002.

The densities of the major sea salts (NaCl, Na_2SO_4, $MgCl_2$, and $MgSO_4$) have been measured from 25 to 95°C and to saturation. (From the authors' abstract)

CONRAD, M.E., PETERSEN, U., JACOBSON, R.A. and O'NEIL, J.R., 1986, Variations in fluid flow patterns in the fossil geothermal system at Tayoltita, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 570. First author at Dept. Geo. Sci., Harvard Univ., Cambridge, MA 02138.

Fluid inclusion homogenization temperatures and oxygen isotope analyses of hydrothermal quartz and whole-rock samples from in and around the Culebra vein suggest that two distinct types of fluid flow took place in the Tayoltita mining district of Mexico:

1. Pervasive hydrothermal circulation - Fluids at temperatures up to 320°C permeated the host rock and deposited small, discontinuous veinlets of quartz (<5 cm wide). Calculated $\delta^{18}O$ values of these fluids vary from an average of -7.6 permil at deep levels to an average of -3.2 permil at high levels. $\delta^{18}O$ values of rocks collected near the veinlets were lowered from an initial value of 6.5 permil to values of between 2 and 4 permil. None of the altered rocks are in isotopic equilibrium with even the most ^{18}O-rich fluids, indicating that the degree of ^{18}O shift is controlled by the rate of exchange rather than the fluid/rock ratio.

2. Fracture-controlled hydrothermal circulation - The large veins, including the ore minerals, were deposited from fluids at fairly uniform temperatures of between 245° to 270°C. The calculated $\delta^{18}O$ values of these fluids are relatively constant at -3.5 to -5.5 permil, with no significant variations related to their position in the system, such as must have existed in the veins.

In addition to these two generations of fluids, evidence was found for a very high $\delta^{18}O$ fluid (+4 to +10 permil). These samples were found throughout the system, but were concentrated at the higher levels. Inclusions in the quartz, where visible, are dominated by vapor-phase inclusions. Several of the other samples appeared to be chalcedonic in nature. The fluids that precipitated this quartz are postulated to be either the result of extreme fractionation due to boiling, lower temperature, or a combination of both. (Authors' abstract)

CONTI, G., GIANNI, P. and TINÉ, M.R., 1986, Heat capacities of aqueous mixed electrolyte solutions at high temperatures. Application of the Pitzer equations to the mixed system K-Na-Cl-SO_4: J. Solution Chem., v. 15, no. 4, p. 349-362. Authors at Dept. Chem. & Industrial Chem., Univ. Pisa, Pisa, Italy.

Specific heats at constant pressure for the mixed system K/Na/Cl/SO_4 in H_2O have been obtained from heat content measurements by means of a drop calorimeter between 60 and 220°C over the salt concentration range 0.5-5 m, with ionic strengths up to 7.5. Measurements have also been made on aqueous K_2SO_4 solutions in the same temperature range between 0.3 and 1.6 m. The heat capacities of the quaternary system were represented using the semiempirical Pitzer equations neglecting the mixed interaction terms as a first approximation. A comparison of experimental with calculated data shows that the ability of this method to describe the system is satisfactory even at rather high concentrations, but only for solutions of low sulphate ion content. (Authors' abstract)

COOK, Lance, 1986, Fluid inclusions and genesis of the Harding pegmatite; Colorado Pegmatites, Colorado Pegmatite Symp., May 30-June 2, 1986, Colorado Chapter, Friends of Mineralogy, p. 52-53. Author at Champlin Petroleum, 5800 S. Quebec, Englewood, CO 80111.

P fluid inclusions contain an average of 15 wt.% CO_2 and 15 wt.% NaCl as determined by freezing point depression measurements. Th for inclusions from the wall zone, massive quartz zone, and quartz-lath spodumene zone fall in the range of 300 to 375°C. S fluid inclusions contain little or no CO_2 and average 30 wt.% NaCl. Th for S inclusions are near 90°C.

Single phase CO_2 fluid densities and stable isotope thermometry indicate initial crystallization of the wall zone at 525 ± 50°C and P of 2.25 ± 0.25 kb (6.0-7.5 km). All primary zones crystallized from a silicate melt in contact with an aqueous, volatile-rich fluid. Late-stage P releases formed sugary albite units by P quenching and prevented formation of pocket pegmatites. Crystallization from residual melt and a coexisting aqueous fluid phase formed cleavelandite replacement bodies. Late-stage hydrothermal lithium replacement features were caused by lithium-rich saline brines near 300°C. Final crystallization occurred in small pockets within the spotted rock replacement zone at 248° ± 25°C. (From the author's abstract)

COOKRO, T.M. and SILBERMAN, M.L., 1986, Low-pressure and low-temperature at the Yellow Pine mining district, Valley County, Idaho (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 570-571. Authors at U.S. Geol. Survey, Denver Federal Center, Denver, CO 80225.

The Yellow Pine mining district is puzzling mineralogically, because scheelite, a mineral that forms at higher temperatures and moderate pressures occurs with stibnite, arsenopyrite, cryptocrystalline quartz, and adularia veins, all characteristic of shallow epithermal deposits. Scheelite is interlayered with low-temperature quartz in colloform bands and occurs in vugs, at times intergrown with euhedral quartz. It is lightly encrusted on rock surfaces of a joint set that hosts an active hot spring containing anomalous tungsten, and as euhedral, clay-sized crystals on the surface of manganese oxides. Jasperoid consistently carries very high tungsten values of 200-1000 ppm.

A survey of prospects and mines in the district provides evidence of both deep metamorphic or batholithic, and near-surface environments. The deep quartz is characterized by ubiquitous wispy planes of secondary inclusions representing healed microfractures, one-phase aqueous inclusions, local concentrations of inclusions with variable liquid-to-vapor volumetric ratios at grain boundaries, and the presence of gases other than H_2O (CO_2?, CH_4?, and N_2?) in many inclusions. Veins of shallow quartz are characterized by cockscomb, cryptocrystalline, or chalcedonic textures. The cryptocrystalline and chalcedonic quartz have inclusions that are too small to study, a common feature of quartz formed at temperatures <200°C. Scheelite and stibnite occur as solid inclusions in this quartz. A clear quartz, which also has solid inclusions of scheelite, is developed around the deep quartz, and both of these types of quartz are cut by the shallow quartz. Mineralogical and textural evidence from the Yellow Pine district study suggests that scheelite forms over a much broader range of pressures and temperatures than previously reported. The wide variety of low-temperature, textures, and occurrences of the scheelite suggest that it may be easily formed in some shallow environments. (Authors' abstact)

COOMBS, D.S., CAS, R.A., KAWACHI, Yosuke, LANDIS, C.A., McDONOUGH, W.F. and REAY, A., 1986, Cenozoic volcanism in North, East, and Central Otago, in I.E.M. Smith, ed., Late Cenozoic volcanism in New Zealand: Roy. Soc. N.Z. Bull. 23, p. 278-312. First author at Geol. Dept., Univ. Otago, Dunedin, New Zealand.

Submarine basaltic activity occurred offshore of North Otago in Paleocene time. The Waiareka-Deborah volcanics result from late Eocene to early Oligocene volcanism extending from 40 ± 2 to about 32 m.y. before present. Fragmental deposits of largely Surtseyan shallow submarine eruptions show a variety of sedimentary forms some suggestive of surge deposits. Products of the volcanism include shallow intrusives and pillow lava of olivine tholeiite which differentiated to high-silica residua, tholeiitic tephra, basanitic and nephelinitic tephra, and probably a range of mildly to more strongly alkalic shallow intrusives. Fluid inclusions of CO_2 in both tholeiitic and alkalic associations suggest the importance of CO_2 in the eruptive history. (From the authors' abstract)

COREY, A.T., 1986, Mechanics of immiscible fluids in porous media: Chelsea, Michigan, Water Resources Pubs., 255 pp.
Of pertinence to the flow and trapping of two-phase fluids. (E.R.)

COUTURE, R.Z. and SEITZ, M.G., 1986, Movement of fossil pore fluids in granite basement, Illinois: Geology, v. 14, p. 831-834. Authors at Chem. Tech. Div., Argonne Nat'l. Lab., 9700 South Cass Ave., Argonne, IL 60439.

The compositions of pore fluids in granite cores from the Precambrian basement in northern Illinois were determined. The estimated chloride concentration in the aqueous phase increases from near zero at the upper contact with sandstone to 2.7 M at 624 m below the contact. Traces of aliphatic oil are present in the overlying sandstone and the upper 516 m of granite, and oil occupies most of the pore space in one sample of unaltered granite 176 m below the contact. The oil has a $\delta^{13}C$ of -25‰, about the same as average petroleum.

The high concentrations of salt more than 500 m below the contact imply that little or no fresh water has reached these levels of the granite by flow. Lower concentrations near the contact are consistent with replacement of brine in the sandstone by fresh water at least 11 m.y. ago and subsequent upward diffusion of salt from the granite. Geologic data suggest that the time of replacement was about 130 Ma. (Authors' abstract)

COUTY, R. and FABRE, D., 1986, A Raman spectrographic study of methane to 3 Kb (abst.): Bull. Minéral., Supplement 1986, v. 109, p. 61-62 (in French). Authors at Lab. de Géol., Ecole Normale Supérieure, 46 rue d'Ulm, 75230 Paris Cedex, France.

The authors studied the effects of pressure from 2 to 3000 bars on the position and mid-height intensity of the vibrational ν_1 ray of methane which is situated at 2916.7 cm^{-1} at 1 bar. Figure 1 shows the ν_1 spectra at 2 bars and at 3000 bars. Figure 2 shows the variation in position ($\nu_1(P)$ curve) and intensity ($\delta(P)$ curve) as a function of pressure from a few bars to 3000 bars. Based on these data, one can estimate the CH_4 pressure in an inclusion by obtaining the Raman spectra of the methane and comparing the ν_1 and δ values with the experimental data. The authors note that these data were obtained for pure methane, and verification that the curves are valid in the presence of other gases remains. (Modified from the authors' abstract by M.J. Logsdon)

COYLE, A.J., ECKERT, J. and KALIA, H., 1986, Brine migration test report: Asse salt mine, Federal Republic of Germany: BMI/ONWI Tech. Report, Jan. 1987, Contract No. DE-AC02-83CH10140, U.S. Dept. Energy., 163 pp.

CRAIG, H. and POREDA, R.J., 1986, Cosmogenic ^3He and model erosion rates in terrestrial rocks (abst.): EOS, v. 67, no. 16, p. 414. Authors at Scripps Inst. Oceanography, UCSD, La Jolla, CA 92093.

We have extended our work on cosmic-ray produced ^3He in the summit lavas of Maui (Craig and Poreda, PNAS 1986) to some 50 analyses of olivine and cpx phenocrysts in nine lava flows from four Kula-age formations on Haleakala Volcano, and ten other Maui lavas from Tertiary to recent ages. The mantle He component, extracted by vacuum crushing of phenocrysts which liberates gases in fluid inclusions, has a very uniform ratio with $R/R_a = 8 \pm 1$ ($R = {}^3He/{}^4He$, R_a = atmospheric helium). He released by melting the vacuum-crushed grains has ratios as high as $R/R_a = 1200$ in olivines and

334 in cpx and contains essentially pure cosmogenic ^{3}He produced by spallation reactions and trapped in the crystal matrix. Maximum ratios observed in total He in phenocrysts are $R/R_a = 99$ in olivine and 70 in cpx. Cosmogenic ^{3}He in the Haleakala phenocrysts ranges from 0.18 to 1.80×10^{-12} cc/g with approximately equal contents in olivine and cpx from individual flows (mean olivine content = 0.987 times mean cpx content). The range represents effects of approximately 400 meters elevation difference and up to one meter of shielding. Production rate estimates indicate a model erosion rate of approximately 6 meters per million years.

Studies of associated neon isotope anomalies (with K. Marti) and ^{10}Be plus ^{26}Al (with K. Nishiizumi) and applications of rare gas studies to other rocks will also be discussed. (Authors' abstract)

CRAIG, H., POREDA, R.J. and MARTI, K., 1986, A new source of ^{3}He in rocks: B. Cosmogenic ^{3}He from cosmic ray induced spallation reactions, a view from the Maui summit (abst.): Terra Cognita, v. 6, no. 2, p. 258. Authors at Scripps Inst. Oceanography, Univ. California at San Diego, La Jolla, CA 92093, USA.

See previous item. (E.R.)

CRAWFORD, M.L. and HOLLISTER, L.S., 1986, Metamorphic fluids: The evidence from fluid inclusions, in J.V. Walther and B.J. Wood, eds., Fluid-Rock Interactions during Metamorphism, New York, Springer-Verlag, p. 1-35.

A very thorough review (∼ 125 references) of all aspects of metamorphic inclusions. (E.R.)

CROCETTI, C.A. and HOLLAND, H.D., 1986, Ionic and ^{87}Sr/^{86}Sr ratios of fluid inclusions in galena from the Viburnum Trend, Missouri (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 575. First author at Exxon Production Res. Co., P.O. Box 2189, Houston, TX 77098.

The ionic ratios of fluid inclusions in galena ores of the Viburnum Trend are similar to those of typical oil field brines. Numerous workers have demonstrated that these fluid inclusions are highly saline (i.e., ≈20 weight % salts) brines. The ionic ratios of the fluid inclusions within a given crystal habit of galena (i.e., cubic or octahedral) are relatively constant throughout the Viburnum Trend; however, the composition of the fluid inclusions in cubic galenas differs considerably from that in octahedral galenas.

Average Ionic Ratios (by weight)

Crystal Habit	K^+/Na^+	Li^+/Na^+	Ca^{++}/Mg^{++}	Ca^{++}/Sr^{++}	Rb^+/Sr^{++}	Ca^{++}/Na^+	Na^+/Cl^-	Br^-/Cl^-	SO_4^-/Cl^-
Cubic	.040	.00021	10	28	.0063	.23	.49	.0019	.006
Octahedral	.13	.00043	2.5	60	--	.19	.46	.0047	.004

The Br^-/Cl^- ratio of the fluids which deposited the cubic galena is considerably lower than that of seawater (.00346), suggesting that much of the salinity in these fluids was derived from the dissolution of halite, while the relatively elevated Br^-/Cl^- ratio of the fluids which deposited the octahedral galena suggests that these fluids may have originated as seawater evaporated past the point of halite precipitation. The high K^+/Na^+ ratios of the fluid inclusions (particularly those in the octahedral galena) may be explained by reactions with K-feldspar bearing basement or sediments. The isotopic composition of Sr in the fluid inclusions (^{87}Sr/^{86}Sr = .7097-.7102) is similar to that of gangue carbonates and indicates that the ore-forming fluids interacted significantly with non-carbonate rocks. (Authors' abstract)

CROXTON, C.A., ed., 1986, Fluid interfacial phenomena: John Wiley & Sons Ltd., Chichester, 1986, 775 pp.

CRYSDALE, B.L., 1986, Flud inclusion evidence for origin and diagenesis of sparry calcite cement in Capitan Limestone, McKittrick Canyon, Permian basin, west Texas (abst.): Am. Assoc. Petrol. Geol. Bull, v. 70, no. 5, p. 578. Author at U.S. Geol. Survey, Denver, CO.

Sparry calcite cement is responsible for major porosity loss in the reef and fore-reef facies of the Capitan Limestone, Permian basin. This cement occurs throughout the massive reef facies where it fills large vugs as much as 0.5 m in diameter, with individual crystals up to several centimeters in length. Sparry cement in the fore-reef facies is less extensive and fills smaller vugs than in the reef, although individual crystals can be as large. The cement is composed of coarse, equant, clear to milky calcite that is rich in fluid inclusions.

Th of P fluid inclusions trapped during cementation record formation T from 55°-85°C. A relatively low geothermal gradient of 2°C/100 m suggests cementation occurred at moderate burial depths of 1-2 km.

Precipitation of sparry cement in fractures and brecciated areas also indicates cementation postdates minor burial compaction. Freezing temperatures (Tf)[Tm ice?] for P fluid inclusions range from about -1° to 0°C (1.7 wt. % NaCl equiv. or less), suggesting the cement was formed in fresh to brackish waters. This range of Tf data is consistent with cement formation in a relatively deep lens of meteoric to mixing-zone waters.

S fluid inclusions with Tf of about -12°C (>16 wt. % NaCl equiv.) indicate that highly saline brines may have migrated along secondary fractures in the cement during later deposition of evaporites in the adjacent Castile and Salado Formations. (Author's abstract)

CZERNY, Jerzy, KIERES, Adam, LIPIEN, Grzegorz and PIESTRZYNSKI, Adam, 1986, Ore mineralization of the foreland of Werenskioldbreen area, SW Spitsbergen (abst.): Abstracts of Posters, VII IAGOD Meeting, Lulea, Sweden, 18-22 Aug., 1986 (unpaginated). Authors at Acad. Mining & Metallurgy, Av. Mickiewicza 30, 30059 Krakow, Poland.

Cu-Pb-Zn-Fe mineralization in the foreland of the Werenskiold glacier is confined to the Vimsodden series of metamorphic rocks of greenschist facies. Both field observations and laboratory studies suggests formation of ore minerals by a decrease of T of the solutions mobilized during metamorphic events. Decrepitation studies of pyrite and sphalerite grains point to a T range of 320-160°C. Mineral parageneses of host rocks suggest their formation above biotite isograde, i.e., in the range 350-450°C. The presence of metamorphosed basic and acid volcanics in the Vimsodden series suggests a primary sedimentary-exhalative origin of the mineralization, resembling "Kuroko" type, modified during metamorphic processes. (From the authors' abstract)

DADZE, T.P. and SOROKIN, V.I., 1986, Solubility of SnO_2 in water at temperatures of 200-400°C and pressure of 1.6-150 MPa: Dokl. Akad. Nauk SSSR, v. 286, no. 2, p. 426-428 (in Russian).

DAHAN, N., COUTY, R. and GUILHAUMOU, N., 1986, A one kilobar pressure heating stage: Application to the study of fluid inclusions in fluorite under confining pressure: Physica, v. 139 & 140B, p. 841-844. Authors at ER. 224, Lab. Géol. de l'Ecole Normale Supérieure, 46 rue d'Ulm 75230 Paris Cedex 05, France.

A microapparatus with experimental volume of 0.2 cm^3, permits the microscopic determination of phase transition T under confining P. The P-T path now available is 1 to 1000 bar and 77 K to 800 K. In a first application we have studied the mechanism of deformation of cavities (with fluid content) in fluorite, during heating under confining P. (Authors' abstract)

Stretching of inclusions (including hydrocarbons) under given conditions of internal and external (confining) pressure was explored. Stretching can be partly reversed by application of external pressure. (E.R.)

DAHAN, N., GUILHAUMOU, N. and COUTY, R., 1986, A study of aqueous fluid inclusions under confining pressure (abst.): Int'l. Symp. Experimental Mineralogy and Geochem., Nancy, France, April 17-19, 1986, Volume of Abstracts, p. 42-43. Authors at ENS 46 rue d'ulm, Paris, France.

A high P thermodynamic stage for studies under the microscope was recently constructed at the Geological Laboratory of the E.N.S. Paris (Patent No. 85.025.12) (1). As it permits visual monitoring of samples, by the mean of a microscope, during cooling and heating while an external P is applied it should be a very useful new tool, for all experiments that need variations of the two state parameters P and T. Conditions currently available are 77°K to 800°K and 1 to 1000 bars. Especially, we could have information about the behavior of samples (5 µm to 5 mm size) not only from the initial stage and the final stage, but throughout the experimental run. The stage could be used with some physical techniques such as Raman or visible and near IR spectrometry in order to analyze the composition of the different phases observed during experimental P-T paths.

The apparatus (Fig. 1) is composed of a vacuum container (A) (165 mm x h = 58 mm), that permits a good isolation (10^{-3t}) of the cell (F) and the eventual detection of pressure leaks. The cell is a small cryoautoclave with an experimental volume of 0.2 cm^3 (ϕ 0.6 x 6 mm high). T change is with a heater (C) and LN_2 circulation (N_2). It is measured by thermocouple (B). Actually gaseous N_2 is used as a P medium and introduced by means of the high P tubing G. P measurement is by a manometer. The errors of measurement are respectively ±1°K and ±2 bars. Observations are made under a microscope through sapphire windows (D-E) with magnification reaching actually 200X. For safety reasons they are performed on a screen with a TV system.

In the first application we observed the behavior of fluid inclusions in fluorite by overheating them under various confining pressures. Four series of experiments had been conducted on about 120 cavities containing aqueous fluid (H_2O + 15% NaCl) in samples from Djebel Guebli (Tunisia). Experimental conditions were between 1 to 850 bars and 298 to 700°K. Under these conditions, we observed that stretching (yielding with volume change) is the main mechanism of deformation. The stretching temperature Tst is very dependent on the confining pressure Pc and the volume of the cavity V. Fig. 2 shows the correlation between the increase of volume induced expressed in terms of Th: ΔTh and the amount of overheating: ΔToh. Regressing curves were calculated for different initial volumes.

From these experiments we have established an empirical law of P effect: $Ps^{Pc} = Ps^1 + 0.73\ Pc$, where Ps^{Pc} is the internal P of the cavity at the stretching T under confining Pc, and Ps^1 is the internal P at the stretching T under 1 bar, according to the empirical law published by Bodnar and Bethke 1984 (4) and our own results (2). This relation confirms that the internal P necessary to initiate stretching is greatly dependent on the confining P.

This first series of microscopic observations on fluid inclusions submitted both to controlled P and T parameters shows that external P is strongly opposed to the internal P during overheating and prevents most of the cavities from exploding or leaking. In some cases we have observed that inclusions which had been deformed by overheating under confining P are able to contract again by increasing this P.

From our preliminary results we think that the mechanism of deformation of fluid inclusions in fluorite could be tentatively explained by a microfracturing effect in a themo-elasto viscoplastic matrix with possibility of relaxation (5).

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(2) Guilhaumou, N., Couty, R. and Dahan, N. (1987), Deformation of fluid inclusions in fluorite under confining pressure. Chemical Geology, v. 61, p. 47-54.

(3) Dahan, N., Couty, R. and Guilhaumou, N. (1986), A one kilobar pressure heating stage: Application to the study of fluid inclusions in fluorite under confining pressure. Physica, v. 139 & 140B, p. 841-844.

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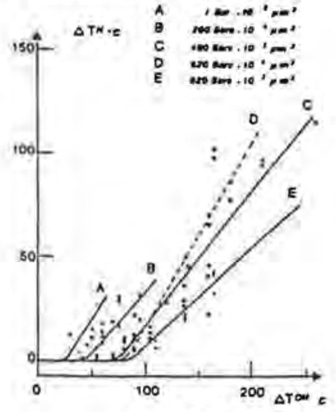
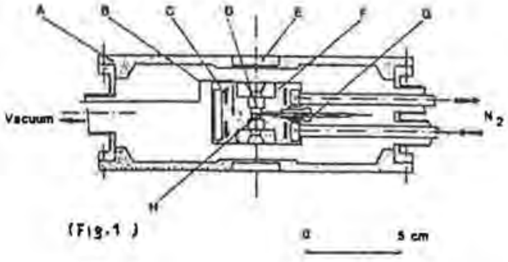
(5) Truesdell, C. (1973), Handbook der Physik VI-a/1. Springer-Berlin.

(Authors' abstract)



(Fig. 2)



(Fig. 1)

DAHLGREN, Sven and BOGOCH, Ron, 1986, Petrogenesis of the Asen dolomite, Kragero area, southern Norway: Preliminary models (abst.): Israel Geol. Soc. Annual Meeting, Maalot, 4-7 May 1986, p. 31. First author at Mineralogisk-Geologisk Museum, Oslo, Norway.

Several small bodies of dolomite occur in greenschist to amphibolite facies schists and amphibolites in the Kragero area of southern Norway. An ultimate mantle origin for the Asen dolomite is envisaged and two models may be considered based on its spatial relationship to the Bamble Series granulite facies rocks and to dolomite-bearing serpentinites. (1) The serpentinites may represent mantle-derived ultramafics; the carbonate originated in them under conditions of mantle P and T, as shown experimentally by Wyllie and others. (2) The nearby granulites yield CO_2-rich mineral inclusions, consistent with the carbonic high grade metamorphism. The CO_2 in this process may have derived either from mantle degassing or from crustal carbonates subducted to the mantle. (From the authors' abstract)

DARDENNE, M.A., 1986, Fluorite vein ore deposits of Santa Catarina district, Brazil (abst.): Terra Cognita, v. 6, no. 3, p. 514-515. Author at Geosci. Dept., Brasilia Univ., Brasilia-DF, 70910, Brazil.

The fluorite veins show a symmetrical and/or asymmetrical zoning, characterized by banded fluorite, fine and coarse breccias, "Cocardes" and associated geodes. Fluorite has purple, green, yellow and white colors, and is associated with chalcedony, quartz, barite, pyrite and kaolinite. Hydrothermal alteration is common and internal sediments are frequent. Fluid inclusion studies indicate that ore-forming solutions have low salinity (0-2%) and temperatures between 125 and 145°C. (From the author's abstract)

DAVEY, H.A. and VAN MOORT, J.C., 1986, Current mercury deposition at Ngawha Springs, New Zealand: Applied Geochem., v. 4, p. 75-93.

DAVIDENKO, N.M., KOVALISHIN, Z.I. and SHCHIRITSA, A.S., 1985, Fluid inclusion typomorphism in minerals of various gold-ore and barren quartz veins of northeastern Soviet Asia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 59-60 (in Russian: translation by I.V. Kulikov). First author at TsNIGRI, Moscow, USSR.

Minerals of Au-ore quartz veins of the low-sulfide quartz type contains many fluid inclusions with dimensions of 0.00n to 0.0n mm, less often 0.n mm. In the main generations of quartz different type syngenetic inclusions are present. Vapor, three-phase (with liquid CO_2) and vapor-liquid inclusions can occur. In the gas composition of vapor phase in P inclusions CO_2 makes up to 82-96%, the rest is mainly N_2 and CH_4.

For this formation the following Th distribution pattern is characteristic: from the sides of Au-veins Th decreases in uniform type inclusions toward the accompanying quartz veinlets, which go perpendicular or at an angle to the main vein.

Pressure, determined by 3-phase inclusions in early coarse-grained milk-white quartz, reaches 1000-1200 bar; but in finer-grained quartz of the late productive stage it is near 280-320 bar. Aqueous extracts showed high NaCl and relatively high Ca and Mg.

It should be noted that inclusion analysis in minerals permits identification of such types of veins not only in outcrop, but also in alluvial pebbles. The analysis of fluid inclusions is especially valuable in minerals trapped in gold nuggets, or intergrown with gold. This permits identification in placers of the types of primary gold sources, even when these are gone or unknown. (From the author's abstract; shortened by E.R.)

DEICHA, G.A., 1986, Inclusions in minerals and crystallogenesis (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 86.

DEINES, P and HARRIS, J.W., 1986, Relationships among nitrogen and ^{13}C content of diamonds and the composition of their mineral inclusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 582. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

The nitrogen content of 66 Premier mine diamonds ranges from 0 to 1359 ppm. Twenty diamonds containing peridotitic inclusions show a more restricted range (0-400 ppm), lower average concentrations and a higher frequency of Type-II diamonds than 41 diamonds containing eclogitic minerals. On the basis of their N_2 and ^{13}C content P-Type diamonds can be divided into two groups, one of a mean $\delta^{13}C$ of -3‰ vs. PDB and variable N_2 (41 to 389 ppm), the other of a lower N_2 content (27 ppm) and variable $\delta^{13}C$ (-5.7 to -12.2‰) values. The first group occludes olivines and garnets of higher Fe-content than the second.

Type-I diamonds occluding eclogitic minerals have nitrogen contents between 29 and 1359 ppm and $\delta^{13}C$ values between -2.5 to -6‰. No correlation between the two variables is observed. Based on N_2 and $\delta^{13}C$ as well as the composition of the inclusions, sub-groups are recognized. The tightest cluster includes 5 diamonds ($\delta^{13}C$ = -3.8 ± 0.5; N_2 = 126 ± 38 ppm) containing garnets of a narrow composition range (FeO = 14.5 ± 0.1, CaO = 14.0 ± 0.3, MgO = 9.3 ± 0.3 wt%). This group is observed also for diamonds containing clinopyroxenes. A rough correlation between N_2 content and cpx-gt equilibration temperature may be recognized.

It is concluded that the suite of samples represents mantle environments differing in the abundance of the major elements as well as the N_2 and ^{13}C-content. Variation in N_2-content of the diamonds may be in part the result of source concentration differences and temperature. Consideration of the chemical species in the system C-H-O-N and the distribution of nitrogen between fluid and melt suggest that some of the variation may also be related to the prevailing partial pressure of oxygen. (Authors' abstract)

DELANEY, J.R., KELLEY, D.S., GOLDFARB, M.S. and McDUFF, R.E., 1986, Indirect evidence for two-phase separation in submarine hydrothermal systems (abst.): EOS, v. 67, p. 392. Authors at Sch. Oceanography, Univ. Washington, Seattle, WA 98195.

At least three lines of evidence indicate that T-P conditions for fluids commonly found in the oceanic crust fall within the liquid-vapor field. [One is that] fluid inclusion arrays trapped on individual microcracks in apatite-bearing gabbros from the MAR contain coexisting vapor-dominated(V) inclusions and liquid-dominated(L) inclusions which remain unhomogenized at temperatures >700°C. NaCl-equivalent salinities fall in the ranges 1.0 to 2.0 wt%(V) and 40 to 50 wt%(L). Relationships between the two sets of inclusions may readily be explained by phase separation at pressures in the range 100 to 120 MPa. (From the authors' abstract)

DELANEY, M.L. and BOYLE, E.A., 1986, Lithium in foraminiferal shells: Implications for high-temperature hydrothermal circulation fluxes and oceanic crustal generation rates: Earth & Planet. Sci. Letters, v. 80, p. 91-105.

DELBOVE, F., LEBEDEV, E.B. and MALININ, S.D., 1986, Behavior of chlorine ion and cation exchange in an experimental system: Magmatic melt-hydrothermal fluid: Geokhimia, 1986, no. 11, p. 1550-1558 (in Russian; English abstract).

Using radioactive isotope ^{36}Cl, a distribution of Cl-ion between aluminosilicate melts (of albite and granite initial composition) and aqueous chloride fluids, with initial concentration of NaCl and KCl varying from 0.1 to 4.0 N, has been investigated at 900°C and 3 kbar. Cl-solubility in the melts shows significant differences, according to the overall cation composition. Based on an analysis of the experimental data, the exchange (Na-K) and (Na-Ca) between melts and fluids has also been considered. (Authors' abstract)

DELÉ-DUBOIS, M.-L., POIROT, J.-P. and SCHUBNEL, H.-J., 1986, Identification of micro-inclusions in synthetic rubies and emeralds by Raman spectroscopy: Rev. Gemm. a.f.g., v. 88, p. 15-17 (in French).

Raman spectroscopy provides a nondestructive means of distinguishing synthetic faceted gemstones from natural stones by identification of solid inclusions. It is also possible to determine the method of synthesis. Inclusions of phenacite, alkali polymolybdates, carbonates, cryolite, Na(?) orthovanadate, beryl, quartz and MoO_3 polymorphs have been identified in synthetic rubies and emeralds. (Abstract by C.J. Eastoe)

DELE-DUBOIS, M.L. and SCHUBNEL, H.J., 1986, Identification of inclusions in natural and synthetic rubies and emeralds by use of a Raman microprobe (abst.): Bull. Minéral., Supplement 1986, v. 109, p. 62 (in French). First author at Lab. de Spectrochimie I.R. & Raman, CNRS LP 2641, Univ. de Lille, Bât. C5, 59655 Villeneuve d'Ascq Cedex, France.

Raman spectroscopy may be used to systematically differentiate between natural and synthetic gems in situations requiring nondestructive analyses. The authors used a monochromatic argon laser source in the 458-514.5 nm range to analyze natural gems of differing provenance and synthetic gems produced by both hydrothermal and flux-fusion systems.

The natural gems showed inclusions of the following types: Ruby: calcite, zircon, sphalerite (Burma); pyrite, chromite, calcite, zircon (Africa); nepheline (Cambodia); and fassaite, rutile (Thailand). Emerald: apatite, pyrite, calcite, fluid inclusions with N_2, CO_2, and hydrocarbons (Columbia); and zircon, calcite, phlogopite, rutile (Siberia).

The synthetic stones showed inclusions of the following types: Ruby: polymolybdates (Knishke, Chatham); sodium orthovanadate (Ramoura); and cryolite (Kashan). Emerald: phenacite (Linde, Gilson, Seiko, Lennix); quartz (Lennix); MoO_3 polymorph (Lennix); and polymolybdates (Igmerald, Gilson, Chatham). (Modified from the authors' abstract by M.J. Logsdon)

DELOULE, Etienne, ALLEGRE, Claude and DOE, Bruce, 1986, Lead and sulfur isotope microstratigraphy in galena crystals from Mississippi Valley-type deposits: Econ. Geol., v. 81, no. 6, p. 1307-1321. First author at Lab. Géochimie & Cosmoch., Inst. Physique du Globe de Paris & Dépt. Sci. de la Terre, Univ. Paris VI & VII, 4, Place Jussieu, 75230 Paris Cedex 05, France.

The development of an analytical procedure for lead and sulfur isotope analysis by secondary ion microprobe mass spectrometry allowed us to provide in situ isotopic microanalyses of galena crystals.

We performed analyses across the growth zones of two crystals of galena from Mississippi Valley-type ore deposits, with a spatial resolution of 50 µm and a spacing of 250 µm. These analyses show frequent variations for both lead and sulfur isotope compositions which occurred during the time of the crystal growth. We can demonstrate that, for both elements, these variations involved changes in the sources of the brines which formed the ore deposits. The comparison of lead and sulfur isotope behavior suggests that the Picher deposit lead and sulfur originated from common sources, whereas the Buick mine deposit lead and sulfur had separate sources.

The two galenas exhibit rapid and frequent change in isotopic composition; this suggests numerous and discontinuous inputs of lead and sulfur to the ore deposits. This model agrees well with a physical model for Mississippi Valley-type deposits proposed by Cathles and Smith (1983). The isotopically different sources were probably different sedimentary layers and perhaps basement rocks in the same basin, whose formation waters were channeled in preferred water conduits to the ore deposit location during the subsidence of the basin, allowing mixing between the different sources to occur during the brines' travel. (Authors' abstract)

DEMIN, Yu.I., 1985, On the theory and practice of integrating thermobarogeochemical, lithochemical and geological parameters on endogenetic aureoles in prospecting for deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 248-249 (In Russian; translation by Dorothy B. Vitaliano). Author at Moscow State Univ., Moscow, USSR.

The author combined various geological and geochemical parameters with decrepitation data into a mathematical model, and applied it successfully at three chalcopyrite-polymetallic deposits in the Rudnyy Altay to increase the contrast of the endogenetic aureole (Abbreviated from the author's abstract by ER)

DEMIN, Yu.I. and SERGEYEVA, Nat.Ye., 1985, The physicochemical parameters of formation of pre-orogenic massive-sulfide - polymetallic deposits, based on different study methods (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 80-81 (in Russian; translation by D.A. Brown). Authors at Moscow State Univ., Moscow, USSR.

Current geological information suggests that pre-orogenic massive-sulfide - polymetallic deposits of various ages are polygenic. Among them, the most important are the hydrothermal-sedimentary, hydrothermal-metasomatic, and the ore-mineral associations which arose during various subsequent transformations. Microthermobarogeochemical studies, distribution of components between coexisting minerals, physicochemical analysis of the ore parageneses, and computer modelling of the ore-forming processes has enabled us to define the most likely environment of ore deposition, and also to assess the applicability of the methods employed.

The hydrothermal-sedimentary ore lodes, beginning with the results of a study of gas-liquid inclusions in the quartz and sphalerite of the stratified ores, and also modelling of the process of mixing of hydrothermal solutions with seawater on a computer, have in most cases been formed at <250°C. Similar temperature data have been obtained using the pyrite-chalcopyrite thermometer. $P(O_2)$ lies between 10^{-7} - 10^{-10} bars, and $P(S_2)$ between 10^{-10} - 10^{-12} bars. Inclusions with Th >300°C, and assemblages formed at low $P(O_2)$, arose either as a result of hydrothermal-metasomatic processes after burial or under later metamorphism.

The hydrothermal-metasomatic orebodies accompany the hydrothermal-sedimentary forms and sometimes the environmental conditions overlap, but the former are always hotter. Although the overall temperature interval of mineral-formation frequently exceeds 300-400°C, the bulk of the ores have been precipitated in quite a narrow range (80-100°C). Lateral and vertical temperature zonation has similar limits.

Computer modelling of heat-mass-exchange, and of infiltration-diffusion processes, suggests that such temperature conditions were maintained for several tens of thousands of years in the hydrothermal-metasomatic orebodies. These results agree closely with data from thermometry and thermometers based on the distribution of components between coexisting minerals.

Th values provide underestimates, and more reliable information has been obtained from diffusion zones and the distribution of components between coexisting minerals.

The data obtained differ most under high PT conditions, and intensely variable potentials of alkalies, sulfur, and other completely mobile components. (From the authors' abstract)

DERNOV-PEGAREV, V.F. and MALININ, S.D., 1985, The solubility of apatite in aqueous alkali-carbonate solutions at 300, 400, and 500°C: Geokhimiya, no. 8, p. 1196-1205 (in Russian; translated in Geochem. Int'l., v., 23, no. 2, p. 96-104, 1986).

DE RONDE, C.E.J., 1986, The Golden Cross gold-silver deposit: Monograph Ser. on Mineral Deposits, v. 26, p. 165-183: Berlin-Stuttgart, Gebrüder Borntraeger.

This is the published version of the author's M.S. thesis (see Fluid Inclusion Research, v. 18, p. 96-97). (E.R.)

DES MARAIS, D.J., 1986, Carbon abundance measurements in oceanic basalts: The need for a consensus: Earth & Planet. Sci. Letters, v. 79, p. 21-26. Author at NASA-Ames Res. Center, Moffett Field, CA 94035, USA.

Large systematic discrepancies currently exist among the carbon data reported for oceanic basalts by different laboratories. These discrepancies are likely attributable both to non-uniform criteria for the removal of carbon contamination from the samples, and to systematic errors in analytical procedures. In order to solve these problems, investigators must agree upon effective criteria for the removal of carbon contamination, and they must create an accurately calibrated set of basaltic glass carbon standards. (Author's abstract)

DEVIRTS, A.L., LAGUTINA, E.P. and SHUKOLYUKOV, Yu.A., 1986, Variations of isotopic composition of hydrogen in carbonaceous chondrites: Geokhimiya, 1986, no. 10, p. 1378-1388 (in Russian; English abstract).

DE VIVO, B., FREZZOTTI, M.L. and GHEZZO, C., 1985, Fluid inclusions from Mt. Pulchiana Hercynian leucogranitic intrusion (North Sardinia) (abst.): Abstr. Sci. Mtg., CNR Gruppi di Lavoro "Paleozoico" and "Evoluzione magmatica e metamorfica della crosta fanerozoica," Siena, p. 73.

DE VIVO, B. and TECCE, F., 1985, Fluid inclusion study of fluorite from Camissinone deposit, Brembana Valley, Bergamasc Alps: Boll. Soc. Geol. Ital., v. 104, p. 87-91.

Fluorite samples from Camissinone deposit (Brembana Valley, Bergamasc Alps) have been checked for a fluid inclusion study to gain information about the nature and the origin of the fluids responsible for the deposition of the ore. The salinity data suggest for the fluid that a mixing of two different components is responsible for the deposition of the fluorite. The homogenization temperatures suggest that a hydrothermal system developed along the fractures that localized the precipitation of the fluorite. (Authors' abstract)

DHAMELINCOURT, P. and DUBESSY, J., 1986, Parameters controlling the Raman spectrographic analysis of gases in fluid inclusions (abst.): Bull. Minéral., Supplement, v. 109, p. 63 (in French). First author at LASIR-CNRS, UER de Chimie C5, 59655 Villeneuve d'Ascq, France.

An important application of Raman microspectrometry is the identification in fluid inclusions of simple gases in the system C-O-H-N-S and the determination of their molar fractions. The goal of the authors' paper is to indicate important optical and molecular parameters that may control the ability to interpret the Raman spectrographic data.

The authors briefly review some principals of physical optics, pointing out the importance of the use of immersion oils in optical and TEM studies of fluid inclusions. The authors emphasize that the interpretation of data is not highly sensitive to alignment with the absolute critical section.

Finally, the authors discuss the effects of internal fields and molecular interactions in interpreting the Raman spectra of CO_2-rich mixtures of CO_2-N_2. (Modified from the authors' abstract by M.J. Logsdon)

DICKSON, F.W. and RADTKE, A.S., 1986, Physical chemical processes affecting deposition of silica in Carlin-type gold deposits (abst.): J. Geochem. Explor., v. 25, p. 238.

DICKSON, J.A.D., 1985, Diagenesis of shallow-marine carbonates, in P.J. Brenchley and B.P.J. Williams, eds., Sedimentology: Recent developments and applied aspects: Geol. Soc., Blackwell Sci. Pubs., p. 173-188.

The utility of carbonate petrography in solving diagenetic problems is often underrated. Staining and cathodoluminescence are complementary to petrographic studies; their application is compared. Interpretation of carbonate trace element concentration through the distribution coefficient, as illustated by Sr^{2+}, was oversimplified in the 1970s and often tied to repeated recrystallization episodes in meteoric waters. Kinetic factors complicate the use of the distribution coefficient in calcite. $\delta^{13}C$ values from carbonates help in identifying the source of carbon but $\delta^{18}O$ values are difficult to interpret due to control by temperature as well as the isotopic composition of the precipitation fluids. Data on the composition of sedimentary waters, geothermometry and geobarometry of buried sedimentary rocks can be provided by fluid inclusion studies but interpretation has often been over-optimistic, because insufficient account has been taken of the difficulties which exist with fluid inclusion work.

Near-surface, carbonate diagenesis is well understood through field studies of Recent and Pleistocene sediments. Research effort in the future, it is predicted, will concentrate on burial diagenesis because it is the least understood diagenetic realm. The large variations in temperature, pressure and time which distinguish burial from near-surface environments are exemplified by the burial history of the Carboniferous Limestone of South Wales. (Author's abstract)

DING, T.P., YONGE, C., SCHWARCZ, H.P. and PENG, Z.-C., 1986, Oxygen, hydrogen, and lead isotope studies of the Taolin lead-zinc ore deposit, China: Econ. Geol., v. 81, p. 421-429. First author at Inst. Geol. of Min. Deposits, Chinese Acad. Geol., Beijing, China.

The Taolin Pb-Zn deposit consists of a series of hydrothermal veins emplaced in a fault zone between the 136-m.y.-old Mofushan granitic batholith and the Proterozoic metasediments of the Lengjiaxi formation. Two stages of ore deposits were distinguished: I, sulfides-quartz-fluorite and II, barite-sulfides-quartz-calcite. The $\delta^{18}O$ values of the vein quartz have been used, together with temperatures based on sulfur isotope fractionation between cogenetic sulfides (Ding and Rees, 1984), to show that $\delta^{18}O$ values of water of the hydrothermal fluid tended to decrease throughout the cooling and progressive precipitation of the ore deposit. The D/H ratios of water in fluid inclusions vary erratically through this sequence but show no overall trend between stages I ($x = -46 \pm 10‰$) and II ($x = -48 \pm 13‰$). A stage II quartz-calcite assemblage was precipitated at the lowest observed temperature, from essentially pure meteoric water ($\delta D = -46‰$). The isotopic evolution of the hydrothermal fluid can be accounted for by circulation of meteoric water through a convection system heated by the granite, causing exchange of oxygen isotopes with the granite and country rock, and possibly involving some admixture of magmatic water. Lead isotopes in both the ore and granite give a model age of 418 m.y.; this, combined with the high $\delta^{18}O$ values of least-altered granite, suggests that the granite formed by anatexis of lower crustal, U-depleted rock. The lead of the ore deposit was probably derived from the granite. (Authors' abstract)

DINGWELL, D.B., 1986, Volatile solubilities in silicate melts, in Short course in silicate melts, C.M. Scarfe, ed.: Mineral. Assoc. of Canada, Ottawa, May 1986, p. 93-129. Author at Geophys. Lab., Carnegie Inst. Washington, Washington, DC 20008, USA.

A thorough review, with >100 references. (E.R.)

DIXON, J.E., ROSENER, Paula, STOPLER, Edward and DELANEY, J.R., 1986, Infrared spectroscopic measurements of H_2O and CO_2 contents in Juan de Fuca Ridge glasses (abst.): EOS, v. 67, no. 44, p. 1253. First author at Caltech 170-25, Pasadena, CA 91125.

Dissolved H_2O and CO_2 contents of basaltic glasses from the Juan de Fuca Ridge and neighboring seamounts were determined by infrared spectroscopy. Hydroxyl groups are the only detectable form of dissolved water and carbonate ions are the only detectable form of dissolved carbon dioxide. H_2O contents vary from 0.19 to 0.34 wt %. CO_2 contents range from about 50 ppm to 300 ppm by weight. The ranges for the seamount samples are similar to those of the ridge samples. Typical analytical precisions (2σ) based on multiple analyses of the same glass chip or different chips from the same hand sample are ~0.02 wt % for H_2O and ~10 ppm for CO_2.

H_2O contents show no systematic variation with depth or proximity to the Cobb hotspot, but show positive correlations with FeO*/MgO and K_2O content. CO_2 contents do not vary systematically with depth, proximity to the hotspot, FeO*/MgO, or K_2O content. The absence of a correlation with depth and the wide range of dissolved CO_2 contents of basalts erupted at a single depth confirm the conclusions of Fine and Stopler (EPSL, 76, 263-278, 1986). We suggest that the solubility of CO_2 in basaltic melt at a given pressure is defined by the lowest dissolved CO_2 contents of glasses erupted at the water depth corresponding to this pressure; all higher CO_2 values observed in glasses at this eruption depth represent incomplete degassing. Based on our data, we thus predict that CO_2 solubility in basaltic melt is about 50 ppm by weight at a CO_2 pressure of 200 bars.

The results of this study using the IR technique will be compared to combustion analyses on the same samples (Blank, Delaney, and Des Marais, this volume). (Authors' abstract)

DMITRIEV, E.A., GILEEV, A.V., ISHAN-SHO, G.A. and LITVINENKO, A.K., 1985, Thermobarogeochemical conditions of formation of precious stones in pegmatites of Central Pamir (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 8-9 (in Russian; translation by S. Jaireth). Authors at Inst. Geol. Acad. Sci., Tadzhik SSR, Dushanbe, USSR.

Granitic pegmatites of Central Pamir are associated with three different granitoids - Precambrian migmatite-granites, alpine quartz-syenite granites and leucogranites. Precious stones are located in miarolitic cavities of pegmatites associated with alpine leucogranites, which are also marked by widespread development of quartz-albititic and quartz-albite-lepidolite replacement zones. Precious stones are also observed in secondary cavities of Precambrian and younger pegmatites.

Miarolitic pegmatites are usually differentiated bodies located 3 to 5 kms away from the parent intrusive. The cavities contain crystals of K-Na feldspars, tourmaline, schorl, smoky quartz, beryl and dravite. Crystallization of these minerals occurred at 560 to 480°C and 2.3 to 1.10^8 Pa. During development of quartz-albitite and quartz-albite-lepidolite replacement zones, topaz, polychromic tourmaline, rubellite, amazonite, adularia, optical quartz and transparent scapolite were formed. Their crystallization occurred at 420 to 320°C and 1.6 to 1.10^8 Pa. In the secondary cavities of older pegmatites, alpine metamorphism and metasomatism led to the formation of gem grade scapolite, moonstone apatite, sphene, and optical quartz. These are formed at 650 to 230°C and 2.4 to 0.6 10^8 Pa.

Crystallization of minerals in miarolitic cavities took place from solutions, residual fractions of which had chloride-sulfate composition, low density and low salinity (47 g/liter). On cooling, solutions become chloride-bicarbonate with simultaneous increase in density and salinity (140 g/liter). At all stages of formation of precious stones, solutions contained Al, Si and volatiles (CO_2, Cl, F, B).

Evolution of solutions was regulated by changes in pH of mineral forming system. Solubility of elements was achieved through acid complexes with Cl, F, CO_2 and S serving as common ligands.

Narrow range (560-480°C) of crystallization temperature of precious stones without any signs of replacement is explained by closed nature of the system. On cooling, when the system became open, action of postmagmatic solutions rich in Cl, F, B and alkalies led to replacement and recrystallization of pegmatites, during which topaz, adularia, rubellite, scapolite, optical quartz, sagenitic quartz and other rare minerals like danburite and hambergite formed. Crystallization temperature of these minerals shows large variation with values between 420 to 320°C. Crystallization of gem grade scapolite, adularia and optical quartz in secondary voids of older pegmatites took place within a still larger temperature interval (650 to 230°). This large temperature interval (270°C[sic]) overlaps with temperature of crystallization of minerals in both miarolitic cavities as well as in replacement complexes.

Thus, these first results will stimulate exploration and also help solve theoretical problems of the genesis of gemstones. (From the authors' abstract)

DOBEŠ, P. and ŽÁK, K., 1986, A comparison of stable isotope studies with fluid inclusion data from the Vrančice Zn-Pb-Cu deposit: Proc. of the II Geochem. Meeting, "Selected topics of geochemistry," Mariánská, Jáchymov, Sept. 22-26, 1986, v. 2, p. 21-26, Praha, Geol. Survey, Acad. Sci. (in Czech).

Stable isotopes and fluid inclusions were studied in sphalerite, galena, carbonates and quartz of the Vrančice Zn-Pb-Cu deposit. This hydrothermal vein deposit is situated in Variscan granitoids in the center of the Bohemian Massif. The veins are spatially bound to a distinct fault zone. The average values of $\delta^{34}S$ of sphalerite is -1.5‰, galena -4.9‰. The difference, 3.4‰, corresponds to average T of crystallization 180-190°C. Oxygen isotopic composition of hydrothermal carbonates indicates the same T . Th of fluid inclusions in quartz are 160-196°C, in sphalerite 143-187°C. Salinity of the mineralizing fluids reaches as high as 23% wt. NaCl eq. The major components are $CaCl_2$, NaCl and H_2O. The T acquired from both the methods are in good agreement. (Authors' abstract, translated by J. Ďurišová)

DOLIDZE, I.D., and OTKHMEZURI, Z.V., 1985, Chemical composition of the ore-forming solutions of the barite-polymetallic deposits (illustrated by Georgia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 178-179 (In Russian; translation by Dorothy B. Vitaliano). Authors at Geol. Inst. Acad. Sci. Georgian SSR, Tbilisi, USSR.

The Pb-Zn plus barite (with galena predominant) and barite-calcite vein mineralization, confined to Middle Jurassic volcanics, form a complex barite-polymetallic formation, the development of which took place in two stages of mineralization: Pb-Zn and barite-calcite. The vein-metasomatic (with predominant sphalerite) mineralization with collomorphic textures of the ores, confined to Middle Jurassic volcanics and Upper Jurassic and Cretaceous carbonate rocks, represent the deposits of the Kvaysa ore field, which formed in one stage of mineralization.

We investigated the mineral-forming solutions by the method of triple aqueous extracts. In the solutions forming the Pb-Zn plus barite mineralization, Cl, HCO_3, Ca and Na are predominant. In the barite-calcite deposits, Cl and Ca predominate. The role of alkaline elements is insignificant. The Pb-Zn deposits with collomorphic ores are of Ca-HCO_3 character. (Abbreviated by ER from the authors' abstract)

DOLISHNIY, B.V., 1985, On gas-liquid inclusions in hydrothermal anhydrite (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 181 (In Russian; translation by Dorothy B. Vitaliano). Author at IGGGI of the Acad. Sci. Ukrainian SSR, L'vov, USSR.

Information on P GLI inclusions in anhydrite is very sparse. This is related to the insignificant occurrence of anhydrite of hydrothermal origin. In particular, as V. A. Suprychov and Yu. I. Shutov (1967) point out, in the Ukraine hydrothermal anhydrite was not found until relatively recently -- in 1963.

We studied anhydrite from the Devonian rock salt of the Bantyshevo salt dome structure (southwestern part of the Dniepr-Donets basin). In the water-insoluble residue of the salt, anhydrite is observed along with quartz, scapolite, muscovite, albite, sphene, tourmaline, carbonates, sulfides, and other minerals. Like the minerals of the accompanying association, the anhydrite is distinguished by the clearly expressed idiomorphism of the crystal individuals. It is water-clear, colorless, sometimes light pink or pale violet. The thick tabular crystals of anhydrite are separate; intergrowths with other minerals are rarely observed. The size of the crystals usually is 1-2 mm, and the content of the mineral in the insoluble residue of the salt from various parts of the salt stock varies from a few percent to 60-70%.

The GLI in the anhydrite usually are P, three-phase. The volume of the solid phase (halite) is variable, often constituting 50-70 vol.%, which indicates the xenogenic nature of the solid phase. The volume of the gas phase does not exceed 2-4%. The shape of the inclusions is mainly rectangular, almost isometric, less often irregular; the size of the vacuoles reaches 0.1-0.2 mm. When the anhydrite is heated in a heating chamber, partial homogenization is observed (disappearance of the gas bubble) at a temperature of 80-100°C in the course of further heating the inclusions decrepitate at 105-110°C.

In addition to GLI, round solid inclusions of halite up to 0.1-0.3 mm in size are also often observed in the anhydrite.

The particulars of the inclusions in the anhydrite, the form of its deposition and composition of the accompanying mineral association indicate a hydrothermal origin of the anhydrite from the Bantyshevo salt dome. (Author's abstract)

DOLISHNIY, B.V., 1986, Hydrothermal anhydrite from rock salt of the Dnieper-Donets Basin: Dokl. Akad. Nauk SSSR, v. 291, no. 1, p. 197-198 (in Russian).
See previous item. (E.R.)

DOLLAR, P., FRAPE, S.K., McNUTT, R.H., FRITZ, P. and MACQUEEN, R.W., 1986, Geochemical studies of formation waters from Paleozoic strata, southwestern Ontario: Ontario Geol. Survey Miscellaneous Paper 130, p. 147-154. First author at Dept. Earth Sci., Univ. Waterloo, Waterloo.

The groundwater of southwestern Ontario has been analyzed for: major, minor, and trace element geochemistry; stable isotope content; tritium; and strontium isotopic content. Most sedimentary formations contain very concentrated brines (>250 grams per litre (g/L)). Some have distinctive geochemical and isotopic signatures for individual units. However, some samples appear to be mixtures of brine from various formations and/or mixtures of formation brines with more dilute groundwaters. (From the authors' abstract)

DONALDSON, C.H. and HENDERSON, C.M.B., 1986, Experimental studies of quartz dissolution in a rhyolite melt (abst.): Mineral. Soc. Bull., no. 73, Dec. 1986, p. 3. First author at Univ. of St. Andrews.

Faceted quartz crystals partially dissolved in superheated, H_2O-saturated rhyolite at 0.8 kb, 850°C for 8 days have become round and the surfaces are saturated with perfectly smooth hemispherical pits, 20-100 μm in diameter. The pits are commensurate with bubbles in the quenched melt, and so the texture is attributed to accelerated dissolution where bubbles have touched the crystal. This results in rapid transfer of undersaturated melt of low surface tension along the surface of the bubble to the crystal, and removal of silica-enriched melt of higher surface tension from the crystal-liquid interface (so-called Marangoni convection), and hence very locally enhanced dissolution.

Though we know of no natural occurrence of crystals saturated with such pits, the mechanism may account for the presence of solitary, round embayments in some quartz xenocrysts in hybird mafic magmas. (Authors' abstract)

DONETS, A.I., 1985, Geologic-genetic peculiarities and models of stratiform lead-zinc ore deposits in carbonate beds: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 2, p. 25-26 (in Russian).

Cited in Naumov, 1986 (this volume).

DOROGOVIN, B.A., SUCHKOVA, Ye.M., PESTRIKOV, N.N., 1985, Stages in the formation of emeralds, on the basis of data of thermobarometric and structural investigations (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 213-214 (In Russian; translation by Dorothy B. Vitaliano). Authors at VNIISIMS, All-Union Sci. Research Inst., Aleksandrov, USSR.

On the basis of data of thermobarometric study of emeralds and associated minerals (beryl, plagioclase, quartz, fluorite) from deposits of emerald-bearing micaceous greisens, a scheme of evolution of the mineralizing solutions, to which two stages of emerald formation are related, was established. The thermometric measurements were made on a "Pyrite" apparatus, and the cryometric ones in a chamber designed by L. M. Bazarov.

Syngenetic two-phase CO_2-water inclusions correspond to emerald of generation I (early stage); less often, highly concentrated solution-melts with minimal Th of 480-500°C correspond to this stage. The fluid P calculated on the basis of CO_2-water inclusions, is 2.0-2.5 kbar. The location of pockets of emerald mineralization is limited to subvertical ore shoots.

Syngenetic two-phase and three-phase inclusions with CO_2 are typical of emerald of generation II (late stage); the Th is 240-290°C and calculated fluid P, 0.7-0.9 kbar. The main components of the emerald-forming solution (not taking into account the stoichiometry of the "host" mineral) were: for the first stage, K, CO_2, F; for the second, Na, CO_2.

Emerald mineralization of generation II is more widespread and was related to the formation of quartz-albite veins. The types of structures controlling it were very diverse -- from strike-slips to reverse faults. The total productivity of the blocks is determined by the intensity of the process of formation of emerald of generation i and the preservation of its crystals when generation II was superposed, i.e., by the structures of the late stage. (Authors' abstract).

DOROSHENKO, Yu.P. and DOROSHENKO, N.Yu., 1985, Step-wise nature and thermobaric regime of formation of the tungsten-molybdenum mineralization of the East Kounrad ore field (Central Kazakhstan) (abst.): Abst. Seventh All-

Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 142-144 (in Russian; translation by Dorothy B. Vitaliano). First author at L'vov State Univ., L'vov, USSR.

The W-Mo mineralization of the East Kounrad ore field is localized in granitoids of the Kaldyma comples (C_3). In the ore field there are the East and North Kounrad deposits. The tungsten hills, the mineralization of which is confined to veins striking roughly east-west, northwest and north-south. [Incomplete sentence in the Russian.] The ore veins are accompanied by K-feldspathization, greisenization and silicification. Muscovite-quartz, quartz-muscovite and quartz facies are distinguished in the greisens. The ore veins consist of these mineral associations (in order of deposition): molybdenite-quartz, "banded" quartz with molybdenite, rare metal-wolframite-quartz, wolframite-quartz, galena-sphalerite-quartz, rhodochrosite-quartz, fluorite-quartz and desmine [stilbite]-calcite.

Thermobarogeochemical investigations of the mineral associations made it possible to ascertain the P-T-X conditions of formation. The early associations--molybdenite-quartz and "banded" quartz with molybdenite, which are accompanied by wall-rock K-feldspathization--were formed at 435-280°C and 900-1200 bar; the concentration of the solutions was 42-25 wt.% (according to NaCl + KCl). Inclusions with a solid phase of NaCl are typical; boiling of the solutions at 410-380°C is established. The rare metal-wolframite-quartz and wolframite-quartz associations are accompanied by wall-rock greisenization and were formed (respectively) at 380-305°C and 315-245°C and 650-800 bar; the concentration of the solutions was 47-30 wt.%. Boiling of the solutions at 375-360°C was established. Crystallization of the main ore minerals was limited to certain temperature intervals: molybdenite -- 420-360°C; wolframite -- 250-280°C; bismuthinite -- 275-265°C. The galena-sphalerite-quartz association is accompanied by wall-rock silicification. The deposition of this association occurred at 310-165°C and 420-530 bar. Inclusions with liquid CO_2 are typical. The rhodochrosite-quartz association was formed at 240-160°C; deposition of the minerals of the final fluorite-quartz and desmine-quartz associations took place at 145-90°C and 110-65°C, respectively. These mineral associations are grouped in stages of mineralization: molybdenum-quartz (T = 435-280°C, P = 900-1200 bar), complex rare-metal (T = 380-245°C, P = 650-800 bar), sulfide-quartz (T = 310-160°C, P = 420-530 bar) and calcite-fluorite-quartz (145-65°C). In the deposits and in the ore field as a whole, a systematic distribution of the mineral associations in space is observed. The variation in temperature of mineralization also is established, expressed in the existence of quite systematic temperature gradients both along the strike and down the dip of the ore bodies. On the average, for the associations of the molybdenite-quartz stage the value of the first parameter varies from 8 to 12°C per 100 m, while for the second it ranges from 18 to 25°C per 100 m; for the complex rare-metal stage, they vary from 7 to 10°C per 100 m and 15-20°C per 100 m, respectively. Analysis of the geological-structural features of the deposits and of the whole ore field, the existence of the step-wise nature and temperature zoning, the narrow temperature ranges of crystallization of the main ore minerals, and the value of the vertical paleotemperature gradient are of essential importance for determining the level of erosion of the ore bodies and predicting concealed mineralization. (Authors' abstract)

DOROSHENKO, Yu.P., PAVLUN', N.N., 1985, Some applied aspects of thermobarogeochemical analysis of fluid inclusions in minerals (illustrated by the molybdenum-tungsten deposits of Central Kazakhstan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 244-246 (In Russian; translation by Dorothy B. Vitaliano). Authors at L'vov State Univ., L'vov, USSR.

Fluid inclusions in minerals from different types of Mo-W greisen deposits provided a model for the variation in PTX conditions of ore formation.

Among the most important conditions for economic deposits of Mo and W (and for exploration application), are: a) optimal T range of crystallization of molybdenite and wolframite -- more than 440-350°C; b) amount of P and its fluctuation during ore genesis -- from 1600-1200 to 1000-500 bar; c) transition from gaseous to liquid concentrated solutions (critical phenomena, retrograde boiling, episodes of "pneumatolysis" in hydrothermal mineralization); d) essentially alkali-halide (K-Na-F-Cl) composition of solutions and their high salt concentration ((from 26 to 65% NaCl-equiv.; e) phase composition of syngenetic mineralization of inclusions -- exceptional saturation with numerous crystals of chlorides of aforementioned alkali metals is typical; f) intensity of rate of cooling of ore-forming solutions as they migrate in the upper horizons of the ore bodies (vertical and laterally) of cation-anion and gas components of mineralizing solutions of productive stage of mineralization. (Abbreviated by ER from the authors' abstract)

DOUKHAN, J.-C. and PATERSON, M.S., 1986, Solubility of water in quartz: A revision: Bull. Minéral., v. 109, p. 193-198.

DREIBUS, G. and WANKE, H., 1986, Water, rare gases and other volatiles on Earth and Mars (abst.): Lunar & Planetary Sci. XVIII, p. 248-249.

DROBECK, P.A., HILLEMEYER, F.L., FROST, E.G. and LIEBLER, G.S., 1986, The Picacho mine: A gold mineralized detachment in southeastern California: Ariz. Geol. Soc. Digest, v. 16, p. 187-221. First author at Western State Minerals, 37 Bluejay Road, Kingman, AZ 86401.

Preliminary Th data on inclusions in quartz show 201-226°C and salinities of 0.5-0.7 wt%, quoted from "Liebler, G.S., 1986, MS thesis, Univ. Ariz., in prep." (E.R.)

DU, Letian, 1986, Granite-type uranium deposits of China, in Vein type uranium deposits, IAEA - TECDOC-361, p. 377-393. Author at Uranium Geol. Res. Inst., Beijing, PRC.

The granite-related U deposits of China are of acid hydrothermal and alkaline hydrothermal origin. Their geological features, the correlation with each other and their metallogenesis are discussed. The close relationship of the U mineralization with the geotectonic history and the existence of a 'carapace of ore formation' as a barrier for precipitation and concentration of U from ascending solutions are emphasized. (Author's abstract)

Author presents unpublished 1980 data of others on fluid inclusions (p. 389). Th and salinity vary widely (salinity 8-25 wt.%), suggesting boiling. The "freezing points" of the inclusions are -23.4 to -33.0°C, suggesting that they are pure and have no material in suspension [i.e., "freezing point" means Tn ice?]. Unpublished 1982 data by another gives composition of inclusion fluids as follows, in g·ion/L: K 0.2-0.5; Na 0.2-0.6; Ca 0.4-1.4; Mg 0.05-0.2; HCO_3 0.4-3.0; SO_4 0.05-0.3; F 0.1-0.5; Cl 0.1-0.3; pH 7.05 to 8.12; Eh -0.46 - -0.55(v). (E.R.)

DU, P.-C. and MANSOORI, G.A., 1986, A continuous mixture computational algorithm for reservoir fluids phase behavior: Soc. Petrol. Engineers, Golden Gate Sec., Proc. 56h Ann. California Regional Meeting, v. 1, p. 391-398, paper SPE 15082.

DUBESSY, Jean, BENY, Claire, GUILHAUMOU, Nicole, DHAMELINCOURT, Paul and POTY, Bernard, 1984, Applications of the MOLE Raman microprobe to the study of fluid inclusions in minerals: J. de Physique, Colloque C2, Suppl. no. 2, v. 45.

A review. (E.R.)

DUBESSY, Jean, BURNEAU, André and DHAMELINCOURT, Paul, 1986, Control parameters of gas analysis in fluid inclusions by micro Raman spectroscopy (abst.): Georaman-86, Special Meeting Soc. Franc. de Min. et de Crist., Paris, 16-17 Oct., 1986 (in English). First author at CREGU, GS CNRS-CREGU, BP 23, 54501 Vandoeuvre lès Nancy Cedex, France.

The identification of simple gases of the C-O-H-N-S system inside fluid inclusions and the determination of their molar fractions has been an important application of micro Raman spectrometry in Earth sciences. The aim of this work is to study the optical and molecular parameters which control these analyses.

When the laser beam crosses a single-refractive index medium all the light converges to a single point, either in air for dry objectives, or in the medium for immersion objectives. Inside a transparent mineral with a refractive index n_m, the optical path of a laser beam focused by a Leitz NPL x 160 objective with a numerical aperture (na) of 0.95 and a focal depth $F = 70$ µm is calculated as a function of the distance h between the objective and the host crystal and the refractive index of the immersion medium n_i. The light beams do not converge to a single point along the optical axis of the system but along a segment of line of length $d = (F-h) \cdot n_m/n_i \cdot (1-(1-na^2/n_m^2)1/2/(1-na^2/n_i^2)1/2)$.

From the Gaussian energy distribution in the TEM00 laser mode, the energy distribution of light along the optical axis is calculated, as a function of the depth of the inclusion and n_m and n_i. The energy decreases strongly with the depth of the inclusion and increases by more than one order of magnitude if n_m and n_i are similar. The optical paths inside spherical fluid inclusions are very close to those calculated in the absence of fluid inclusions. Thus, the previous calculations of energy distributions remain valid and confirm the improvement expected if an immersion objective is used.

From the Placzek theory of Raman intensity the differential cross-section of Raman scattering is a function of depolarization ratio ρ and θ which is the angle between the direction of observation (without polarizer) and the electric field of the light beam: $(d\sigma/d\Omega) = A \cdot (2\rho + (1-\rho)\sin^2\theta)/(1 + \rho)$. For preliminary calculations, if θ is assumed to take all values between 0 and 90°, which is an unfavorable case never realized, the ratios between the Raman cross-sections differ by less than 13%. Consequently, the peculiar geometry of Raman scattering with a Raman microprobe does not significantly modify the Raman cross-sections determined in the classical geometry for ($\theta = 90°$).

The internal field effect is negligible for the calculation of the molar fractions because the refractive index of the analyzed medium is almost the same at the different Raman lines of gases. By contrast, using the intensity measurements of the $2\nu_2$ and ν_1 lines of CO_2 (Wang and Wright, 1973, Chem. Phys. Lett., 23, 241), it can be shown that the Raman scattering cross-section of the $2\nu_2$ CO_2 varies more than 30% as a function of density. Experimental measurements of Raman cross-section as a function of fluid compositions and densities are necessary and iterative procedures for V-X determinations have to be used from Raman data and temperatures of liquid-vapor equilibria. (Authors' abstract)

DUBESSY, J., CATHELINEAU, M., CHAROY, B., CUNEY, M., LEROY, J., NGUYEN, C., POTY, B., RAMBOZ, C. and WEISBROD, A., 1986, The effect of temperature, fO_2

and pH on the distribution (in space and time) of U and Sn-W mineralizations associated with Hercynian leucogranites (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 55 (in French). First author at GS CNRS-CREGU, BP 23, 54501 Vandoeuvre Cedex, France.

Hercynian leucogranites have a high U and Sn-W background, but U and Sn-W deposits occur always separated in space and time. The behavior of these three elements is similar at the magmatic stage; their different behavior must therefore be related to physico-chemical parameters at the hydrothermal stage between 300 and 500°C.

Iron oxide and sulfides associated with the U deposits show that fO_2 and fS_2 are always at or above the conditions of the triple point pyrite-hematite-magnetite. The stability of feldspar that is slightly altered to muscovite indicates neutral pH. Fluid inclusions in most Sn-W deposits contain CO_2-CH_4-N_2 and their compositions indicate fO_2 values between Ni-NiO and Q-F-M, whereas their pH-values range from acid (in greisens) to neutral.

The solubility of SnO_2, $FeWO_4$ and $CaWO_4$ as a function of T and fO_2 shows an opposite behavior from UO_2. At neutral pH, a high fO_2 (>H-M) is needed to transport U. The Sn-W fluids are too reduced and too high in T to transport U. Below 350°C the stability of U complexes increases and the fO_2 probably is not buffered anymore by equilibria in the C-O-H system. Therefore, the low T fluids can play a role in the formation of U deposits, after they have deposited most of their Sn and W. (Authors' abstract; translated by R. Kreulen)

DUBESSY, Jean, GEISLER, Dominique, KOSZTALOANYI, Chareles and VERNET, Michel, 1982, Détermination à la microsonde à effet Raman (MOLE) de l'ion sulfate dans des inclusons fluides de halites actuelles (Camargue, France): Sciences de la Terre, v. 24, no. 2, p. 197-212, 1982.

See Fluid Inclusion Research, v. 16, p. 62, 1983. (E.R.)

DUBESSY, Jean and RAMBOZ, Claire, 1986, The history of organic nitrogen from early diagenesis to amphibolite facies: Mineralogical, chemical, mechanical and isotopic implications (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 171-174. First author at CREGU, GS-CNRS-CREGU, BP 23, 54501 Vandoeuvre les Nancy Cedex, France.

Gas chromatography and Raman spectrometry have provided strong evidence that N_2 is a common fluid component in the continental crust. Despite this evidence, the influence of nitrogen on geological processes has seldom been considered. The purpose of this paper is to show that, far from being inert, nitrogen is involved in major mineralogical, chemical and mechanical processes. (Authors' abstract)

DUCKETT, L.M., HOLLIFIELD, J.M. and PATTERSON, C.S., 1986, Osmotic coefficients of aqueous $CaCl_2$ solutions from 3 to 12 m at 50°C: J. Chem. Eng. Data, v. 31, p. 213-214.

DUDKIN, O.B. and SKIBA, V.I., 1986, Role of alkaline carbonate melts during formation of the apatite rocks: Dokl. Akad. Nauk SSSR, v. 290, no. 4, p. 916-920 (in Russian). Authors at Geol. Inst. of Kola Div. of Acad. Sci. USSR, Apatity, USSR.

The "system" $Ca_5(PO_4)_3F$-Na_2CO_3 was studied by DTA and quenching methods under 1 atm air and 1.5 atm CO_2 pressures at T 600-1600°C. Alkaline-carbonate melt is able to contain up to 15 wt. % of dissolved apatite at T close to the solidus of the phonolite magma. Crystallization of such apatite from melt occurs rapidly on relatively small T decrease. This explains the high apatite content in the neck facies of many carbonatite volcanoes. (Abstract by A.K.)

DUIT, Willem, JANSEN, J.B.H., VAN BREEMEN, Arno and BOS, Ariejan, 1986, Ammonium micas in metamorphic rocks as exemplified by Dôme de l'Agout (France): Am. J. Sci., v. 286, p. 702-732. Authors at Dept. Geochem. & Exper. Petrology, State Univ. Utrecht, Budapestlaan 4, 3584 CD Utrecht, The Netherlands.

Ammonium-bearing micas were studied in metamorphic, pelitic, and granitic rocks, mostly from Dôme de l'Agout (France). From the + biotite isograd into the gneisses and anatexites, the average NH_4+ concentrations decrease for the muscovite from 500 to 120 ppm and for the biotite from 1500 to 300 ppm. Although average NH_4+ concentrations decrease with the increase of metamorphism there is considerable scatter in the NH_4+ concentrations of both micas at any metamorphic grade. This scatter is mainly a reflection of local variation in nitrogen concentrations in the original rocks. The nitrogen itself is considered to be of sedimentary origin. Distribution coefficients of NH_4+ between muscovite and biotite are fairly constant for 21 samples (avg. 0.33; std. deviation 0.06). They may represent an equilibrium or near equilibrium distribution. The breakdown of NH_4+-bearing minerals during prograde and especially during retrograde metamorphism seems to be the main process responsible for the high nitrogen concentrations in fluid inclusions in Dôme de l'Agout. (Authors' abstract)

DUJON, S.C. and LAGACHE, M., 1986, The influence of fluid unmixing on cation exchange between plagioclases and aqueous chloride solutions at 700°C, 1 kbar: Contrib. Min. Pet., v. 92, p. 128-134.

DUKE, E.F. and RUMBLE, Douglas III, 1986, Textural and isotopic variations in graphite from plutonic rocks, south-central New Hampshire: Contrib. Mineral. Petrol., v. 93, p. 409-419. First author at Inst. for the Study of Mineral Deposits, South Dakota Sch. of Mines & Tech., Rapid City, SD 57701-3995, USA.

Graphite occurs in two distinct textural varieties in syntectonic granitoids of the New Hampshire Plutonic Series and in associated metsedimentary wall rocks. Textural characteristics indicate that coarse graphite flakes were present at an early stage of crystallization of the igneous rocks and thus may represent xenocrystic material assimilated from the wall rocks. The range of $\delta^{13}C$ values determined for flake graphite in the igneous rocks (-26.5 to -13.8‰) overlaps the range for flake graphite in the wall rocks (-26.0 to 16.7‰), and spatial correlation of some $\delta^{13}C$ values in the plutons and wall rocks supports the assimilation mechanism. The textures of fine-grained irregular aggregates or spherulites of graphite, on the other hand, indicate that they formed along with secondary hydrous silicates and carbonates during retrograde reactions between the primary silicates and a carbon-bearing aqueous fluid phase. Relative to coexisting flake graphite, spherulitic graphite shows isotopic shifts ranging from 1.9‰ higher to 1.4‰ lower in both igneous and metasedimentary samples.

The observed isotopic shifts and the association of spherulitic graphite with hydrous silicates are explained by dehydration of C-O-H fluids initially on or near the graphite saturation boundary. Hydration of silicates causes dehydration of the fluid and drives the fluid composition to the graphite saturation surface. Continued dehydration of the fluid then requires coprecipitation of secondary graphite and hydrous silicates and drives the fluid toward either higher or lower CO_2/CH_4 depending upon the initial bulk composition. Isotopic shifts in graphite formed at successive reaction stages are explained by fractionation of ^{13}C between secondary graphite and the evolving fluid because ^{13}C is preferentially concentrated into CO_2 relative to CH_4.

Epigenetic graphite in two vein deposits associated with the contacts of these igneous rocks is generally enriched in ^{13}C (-15.7 to 11.6‰) relative to both the igneous and wall-rock $\delta^{13}C$ values. Values of $\delta^{13}C$ vary by up to 3.4‰ within veins, with samples taken only 3 cm apart differing by 2.0‰. These variations in $\delta^{13}C$ correlate with textural evidence showing sequential deposition of different generations of graphite in the veins from fluids which differed in proportions of carbon species or isotopic composition (or both). (Authors' abstract)

DUNBAR, N.W. and KYLE, P.R., 1986, H_2O and Cl contents, and temperature of Taupo volcanic zone rhyolitic magmas (abst.): Int'l. Volcan. Congress, Auckland, N. Z, Abstracts, p. 148. Authors at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

The Taupo Volcanic Zone, New Zealand, has been a major rhyolitic eruption center over the last 0.5 m.y. In this study, the pre-eruptive volatile content and magmatic temperatures were examined in a number of tephra units.

H_2O content in rhyolitic obsidian clasts from tephra units vary from 0.3 to 2.6 wt.%. A degassed obsidian flow sample contains 0.1 wt.% H_2O, close to estimates for atmospheric equilibrium of water in silicate glass.

Chlorine was measured in obsidian clasts, and in melt inclusions in magmatic phenocrysts. The melt inclusions have major element composition similar to the obsidian but are enriched in Cl. Cl contents of melt inclusions range from 0.18 to 0.24 wt.%. Sulfur contents were below the detection limit of 200 ppm. The Cl analyses show that the obsidian is partially degassed relative to the parental melt. There is a positive correlation between the average water and Cl contents in obsidian clasts, indicating that the two volatile species degas at approximately the same rate. An original magmatic water content of between 2.5 and 4.0 wt.% has been estimated by extrapolating the Cl/H_2O correlation of the Cl content of glass inclusions. (From the authors' abstract)

DUNLOP, H.M. and FOUILLAC, A.M., 1986, Isotope geochemistry of Oman basic-ultrabasic rocks and chromite deposits, in Metallogeny of basic and ultrabasic rocks: Spec. Pub. Inst. Mining & Metallurgy, p. 291-304. First author at Sys. d'Analyse de Surface des Matériaux, Orléans Cedex 2, France.

δD values of minute fluid inclusions in fresh spinels from chromite ore (δD = -56 to -79‰) are typical of magmatic waters and radiogenic isotope ratios of chromitite (ε Nd = +8.5) and diopside (ε Nd = +9.2, $^{87}Sr/^{86}Sr$ = 0.70385) are compatible with the overlying crustal sequence and to primitive arcs - back arc basins. These results are consistent with the hypothesis that the Semail ophiolite formed in a supra-subduction zone setting. Whole rock oxygen analyses of 14 harzburgites (mean = 6.1‰) reflect a low T modification during late stage, post ophiolite emplacement serpentinization (unaltered harzburgite has a calculated value of 5.4‰). Marked seawater interaction did not penetrate below the MOHO during the oceanic stage of the ophiolite's evolution. Alkali- and volatile-rich fluids which migrated from the subducted slab and re-equilibrated with the overlying mantle wedge could have provoked chromite crystallization. (From the authors' synopsis)

DUPUY, J.-J. and TOURAY, J.-C., 1986a Multistage ore deposition at the Oued Mekta strata-bound lead deposit, Touissit-Bou Beker district, eastern Morocco: Econ. Geol., v. 81, p. 1558-1561. Authors at Lab. Métal. & Géochimie Min., Univ. d'Orléans, 45067 Orléans-Cédex, France.

Th of ~50 inclusions in sphalerite ranged from 73 to 101, with most 85-95°C. Salinities were ~23 equiv. % NaCl. No trapped hydrocarbons were found. (E.R.)

DUPUY, J.-J. and TOURAY, J.-C., 1986, The stratabound lead deposit from Oued Mekta (Touissit-Bou Beker district, Pays des Horsts, eastern Morocco): Chron. Rech. Min., no. 485, 1986, p. 17-32 (in French; English abstract). Authors at Lab. Métal. & Géoch., ESEM, Univ. d'Orléans, 45067 Orléans Cedex 02, France.

Includes a brief reference to saline fluids (p. 31). (E.R.)

ĎURIŠOVÁ, J., KNYAZEVA, S.N. and SUSHCHEVSKAYA, 1985, Composition of the fluids forming the tin-tungsten deposits of the Krušné hory (Erzgebirge) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 141-141 (in Russian; translation by Dorothy B. Vitaliano). First author at Vernadsky Inst. Geochem. & Anal. Chem., USSR Acad. Sci., Moscow, USSR.

1. The high-temperature deposits of the Krušné hory are a classic example of the formation of economic tin mineralization of quartz-cassiterite type in close association with highly differentiated granitoid intrusions. Typical features of the mineralizing fluids found in inclusions in quartz, topaz, and cassiterite of the ore veins and associated greisens are low density, low salinity (~2-3 wt.% NaCl equiv.), high temperature (>390°C), moderate pressure (<800 bar), and heterogeneous solutions.

2. The composition of the gas phase of the fluids was determined by gas chromatography using thermal decrepitation. The samples were first treated with hydrochloric acid and acetonitrile in accordance with previous operating procedure. According to the data on Th and preliminary experiments, the following decrepitation temperatures were used for the samples of the ore veins and greisens: S inclusions, 350°C; P inclusions, 700°C. Thus the analyzed range of composition of the fluids corresponds to 300-650°C.

3. The fluids forming the Krušné hory tin-wolframite veins and greisens are characterized by a unique composition of the gas phase: with the predominance of CO_2 fairly typical of hydrotherms of various types, the gas relationships seems to be $CO_2 > N_2 > CO \geqslant CH_4$.

The concentration of CO_2, amounting to an average of 1.5 m for the fluid inclusions of samples from the ore veins, is substantially higher than the corresponding values for the greisens. In accordance with this, the arrival of CO_2 in the hydrothermal system, directly related to the formation of vein inclusions, should be presumed. At the level of the measurements that were made, however, it is impossible to relate the heterogenization of the ore fluid and the formation of tin-tungsten mineralization. (Authors' abstract)

DUSCHEK, A., KUMANN, R. and BAUMANN, L., 1986, The hydrothermal paragenesis of the tin-ore-deposit Ehrenfriedersdorf, in Probleme der Parageneses. Topical Report of IAGOD, v. XV-1985, Freiberger Forschungshefte, Veröffentlichung Nr. 1841 (in German).

In the present publication all known mineralizations in the region Ehrenfriedersdorf are analyzed, listed and treated. Similarities could be found among all hydrothermal vein-ore-formations known from the Erzgebirge. The diagram (fig. 1) gives a general view of the paragenetic and structural development of the mineralizations in the Variscan and post-Variscan forming period.

The tectonic analysis showed a distinct relationship of the equivalents from the first mineralization cycle on E-W to ENE-WSE-elements, whereby the NNW-SSE-structure-element gets an increasing importance. A closer assignment is not possible for the formations of the second mineralization cycle.

Mineralized structures were reactivated several times and covered with younger mineralizations (fig. 5 and 6).

Some [new] thermometric data can easily be compared with earlier results (fig. 2). [New data on inclusion cation composition are provided.] (Authors' abstract, translated by H.A. Stalder and modified by E.R.)

DUSSELL, Eric, 1986, Listwanites and their relationship to gold mineralization at Erickson mine, British Columbia, Canada: MS thesis, Western Washington Univ.

"Listwanites" are silica-carbonate metasomatic rocks derived by the hydrothermal alteration of serpentinized ultramafics. Because listwanites host or are spatially associated worldwide with Hg, Au, Ni, Co and W deposits, it is probable that they contribute to the process of ore formation.

Erickson Gold Mine, located in northernmost central British Columbia, Canada, contains Au-quartz veins which cut numerous bodies of listwanite. Au values are frequently higher in those portions of quartz veins which cut or directly underlie a listwanite body. The main objective of this study is to determine how the listwanites at Erickson might have controlled or affected Au mineralization.

From thermodynamic calculations based upon a mineralogical and fluid-inclusion study of the Erickson lodes, it was determined that gold was transported predominantly as the bisulfide complex, $Au(HS^-)_2$ in a moderately saline ore solution.

It is proposed that the ore solution infiltrated and metasomatized bodies of partially serpentinized peridotite, producing a mineralogically zoned rock called "listwanite." Au precipitation was triggered by a decrease in the sulfur activity resulting from chemical reactions set up by fluid mixing. This process may account for the common association between listwanites and Au-quartz deposits elsewhere. (Author's abstract)

DYMKIN, A.M., BOBYLEV, I.B., ANFILOGOV, G.I. and ANFILOGOV, V.N., 1986, The effect of CaO on liquid immiscibility in melts of the system leucite-fayalite-silica: Dokl. Akad. Nauk SSSR, v. 288, no. 5, p. 1201-1204. Authors at Inst. Geol. & Geochem. of Urals Sci. Center of Acad. Sci., Sverdlovsk, USSR.

In the cross-section Lc-An-0.55Fa$\cdot$0.45SiO_2 at 1273-1423 K and PO_2 $\sim 10^{-11}$ mm Hg, the most extensive immiscibility field is observed at 1323-1373 K; T increase quickly causes the homogenization of melt. At T <1323 K the immiscibility field also decreases due to crystallization of the melt components. Superliquidus immiscibility occurs at ~1423 K, and at T ≤ 1373 K practically whole immiscibility field is subliquidus with respect to fayalite and leucite or tridimite and fayalite. Immiscibility was observed down to 1273 K and it was found only in samples quenched in water or liquid Wood alloy but not in specimens quenched in air at room T, when only globular anisotropic inclusions were found in homogeneous glass, since cooling was too slow. Adding anorthite to the system Lc-Fa-SiO_2 causes quick decrease of the immiscibility field, which is detectable up to An content 15 wt.% (3 wt.% CaO), when the initial melt contained ~60 wt.% SiO_2. Such low CaO contents are rare in magmatic melts of the intermediate composition. The immiscible phases are high-SiO_2 low FeO and low-SiO_2 high FeO (electron microprobe analyses). (Abstract by A.K.)

DZAINUKOV. A.B., FAIZIEV, A.R., AVER'YANOV, G.S., ISKANDAROV, F.Sh., KORYTOV, F.Ya. and KOPLUS, A.K., 1986, Pamirs - a fluorite-containing province of the USSR: Dokl. Akad. Nauk SSSR, v. 286, no. 3, p. 678-679 (in Russian). Authors at Upr. Geol., Dushanbe, USSR.)

Mineralogically, the hydrothermal fluorite ore deposits of the Pamirs can be grouped into (1) rare metal-sulfide-fluorite (Alichur), (2) quartz-fluorite (Kulak-Keste, Kara-Dzhilga), (3) quartz-carbonate-fluorite

(Akdzhilga, Elisu, etc.), (4) sulfide-fluorite (Sasyk), (5) barite-quartz-fluorite (Pereval'noe), and (6) stibnite-fluorite (Dzhaambai) types. Thermobarogeochemical studies show that the temperature of mineral formation in fluorite occurrences of the Pamirs ranges from 85 to 700°. The rare earth-fluorite mineralization is the highest temperature type (320-700°). The total concentration of salts (chlorides of Na, K, Ca and other components in the ore-forming fluids was 4-75%. The dominant fluorite ore mineralization has an age of 25-14 Myr and is localized in F-rich (0.67%) potassic alkaline basaltic rocks. (C.A. 104: 171752s)

DZULYNSKI, S. and SASS-GUSTKIEWICZ, M., 1985, Hydrothermal karst phenomena as a factor in the formation of Mississippi Valley-type deposits, in K.H. Wolf, ed., Handbook of strata-bound and stratiform ore deposits, Part IV, Vol. 13, Regional studies and specific deposits: Amsterdam Elsevier Sci. Pub., p. 391-435.

EAKIN, Paul, 1986, Hydrocarbon-hosted uranium mineralization in the north Wales and Isle of Man areas (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 8. Author at Dept. Geol., Queen's Univ. of Belfast, Belfast, TY7 1NN.

Uranium-bearing hydrocarbons are associated with low temperature, hydrothermal Pb/Zn and Cu sulphide deposits in the North Wales and Isle of Man areas. The metallic veins are hosted in Lower Carboniferous limestones, or in Lower Palaeozoic rocks, where pre-existing Dinantian strata are presumed to have been removed by erosion.

Uranium concentrations within the hydrocarbons range from 1.36% to 9.6%. The metal occurs as uraninite distributed as regular arrays of inclusions in a pattern indicative of exsolution from a metal-saturated hydrocarbon. The organics are sulphur-enriched, the sulphur concentration increasing with that of uranium to a point of saturation, by complexing of the hexavalent ion in the mineralizing solutions to the oxygen-bearing functional groups of the organic matter. Later episodes of sulphate-reduction produce sulphide ions which reduce U (VI) in complex to U (IV) in uraninite which exsolves from the hydrocarbon.

Other occurrences of uraniferous hydrocarbon from southern Scotland and central England reflect either alteration and replacement of uraninite veins by hydrocarbons, or minor enrichments of organic matter by uranium (~30 ppm).

Some uraniferous hydrocarbons also host a suite of Ni/Co/As minerals predominantly of the niccolite and gersdorffite series. (Author's abstract)

EASTOE, C.J. and EADINGTON, P.J., 1986, High-temperature fluid inclusions and the role of the Biotite Granodiorite in mineralization at the Panguna porphyry copper deposit, Bougainville, Papua New Guinea: Econ. Geol. v. 81, p. 478-483. First author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

Fluid inclusions of salt-rich liquid and vapor were trapped in quartz phenocrysts of the Biotite Granodiorite of Panguna. Textural evidence indicates that the fluid inclusions are primary. On the basis of Th and Tm NaCl data, the salt-rich liquid is clearly different from that trapped in a nearby vein in one specimen and may also be different in two other specimens. Thus, there is evidence that the salt-rich liquid and vapor are of magmatic origin and coexisted with silicate melt as the Biotite Granodiorite crystallized. The fluids bore copper but did not bring about significant mineralization beyond the intrusion. High homogenization temperatures, near 1,000°C, of the salt-rich inclusions cannot be reconciled with experimental data for artificial silicate melt-water systems at present. (Authors' Conclusions)

EDMOND, J.M., CAMPBELL, A.C., PALMER, M.R. and KLINKHAMMER, G.P., 1986, Preliminary report on the chemistry of hydrothermal fluids from the Mid-Atlantic Ridge (abst.): EOS, v. 67, p. 1021. Authors at Dept. Earth, Atmos. & Planet. Sci., M.I.T., Cambridge, MA 02139.

Hydrothermal fluid samples were obtained in May/June of 1986 from two active vent sites at 26°N (TAG) and 23°N (MARK) on the Mid-Atlantic Ridge. The occurrence of hydrothermal vents at slow spreading rate centers was unknown until recently. This is the first opportunity to compare and contrast their solution composition and temperature with vent waters from moderate and fast spreading centers on the East Pacific Rise. The highest temperature measured at a black smoker at the MARK site was 350°C and was reproducible to 0.1°C. A water sample from this chimney that was 98% hydrothermal fluid had a pH of 4.02 ± 0.08 and an alkalinity of -64 μEq. The end member concentrations for several fluid components were as follows: $Si(OH)_4$ - 17.80 mM, H_2S - 5.8 mM, Cl^- - 0.558 mM, Mn - 483 μm, and Fe - 2136 μM. Another vent at the MARK site had a measured temperature of 335°C, a pH of 3.66 ± 0.02 and an alkalinity of -243 μEq ± 14. The end member values for this vent were $Si(OH)_4$ - 18.3 mM, H_2S - 6.0 mM, Cl^- - 0.559 mM, Mn - 506 μM and Fe - 1848 μM. Despite the much greater depth of these vents (3700 m) relative to those at 21°N EPR (2600 m) they display similar fluid compositions. Dissolved silica concentrations are slightly higher, but this appears to be a reflection of the greater water depth. The boron isotope values for the MARK fluids are distinctly different from the 21°N fluids. (Authors' abstract)

EGGLESTON, Ted and NORMAN, D.I., 1986, Vapor phase crystallization related to the origin of tin deposits, Black Range, New Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 593. Authors at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Veinlets of hematite, cassiterite, and wood tin occur in high silica rhyolite domes. Topaz and quartz are found as drusy linings in lithophysae and as gangue associated with the veinlets. The tin mineralization and recrystallization of the host rhyolites is believed to be the result of vapor phase crystallization (VPC).

Vapor-filled inclusions and inclusions filled with glass, vapor, and as many as 5 daughter minerals occur in cassiterite, quartz, and topaz. Microthermometric studies of the glass-bearing inclusions show that at about 350°C, the glass melts to form liquid-vapor inclusions that homogenize to liquid at about 670°C. Two daughter minerals dissolve between 600 and 650°C and an opaque daughter mineral does not dissolve. Similar inclusions are found in quartz overgrowths on quartz phenocrysts from zones of intense VPC. The glass in these inclusions melts at about 500°C but the inclusions do not homogenize below 680°C, suggesting higher trapping temperatures than for the associated tin mineralization. Hematite replaces magnetite in the veinlets and indicates that the log $f(O_2)$ is above -13. $\delta^{18}O$ of quartz phenocrysts and quartz in the lithophysae is about +7.5%.. In zones of intense VPC the host rhyolite exhibits an increase in groundmass crystallite size from about 0.1 mm to 0.5 mm; Rb, Th, Nb, and Ta are depleted; Sr and the REE are enriched; and $\delta^{18}O$ is unchanged.

These data indicate that the fluids responsible for the recrystallization and tin mineralization were high temperature, high $f(O_2)$, boiling, magmatic fluids. These fluids also deposited tin in response to very high thermal gradients at margins of the host rhyolite domes.

Passage of the fluids responsible for VPC produce significant changes in trace element distributions of the effected rhyolites. (Authors' abstract)

ELLISON, A.J. and HESS, P.C., 1986, Partitioning of rare earth elements between immiscible liquids of the system SiO_2-TiO_2-Al_2O_3-MgO-CaO-K_2O (abst.): EOS, v. 67, p. 415.

ELPHICK, S.C., DENNIS, P.F. and GRAHAM, C.M., 1986a, An experimental study of the diffusion of oxygen in quartz and albite using an overgrowth technique: Contrib. Mineral. Petrol., v. 92, p. 322-330.

ELPHICK, S.C., DENNIS, P.F. and GRAHAM, C.M., 1986b, The relationship between oxygen and hydrogen diffusivity in minerals and the speciation of the grain boundary fluid (abst.): Mineral. Soc. Bull., no. 73, Dec. 1986, p. 7.

EMO, G.T., 1986, Some considerations regarding the style of mineralization at Harberton Bridge, County Kildare, *in* Geology and genesis of mineral deposits in Ireland, C.J. Andrew et *al.*, eds.: Irish Assoc. Econ. Geol., p. 461-469. Author at Prospex Ireland Ltd., Robinstown, Mullingar, Co. Westmeath.

Cites fluid inclusion data of Finlow-Bates (pers. comm.) that fluids were warm (~100°C) and very acidic at this Zn-Pb-Fe mineralization. (E.R.)

ENTING, I.G. and MANSBRIDGE, 1985, The effective age of bubbles in polar ice: PAGEOPH, v. 123, p. 777-790. Authors at CSIRO, Div. Atmos. Research, Private Bag 1, Mordialloc, Victoria, 3195, Australia.

A mathematical description of the trapping of air bubbles in polar ice is analyzed in order to assist in the interpretation of measurements of anthropogenic constituents which have recently increased on time scales comparable to the firn closure time. The effective age of a layer of ice is defined in terms of the time at which the atmospheric concentration of a constituent was equal to the mean concentration for bubbles found in that layer. Under the assumption of uniform snow deposition at a particular site, the effective age is found to be the same for all constituents that vary linearly throughout the trapping period for a layer. Using a trapping distribution based on theoretical and observational studies, the corrections for non-linearity are found to be small for typical anthropogenic constituents.

This property makes it possible to use smoothly increasing tracers such as the chlorofluorcarbons to determine the effective age empirically, even though it is an extremely poorly-conditioned problem to determine the entire trapping time distribution function by inversion of tracer concentrations. (Authors' abstract)

EPLER, N.E., BOLSOVER, L.R. and LINDSLEY, D.H., 1986, Nature and origin of the Sybille Fe-Ti oxide deposit, Laramie anorthosite complex, SE Wyoming (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 595. Authors at ESS Dept., State Univ. of New York, Stony Brook, NY 11794.

Fe-Ti oxide bodies are ubiquitous and enigmatic adjuncts to virtually every (Proterozoic) massif anorthosite. In field occurrence they appear to have intruded as magmas, but the mechanism for producing oxide magmas is unclear. The Sybille deposit consists mainly of ilmenomagnetite and ilmenite, with lesser amounts of green spinel, olivine, pyrrhotite, and graphite. Apatite is very patchy: it comprises less than one percent of most ore, but locally 50% or more, especially in the upper portions of the ore body and adjacent to anorthosite. The oxide body in places grades upwards into a coarse-grained troctolite; both units crosscut host anorthosite with sharp contacts, suggesting that at least some oxide formed by gravity separation from an oxide-rich troctolitic magma. Experiments on a rock that approximates such a magma, and with carbon, apatite, and Fe phosphate as candidate fluxes, show melting of silicates in the range

1050-1150°C but no unequivocal evidence for oxide liquid up to 1200°. Apatite does, however, greatly enhance the solubility of oxides in the silicate melt. Small amounts (<3%) of water promote immiscible oxide liquid at 1200°C; the minimum temperature for such melts has not yet been established. Little direct evidence for the presence of water is seen in the Sybille deposit. However, textural and chemical evidence for extensive oxyexsolution of ilmenite from a primary Fe_2TiO_4-rich spinel is compatible with the inferred presence of a reduced C-H-O component in the melt. After crystallization and subsolidus oxidation of the oxides, C was precipitated as graphite and H presumably escaped. We suggest that phosphate enhances the formation of oxide-rich silicate magmas (which could explain the common occurrence of apatite in and around such ore bodies) but that the actual oxide melt may require the presence of hydrogen, perhaps together with carbon. Goldberg's data (CMP 87:376-387, 1984) shows the troctolite to be in the liquid line-of-descent of the anorthosite. (Authors' abstract)

ERGIN, M. and FRIEDMAN, G.M., 1986, Burial significance of Middle Silurian Lockport dolomite, northwestern New York (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 1, p. 15. Authors at Brooklyn College & Rensselaer Center of Applied Geol., Brooklyn College - CUNY, P.O. Box 746, Troy, NY 12181.

Petrographic, stable isotope and fluid-inclusion studies suggest the presently exposed Middle Silurian Lockport Dolomite in northwestern New York underwent deep-burial diagenesis.

The very coarse-crystalline nature of late-diagenetic saddle dolomite, relatively light oxygen isotope compositions ranging from -9‰ to -11‰ (PDB $\delta^{18}O$), high Th (avg. 150°C) and freezing point depressions of inclusion fluids from 7 to 23 wt. % NaCl equiv., all suggest diagenetic changes occurred under deep-burial conditions.

Assuming a geothermal gradient of 26°C/km, fluid inclusion Th for late-diagenetic saddle dolomite range from 110 to 200°C, revealing a former depth of burial for the Lockport Formation strata of the western Appalachian Basin up to 6.5 km, much greater than the present estimates of less than 2 km of paleogeographic reconstruction. (From the authors' abstract)

ERICKSON, C.L. and BODNAR, R.J., 1986, Determination of critical properties of aqueous solutions using synthetic fluid inclusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 595. Authors at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Relatively few data are available on the critical properties of aqueous solutions, owing to the difficulty of obtaining this information using conventional experimental techniques. In particular, the location of the critical point must be inferred from external physical measurements because the system cannot be monitored optically at the high temperatures and pressures involved. Synthetic fluid inclusions, however, provide a relatively simple and highly accurate technique for determining these parameters, because the inclusion, which contains a fluid of the critical density, is viewed through a microscope during heating. The homogenization temperature, which is identical to the critical temperature of the fluid, is measured using a thermocouple, and critical behavior at homogenization is confirmed by monitoring the mode of homogenization optically. Furthermore, the P-T trend of the critical isochore is easily determined from these data because (1) isochores are defined by straight lines over relatively small intervals of temperature and pressure and (2) the end points of this line are defined by the known formation conditions of the inclusion and the measured critical point.

To test the applicability and accuracy of this technique, the critical point of pure H_2O has been determined using synthetic fluid inclusions, and the results compared to the known critical point for pure H_2O (374°C, 220 bars). Pure H_2O synthetic fluid inclusions were trapped at 800°C and 1350 bars, and the homogenization mode and temperature of these inclusions determined using a heating-freezing stage. According to published PVT data for H_2O, inclusions formed at these conditions should contain H_2O with a density equal to the critical density, and this was confirmed by the fact that the inclusions homogenized by critical behavior at 374.2 ± 0.2°C. The intersection of the critical isochore (obtained from published data) with this measured temperature defines a critical pressure of 220 ± 5 bars, and these tests verify that synthetic fluid inclusions may be used to determine the critical properties of aqueous fluids. Results for 5 wt.% NaCl fluids indicate that the critical point lies between ~410-430°C, and that the critical isochore lies above 700°C and 1200 bars. (Authors' abstract)

ERICSON, J.E., TANG, J.Y., SHI, C.R. and TOMBRELLO, T.A., 1986, Quartz dating: Diffusion of water in quartz (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 2, p. 104-105.

EROKHIN, A.M., RUB, A.K. and NAUMOV, V.B., 1985, Pecularities of fluid regime in rare metal granites from an area in Far East (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 3-4 (in Russian; translation by S. Jaireth). First author at GEOKHI, Inst. Geochem. & Anal. Chem., Moscow, USSR.

Fluid inclusions in quartz from lower to middle Paleozoic rare metal granites of an area in Far East have been studied to decipher physicochemical parameters of fluid evolution. The porphyrytic, leucocratic biotite granites (first type) contain tin-tungsten (cassiterite-quartz formation) and tin mineralization (cassiterite-fluorite-silicate formation).

Lithium-fluorite rich granites (second type) hosting rare metal mineralization form small stocks, deeper levels of which (500 to 1200 m and more) are homogeneous protolithionitic[?] granites with their apical portions marked by albitization and greisenization. Altered granites in their upper parts contain tantalum mineralization while mica-fluorite mineralization is concentrated in the country rocks.

Quartz of biotite granites bears inclusions of high temperature supersaline fluids containing up to five solids - halite, sylvite, carbonates and opaques (ore minerals). Salinity of chloride fluids is >60 wt%. Th = 730-800°C (in few cases even higher). P - 2.0 to 8.6 kbar. Predominantly gaseous inclusions with solid phases have also been recorded. Inclusions of supersaline fluids are less common in quartz from other parts of the granite indicating non-uniformity in the regime of fluid evolution during crystallization of these granites.

Quartz of protolithionitic granites of deeper levels contain only small biphase inclusions, the size of which increases towards the apical parts. Apical parts, in addition, contain three-phase CO_2-H_2O and predominatly CO_2 inclusions (CO_2 density ≤0.83 g/cm^3). CO_2-H_2O inclusions homogenize at 350°C at pressures of about 2 kbars.

Difference in composition of fluid inclusions in the two types of granites from a single mineralized area indicates significant differences in the history of fluid evolution during crystallization of two types of granites. (Authors' abstract)

ERSHOV, E.D., 1986, Freezing of water and melting of ice in disperse rocks: Vestnik Moskovskogo Universiteta, Geologiya, v. 41, no. 1., p. 53-66 (in Russian; translated in Moscow Univ. Geology Bull., v. 41, no. 1, p. 55-67, 1986).

The foundations of the crystallization of water in disperse rocks from physicochemical and thermodynamic aspects are given, and the phase transformations of bound water and ice in a range of subzero temperatures are discussed. (Author's abstract)

ETMINAN, Hashem, DUBESSY, J., KOSZTOLANYI, C., LAMBERT, I.B. and GROVES, D.I., 1986, Laser Raman microprobe studies of fluid inclusions in bedded barite from North Pole, Pilbara Block, W.A. (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 96. First author at Baas Becking Lab., G.P.O. Box 378, Canberra, 2601, Australia.

Barite from the ca. 3.45 b.y. old sedimentary sequence at North Pole appears to have formed largely by replacement of evaporitic gypsum. $\delta^{34}S$ values for the barite are concentrated around 3‰, implying that sulfate was generated by surficial oxidation of reduced sulfur (possibly by photosynthetic bacteria). Fluid inclusions are very abundant in bedded barite from North Pole and have been studied to obtain information on the physicochemical conditions of baritization. The fluid inclusions are 1 to 15 µm, but most are between 3 and 7 µm. Because of cleavages and abundant microfractures, the origin of fluid inclusions cannot be ascertained without ambiguity. Large, isolated fluid inclusions could be of P origin.

S fluid inclusions occur along microfractures and appear to represent several generations of fluids. The isolated large fluid inclusions consist mainly of a vapor phase (25-35 volume %), an immiscible liquid (CO_2), an aqueous solution and in places a small cubic daughter mineral (halite?). Occasionally one of several irregular shaped, birefringent and/or opaque phase(s) are also observed. Microthermometry measurements on these inclusions reveals a limited range of Th (CO_2 gas to liquid at 24 to 31°C), suggesting that the internal P (at 40°C) for these fluid inclusions is ~120 bars. Due to decrepitation (Td), Th cannot be obtained. Td vary from 150-220°C. Laser Raman microprobe studies of these inclusions show that CO_2 is the major and H_2S the minor constituent of the gas phase. In one inclusion N_2 and CO were also detected. The average composition of the fluid inclusions (with no dm) based on microthermometry and laser Raman microprobe studies is: H_2O = 80.70, NaCl (equiv) = 10.64, CO_2 = 8.39, H_2S = 0.26 mol %. The hydrothermal fluids trapped in the barite could be representative of the baritizing fluids or of fluids present during subsequent recrystallization. (Authors' abstract)

ETMINAN, H. and LAMBERT, I.B., 1986a. Fluid inclusion studies in carbonate hosted lead-zinc mineralization, Canning Basin, W.A. (abst.): Eighth Australian Geol. Conv., Geol. Soc, of Australia, "Earth Resources in Time and Space," Feb. 16-21, 1986, Flinders Univ., Adelaide, Abstracts, no. 15, p. 66. Authors at Baas Becking Geobiological Lab., Bureau of Min. Resources, Canberra.

The Pb-Zn mineralization of Wagon Pass is concentrated in a semi-massive lens in fore-reef facies of the Frasnian and Famenian Virgin Hills Formation. The country rocks are dolomitized and chloritized and contain late calcite spar. At Pillara Pb-Zn mineralization occurs in calcite-rich veins and breccia cements in the ca. 600 m thick platform facies Pillara Limestone; there is no dolomitization associated with this mineralization.

Fluid inclusion studies on Wagon Pass samples reveal that brines at 70-110°C were involved in the formation of dolomite closely associated with mineralization. Tm[ice?] measurements were complicated by the formation of waxy phases but limited measurements indicate high salinities. At Pillara Tm in sphalerite vary between -15 and -32°C; Tm below the eutectic of NaCl-H_2O system (-20.8°C) imply the presence of major concentrations of Ca and/or Mg in solution. Th in sphalerite varies between 70 and 110°C.

The wide range of Tm and Th in early and late veins at Wagon Pass and at Pillara are consistent with variable degrees of mixing of ascending basinal brines with relatively low salinity waters of marine and meteoric derivation. This interpretation is in accord with isotopic data for early and late cements. Further evidence for the role of basinal brines comes from the presence of hydrocarbons in fluid inclusions. Application of laser Raman microprobe and Fourier transform infrared micro-spectrometry has permitted the detection of aliphatic and aromatic hydrocarbons in fluid inclusions in sphalerite and in dolomite at varying distances from mineralization.

The purplish color zoning in crystalline sphalerite from Pillara has been found to be caused by aromatic and aliphatic hydrocarbons which have comparable infrared absorption bands to the hydrocarbon-bearing fluid inclusions in clear zones of Pillara sphalerite, and to the Blina crude oil (Canning Basin).

Abundant oil inclusions have been found in late barite associated with saddle dolomite and Pb-Zn sulphides elsewhere in the basin. The association of hydrocarbons with Pb-Zn mineralization and later barite provides further information on timing and genesis of petroleum and metal-bearing fluids in this region. (Authors' abstract).

ETMINAN, Hashem and LAMBERT, I.B., 1986. Fluid inclusion studies of mineralized and unmineralized Devonian carbonates, Canning Basin, western Australia (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 96-97. (Also in Proc. Eighth Australian Geol. Conv., Geol. Soc. Australia, Earth Resources in Time and Space, Feb. 1986, Abstracts, v. 15, p. 66.) Authors at Baas Becking Lab., G.P.O. Box 378, Canberra, 2601, Australia.

Paleofluids trapped as inclusions in carbonate, sulphate and sulfide cements in carbonate reef complexes of the Lennard Shelf have been studied in an attempt to elucidate the origin and nature of diagenetic fluids and their role in oil and metal accumulation. Early carbonate cements are commonly too fine grained to see fluid inclusions, but the spars contain minute single-phase inclusions. Isotopic values suggest the early cements are predominantly marine. Later sparry cements from unmineralized areas formed mainly between 40 and 110°C from fluids that were variably more saline than sea water. Together with isotopic features, these data imply that later carbonate cements formed from waters which incorporated brines from different depths in the basin; the general absence of hydrocarbons in the inclusions implies that the hotter brines were derived from organic-poor strata. In sphalerites from the Pillara Pb-Zn prospect, Th are between 70 and 110°C and Tm [ice?] range from -15 to -32°C. Laser mass spectrometry reveals appreciable amounts of Ca (but no Mg) in the aqueous phase of the fluid inclusions, which explains the low Tm. Laser Raman and infrared microprobe studies show that aliphatic and aromatic hydrocarbons occur in fluid inclusions in the sphalerite and that purplish zones in this mineral have relatively high proportions of hydrocarbons. Fluid inclusion data from some Pillara calcite and from dolomite at the Wagon Pass Pb-Zn prospect are comparable to those from Pillara sphalerite. Oil inclusions also occur in barite which formed penecontemporaneously with minor Pb-Zn mineralization in the southern Canning Basin. The atomic ratio of K/Na (0.02 to 0.07) of fluids extracted from minerals in the Lennard Shelf Pb-Zn deposits are higher than in most oil field brines and are comparable to values from other M.V.T. deposits. The available fluid inclusions and isotopic data from the mineralized areas are consistent with major contributions of brines which ascended from, or through, zones of hydrocarbon generation deep in the basin. These brines mixed to varying degrees with less saline waters of marine and meteoric derivation. K was probably enriched by interaction with K-rich minerals in the basin strata, and it may have played an important role in release of metal ions to the basinal brines. (Authors' abstract)

ETMINAN, Hashem, SUMMONS, Roger and LAMBERT, Ian, 1986, Hydrocarbon fluid inclusions and timing of oil migration: BMR Res. Newsletter [Bureau of Min. Resources, Canberra, Australia], no. 5, back page and p. 15.

A review of various procedures used to study fluid inclusions in oil-basin rocks (UV microscopy, microthermometry, laser Raman microprobe, Fourier transform IR microprobe, GC and GC-MS. (E.R.)

EUGSTER, H.P., 1986, Minerals in hot water: Am. Mineral., v. 71, p. 655-673. Author at Dept. Earth & Planet. Sci., Johns Hopkins Univ., Baltimore, MD 21218.

A thorough review of the geochemistry of hydrothermal solutions.(E.R.)

EUGSTER, H.P. and WILSON, G.A., 1985, Transport and deposition of ore-forming elements in hydrothermal systems associated with granites, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 87-98. Authors at Dept. Earth & Planet. Sci., John Hopkins Univ., Baltimore, MD, USA.

See previous item and Eugster, 1985, Fluid Inclusion Research, v. 18, p. 112. (E.R.)

EVAN, B., HICKMAN, S.H. and BRANTLEY, S.L., 1986, Temporal variation of permeability in rocks (abst.): EOS, v. 67, p. 242. First author at Dept. Earth, Atmos. Plan. Sci., M.I.T., Cambridge, MA 02139.

Fluid inclusion and crack petrology studies often indicate episodic fluid flow along several generations of fractures, and evidence for sealed cracks is very common. In some cases oxygen isotope analyses suggest that fluid flow was local in scale, but, in other cases, large volumes of water may have transited a particlar formation, implying the persistence of (possibly sporadic) fluid flow for a long period of time. (From the authors' abstact)

EVANS, B., HAY, R.S. and SHIMIZU, N., 1986, Diffusion-induced grain-boundary migration in calcite: Geology, v. 14, p. 60-63. Authors at Dept. Earth, Atmos., & Planet. Sci., Massachusetts Inst. Technology, Cambridge, MA 02139.

Of possible pertinence to the problems of the origin of inclusions in recrystallized samples. (E.R.)

EVANS, I.B., 1986, Comments on the paper "Fission-track dating of glass inclusions in volcanic quartz" by D. Vincent, R. Clocchiatti and Y. Langevin: Earth & Planet. Sci. Letters, v. 77, p. 257-258.

EVANS, T., HARRIS, J.W., 1986, Nitrogen aggregation, inclusion equilibration temperatures (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 386-388.

EXLEY, R.A., MATTEY, D.P., BOYD, S.R. and PILLINGER, C.T., 1986, Nitrogen isotope geochemistry of basaltic glasses (abst.): Terra Cognita, v. 6, no. 2, p. 191. Authors at Dept. Earth Sci., The Open Univ., Milton Keynes, MK7 6AA, UK.

The nitrogen contents and nitrogen isotopic compositions of basaltic glasses have been measured using stepped heating and high sensitivity static vacuum mass spectrometry. Nitrogen contents are low, ranging from 0.25 to 2 ppm (average = 0.8 ppm). Most of this nitrogen is released at high T, usually with a maximum release at 1000°C. The small amounts of nitrogen liberated at lower T (<600°C) have $\delta^{15}N$(Air) values close to 0‰, suggesting surficial adsorption of atmospheric gas. The $\delta^{15}N$ values of the high T release show a large range from -4.0 to +14.0‰ (average +7.5‰), and are not correlated with N concentration. The highest $\delta^{15}N$ values (+12.0 to +14.0‰) are for tholeiitic glasses with very high $^3He/^4He$ from Loihi Seamount. MORB glasses from the Mid-Atlantic Ridge (MAR) have a small range in $\delta^{15}N$, averaging +6.8‰. MORB glass from the N. Fiji basin has $\delta^{15}N$ = +6.5‰, similar to MAR glasses, but back-arc basin basalt characterized by low $\delta^{13}C$ (-13.0‰) has much higher $\delta^{15}N$ (+12.0‰), consistent with an input of sedimentary nitrogen. The lowest measured value (-4.0‰) is for MORB glass from the Carlsberg Ridge. The glasses show a weak anti-correlation of $\delta^{15}N$ and $\delta^{13}C$ similar to that observed previously for diamonds. The data suggest that residual nitrogen in the mantle may be relatively enriched in ^{15}N. (Authors' abstract)

EXLEY, R.A., MATTEY, D.P., CLAGUE, D.A. and PILLINGER, C.T., 1986, Carbon isotope systematics of a mantle "hotspot:" A comparison of Loihi Seamount and MORB glasses: Earth & Planet. Sci. Letters., v. 78, p. 189-199. First author at Planet. Sci. Unit, Dept. Earth Sci., The Open Univ., Walton Hall, Milton Keynes MK7 6AA, UK.

The carbon isotope geochemistry of glasses from Loihi Seamount has been compared with that of MORB glasses. Stepped heating shows two carbon components in both sample suites: (1) isotopically light carbon (avg. $\delta^{13}C$ = -26.3‰) released <600°C, ascribed to surficial contamination, and (2) isotopically heavy carbon released >600°C, regarded as indigenous. The high-temperature component in MORB samples varied from 52 to 169 ppm C, average $\delta^{13}C$ = -6.6‰, consistent with previous studies (overal MORB average $\delta^{13}C$ = -6.4 ± 0.9‰), and new results for Indian Ocean glasses are similar to Atlantic and Pacific Ocean samples. Carbon release profiles produced by stepped heating may be typical of locality, but there are no significant differences in $\delta^{13}C$ values between MORB samples from different areas. Lower yields (17-110 ppm C) correlated with depth in the Loihi samples suggest that they are partially degassed. This degassing has not affected $\delta^{13}C$ values significantly (avg. -5.8‰). Loihi tholeiites have higher $\delta^{13}C$ (avg. -5.6‰) than the alkali basalts (avg. -7.1‰). Carbon abundances correlate well with He concentration data. Comparison of the $\delta^{13}C$ values with trace element and He, Sr, Nd, and Pb isotope data from the literature suggests that the Loihi samples with highest $\delta^{13}C$ have high $^3He/^4He$ and possibly the least depleted $^{143}Nd/^{144}Nd$ and $^{87}Sr/^{86}Sr$. The carbon isotope data are consistent with previous models for Loihi involving several mantle sources, lithospheric contamination, and mixing. The slightly higher $\delta^{13}C$ of Loihi tholeiites suggests that the undegassed "plume" component manifested by high $^3He/^4He$ values might have $\delta^{13}C$ about 1‰ higher than the MORB average. (Authors' abstract)

FABRE, Denise and COUTY, René, 1986, Investigation on the density effects in the Raman spectrum of methane up to 3000 bar. Application to the determination of pressure in fluid inclusions trapped in minerals: C.R. Acad. Sci. Paris, v. 303, Ser. II, no. 14, p. 1305-1308 (in French; English abstract).

We have investigated the pressure shift and broadening of the Raman line ν_1 (2916.7 cm^{-1}) of methane; the compressed gas was introduced in a beryllium copper cell and observed through sapphire windows. The 5.145 Å line of an argon-ion laser, operated at 400 mw, was used as a light source. The pressure range was 2 to 3000 bar and the temperature was 293 K. The position and the width δ of the ν_1 frequency were measured with a triple monochromator. The spectra were calibrated with the spectral line at 2912.8 cm^{-1} of an argon lamp. The results are reported on table I and represented on figure 2 and can be used to determine the pressure of CH_4 in fluid inclusions trapped in minerals. (Authors' abstract)

FAIZIEV - See FAYZIYEV

FAIZOVA, F.Kh., 1986, Study of the geochemical conditions of natural mineral formation based on the triple aqueous extraction method (abst.): Geokhim. Osobennosti i Kharakteristika Rud. Assots. Mestorozhd. Kazakhstana, Alma-Ata, p. 126-132 (in Russian).

FALLICK, A.E. and HAMILTON, P.J., 1986, Hydrogen isotope studies on basaltic glasses (abst.): Terra Cognita, v. 6, no. 2, p. 190. Authors at Scottish Univ. Research and Reactor Centre, East Kilbride, Glasgow G75 0QU, Scotland.

Detailed measurements have been made on 13 well characterized glasses from a variety of contrasting oceanic settings. Replicate analyses of two samples show that different individual glass fragments from a given site can retain a wide range of δD values.

Stepwise degassing techniques have been investigated for their potential in distinguishing different hydrogen components. Control experiments on olivine inclusion water, and mica and illite bound water indicate reasonably well-behaved release characteristics with kinetics following linear Arrhenious plots. For the basaltic glasses, although systematic features emerge, interpretation of the data is not straight-forward. (From the authors' abstract)

FALLOON, T.J. and GREEN, D.H., 1986, Glass inclusions in magnesian olivine phenocrysts from Tonga: Evidence for highly refractory parental magmas in the Tongan arc: Earth & Planet. Sci. Letters, v. 81, (1986/87)(copyright 1986), p. 95-103. Authors at Geol. Dept., Univ. Tasmania, Hobart, Tasmania 7001, Australia.

During the 1984 "Natsushima" cruise to the North Tonga arc, fresh volcanic rocks were recovered from the Tongan forearc. Olivine phenocrysts in some of the dredged rocks are highly magnesian (Fo94) and contain large (up to 0.2 mm) glass inclusions. The glass inclusion chemistry, as analyzed by electron microprobe, is characterized by high CaO (>13 wt.%) and low Na_2O (<0.8 wt.%) contents, resulting in very high CaO/Na_2O ratios (18-29). Such high CaO/Na_2O ratios in glasses provide a ready explanation for the occurrence of extremely calcic plagioclase (up to An100) in the Tongan arc lavas. The prevalence of magma mixing and the existence of a spectrum of liquids, ranging to the extremely refractory glasses analyzed is a characteristic of this intra-oceanic island arc environment. High $P(H_2O)$ is not important in precipitation of extremely calcic plagioclase from common low CaO/Na_2O liquids, although water plays a significant role in controlling melting in refractory source compositions. (Authors' abstract)

FARR, M.R., 1986, Regional isotopic variation in Bonneterre Formation dolomite cements: Implications for brine migration pathways and sources (abst.): Symp. on the Bonneterre Formation (Cambrian), southeastern Missouri, May 1 and 2, 1986, Univ. of Missouri-Rolla, Rolla, MO [Abstracts], p. 8.

FAYZIYEV, A.R., 1985, Physicochemical conditions of crystallization of fluorite in deposits and prospects of Northern Tadzhikistan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 166-167 (in Russian; translation by Dorothy B. Vitaliano). Author at Tadzhik State Univ., Dushanbe, USSR.

The formation of fluorite in hydrothermal deposits and prospects of the West Karamazars (Kaskana, Chashli, Mishikkolsay, Barite, Unksay, Kurbankul, Koktashkan, Mishikkol, Karkhana, Chalata) took place in the range 50-280° at P = 250-450 bar or less. The fluorite-forming solutions (according to the data of triple aqueous extraction) had a SO_4-Cl-HCO_3 composition with a concentration of 5-23 wt.% (from cryometric data). The main cations in the solutions of the gas-liquid inclusions are Ca and Na; Mg and K are less important. In the fluorite, inclusions of bitumoids occur in the amount of 0.0012-0.005% (data of luminescence-bituminological analysis).

Fluorite shows in the Southwest Karamazars (Tokmak, Dzhangalyk) have lower P-T parameters: Th 95-170°, Pt 100-250 bar. The composition of the liquid phase of the inclusions is F-SO_4-HCO_3 with sharp predominance of Ca over Na, K, and Mg. The total salt content in the solutions of the inclusions is 8-17 wt.%, and the concentration of bitumoids in the fluorite is 0.0010-0.0012%.

Fluorite in the prospects in the Mogoltau mountains (Akmogol, Beshkutan, Chashma, Shurale) crystallized in the range 50-190°. The mineralizing solutions were mainly SO_4-F-HCO_3-Na-K in composition. The role of other ions (Cl, Mg, K) was negligible.

In the deposits and prospects of the Central Karamazars (Kanimansur, Jubilee, Tary-Ekan, Kuruk, Dolony, Chukur-Dzhilga), the fluorite was formed in a broad interval of 90-390° at P ≤240-410 bar or less. The mineralizing solutions had a F-SO_4-K-Na composition with an insignificant content of HCO_3, NO_3, Mg and K. The concentration of the solutions of the gas-liquid inclusions is estimated at 10-35 wt.%, and the content of bitumoids in the fluorite as 0.0015-0.005%.

Fluorite in the deposits and prospects of the East Karamazars (Naugarzan, Kengutan, Kazansay, Gudasskoye, Kumbel', Shurbakht) was formed in the range 50-290°C. In the liquid part of the gas-liquid inclusions about equal amounts of F, HCO_3 and Cl and small amounts of SO_4 were determined. The main cations are Ca[sic] or Na, with lesser Mg and K. The concentration of the solutions of the inclusions is 9-34 wt.%.

In some deposits in Northern Tadzhikistan, a direct vertical temperature zoning has been established, with a paleogradient (°C/100 m depth) of 5-12° (Kanimansur), 10-15° (Chashly), 9-17° (Kengutan) and 20-22° (Naugarzan). A tendency for the concentration of solutions of the gas-liquid inclusions to decrease in fluorite from the lower horizons of the deposits to the upper is also observed. (Abbreviated by E.R. from the author's abstract)

FAYZIYEV, A.R., ISKANDAROV, F.Sh., BAYKOV, V.N., DZAYNUKOV, A.B., ZINCHUK, I.N., SUVOROV, P.K. and PULATOV, M., 1985, The physicochemical conditions of emplacement of one of the lead-silver deposits of Tadzhikistan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 110-112 (in Russian; translation by D.A. Brown). First author at TGU, Geol. Survey of Tadzhik SSR, Dushanbe, USSR.

1. The deposit is located within a depression, filled with volcanogenic-sedimentary formations of late Paleozoic age and at the intersection of sublatitudinal, submeridional, NW, and NE tectonic fractures. The ore bodies represent a combination of mineralized zones along steeply-dipping fractures with gently-inclined lodes, developed in 'stratified' volcanogenic sequences. They consist of zones of veinlet-segregated mineralization and isolated veins. The ores consist of galena, sphalerite, chalcopyrite, pyrite, hematite, fahlores [tetrahedrite-tennantite], bornite, native silver, freibergite, argentite, sulfosalts of silver, fluorite, quartz, barite and calcite.

2. T studies of the minerals indicate that the formation of the ores took place over a wide T range from <60 to 430°C (quartz - ~100-430°, fluorite - ~120-390°, sphalerite - ~125-265°, calcite - ~125-150° and below, and barite - ~65-125°C). The hypogene ore mineralization was formed at ~120-380°, and its principal amount in the narrow interval of ~150-300°C. The pressure has been estimated at ~850-200 bars and below.

3. A vertical temperature zonation in the ore-deposition has been revealed in the deposit, with a paleo-T gradient of 5-12° per 100 m of depth, and an inverse correlation has been observed between the depth of occurrence of the ore bodies and the value of the T-gradient: whereas the paleo-T gradient in the upper and middle horizons of the deposit (down to depths of ~300 m) was 11-12°/100 m, at depths of ≥800 m it was 5-6°/100 m.

4. A horizontal T-zonation has shown up in the deposit, involving a lowering of Tf away from the ore-conducting fissures by 15-20°C/100 m.

5. Analyses of triple aqueous extracts from fluorite have shown that the mineral-forming solutions were essentially of Na-Ca-F-Cl composition. HCO_3, SO_4, Mg, and K are of lesser importance. Decrease in the content of F, HCO_3, and SO_4 has been discovered, as well as a sharp increase in Cl from the early to the late generations.

6. The composition of the gases, dissolved in the mineral-forming fluids, has been examined by mass-spectrometer. The analyses show that the minerals of the ores are characterized by extremely low amounts of inclusion gases, amongst which the main species are CO_2 (≤95.8 vol %) and N_2 (≤83.0 vol %). Methane has also been found in insignificant amounts (≤9.2 vol %).

7. The absence of dms in the GLIs indicates the low concentration of the mineral-forming solutions. Cryometric analyses have shown salt concentrations in the solutions equal to 10-30 wt %. A decrease in the concentration of the solutions in the inclusions has been observed from the early to the late generations.

8. In some minerals (fluorite, quartz, and sphalerite), syngenetic inclusions of bituminous matter have been found along with the GLIs. The amount of bituminous matter has been determined by luminescence-bituminological analyses at 15-37 ppm.

9. Bulk-sample analyses from mine workings and drill-holes demonstrate the high decrepitation activity of the ore host rocks, exceeding the background by many times. In order to reveal the scale of the zones of "steaming-out" haloes, samples collected across the strike of the richest ore zones were examined. As a result, it has been established that these haloes are 12 to 15 times as thick as the ore veins (we may note, for comparison, that the scale of the primary geochemical haloes around the veins in the deposit is almost half [of this thickness?]). These data emphasize that thermobarometric methods may be successfully employed during exploration for and assessment of veined Pb-Ag deposits. (From the authors' abstract)

FAYZIYEV, A.R., KOPLUS, A.V. and ISKANDAROV, F.Sh., 1985, Thermodynamic parameters of formation of fluorite mineralization (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 164-165 (in Russian; translation by Dorothy B. Vitaliano). First author at Tadzhik State Univ., Dushanbe, USSR.

For deposits of different genetic and formational types, the following ranges of T and P of crystallization of fluorite have been established: fluorine-iron-rare earth formation - 320-800°C and 1000-4000 bar; pegmatite -- 80-500° and 150-450 bar; rare-metal skarns - 130-250°; rare-metal greisens - 90-450° and 400-1000 bar; hydrothermalites - 45-390° and 10-1000 bar

(Au-fluorite - 220-380° and 275-1000 bar; polymetallic-fluorite - 70-390° and 50-350 bar; Hg-Sb-fluorite - 45-150° and 60-200 bar; fluorite proper - 50-370° and 60-450 bar). A T on the order of 120-200°C was optimal for deposition of economic concentrations of fluorite. In many deposits a direct vertical T zoning with a gradient of 5-10 to 15-18° per 100 m depth is established. Cryometric analyses established the following values of the concentration of mineral-forming fluids in fluorites from deposits of different type (in wt.%): carbonatites - 40-75; pegmatites - 20-30; rare-metal skarns - 25-30; rare-metal greisens - 20-35; hydrothermalites - 5-43. (From the authors' abstract)

FAYZIYEV, A.R., KOPLUS, A.V. and ISKANDAROV, F.Sh., 1986, Thermobaric conditions of formation of fluorite ores: Izvestiya Akad. Nauk SSSR, Ser. Geol., no. 1, p. 103-112 (in Russian). First author at the Tadzhik State Univ., Dushanbe, Tadzhikistan, USSR.

The authors collected Th data from 133 fluorite and fluorite-bearing deposits from various parts of the USSR. For various formations the following conditions were determined (all data for inclusions in fluorite): 1) barite-hematite-fluorite formation with fluorcarbonates of rare earths, Th 700-320°C, total salt conc. 40-75 wt.% (up to 10 dms) + LCO_2, P 4000-1000 atm; 2) fluorite-bearing rock-crystal pegmatites, Th 500-80°C, salt conc. 20-30 wt.%, P 450-350 atm, sometimes 50-30 atm; 3) fluorite-bearing rare metal (with Sn, W, Mo) skarn ore formation, Th 225-130°C, salt conc. 25-30 wt.%, but in Tyrnyauz Th ≥800°C, salt conc. 60-90 wt.%, P 1200-1300 bar; 4) mica-rare metal-fluorite apocarbonate greisen formation, Th 360-90°C, salt conc. 35-20 wt.% + LCO_2, P 400-100 atm; 5) fluorite ore formation, Th from 370-340 to 65-50°C, total salt conc. from 40-35 or 32-30 wt.% (rarely) to 25-5 wt.% plus sometimes LCO_2 in variable amounts, P 1200, 800-750 down to 450-60 atm, vertical gradients of Th range from 22 to 9°C per 100 m; 6) fluorite-mercury-antimonite formation, Th 150-46°C, salt conc. 7-14 wt.%, 7) polymetal ore formation with fluorite Th 390-100°C, salt conc. 35-11 wt.%, P 1000-275 atm. Fluid inclusion data may and should be used in ore prospecting for primary deposits and for the determination of the commercial value of the deposits. (Abstract by A.K.)

FEHN, Udo and CATHLES, L.M., 1986, The influence of plate movement on the evolution of hydrothermal convection cells in the oceanic crust: Tectonophysics, v. 125, p. 289-312.

FEIN, J.B. and WALTHER, J.V., 1986, The solubility of calcite in supercritical CO_2-H_2O fluids (abst.): EOS, v. 67, p. 388.

FENN, P.M., 1986, On the origin of graphic granite: Am. Mineral., v. 71, p. 325-330.

FERGUSON, K.J., 1986, The Kelian gold prospect, Kalimantan, Indonesia, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 41-46. Author at P.T. Rio Tinto Indonesia, Jakarta, Indonesia.

Detailed exploration has indicated a world class, open cuttable, low grade Au deposit of epithermal, stockwork/disseminated style. The geology of the general prospect area consists of a thick acidic pyroclastic pile of tuffs, breccias and agglomerates intruded by a number of small subvolcanic calc-alkaline to alkaline stocks, pipes or dikes. Au and sulphide mineralization occurs within areas of fracturing and alteration that overlap many of the intrusive contacts and extend for considerable distances into the pyroclastics. Mineralization is most likely connected to the period of intrusive activity. Limited fluid inclusion and mineralogical studies suggest that the earliest alteration probably resulted from hydrothermal solutions of neutral pH at T >250°C whilst a later overprint alteration resulted from more acid solutions <200°C. (Author's abstract)

Th 260-300°C, salinities 3.5-4.0%, with boiling and with possibly a second generation at lower T. (E.R.)

FERNANDES, T.R.C., 1986, Report on a training program in the USA funded by USAID: Report - Inst. Mining Res., Univ. Zimbabwe 64, 23 pp.

Includes a preliminary study of secondary inclusions in quartz from the Lennox gold mine, Zimbabwe. Th varied widely but those associated with gold mineralization were <200°C. (E.R.)

FERRY, J.M., 1986a, Infiltration of aqueous fluid and high fluid:rock ratios during greenschist facies metamorphism: A reply: J. Petrol., v. 27, Part 3, p. 695-714.

FERRY, J.M., 1986b, Reaction progress: A monitor of fluid-rock interaction during metamorphic and hydrothermal events, in J.V. Walther and B.J. Wood, eds., Fluid-Rock Interactions during Metamorphism, New York, Springer-Verlag, p. 60-88.

FERRY, J.M., MUTTI, L.J. and ZUCCALA, G.J., 1986, Contact metamorphism/hydrothermal alteration of Tertiary alkali basalts from the Isle of Skye, northwest Scotland (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 601.

FILIPPOV, V.N., YUKHTANOV, P.P. and USPENSKIY, M.I., 1985, Nature of high-vacuum decrepitobarograms and use of a computer for their analysis: Trudy Inst. Geologiy Komi Fil. Akad. Nauk SSSR, no. 51, p. 84-88 (in Russian). Cited in Naumov, 1986 (this volume).

FINE, Gerald and STOLPER, Edward, 1986, Dissolved carbon dioxide in basaltic glasses: Concentrations and speciation: Earth & Planet. Sci. Letters, v. 76, p. 263-278. Authors at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125, USA.

Carbon dioxide dissolved in both synthetic Ca ± Mg-bearing silicate glasses and natural basaltic glasses has been characterized using infrared spectroscopy. CO_2 is inferred to be dissolved in these glasses as distorted Ca or Mg carbonate ionic complexes that result in unique infrared absorption bands at 1515 cm^{-1} and 1435 cm^{-1}. This speciation contrasts with the case of CO_2-bearing sodium aluminosilicate glasses, which contain both dissolved molecular CO_2 and dissolved Na-carbonate ionic-complexes. The difference in speciation in Ca ± Mg-bearing melts may result in part from a higher activity of oxygens that react with CO_2 molecules to produce carbonate.

Dissolved CO_2 contents of natural basaltic glasses can be determined from the intensities of the carbonate absorption bands of 1515 cm^{-1} and 1435 cm^{-1}. The uncertainty of the method is estimated to be ±15% of the amount present. The infrared technique is a powerful tool for the measurement of dissolved CO_2 contents in natural basaltic glasses since it is non-destructive, can be aimed at regions of glass a few tens of microns in size, and can discriminate between dissolved carbonate and carbon present as carbonate alteration, contained in fluid inclusions, or adsorbed on the glass.

A set of submarine basaltic glasses dredged from a variety of locations contain 0-400 ppm dissolved CO_2, measured using the infrared technique. These concentrations are lower than most previous reports for similar basaltic glasses. No general relationship is observed between dissolved CO_2 content and depth of magmatic eruption, although some correlation might be present in restricted geographic locales. (Authors' abstract)

FISHER, D.E., 1986a Distribution coefficient of argon in a basalt/feldspar system (abst.): Lunar & Planet. Sci. XVII, p. 230, Lunar & Planet. Inst., Houston.

FISHER, D.E., 1986b Rare gas abundances in MORB: Geochimica Cosmo. Acta, v. 50, p. 2531-2541. Author at Rosenstiel Sch. Marine & Atmos. Sci., Univ. Miami, Miami, FL 33149, USA.

Data are presented for He, Ar, and Xe in a number of MORB glasses and crystalline rocks. The rare gases in the latter group are characterized by atmospheric Ar and Xe, coupled with loss of trapped mantle He, Ar and Xe. The glass data also show clear signs of an atmospheric-like component for Ar and Xe. A reasonably constant world-wide average trapped mantle gas value of $^{40}Ar/^{36}Ar \sim 15000 \pm 3000$ is suggested. Anomalies are seen in the $^{129}Xe/^{132}Xe$ ratio, but at least part of this might be due to mass fractionation rather than to ^{129}I decay. Correlating the data with those from oceanic island basalts in Ar-Xe space indicates that the latter samples are probably also greatly influenced by an atmospheric component rather than (or in addition to) trapping gases from an undepleted mantle source. (Author's abstract)

FISHER, R.S., 1985, Amount and nature of occluded water in bedded salt, Palo Duro Basin, Texas: Geol. Circular 85-4, Bureau of Econ. Geol., The Univ. Texas at Austin, 27 pp.

Includes Karl Fischer titrations of methanol-extracted samples and vacuum heating, to distinguish fluid inclusion water from other sources. (E.R.)

FISHER, R.V. and SCHMINCKE, H.-U., eds., 1984, Pyroclastic rocks: Springer-Verlag, 472 pp.

Includes some discussion of H_2O and CO_2 in magmas (pp. 18 and 44-47). (E.R.)

FLUX, Susanne and CHATTERJEE, N.D., 1986, Experimental reversal of the Na-K exchange reaction between muscovite-paragonite crystalline solutions and a 2 molal aqueous (Na,K)Cl fluid: J. Petrol., v. 27, Part 3, p. 665-676.

FOJT, B., ĎURIŠOVÁ, J., HLADÍKOVÁ, J., KOPA, D., SKÁCEL, J., ŠMEJKAL, V. and ZIMÁK, J., 1986, Paragenetic study of a showing of copper mineralization, Stříbrník, near Nýznerov: Čas. Slez. Muz. Opava, A, v. 35, p. 143-169 (in Czech with Russian and German abstracts).

A showing of Cu mineralization of a vein type at Stříbrník near Nýznerov in the Jeseníky Mts. (ČSSR) was studied by mineralogical, geochemical and isotopic methods. The vein filling consists of quartz with impregnation of galena, chalcopyrite, sphalerite and pyrite in metamorphosed Proterozoic rocks. Barite occurs in the parts devoid of sulphides.

The mineralization occurred in two separate periods - in the younger one sulphides were precipitated. Fluid inclusion study in quartz proved two types of solutions: 1) low salinity (<5 wt.% NaCl eq.), T >1030°C; moderate salinity (up to 28 wt.% NaCl eq.), T <80°C, $CaCl_2$ and $MgCl_2$ predominate over NaCl. Isotopic study of $\delta^{34}S$ in pyrite, chalcopyrite and sphalerite (from -0.4 to 15.5‰) suggests the derivation of S from the nearby Zulova granite massif. Isotopic data of O and C in carbonates show the significant role of the fO_2 in the latest stages of the mineralization process, when mixing of ore-bearing solutions with meteoric water. (From the authors' abstract, translated by J. Ďurišová)

FOLEY, N.K., 1986, Fluid inclusion study of ores from the Fukazawa mine, Hokuroku district, Akita Prefecture, Japan: Mining Geol., v. 36, no. 1, p. 11-20. Author at U.S. Geol. Survey, National Center, M.S. 959, Reston, VA 22092, USA.

Fluid-inclusion thermometry of sphalerite and quartz from the Fukazawa mine indicates that the minerals formed in the range 250°C to 350°C from a fluid with a salinity that varied from 2.1 to 5.2 wt.% NaCl equiv. Th and salinity are positively correlated for sphalerite and some quartz. The slope of a regression line through data points for one sample is equivalent to the slope of a line of constant density suggesting that density may have been a factor in controlling the T-salinity gradient. Local thermal and chemical gradients may have helped in the formation of zones of chalcopyritization. Chalcopyrite-bearing fluid inclusions in sphalerite have hotter Th (350°C) than any other inclusions measured and may contain fluids responsible for chalcopyritization. (Author's abstract)

FOMENKO, V.Yu., TERESHCHENKO, S.I., KORZHNEV, M.N. and PIKOVSKIY, Ye.Sh., 1985, Characteristics of the gas-liquid inclusions in the iron-ore sequence of the Pravoberezhnyy region of the Ukrainian shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 195-196 (in Russian; translation by Dorothy B. Vitaliano). Authors at IGFM, Acad. Sci. Ukrainian SSR, Kiev, USSR.

The iron-ore sequence of this region consists mainly of amphibolites with bands of white micaceous quartzite, ferruginous quartzite,+graphitic gneisses with bodies of carbonate rocks.

An essentially CO_2 and water-CO_2 composition is typical of the inclusions of the metamorphic stage which occurs extensively over most of the iron-ore sectors of the region (Ovnyansk, Nikolayevsk, Kamchatka, West Zelenorechensk [Green River], etc.). Th varies within 430-480°C. A predominance of gas-liquid inclusions with three phases, low content of CO_2 and Th reaching 450°C are typical of sectors in which granitization processes are observed (Petrovsk and Artemovsk ferruginous quartzite deposits). Sectors subjected to considerable tectonic reworking in zones of large faults (South and West Zheltyansk) are characterized by prevalence of a content of gas-liquid and essentially liquid inclusions with Th(L) at 300-350°C.

Thus each geologic stage of transformation of the rocks of the iron-ore sequence of the Pravoberezhnyy region is characterized by inclusions of different composition and Th, which can be used as a supplementary criterion for recognizing these stages in specific geologic bodies. (From the authors' abstract)

FOORD, E.E., STARKEY, H.C. and TAGGART, J.E., Jr., 1986, Mineralogy and paragenesis of "pocket" clays and associated minerals in complex granitic pegmatites, San Diego County, California: Am. Mineral., v. 71, p. 428-439.

FOOSE, M.P., 1986, Setting of a magmatic sulfide occurrence in a dismembered ophiolite, southwestern Oregon: U.S. Geol. Survey Bull. 1626-A, 23 pp.

Inclusions of sulfide globules in cumulus silicate grains show that an immiscible sulfide liquid was present while cumulus grains were precipitating. This sulfide liquid is estimated to have a Ni/Cu ratio of 0.2 and a chondrite normalized precious-metal pattern that is characteristic of sulfide deposits formed from gabbroic melts. (From the author's abstract)

FORBES, Pierre, 1986, Hydrothermal activity and mineralization in the Akouta uranium deposit, Niger (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 67 (in French). Author at CREGU, BP 23, 54501 Vandoeuvre les Nancy, Cedex, France.

T variations experienced by sandstones of the Guezouman formation at

Akouta, were determined by studying 6 generations (I-VI) of fluid inclusions in minerals formed before or during deposition of the U:

Minerals studied	Th°C	Tf°C	interpretation
Quartz, secondary, with the deposit	(1)	0,-1	I, early
Quartz, secondary to the deposit	150,200	0,-1	I, reequilibrated
Barite	100,200	0,-1.5	II, reequilibrated
	50,110	- 4,-10	III
Sphalerite 2	85,175	- 1,-10	IV
	115,175	-11,-18	V
	85,115	-18,-22	VI
Calcite	100,120	-18,-22	

(1) Monophase inclusions; (2) Formation of the U mineralization

The observed temperatures cannot be explained by burial alone (depth <1200 m). They are interpreted as the result of circulation of hot fluids (T >200°C) along an important NS trending fault which cuts off the western part of the deposit. This fluid reequilibrated the existing low-T inclusions and mixed with connate waters, forming a salt-undersaturated environment which evolved rapidly towards equilibrium conditions at the depth of burial. This evolution, during which the mineralization was formed, occurred over a range of 200-100°C, compatible with the formation of corrensite in the deposits. Input of a homogeneous fluid at 200°C implies a P higher than 20 bars (at least 200 m burial); such conditions did not occur at Akouta before the end of the Permian. The post-Permian mineralizations were also deposited by circulating fluids originating from the nearby NS trending fault. (Author's abstract; translated by R. Kreulen)

FORCE, E.R. and CARTER, B.A., 1986, Liquid immiscibility proposed for nelsonitic components of the anorthosite-syenite-gabbro complex, San Gabriel Mountains, California (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 604.

FORNONI CANDIA, M.A., 1984, Petrology of the Mangabal I and Mangabal II mafic-ultramafic complexes, Sanclerlandia, Goias (Brazil) (abst.): Anais da Acad. Brasileira de Ciencias, v. 56, no. 1, p. 110 (in Portuguese).

Mangabal I and Mangabal II constitute two small mafic-ultramafic complexes containing Ni, Cu, and Co sulfide mineralization.

Tectonic/metamorphic processes subsequently [have resulted in recrystallization]. Analyses of the various parageneses evolved and the contained fluid inclusions indicate that recrystallization occurred near 700-800°C and 6.0 to 6.5 kbar. (From the author's abstract, translated by G. Landis)

FRACASSO, M.A. and HOVORKA, S.D., 1986, Cyclicity in the Middle Permian San Andres Formation, Palo Duro Basin, Texas Panhandle: Report of Investigations No. 156, Bureau Econ. Geol., Univ. Texas at Austin, 48 pp.

Of pertinence in interpretation of fluid inclusions in such salt beds. (E.R.)

FRANCE-LANORD, Christian, LE FORT, Patrick, PECHER, Arnaud and SHEPPARD, S.M.F., 1986, Evidence for large scale migration of fluids during evolution of Himalaya reverse metamorphism (abst.): EOS, v. 67, p. 399. Authors at C.R.P.G., B.P. 20, 54501 Vandoeuvre, France.

Isotope and fluid composition trends are not consistent with in situ devolatilization and a single homogeneous fluid. Migration of an exotic fluid is proposed. It possibly came from the more metamorphosed C-rich sheets pinched in the MCT shear root-zone and was drained along and away from the MCT. (From the authors' abstract)

FRANCIS, D., JAVOY, M., NADEAU, S. and PINEAU, F., 1986, Upper mantle xenoliths along the northwestern margin of North America: Fluid inclusions and C and H isotopes (abst.): Terra Cognita, v. 6, no. 2, p. 191-192. Authors at Lab. Géochimie des Isotopes Stables, UER des Sci. Physiques de la Terre and I.P.G.P., Univ. Paris VII, 2 Place Jussieu, 75251 Paris Cedex 05, France.

Upper mantle xenoliths are found in Tertiary to recent alkaline basalts along the northwestern margin of North America. The localities are from north to south: Nunivak Island and Prindle Volcano (Alaska), Alligator Lake and Fort Selkirk (Yukon), Castle Rock and Jacques Lake (British Columbia). Fluid inclusions are observed in all xenoliths and their relative amounts decrease in anhydrous xenoliths from pyroxenite, websterite, composite pyroxenite and spinel lherzolite xenolith, spinel lherzolite, harzburgite and dunite. Fluid inclusion abundances are also related to their host minerals and decrease from clinopyroxene to orthopyroxene, olivine and spinel. Hydrous-bearing xenoliths (Nunivak Island only) do not show such a correlation and all minerals close to the hydrous phases, interstitial and veinlets [of] phlogopite and/or pargasite, are enriched in fluid inclusions. In addition, the inclusion amount decreases away from these hydrous minerals. The fluid phase is almost pure CO_2 (melting temperature -56.6 to -57.4°C ± 0.2°C). Fluid densities range from 1.14 to 1.16 $g \cdot cm^{-3}$ in type I inclusions occurring mainly in anhydrous pyroxenites and hydrous-bearing xenoliths. Type II inclusions have densities from 0.6 to 1.0 $g \cdot cm^{-3}$ and are found in all xenoliths. Type III inclusions have lower densities and are present along mineral margins. δD(SMOW) vary from -72 to -80‰ in hydrous-bearing harzburgite and pyroxenite and from -97 to -109‰ in spinel lherzolite. $\delta^{13}C$(PDB) range from -21.9 to -26.8‰ in spinel lherzolite and pyroxenite. Stepwise heating on a C-rich spinel lherzolite gives a total $\delta^{13}C$(PDB) of -21.9‰ and a heavier $\delta^{13}C$(PDB) fraction of -15.5‰ released at 800°C. Interstitial carbonates have $\delta^{13}C$(PD) between -7.0 and -14.0‰. Comparison of the fluid compositions and isotopes data at the various localities will be presented. (Authors' abstract)

FRANKLIN, J.M., KISSIN, S.A., SMYK, M.C. and SCOTT, S.D., 1986, Silver deposits associated with the Proterozoic rocks of the Thunder Bay District, Ontario: Can. J. Earth Sci., v. 23, p. 1576-1591. First author at Geol. Survey of Canada, 601 Booth St., Ottawa, Ont., Canada K1A 0E8.

This is full paper for abstract by Franklin and Scott, Fluid Inclusion Research, v. 17, p. 97, 1984. (E.R.)

FREUND, Friedemann and OBERHEUSER, Gert, 1986, Water dissolved in olivine: A single-crystal infrared study: J. Geophys. Res., v. 91, no. B1, p. 745-761.

FREY, Martin, 1986, Very low-grade metamorphism of the Alps-an introduction: Schweiz. Mineral. Petrogr. Mitt., v. 66, p. 13-27. Author at Min.-Petrogr. Inst. der Univ., Bernoullistrasse 30, Ch-4056 Basel.

Until recently, studies of very low-grade metamorphism in the Alps have been largely based on illite "crystallinity" and index mineral data and, to a lesser extent, on coal rank and fluid inclusion data. These four methods are briefly outlined and a correlation is presented in Fig. 7. The distribution of mineral assemblages in metabasites and metagraywackes as well as the location of reaction-isograds and mineral zone boundaries with respect to anchimetamorphic areas are shown on a large-scale map of the Alps (Plate 1). In the Eastern Alps, very low-grade metamorphism is predominantly of Eo-Alpine age, while in the Central and Western Alps, it is predominantly of Meso-Alpine and Neo-Alpine age. Finally, some suggestions for future work are given. (Author's abstract)

FREZZOTTI, M.L., GHEZZO, C. and TOURET, J., 1986, Fluid inclusions as post magmatic trajectory tracer: Applications to M. Pulchiana pluton (N Sardinia): Italian Soc. Mineral. and Petrology, Seminar on Role of fluids in petrogenesis, Siena, 3-4 June, 1986, [Program and Abstracts], p. 40. First author at Dipart. di Sci. della Terra, Univ. di Siena.

Fluid inclusions have been studied in four representative samples of the Monte Pulchiana leucogranite (N Sardinia), one of the youngest post-tectonic Hercynian intrusions; the granitic complex is one of the largest cropping out in Sardinia (≈ 15 Km Ø).

The granite is a medium-coarse grained rock, made mainly of quartz, perthitic feldspar, sodic plagioclase and less biotite. Slightly altered, it contains some pegmatitic idiomorphic quartz bearing vugs. Some preliminary results were presented in a previous work (De Vivo et al., 1985).

Microscopic and microthermometric studies of fluid inclusions in quartz have been made, both in the leucogranite and in the pegmatitic vugs, in order to characterize the late magmatic and hydrothermal fluids. In the granite two main events were recognized:

- A first, post magmatic one in which a highly saline fluid was present. Optical and microthermometric investigations suggest that the fluid was heterogeneous and NaCl oversaturated at the time of trapping. Average salinity minimum estimates are around 30 eq. wt.% NaCl. Th L + V are in the range 200-300°C; in three phase inclusions Th liquid + vapor occurs, always before daughter minerals dissolution, showing the so called "halite homogenization." No evidence of boiling could be observed.
- A second much less saline fluid (5 eq. wt.% NaCl; Th → L 90 to 250°C) is present as well in the granite as in the quartz crystals. In the latter it may contain dawsonite. Th decrease in the quartz crystal from the center towards the periphery, with a new increase in the external, smoky envelope. Th in the quartz core are significantly higher than in the granite (Th granite 100-195°C). Some chemical constraints are given by the presence of the dawsonite: high content of Al and decreasing of the fluid acidity.

These observations are consistent with the existence in subsolidus conditions of the first NaCl oversaturated fluid probably of magmatic origin (magmatic immiscibility between brine and silicate melt, e.g., in Ascension Island, Roedder 1967). Later an homogeneous, low salinity fluid, probably of meteoric origin, invaded the pluton at a relatively late stage (~250°C). A post magmatic trajectory is proposed, starting at the inferred conditions of granite crystallization (T = 700°C, P = 1.5 Kb). (Authors' abstract)

FRIEND, C.R.L., 1986, Varying rock responses as an indicator of changes in CO_2-H_2O fluid composition, in Workshop on Early Crustal Genesis: The World's Oldest Rocks, L.D. Ashwal, ed., Grønlands Seminarium, Godthab, Greenland, Denmark, July 21-30, 1985, LPI Tech. Rept. 86-04, p. 37-39. Author at Dept. Geol. & Phys. Sci., Oxford Polytech., Headington, Oxon. OX3 0BP, UK.

A review of the process of granulite formation and discussion of the mechanism. (E.R.)

FRITZ, P. and FONTES, J.Ch., eds., 1986, Handbook of Environmental Isotope Geochemistry, Volume 2, The Terrestrial Environment, B: Amsterdam, Elsevier Sciences Pub., 568 pp.

Consists of 12 chapters on various aspects of isotopes in the crust. (For volume 1, see same authors, 1980, Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 75, 1980.) (E.R.)

FROST, B.R., LINDSLEY, D.H. and FUHRMAN, Miriam, 1986, Silicate-oxide-graphite-sulfide relations in the Sybille monzosyenite, Laramie Anorthosite complex, Wyoming, U.S.A.: Italian Soc. Mineral. and Petrology, Seminar on Role of fluids in petrogenesis, Siena, 3-4 June, 1986, [Program and Abstracts], p. 14. First author at Dept. Geol. & Geophys., Univ. Wyoming, Laramie, WY 82071.

The presence of a CO_2-saturated fluid phase during crystallization is substantiated by the presence of CO_2-rich fluid inclusions in the quartz-bearing rocks. Preliminary measurements indicate that these inclusions have densities that are consistent with trapping at temperature and pressure of the solidus. The occurrence of pyrrhotite with the QUIlF assemblage [quartz-ulvospinel-ilmenite-fayalite] indicates that log $f(S_2)$ was between -3 and -4. At these temperatures and oxygen fugacities log $f(SO_2)$ would be about the same order of magnitude. (From the authors' abstract)

FRY, Brian, GEST, Howard and HAYES, J.M., 1986, Sulfur isotope effects associated with protonation of HS^- and volatilization of H_2S: Chem. Geol. (Isotope Geosci. Sec.), v. 58, p. 253-258. First author at Depts. Chem. & Geol., Biogeochemical Labs., Indiana Univ., Bloomington, IN 47405, USA.

The isotope effects associated with: (1) formation of H_2S from HS^- by protonation in aqueous solution; and (2) volatilization of H_2S have been experimentally determined. Both isotopic distributions in closed systems at equilibrium and differential rates of volatilization of isotopic species in open systems were measured at 22 ± 1°C. It was found that, at equilibrium, aqueous H_2S is enriched in ^{34}S by 2.0-2.7‰ relative to HS^- and that H_2S volatilized from solution is depleted in ^{34}S by 0.5‰ relative to dissolved H_2S. A small kinetic isotope effect accompanying volatilization of H_2S was observed in the open-system experiments. (Authors' abstract)

FUENTES, J.C. and ROSSELLO, E.A., 1986, Topaz in the Province of Catamarca, Argentina: Boletin del Instituto Gemologico Espanol, no. 27, p. 25-28 (in Spanish; English abstract). First author at Dept. de Ciencias Geol., Univ. de Buenos Aires.

Topaz mineralization is described from the contact between a metamorphic host rock and within the granitic stock of the Papachacra Formation, Department of Belen. This topaz is genetically related to the granitic body, as a result of hydrothermal solution of high T, P and rich in volatiles. (From the authors' abstract)

FUGE, R., ANDREWS, M.J. and JOHNSON, C.C., 1986, Chlorine and iodine, potential pathfinder elements in exploration geochemistry: Applied Geochem., v. 1., p. 111-116. First author at Dept. Geol., The Univ. College of Wales, Aberystwyth, Dyfed SY23 3DB, Wales.

Consideration of the geochemistry of Cl and I suggests that both elements would be useful pathfinders for hydrothermal mineralization. The results of published case studies indicate that these halogens form broad dispersion patterns in rocks and soils around many types of such mineral deposits. (From the authors' abstract)

GABELMAN, J.W. and HANUSIAK, W.M., 1986, Gold occurrence at Island Copper mine, British Columbia (abst.): J. Geochem. Explor., v. 25, p. 252. First author at John W. Gabelman & Associates, Inc., Danville, CA, USA.

Systematic search at +500 magnification, of at least a three by three cm surface in each of 27 differently altered and metallized rocks, revealed 26 native gold particles, from 0.5 to 20.8 microns in size (averaging 1.5 x 2.5 microns), loosely held in fluid inclusion cavities in, or weakly appendaged to, larger grains of quartz, hydrobiotite, pyrite, chalcopyrite, magnetite, molybdenite, monazite, and calcite in that order of prevalance. (From the authors' abstract)

GAFFEY, S.J., 1986, Water in skeletal carbonates (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 607. Author at Geol. Dept., Rensselaer Polytech. Inst., Troy, NY 12181.

Vibrational spectroscopy in the near infrared (0.7-2.5 μm) reveals that all skeletal carbonates studied to date contain liquid water in the form of fluid inclusions. Many types of skeletal material also contain additional water phases, including two hydrated $MgCO_3$ phases with differing bond strengths, a hydrated $CaCO_3$ phase, $Ca(OH)_2$, and $Mg(OH)_2$. Total amount of water, phases present, and proportion of water present in specific phases varies with skeletal mineralogy and taxonomic group.

Most biogenic high magnesium calcites (HMCs) appear to contain both hydrated $MgCO_3$ phases. Many contain $Mg(OH)_2$ as well. Many biogenic low magnesium calcites (LMCs) and some biogenic aragonite contain hydrated $CaCO_3$. Some molluscan aragonites also contain $Ca(OH)_2$.

Relative intensities of water bands in reflectance spectra are sensitive indicators of amount of water present. During neomorphic alteration of biogenic aragonites and HMCs to LMC, an order-of-magnitude drop occurs in water content. Both bound and liquid phases are lost during diagenetic alteration. (Author's abstract)

GALABURDA, Yu.A., 1984, Studies of inclusions of the mineral-forming medium and its role in prospecting (example of the non-differentiated pegmatites of the Ukrainian Shield), in Mineralogy of the ore deposits of Ukraine, p. 160-164, Kiev (in Russian).

Cited in Naumov, 1986 (this volume).

GALABURDA, Yu.A and VOZNYAK, D.K., 1985, Role of CO_2 in the formation of undifferentiated pegmatites of Ukrainian Shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 18-19 (in Russian; translation by S. Jaireth). Authors at IGFM Inst. Geol. & Physics of Mantle, Acad. Sci., Ukraine SSSR, Kiev, USSR.

Fluid inclusions have been studied in quartz (milky-white and grey) and tourmaline of weakly differentiated mica-bearing ceramic and rare metal pegmatites from different fields (Korostishevsk*, Gorodnitsk in northeast, Rodionovsk, Eliseevsk, Feodorovsk and Vali-Taramsk in Preazov).

Medium to coarse grained quartz is devoid of any detectable growth zoning, making chronological grouping of inclusions difficult. The earliest, probably primary inclusions are randomly distributed individual or groups of inclusions within single grains, unrelated to healed cracks. Secondary inclusions are distributed along cracks and grain boundaries.

For the first time, predominantly CO_2 inclusions of high density (in g/cm^3) have been observed in quartz. Korostishevsk - 0.95 (Th = -4.5°C), Gorodnitsk - 1.03 (Th = -20°C), Rodionovsk - 1.04 (Th = -23°C), Eliseevsk - 0.94 (Th = -11.5°C). These inclusions are observed in the cental parts of many grains and are the earliest. In such grains inclusions of aqueous solutions are absent.

Secondary inclusions are represented by inclusions predominantly aqueous (occasionally with CO_2) and CO_2 (of lower density). In a sequence from high to low temperature, the concentration of CO_2 decreases while that of aqueous solution increases.

Tourmaline contains primary CO_2 inclusions with density from 0.83 g/cm^3 (Gorodnitsk and Feodorovsk field) to 0.61 g/cm^3 (Rodionovsk field) and syngenetic aqueous inclusions (Rodionovsk, Tt = 250-270°C, Feodorovsk, Gorodnitsk, Tt = 330-350°C).

CO_2 inclusions of higher density in quartz of undifferentiated pegmatites were trapped at P ⩾320 to 450 MPa (Korostishevsk and Feodorovsk field respectively). These values are obtained form CO_2 isochores of corresponding densities at temperature of ≈400°C, the maximum Th of these incusions.

Bulk chromatographic analysis of gases of the inclusions in quartz of undifferentiated pegmatites released by thermal decrepitation indicates predominance of CO_2 over H_2O. In quartz from "zanorsh" pegmatites of Volhyn, this relation is reversed: H_2O predominates over CO_2. In fully differentiated pegmatites as well, high density CO_2 inclusions have not been observed. Calculated value of pressure of CO_2-aqueous fluid is ≈1.2 MPa.

Results of the studies support the known proposition about decrease in H_2O/CO_2 ratio in fluid with depth. Mica-bearing ceramic and rare metal pegmatites characterized by greater depths of emplacement than the optical quartz-bearing pegmatites, were formed from solutions containing as much or more CO_2 than H_2O. (From the authors' abstract)

*Data on fluid inclusion studies in quartz and other accessory minerals of veined pegmatites from Korostishevsk field and on the important role of CO_2 in their formation have been reported by many other workers (Vynar et al., 1980, 1981, Naumko, 1981, 1982; Naumko et al., 1982, 1983) - Editor's comment [i.e., V.A. Kalyuzhnyi]

GALANT, Yu.B., 1986, Characteristics and intensity of gas release from Paleozoic sediments in the Araks zone of the Little Caucasus: Dokl. Akad. Nauk SSSR, v. 286, no. 6, p. 1502-1504 (in Russian).

Gases sampled from the eluent liquid of the boreholes during drilling through Paleozoic clayey shales, marls, limestones and sandstones, were analyzed by gas chromatography for hydrocarbons (essentialy CH_4), CO_2 and N_2. N_2 is the prevailing component, typical of the gases of the platform basement, whereas CO_2 is considered to be the "geosynclinal" component. (A.K.)

GALIY, S.A., KURILO, M.B. and BURMISTROVA, V.V., 1985, New data on sulfides of sedimentary-diagenetic deposits: Zapiski Vses. Mineral. Obshch., v. 114, no. 6, p. 682-687 (in Russian).

Cited in Naumov, 1986 (this volume).

GAMOV, M.I., SAFAROV, Yu.A., SHEVLYAGIN, Ye.V., 1985, Mapping the ore bodies of the Gitchetyrnyauz deposit by the method of thermovacuum decrepitation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 261-262 (In Russian; translation by Dorothy B. Vitaliano). Authors at Rostov State Univ., Rostov-on-the-Don, USSR.

On four exploratory horizons penetrating the Mo-W stockwork, Td of quartz, molybdenite, pyrite, arsenopyrite, sphalerite, chalcopyrite, galena, and pyrrhotite -- the main minerals filling the veinlets of the stockwork -- was studied. When the decrepitograms of the quartz and associated sulfide minerals were compared for each type of ore vein, a typomorphic interval of decrepitation was distinguished. For veinlets of type I it is 360-480°C with a maximum at 400-440°C; for veinlets of type II, 260-400°C with a variable maximum; for veinlets of type III, 220-340°C with a maximum at 260-280°C. Quartz of barren veinlets decrepitates in a broad range of T -- 130-380°C, with two extreme ranges -- 200-240°C and 350-380°C. Wholesale decrepitometric analyses of the quartz of the ore veinlets made it possible to outline aureoles with high Td and intensity of gas liberation, surrounding known ore bodies. The width of the aureoles is 1.5-2 times greater than the outline of the economic mineralization. The aureole mapped on the basis of the parameters of decrepitation of quartz veinlets, the type of which determines the composition of mineralization in the ore body, is the widest.

Comparison of the maps of decrepitation parameters for the exploratory horizons brought out a decrease in Td of quartz by 23-27°C for all types of veinlets, from the upper (2464 m) to the lower (2172 m) horizons. The intensity of gas liberation decreases in this same direction.

Decrepitometric investigations on the Gitchetyrnyauz deposit made it possible to mark the direction of change in the parameters of decrepitation, emphasizing the boundary of the stockwork and recording the scale of economic mineralization and its type in the ore bodies. (From the authors' abstract)

GANEEV, I.G., 1984, A physico-chemical model of the combined transportation of vein and ore substance by hydrothermal solutions: Izvestiya Akad. Nauk SSSR, Ser. Geol., no. 6, p. 66-80 (in Russian). Author at Inst. of Lithosphere of Acad. Sci. USSR, Moscow, USSR.

The paper is the extended version of the publication abstracted in Fluid Inclusion Research, v. 17, p. 104. It presents the calculated (from experiments) conditions and complex ion forms of migration of such elements as Si, Al, Pb, Fe, Sb, Be, Sn, Hg, Bi, etc., in T ranges 150-500°C. (A.K.)

GARANIN, V.K., 1985, New data on formation of zircon in kimberlites: Essential problems of theoretical and applied mineralogy: Abstracts of papers of the scientific conference, Moscow, p. 130-132 (in Russian).

Cited in Naumov, 1986 (this volume).

GARANIN, V.K., KROT, A.N., KUDRYAVTSEVA, G.P. and LEVANDOVSKAYA, M.V., 1985, Mineral inclusions in garnets from the Yakutian kimberlites, their genetic and applied significance: Essential problems of theoretical and applied mineralogy: Abstracts of papers of the scientific conference, Moscow, p. 28-30 (in Russian).

Cited in Naumov, 1986 (this volume).

GARANIN, V.K., KUDRYAVTSEVA, G.P. and BUTKUNOV, A.I., 1986, Inclusions in minerals from Yakutia kimberlites: Methods of investigation and new data (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 109. Authors at Dept. Mineral., Faculty Geol., Moscow State Univ., 119899, Moscow, USSR.

In a study of mineral inclusions in xenocrysts (garnet, olivine, zircon, spinellides, and ilmenite), compound hydrocarbonic inclusions have been found. In zircon, inclusions of minerogenic media of hydrous carbonate composition have been found. (From the authors' abstract)

GAUTHIER-LAFAYE, F. and WEBER, F., 1986, Hydraulic fracturing: Its importance to the formation of ore deposits and Oklo-type natural reactors (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 76 (in French). Authors at Centre de Sédiment. et de Géochimie de la Surface, Strasbourg, C.N.R.S.

U deposits in the Franceville basin are associated with hydrocarbon occurrences. Hydraulic fracturing is one of the important factors controlling deposition of the ores. Hydraulic fracturing is caused by an increase in fluid P, probably produced by tectonically emplaced undercompacted rocks. Fracturing is restricted to the sandstones which are overlain by a 500 to 1000 m thick series of impermeable pelites and occurs in the upper parts of folds, fault zones and tectonic wedges. Overpressure created by fluid production in undercompacted parts of the pelites (brought down by normal faults) were sufficient to fracture the rocks. Variations in grain size determine the permeability of the sandstones and have an effect on hydraulic fracturing. It appears that tectonism does not only form structural traps but also serves to create pathways for fluid movement. Fluid inclusion studies indicate that fracturing occurred under a cover of 3000-3200 m and at 120-140°C. In the field and in drill cores, hydraulic fracturing is recognized in zones (cm to m wide) which are parallel to the stratification and where the rock is cut by many microfractures. Under the microscope it is observed that the quartz is cracked and that the microfractures are filled with calcite, UO_2, sulfides, clays and bituminous matter. In these fractured zones, which have a high secondary porosity, most of the U and bituminous matter were deposited. It is also in these channelways that the rich U ore containing up to 10-20% UO_2 was formed by remobilization of U. In the center of such rich U concentrations, "natural nuclear reactors" may start. The zones of enhanced fluid movement play an important role in the functioning of natural reactors. They are subjected to hydrothermal alteration associated with the nuclear reactions and the natural reactors develop along these zones since they are the places where U concentrations are sufficiently high. (Authors' abstract: translated by R. Kreulen)

GAYDUKOVA, V.S., DUBINCHUK, V.T. and POZHARITSKAYA, L.K., 1985, Microinclusions in pyrochlore and zircon (electron microscopy data) as indicators of the genetic type of the deposit: Essential problems of theoretical and applied mineralogy: Abstracts of papers of the scientific conference, Moscow, p. 143-144 (in Russian).

Cited in Naumov, 1986 (this volume).

GEHRIG, M., LENTZ, H. and FRANCK, E.U., 1986, The system water-carbon dioxide-sodium chloride to 773 K and 300 MPa: Ber. Bunsenges. Phys. Chem. v. 90, p. 525-533. Authors at Inst. Phys. Chemie & Elektro., Univ. Karlsruhe, Kaiserstrasse 12, 7500 Karlsruhe, FRG.

Experimental results are reported for fluid-fluid phase equilibria of the ternary system H_2O-CO_2-NaCl. Measurements were extended to 773 K and pressures to 300 MPa. A "synthetic" method was used: Known quantities of the three components were filled into an autoclave at room temperature. The autoclave with a sapphire window and variable volume is described. Transition points to homogeneous one-phase conditions could be determined from recorded p-T-curves at constant volumes and from visual observation. From the transition points p-T-curves on the three-dimensional phase equilibrium boundary surface at constant compositions, "isopleths," were obtained. Data for 20 isopleths with CO_2-concentrations between 0.2 and 85 mol% and with 6 weight % of NaCl are presented together with a few additional results for higher salt concentrations. Molar volumes were measured at the phase boundary surface and within the one-phase region. Excess molar volume are given. In comparison with the binary H_2O-CO_2 system, the addition of NaCl shifts the range of partial immiscibility to higher temperatures by up to 100 K; for example from 573 to 673 K at 100 MPa for 48 mol% CO_2. Results are in agreement with earlier data of Takenouchi and Kennedy. Considerations of the ternary phase diagram H_2O-CO_2-NaCl within a wide range of conditions are given. (Authors' abstract)

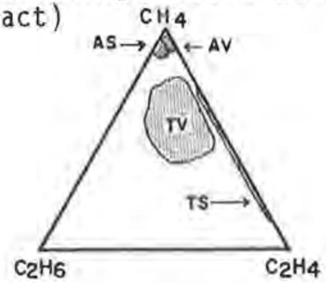
GEORGE, E., PAGEL, M., DUSAUSOY, Y. and GAUTIER, J.M., 1986, Formation conditions of a tetragonal uranium oxide: α-U_3O_7 in the Brousse-Broquiès Basin (Aveyron, France): Uranium, v. 3, p. 69-89. First author at Centre de Recherches sur la Géol. de l'Uranium, B.P. 54501 Vandoeuvre-lès-Nancy Cedex, France.

The uraniferous mineralization in the Brousse-Broquiès Basin, spatially associated with the unconformity between a metamorphic basement and a Stephano-Permian nonmetamorphic cover, is unique among the uranium deposits in Western Europe. It is essentially in the form of the tetragonal uranium oxide α-U_3O_7. The T of formation, deduced from fluid-inclusion study, is

140 ± 25°C and the fluid is a slightly alkaline brine rich in NaCl and containing divalent cations. The presence of α-U_3O_7 for this T indicates a fO_2 around 10^{-30} atm. (From the authors' abstract)

GERDENICH, M.J., HANEL, I.V. and KESLER, S.E., 1986, Alkene/alkane hydrocarbon gas ratios in fluid inclusions from Archean and Tertiary gold deposits (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 611. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Trace amounts (<0.1 mole percent) of C1 through C4 hydrocarbon gases (HC) have been detected by gas chromatography of decrepitated fluid inclusions from sediment-hosted micron Au (jasperoid; TS) and volcanic-hosted vein Au-Ag (TV) deposits of Tertiary age, and from Archean metasediment (AS) and volcanic-hosted (AV) vein Au deposits. CH_4 is by far the most abundant HC gas detected. Of the remaining HC gases, alkenes (C_2H_4 and C_3H_6) are more abundant than alkanes (C_2H_6, C_3H_8 and C_4H_{10}) in most deposits. The C_2H_4/C_2H_6 ratio averaged 3.0 (s = 1.8, n = 66) from the Tv Au-Ag deposits. C_2H_6 was not detected from the TS jasperoid samples analyzed, although C_2H_4 was detected from all samples (n = 25). The C_2H_4/C_2H_6 ratio from As vein samples averaged 0.007 (s = 0.001, n = 3) while AV samples averaged 1.4 (s = 0.26, n = 4). A plot of CH_4-C_2H_6-C_2H_4 shows that the Archean deposits (AV and AS) are dominated by CH_4. However, the micron Au and Au-Ag vein deposits (TS and TV) both contain appreciable amounts of C_2H_4. C_2H_4 is an abundant interstitial gas in soils, and is commonly formed by bacterial oxidation of longer-chain hydrocarbons. The association of C_2H_4 with shallow-level Tertiary systems could reflect the dominance of meteoric fluid recharge. If so, alkene/alkane ratios may be used to delineate former recharge and mixing zones within hydrothermal precious-metal deposits. (Authors' abstract)



GERLACH, T.M., 1986, Exsolution of H_2O, CO_2, and S during eruptive episodes at Kilauea volcano, Hawaii: J. Geophys. Res., v. 91, no. B12, p. 12,177-12,185. Author at Geochem. Div., Sandia Nat'l. Lab., Albuquerque, NM.

A model for the exsolution of H_2O, CO_2, and S from Kilauea magma as it rises from a shallow crustal reservoir predicts that vigorous exsolution occurs only after magma has ascended to shallow depths (≤150 m lithostatic) where pressures are <3 MPa (30 bars). Exsolved vapor at saturation (30-100 MPa) is CO_2-rich (70 vol %, maximum), but H_2O increases and ultimately predominates in the vapor as pressure drops. The model indicates that most H_2O remains dissolved, however, down to pressures as low as 2-3 MPa (20-30 bars) rather than being exsolved abundantly below 8 MPa (80 bars) as is commonly assumed. Most CO_2 is exsolved above 10 MPa, whereas most S, like H_2O is exsolved below 2-3 MPa (<100-150 m lithostatic). The critical condition for major outgassing and disruption of magma into spray is reached at 1.0-0.6 MPa (~40-25 m lithostatic). Gas exsolution apparently continues after disruption. The total quantity of exsolved volatiles as predicted by the exsolution model agrees with that predicted by models of fire fountain dynamics. At 0.3-0.4 MPa (≤20 m lithostatic), the exsolved gases resemble volcanic gases of east rift zone eruptions and coexist with melts containing volatiles at concentrations similar to those observed in fountain spatter. Exsolution from coalesced spatter of previously disrupted melt produces residual gases that are H_2O-rich and sharply depleted in CO_2. The low pressures and shallow depths required for extensive exsolution imply that magma must be transported nearly to the surface before disruption, outgassing, and fountaining are possible. Therefore eruption forecasting techniques based on detection of volatiles outgassed from ascending magma may not provide useful advance warning at Kilauea and other tholeiite basalt systems. (Author's abstract)

GERLACH, T.M. and CASADEVALL, T.J., 1986a Evaluation of gas data from high-temperature fumaroles at Mount St. Helens, 1980-1982: J. Volcan. & Geotherm. Res., v. 28, p. 107-140.

GERLACH, T.M. and CASADEVALL, T.J., 1986b Fumarole emissions at Mount St. Helens volcano, June 1980 to October 1981: Degassing of a magma-hydrothermal system: J. Volcan. & Geotherm. Res., v. 28, p. 141-160.

GERLACH, T.M. and THOMAS, D.M., 1986, Carbon and sulphur isotopic composition of Kilauea parental magma: Nature, v. 319, no. 6053, p. 480-483. First author at Geochem. Div., 1543, Sandia Nat'l. Labs., Albuquerque, NM 87185, USA.

All the available data for the isotopic composition of carbon in gases emitted from summit fumaroles at Kilauea volcano, Hawaii, indicate that the carbon is enriched in ^{13}C compared with oceanic tholeiite and in contrast to most estimates for the isotopic composition of mantle carbon. Several mechanisms proposed to explain this enrichment of ^{13}C have proved unsatisfactory. We show here that recent models for the volatile contents and degassing of Kilauea magma permit a satisfactory reinterpretation of carbon and sulphur isotope data for Kilauea. The results indicate that Kilauea parental magma is significantly enriched in ^{13}C compared with mid-oceanic basalts and with inferred isotopic compositions for mantle carbon. Hence, mantle sources of hot-spot and mid-oceanic basalts may differ in $\delta^{13}C$. In contrast, the isotopic composition of sulphur in Kilauea parental magma is similar to that of mid-oceanic basalts. (Authors' abstract)

GETMANSKAYA, T.I., EROKHIN, A.M., NAUMOV, V.B. and CHERNOV, B.S., 1985, Genetic peculiarities of the cryolite-tin-tungsten-silver mineralization of a new type (Eastern Siberia): Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 3, p. 10-11 (in Russian).

Cited in Naumov, 1986 (this volume).

GHAZBAN, F., SCHWARCZ, H and FORD, D.C., 1986, Stable isotope studies of the Nanasivik ore deposit, Baffin I., NWT, Canada (abst.): Terra Cognita, v. 6, no. 2, p. 134. Authors at Dept. Geol., McMaster Univ., Hamilton, ON, Canada L8S 4M1.

The Nanasivik lead-zinc ore deposit is a Mississippi-Valley type ore deposit hosted in the dolostones of the Proterozoic Society Cliffs formation. The dolostones are isotopically similar to Phanerozoic dolostones (-1.5 to -6.5‰ PDB). $\delta^{18}O$ values of sparry dolomite gangue (-12 ± 3‰) when taken together with $\delta^{18}O$ of fluid inclusions in associated sphalerite indicate T's of deposition of 120 ± 20°C. Fluid inclusion Th range from 90 to 220°C. $\delta^{34}S$ of ore ranges from +23 to +29‰ (sphalerite). $\delta^{34}S$-isotope fractionations (sl-gn) give T of 150 to 260. The sulfur appears to be derived from seawater; however, associated gypsum has $\delta^{34}S$ = +34 to 36‰. $\delta^{13}C$ of gangue dolomite overlaps range of host; replacement dolomite is generally $\delta^{13}C$ enriched; banded dolomite associated with massive ore ranges to $\delta^{13}C$ = -11‰[sic], due to mixing of light carbon from organic matter during sulfate reduction. Fluid inclusions in dolomite gangue and sphalerite have O and H isotope compositions similar to Phaneorzoic oil-field brines ($\delta D = -35$ to $-80‰$). Low $\delta^{18}O$ of vug-filling, late calcite (-15‰, PDB) indicates growth from ice melt-water. (Authors' abstract)

GHENT, E.D., STOUT, M.Z., BROTHERS, R.N. and BLACK, P.M., 1986, Eclogites and associated albite-epidote-garnet paragneisses between Yambe and Cape Colnett, New Caledonia (abst.): EOS, v. 67, no. 44, p. 1251. First author at Dept. Geol. & Geophys., Univ. Calgary, Calgary, Alberta T2N 1N4, Canada.

Late stage healed fractures in quartz contain H_2O-rich fluid inclusions with relatively low density isochores. (From the authors' abstract)

GHOMSHEI, M.M., CROFT, S.A.S. and STAUDER, J.J., 1986, Geochemical evidence of chemical equilibria in the south Meager Creek geothermal system, British Columbia, Canada: Geothermics, v. 15, no. 1, p. 49-61. First author at c/o B.C. Hydro, Box 12121, 555 W. Hastings St., Vancouver, B.C., Canada V6B 4T6.

Meager geothermal reservoir appears to be in "thermochemical" equilibrium as indicated by constant ion-concentration ratios (B/Li, B/K, Na/Li, Na/Cl, etc.). The Na/Li ratio describes the thermal conditions of the first and the deepest equilibrium reached by the thermal waters, whereas the Na/K indicates a secondary and shallower equilibrium. Analysis of the correlations between K, Na and Cl indicate that discharge from well MC1 is probably a mixture between a single brine and high-chloride cool waters. (Authors' abstract)

GIBSHER, N.A., 1985, Ore and gangue quartzites of the Chekmar' (Rudnyy Altay) massive-sulfide - polymetallic deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 98-99 (in Russian; translation by D.A. Brown). Author at Inst. Geol. & Geophys., Sib. Div., Acad. Sci. USSR, Novosibirsk, USSR.

The epigenetic hydrothermal-metasomatic ores of pyrite-chalcopyrite-galena-sphalerite composition represent the principal value of the deposit.

They form zones of veinlet and veinlet-segregated mineralization of the stockwork type. Their main portion is localized in quartzites that occupy a different structural position in the host rocks. They are also distinguished in their relations with the commercial mineralization, and in their thermobarogeochemical characteristics. Three varieties of quartzites have been recognized: I) metasomatic, II) sedimentary, and III) unknown origin.

Quartzites I, along with the dispersed veinlet-segregated sulfide mineralization, form extensive orebodies in depth. The formation of these bodies took place at T = 120-380°C, with ascending hydrothermal solutions gradually cooling (15-22°C/100 m). The mineral-forming solutions were enriched in CO_2.

Quartzites II are found in the form of lenses, and more commonly in the form of clasts, which have been cemented by quartzites III. Thermometric studies have not been carried out on quartzites II, owing to the small size of the quartz grains (<10-20 µm) and, consequently, the even smaller size of the gas-liquid inclusions in them. The amount of CO_2 in quartzites II is half that in the solutions from quartzites I, and one-quarter that in quartzites III.

Quartzites III form a large body, from 20-50 up to 100-140 m thick. This body displays features of both sedimentary and metasomatic origin. Quartzites III contain the Main Ore Lode of the deposit, comprising virtually half of the ore reserves in the deposit. They have been formed by hydrothermal solutions at T = 120-280°C on the near-surface level, as indicated by the high value of the temperature gradient (140°C/100 m). Carbon dioxide is a constant component of the mineral-forming solutions.

The mineral-forming solutions of the ore-quartzites are characterized by extremely high T values and by significant amounts of CO_2. The most promising for concentrated commerical mineralization are the quartzites formed under conditions of marked T gradient and increased amount of CO_2 in the mineral-forming solutions. (From the author's abstract)

GIBSON, E.K., Jr., BUSTIN, R., SKAUGSET, A., CARR, R.H., WENTWORTH, S.J. and McKAY, D.S., 1986, Hydrogen distributions in lunar materials (abst.): Lunar & Planetary Sci. XVIII, p. 326-327.

GIBSON, E.K., CARR, L.P. and PILLINGER, C.T., 1986, Earth's atmosphere during the Archean as seen from carbon and nitrogen isotopic analysis of sediments: Lunar Plan. Sci. XVII, p. 258-259.

GIBSON, L.S., 1986, Geology and genesis of gold-bearing quartz veins on Ophir Mountain, near Murray, Shoshone County, Idaho: MS thesis, Univ. Arizona.

Three principal types of quartz vein occur on Ophir Mountain: gold-bearing bedding veins which contain sulfide ribbons; the zinc-lead-copper Goldback vein; and the gold-bearing Mead vein. Structure mapping combined with mineralogical, fluid inclusion, and sulfur isotope studies indicates that the bedding and Goldback veins formed at different times during metamorphism. Bedding veins formed by replacement along bedding faults prior to the East Kootenay orogeny during an event that produced bedding-parallel foliation in the Prichard Formation. The Goldback vein cuts bedding veins, and formed during the East Kootenay orogeny cogenetically with the main-period veins of the Coeur d'Alene district. The Mead vein is coeval with or later than the East Kootenay orogeny and fills a reverse fault formed during the orogeny. Its relationship to the other veins is unknown. (Author's abstract)

Primary fluid inclusions from unstrained vug quartz of the Mead vein contain brine (Tm ice = -0.5, -5.6°C) with Th between 200 and 230°C. The younger Wolf vein yielded primary inclusions of brine (Tm ice = -4 to -9°C) with Th between 180 and 270°C. (C.J. Eastoe)

GIEBINK, B.G. and PATERSON, C.J., 1986, Stratigraphic controls on sediment-hosted epithermal gold mineralization: Evidence from the Annie Creek mine in the Cambrian Deadwood Formation, Black Hills, South Dakota (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 613. Authors at Dept. Geol. & Geol. Engrg., South Dakota Sch. Mines & Tech., Rapid City, SD 57701.

Epithermal gold-silver deposits in the northern Black Hills are associated with sub-vertical fracture systems in the Deadwood Formation, which consists of quartzite, quartz sandstone, shale, calcareous and dolomitic sandstones, and limestone. The fractures locally cut monzonitic and trachytic sills of Laramide age, suggesting that the hydrothermal system post-dated or was late in the igneous event. In the past, mining has been focused near the upper and lower contacts of the Deadwood Formation, but the Annie Creek mine begins 10 meters below the top of the Deadwood Formation, and extends downward for 45 meters stratigraphically. 30 stratigraphic units have been defined. Two sequences of units have been preferentially mineralized, and from examination of the equivalent stratigraphy in an area outside the mine, the mineralized units were predominantly calcareous, quartz-poor sandstones. Within favored units, replacement extends for several meters from the fractures, and is manifested by silicified, pyrite-arsenian pyrite-marcasite-gold-bearing zones near the fractures.

Sulfide-bearing breccias occur within some fractures, and contain clasts of igneous, sedimentary, and rarely metamorphic (Precambrian) rocks, the latter suggesting explosive emplacement.

Salinities of 3-10 wt% equivalent NaCl and filling temperatures of 150-240°C were obtained from primary fluid inclusions in fluorite. There is a broad correlation of high gold grades with the presence of fluorite. By combining previous isotopic studies with these data, the ore fluids had $\delta^{18}O$ values of 1-4 per mil, and δD values of -50 to -70 per mil, suggesting that the ore fluid was either a mixture of magmatic and meteoric waters, or meteoric water altered by wall rocks. (Authors' abstract)

GIGGENBACK, W.F., 1986, The use of gas chemistry in delineating the origin of fluids discharged over the Taupo volcanic zone, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 47-50. Author at Chem. Div., Dept. Sci. & Industrial Research, Petone, New Zealand.

On the basis of relative CO_2, N_2, He and Ar contents of New Zealand geothermal well and volcanic fumarole discharges three major source components can be distinguished: a meteoric component derived from local groundwater, enriched in helium of originally much deeper origin, contributing nitrogen, helium and almost all the argon; a magmatic component produced in the lower crust or upper mantle and contributing most of the CO_2 and some N_2; a crustal component resulting from the decomposition of sedimentary material and the mobilization of accumulated helium giving rise to increased nitrogen and helium contents in volcanic gas discharges. (Author's abstract)

GILAT, Arieh, MILSZTAJN, Nicole and LANG, Barbu, 1986, Low temperature hydrothermal barite of Nahal Hever (abst.): Israel Geol. Soc. Annual Meeting, Maalot, 4-7 May 1986, p. 45. First author at Geol. Survey of Israel, Jerusalem.

More than 200 measurements of Th were carried out. The data show a very large range of T, between 120° to 300°C, obviously, as a result of secondary modification of the initial liquid/gas ratio within the fluid inclusions. However, maximum frequency of the determinations between 140°C and 180°C can be considered as indicative for the thermal conditions at the time of trapping.

T of last melting [of ice?] were measured in 42 P, two-phase fluid inclusions. The results indicate a relatively homogeneous character of the initial solutions, which exhibit a concentration of 3 to 5% weight NaCl equ.

The low-temperature, hydrothermal solutions circulating through the upper part of the geological section are valuable indications regarding the thermal regime present in the Pliocene-Pleistocene time, in the vicinity of the active Dead Sea transform. (From the authors' abstract)

GILMER, A.L., CLARK, K.F., HERNANDEZ, C.I., CONDE, C. and FIGUEROA, Juan, 1986, Ore mineral variations with depth, Santa Maria dome, Velardena, Durango, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 614-615. First author at Univ. Texas, El Paso, TX.

The elliptically-shaped Santa Maria dome, 7 km long and 5 km wide, is located in northeastern Durango, and regionally situated at the western margin of the Cross Ranges and the eastern flank of Sierra Madre Occidental. Locally, it occurs in a portion of a large circular structure. Carbonate replacements in the northeastern part of the dome occur within the Cretaceous Aurora and Cuesta del Cura Formations, adjacent an Oligocene-aged stock and genetically related dikes. Post-mineralization normal faulting has juxtaposed shallow and deep portions of a 1 km long rhyolite dike with which mineralization is associated. The stratigraphically highest mineralization is rich in Pb and Ag in a galena-pyrite-calcite-fluorite assemblage, with sericitization in the dike. At approximately 300 m depth, Zn values increase in a sphalerite-pyrrhotite-arsenopyrite-(galena)-calcite-fluorite assemblage. Wall rocks are silicified and the intrusive is sericitized and propylitized. The deepest portion is Cu rich in a chalcopyrite-pyrrhotite-quartz-calcite-fluorite assemblage. Garnet skarn is common, as is sericitc and propylitic alteration of igneous rocks. Fluid inclusions indicate temperatures of formation from 270-400°C, increasing with depth. Vein mineralization is localized in the southwest portion of the dome, and exhibits cavity-fill textures in a galena-sphalerite-stibnite-boulangerite-fluorite-quartz assemblage. (Authors' abstract)

GIRARD, J.P., 1985, Late hydrothermal diagenesis of siliciclastic sediments in Upper Proterozoic of the Taoudeni Basin (West Africa): Ph.D. dissertation, Univ. de Poitiers, 250 pp. plus appendices (in French with English abstract).

See next item. (E.R.)

GIRARD, J.-P., DEYNOUX, M., NAHON, D. and PAGEL, M., 1986, "Hydrothermal diagenesis" in the Upper Proterozoic siliciclastic sediments of Taoudeni basin (west Africa) (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 615. First author at Dept. Geol. Sci., Case Western Reserve Univ., Cleveland, OH 44106.

The predominantly siliciclastic Upper Proterozoic sediments of the Taoudeni basin have been buried to depths of 2 to 4 km. In a normal geothermal gradient maximum burial temperatures of the section studied would be 75 to 120°C. However, detailed petrographic and fluid inclusion data of sandstones and shales indicated two episodes of diagenesis: an earlier low temperature (<70°C) quartz cementation of the sandstones and a later and profound high temperature (130 to 600°C) diagenesis/metamorphism that affected both shales and sandstones. These temperatures are too high to have occurred simply in response to burial.

The sediments are cut by numerous diabase intrusions, which outcrop especially commonly in the south and the northeast. The intrusion of these Jurassic diabases was probably related to the opening of the Atlantic Ocean. Contact metamorphic effects and hydrothermal alteration are clearly visible near intrusive contacts. However, in Western Mali (southern part of the basin) where the largest known sill in the basin occurs, even at 50 or 60 km from any outcropping massive diabase, the late diagenetic paragenesis remains high grade (130-200°C) with illite, chlorite, siderite and ankerite present. High grade diagenesis is also observed in the Adrar of Mauretania (northwestern part of basin) where outcropping diabases are extremely rare. There, calcite, illite and chlorite cements formed at a temperature of about 165°C.

Thus, in spite of a thin sedimentary pile, the Taoudeni basin experienced high grade diagenesis which we term "hydrothermal diagenesis." We propose that this resulted from circulation of hot fluids over great distances within the basin. The circulating fluids were sedimentary pore fluids that were heated by the diabases and migrated under the influence of lateral thermal gradients generated by the intrusions. (Authors' abstract)

GITTINS, John, 1986, Genesis and evolution of carbonatite magmas (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 73. Author at Dept. Geol., Univ. Toronto, Toronto, Canada M5S 1A1.

Liquid immiscibility has been greatly exaggerated: it is a late, low-pressure phenomenon that plays only a minor role in carbonatite petrogenesis, and is largely restricted to very alkalic compositions. (From the author's abstract)

GIZE, A.P. and RICHARDSON, C., 1986a Fluid inclusions studies of the Illinois fluorite district (abst.): Geol. Soc. Newsletter, v. 15, no. 2, p. 55. First author at Southampton.

A detailed study of the mineral paragenesis and fluid inclusion compositions has been undertaken on the Cave-in-Rock fluorite district, Illinois. The mineral predominantly studied was fluorite, but sphalerite, quartz, calcite and barite were also studied. Fluorite crystals from the bedded replacement deposits are color banded. The color banding can be correlated between crystals within a deposit, and either the general color sequence, or parts of it, can be observed throughout the district.

Four basic types of inclusions have been recognized (by CR). Type I inclusions (most abundant) are aqueous fluid-vapor inclusions. Type II inclusions contain oil-vapor, with dark brown inclusions. Type III inclusions are aqueous fluid-vapor-liquid oil inclusions. Type IV inclusions contain an aqueous fluid, vapor, and a daughter phase.

Salinity and Th data are presented for the deposits. Organic inclusions have been studied by quantitative ultraviolet fluorescence microscopy, Fourier Transform infrared spectroscopy, and decrepitation-gas chromatography-mass spectroscopy. (Authors' abstract)

GIZE, A.P. and RICHARDSON, C.K., 1986b Composition of petroleum inclusions from the Cave-in-Rock fluorspar district, Illinois (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 615. First author at Dept. Geol., The Univ. Southampton, Southampton S09 5NH, UK.

Primary and secondary petroleum inclusions occur frequently in zoned fluorite from the Cave-in-Rock district, particularly in fluorite zones Y2 to P3, P5, and P7 (see Richardson and Pinckney, 1984, Econ. Geology, v. 79). The petroleum inclusions are crystallographically controlled, varying markedly in size and morphology from one zone to another but have a uniform morphology and size within a single zone. The inclusions are petroleum + vapor ± water ± solid. The solids may be inorganic (e.g., quartz), a transparent microcrystalline material (e.g., wax?), or a black opaque material.

Under transmitted light microscopy, the petroleum color changes from pale yellow in the inclusions in the later (outer) fluorite zones to a dark orange with a black solid material in the inclusions in the early zones, an optical change that has been previously interpreted as due to a heating effect. Fourier transform infrared (FTIR) spectroscopy of individual inclusions indicates that the vapor phase is CO_2. The FTIR spectra show that the liquid is a highly saturated petroleum and that there is little change in the composition of the petroleum in the inclusions with paragenesis either within a single fluorite crystal or throughout the ore body. Quantitative ultraviolet spectroscopy (UV) similarly shows little change in the emission spectrum as a function of paragenesis, the spectra being smooth with a peak emission around 500-530 nm. Decrepitation gas chromatography mass spectroscopy of the most unaltered inclusions also supports the FTIR spectroscopy and indicates a markedly saturated petroleum. Both the UV and FTIR spectra suggest that the black solid material present in the inclusions in the early fluorite zones is a precipitate rather than a thermal degradation product. (Authors' abstract)

GIZE, A.P. and RICHARDSON, C.K., 1986c Secondary migration of petroleum: Evidence from the Illinois Fluorite District (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 11. First author at Dept. Geol., The Univ., Southampton, S09 5NH.

Secondary petroleum migration occurred during and afer mineralization in the Illinois Fluorite District. The temperatures and salinities of the associated brines can be obtained from the aqueous inclusions. The petroleum inclusions are multi-phase, the simplest situation being petroleum + vapor. The composition of the petroleum, determined by decrepitation - gas chromatography-mass spectrometry is that of a strongly aliphatic oil with an odd-even preference of 1.0.

The combination of petroleum and aqueous fluid inclusion studies has enabled study of the alteration of petroleum within a thermodynamically closed system for varied times. The changes in the petroleum composition are most easily monitored in the visible spectrum, with limited success in the infra-red, and undiscernible in the ultra-violet. The infra-red spectra of petroleum inclusions indicates CO_2 to be present both as a liquid and vapor. As a vapor phase is ubiquitous to all petroleum inclusions, even inclusions formed after necking, CO_2 must be generated within the inclusions after entrapment. (Authors' abstract)

GLEASON, R.J., 1977, Wall-rock alteration, fluid inclusion, and mine water analyses of the Panteon vein system, Limón, Nicaragua: Masters thesis, Dartmouth College, Hanover, NH, 105 pp.

The Limón mining district in southwestern Nicaragua is a characteristic epithermal Au-Ag district, with quartz veins filling fractures in Tertiary andesites. Samples of wall-rock, hot subsurface waters, and vuggy vein quartz specimens were collected from underground workings in the Panteon vein system, the major producing vein in the district at present.

Results of wall-rock analyses indicate that during vein formation, SiO_2, K_2O, and volatiles were pumped into the wall-rock, while Na_2O, CaO, MgO, FeO*, MnO, TiO_2, and Al_2O_3 were mobilized out of the wall-rock and into the vein-forming solutions. Mineralogically, the country rocks which were originally labradorite-augite andesites, were altered to a mass of chlorite, adularia, illite, montmorillonite, sphene and pyrite.

There appears to be a correlation between gold assays in the vein and K_2O content of the associated wall-rock samples. Higher K_2O values were found in wall-rock associated with parts of the vein system enriched in gold content.

Th and Tm [ice?] data were obtained for fluid inclusions in polished slices of selected vein quartz samples, using a combination heating-freezing stage mounted on an optical microscope. All inclusions froze at ~0°C with no detectable freezing point depression. A pressure correction of 10° was added to Th, based on a maximum possible depth of 1000 meters for the lowest mineralized level of the vein system. Resulting Tf for the inclusions ranged from 160-275°C, but the distribution of temperatures was strongly clustered about a median interval of 216-220°C.

Interpretation of the present-day hot water and fluid inclusion data indicates that vein-forming solutions were not highly different chemically than the present subsurface waters, though they were likely somewhat more enriched in Si, Mg, Fe, and K as well as precious metals. The temperature of the solutions was on the order of 220°, likely spanning the temperature range of the inclusion filling analyses. The mechanisms of fluid circulation, heating, and wall-rock alteration in the vein-forming episode are thought to have been similar to those controlling the present isolated subsurface hot water systems in the Panteon veins system. (From the author's abstract)

GLEBOVITSKIY, V.A. and SEDOVA, I.S., 1985, Possibilities of evaluation of parameters of the geothermal regimes of deep petrogenesis, in History of development of the heat fields in zones of the various endogenic regimes of the East European countries, Moscow, p. 11-21 (in Russian).
Cited in Naumov, 1986 (this volume).

GLEBOVITSKIY, V.A., SEDOVA, I.S. and SAMORUKOVA, L.M., 1985, Fluid regime and thermodynamic conditions of amphibolite facies ultrametamorphism (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 200-202 (in Russian; translation by Dorothy B. Vitaliano). Authors at IGGD, Acad. Sci. USSR, Leningrad, USSR.

A check of the equilibrium of the composition of the fluid, investigated by the method of gas chromatography (gases liberated by heating) showed that the ratios of the components do not correspond to the conditions of formation of the rock and are not in equilibrium. A simple method of recalculation is proposed, obtained by analyzing the fluid for the composition corresponding to the conditions of formation of the rock, on the basis of determination of the equilibrium constant of two independent reactions: $CO_2 + 3H_2 = CH_4 + H_2O$ and $CO_2 = CO + H_2O$.

Comparing the raw data and the results obtained, one is convinced that there are systematic linear changes in the composition of the fluid, reduced to specific cases which were determined on the basis of critical mineral equilibria using the garnet-biotite thermobarometer and the method Th of solidified inclusions; for gneisses and vein material, these changes come down to an increase in the molar percentage of H_2O, CH_4 and CO at the expense of a decrease in H_2 and O_2. Carefully analyzing material on various metamorphic complexes including zoned complexes (Muzkol, Belomore, Ladoga, Yazgulem, and others) in that way, it is possible to come to some conclusions concerning the general features of the composition and regularities of the evolution of the fluid in the course of ultrametamorphism. The fluid of complexes metamorphosed in a regime of the andalusite-sillimanite facies series is characterized by a high content of H_2, which is reflected in high values of the H_2/H_2O and K_{vos}[?] and low O_2 fugacity. High-pressure complexes are distinguished by high contents of CO_2 and CO in the fluid. A decrease in hydrogen in all cases is accompanied by simultaneous increase in the contents of O_2 and C.

In series reflecting the development of ultrametamorphism and the transition from autochthonous to allochthonous granitoids, the fluid is oxidized, the extent of oxidation increasing with increasing distance of migration of the melt from the zone of generation; this effect is especially intensively manifested in high-P complexes.

Determination of the concentration of H_2O on the basis of the Th of inclusions and P, known from geobarometry, for the P-T diagram of the system granite-water with independent P(tot) and $P(H_2O)$, showed that in all leucosomes of the migmatites and granites, $P(H_2O) < P(tot)$. $P(H_2O)$ and $X(H_2O)$ on this diagram coincide with these same values calculated on the basis of the gas chromatography data. The extent of water saturation of the ultrametamorphogenic granitoids is greater in the andalusite-sillimanite facies series than in the kyanite-sillimanite. Intrusive granitoids are less water-saturated than the ultramorphic granitoids (for instance, for the North Ladoga area, $\Sigma g/H_2O = 0.680$ in the former compared to 0.601 in the latter). (From the authors' abstract)

GLEBOVITSKIY, V.A., ZINGER, T.F., KOZAKOV, I.K., KOTOV, A.B., KRYLOV, D.P., MANUYLOVA, M.M., MITROFANOV, F.P., ORLOVSKAYA, K.V., SAMORUKOVA, L.M. and SEDOVA, I.S., 1985, Migmatitization and granite-formation in various thermodynamic regimes. Leningrad, "Nauka," 310 pp. (in Russian).

Cited in Naumov, 1986 (this volume).

GLEN, William, 1986, Comment on "Particles in fluid inclusions from Yellowstone National Park - bacteria?" [Barger et al., Fluid Inclusion Research, v. 18, p. 27]: Geology, v. 14, p. 90.

GODWIN, C.I., WATSON, P.H. and SHEN, Kun, 1986, Genesis of the Lass vein system, Beaverdell silver camp, south-central British Columbia: Can. J. Earth Sci., v. 23, p. 1615-1626. First author at Dept. Geol. Sci., The Univ. British Columbia, Vancouver, B.C., Canada V6T 2B4.

The Lass vein is in the Beaverdell silver, lead, zinc (gold) vein camp in south-central British Columbia. Veins in this camp are generally hosted within propylitized Westkettle granodiorite of Jurassic age, but mineralization is related to the Beaverdell quartz monzonite stock of Late Paleocene age (based on a K-Ar biotite date of 58.8 ± 2.0 Ma). Galena lead isotopes, interpreted using the recent "shale," "Bluebell," and "mixing-line isochron" models for the Canadian Cordillera, confirm a Tertiary age for all major vein mineralization in the Beaverdell camp.

Examination of metal zoning, mineralogy, fluid inclusions, and sulfur isotopes indicates that the Lass vein system can be divided into two distinctly different parts, an upper western portion and a lower eastern portion. Differences between the two parts are related to the dominance of one of two mineralizing events.

Event 1, the earlier, was most dominant in the lower portion of the Lass vein system. By comparison with event 2, event 1 is characterized by (i) relatively gold-, zinc-, and lead-rich but silver-poor ore (Au, 3163 ppb; Zn, 5.34%; Pb, 2.34%; Ag, 208 ppm); (ii) thicker veins (20 cm); (iii) sulfides with abundant pyrite, arsenopyrite, and dark sphalerite with exsolved chalcopyrite; and (iv) fluid inclusions with higher salinities (15 wt. eq. wt.% NaCl), local CO_2 phases, and higher Th (287°C) with matching equilibrium T indicated by sulfur-isotope geothermometry from galena and sphalerite (294°C).

The younger event 2 is responsible for most of the mineralization in the upper portion of the Lass vein. Many characteristics of this event are statistically different from those associated with event 1. Namely, event 2 (i) is relatively silver rich and gold, zinc, and lead poor (Ag, 291 ppm; Au, 764 ppb; Zn, 3.07%; Pb, 1.27%); (ii) has narrower veins (10 cm); (iii) has sulfides characterized by silver-sulfosalt-bearing galena and pale sphalerite; and (iv) is represented by fluid inclusions that are variable but on average lower in salinity (7 eq. wt.% NaCl), have lower Th (225°C), and do not contain CO_2 phases.

Estimates from fluid inclusions indicate that event 1 could have occurred at depths equivalent to those of event 2 if the former was under lithostatic P at T near the boiling point and if the latter formed at hydrostatic P near boiling T. Sulfur-isotope data indicate that event 1 was nearly boiling; no similar definition is available for event 2. Thus, only minimum depth estimates are available for event 2.

The most likely scenario for formation of the Lass vein system starts with event 1 and is followed by event 2. During event 1, minerals were deposited in a confined system under lithostatic P from high-salinity fluids where chloride complexing could have been important in the transportation of gold. Fracturing of the vein system to the surface changed the P regime to hydrostatic, and CO_2 was released. Consequently, T and salinities of the fluid dropped, presumably mainly in response to mixing with cooler and less saline groundwater. Thus, gold solubilities concomitantly decreased, and silver deposition became more significant.

Fluid-inclusion and lead-isotope analyses appear to be useful exploration procedures in the Beaverdell area in the identification of gold-rich systems. A further practical observation is that gold should continue to depth in the Lass system, if the vein can be followed. (Authors' abstract)

GOLDBERG, E.D., 1986, Black carbon in the environment, properties and distribution: John Wiley & Sons, NY, 1985, 198 pp.

GOLDFARB, R.J., LIGHT, T.D. and LEACH, D.L., 1986, Nature of the ore fluids at the Alaska-Juneau gold deposit: U.S. Geol. Survey Circular 978, p. 92-95.

Fluid inclusions in quartz samples from the auriferous veins are as large as 50 microns in maximum dimension.

Type 1 fluid inclusions appear as 2-phase liquid CO_2 + liquid H_2O at room temperature and can be characterized by the H_2O-CO_2-N_2-NaCl system. Generally, a CO_2 vapor phase forms upon cooling. The fluids range in composition from H_2O-dominant inclusions containing a few mole percent CO_2 to inclusions that are CO_2 dominant with no visible H_2O. Gas hydrate melting occurs between +7.8°C and +10.2°C. Melting of CO_2 ranges from the CO_2 triple point (-56.6°C) to -61.8°C, indicative of relatively pure CO_2 and CO_2 containing as much as 50 mole percent N_2.

Some sets of inclusions with variable ratios clearly result from heterogeneous trapping of immiscible fluids. Homogenization temperatures for CO_2 vapor to CO_2 liquid range from -13°C to +17°C, corresponding to densities of 0.98 to 0.85 g/cm^3, respectively. Homogenization of the CO_2 fluid with the H_2O liquid occurs at temperatures between 230 and 280°C.

Type 2 fluid inclusions are water-dominant with no detectable gases. Ice-melting temperatures for 2-phase inclusions range from -1.2°C to -6.5°C, corresponding to 2-10 weight percent NaCl equivalent salinity. Type 2 inclusions homogenize in the range of 145°C to 190°C. Several groups of one-phase inclusions froze between -35°C and -40°C, but ice melting was not observed; these may represent a later entrapment of a second generation of aqueous fluids.

In many samples, type 1 and type 2 inclusions were interpreted to be coevally trapped, suggesting that they represent immiscible fluids derived from a boilng system. Isochores determined from measured homogenization temperatures of selected pairs of H_2O- and CO_2-dominant inclusions intersect at about 230°C and 1.5 Kb.

A second minimum pressure estimate results from use of the quartz decrepitation data of Leroy (1979). Just prior to homogenization, inclusions with diameters of 15 microns decrepitated at temperatures between 250°C and 255°C, indicative of maximum internal pressures of about 1.2 Kb. This agrees closely with the value determined from the crossing isochore method. (From the authors' text)

GOLDSMITH, J.R., 1986, The role of hydrogen in promoting Al-Si interdiffusion in albite ($NaAlSi_3O_8$) at high pressures: Earth & Planet. Sci. Letters, v. 80, p. 135-138. Author at Dept. Geophys. Sci., Univ. Chicago, 5734 South Ellis Ave., Chicago, IL 60637, USA.

The rate of Al/Si disorder in "dry" low albite is greatly enhanced at high pressures. This enhancement takes place in a P-T regime where the presence of water would induce melting; none was observed. The experimental work was carried out in piston-cylinder apparatus using NaCl pressure medium. Modification of the experimental conditions to avoid production of hydrogen by dissociation of moisture in the pressure medium, as well as to capture hydrogen with Fe_2O_3 and ZnO indicates that hydrogen is the active agent in promoting Al/Si diffusion at high pressures in $NaAlSi_3O_8$. A mechanism involving transient OH groups that stimulate coordinations greater than 4, simultaneously breaking Al-O and Si-O network bonds is proposed. (Author's abstract)

GOLDSTEIN, R.H., 1986a Integrative carbonate diagenesis studies: Fluid inclusions in calcium-carbonate cement; paleosols and cement stratigraphy of Late Pennsylvanian cyclic strata, New Mexico (USA): PhD dissertation, Univ. Wisconsin, Madison, WI, 361 pp.

Indexed under fluid inclusions. (E.R.)

GOLDSTEIN, R.H., 1986b Reequilibration of fluid inclusions in low-temperature calcium-carbonate cement: Geology, v. 14, p. 792-795. Author at Dept. Geol., Univ. Kansas, Lawrence, KS 66045.

Calcium-carbonate cements precipitated in low-T, near-surface, vadose environments contain fluid inclusions of variable vapor-to-liquid ratios that yield variable Th. Cements precipitated in low-T, phreatic environments contain one-phase, all-liquid fluid inclusions. Neomorphism of unstable calcium-carbonate phases may cause reequilibration of fluid inclusions. Stable calcium-carbonate cements of low-T origin, which have been deeply buried, contain fluid inclusions of variable Th and variable salt composition. Most inclusion fluids are not representative of the fluids present during cement growth and are more indicative of burial pore fluids. Therefore, low-T fluid inclusions probably reequilibrate with burial fluids during progressive burial. Reequilibration is likely caused by high internal P in inclusions which result in hydrofracturing. The resulting fluid inclusion population could contain a nearly complete record of burial fluids in which a particular rock has been bathed. (Author's abstract)

GONCHAROV, V.I., VORTSEPNEV, V.V. and AL'SHEVSKIY, A.V., 1984, Conditions of formation of the silica-rich volcanic rocks of the Okhotsk-Chukotha volcanic belt (results of the magmatic inclusion studies), in Problems of the metallogeny of the North-East USSR, p. 87-96, Magadan (in Russian).

Cited in Naumov, 1986 (this volume).

GONCHAROV, V.I., VORTSEPNEV, V.V. and AL'SHEVSKIY, A.V., 1985, Magmatogenic nature of the gold ore mineralization in the folded structures of the North-East part of the USSR: Tikhookeanskaya Geologiya, no. 5, p. 53-61 (in Russian).

Cited in Naumov, 1986 (this volume).

GONZALEZ PARTIDA, Eduardo, 1984a Analysis of fluid inclusions and sulfur, hydrogen, and oxygen isotopes of the massive sulfide ores of Tizapa-Santa Rosa, State of Mexico, Mexico: Geomimet, v. 128, p. 66-76 (in Spanish).

The ore bodies are in Paleozoic rocks. Zones of fluid circulation are characterized by ferromanganiferous minerals, principally actinolite and chlorite, each one associated with multicomponent fluid inclusons: NaCl, KCl, CH_4 [by Raman] and H_2O, having Th of 440 to 550°C [Tm KCl 100-180°C, Tm NaCl 400-536°C].

The $\delta^{18}O$-δD composition calculated for fluids in equilibrium with chlorite and actinolite are comparable with those of marine and/or meteoric fluids. $\delta^{34}S$ demonstrates that the sulfide sulfur was remobilized biogenic S in the pelitic series. (From the author's abstract, translated by G. Landis)

GONZALEZ PARTIDA, Eduardo, 1984b Microthermometric studies of the Fresnillo mining district, Zacatecas, Mexico: Geomimet, v. 130, p. 17-21 (in Spanish).

The results are reported for 300 analyses of heating and freezing microthermometry from different samples in the Fresnillo District that represent chimneys, mantos, disseminated mineralization, and veins. The T, salinity, density, and P of the fluid varied systematically with space (depth). The fluids that transported the different faces of mineralization in the Fresnillo mine are characterized by the following:

The chimney ores of Cu and small amounts of Pb and Zn formed at 350-390°C, 200 bars, a density of 0.641 g/cm^3, and ~3 eq. wt.% NaCl.

The manto and disseminated ores of Pb and Zn formed between 200-305°C, ~100 bars, from a fluid of 0.740 g/cm^3 density and 3-5 eq. wt.% NaCl salinity. The fluid P was the major variable for formation of this mineralization.

Two systems of veins with quartz-calcite gangue were observed at the shallow 270 level and the much deeper 920 level, with a range from 146°C to 329°C, salinities from 5-12 eq. wt.% NaCl, with the higher salinity determined for the shallow 270 level fluids. Fluid P ranged from 100-200 bars and densities from 0.984 to 0.721 g/cm^3 between the 270 and the 920 level. (Abstract by G. Landis)

GORNITZ, Vivien, 1986, Uranium mineralization at the Orphan mine breccia pipe, Grand Canyon, Arizona (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 357. Author at Columbia Univ & Inst for Space Studies, 2880 Broadway, New York, NY 10025.

The Orphan Mine deposit lies in a nearly circular, vertical breccia pipe, 50-150 m across [in sediments]. Uranium ore has accumulated along the pipe boundary and within the pipe. Uraninite and pyrite at the pipe core grade into a complex assemblage of uraninite plus copper and lead minerals toward the margins. Small amounts of As, Ni, Co, Mo and V are found. Precipitation of uraninite was accompanied by hematitization. Carbonate addition has occurred along the pipe margins. Red Supal sandstone is strongly bleached along the contact and within the pipe.

Fluid inclusion temperatures of calcite (60-110°C) slightly exceed estimated burial temperatures. (From the author's abstract)

GOROSHENKO, A.R. and SHLUKOVA, Z.V., 1985, Study of inclusions in minerals of sapphire-bearing pegmatite of criss-cross line, Khibiny massive (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 22-23 (in Russian; translation by S. Jaireth). Authors at IGEM Acad. Sci. USSR, Moscow, USSR.

Sapphire-bearing pegmatites of Kukisvumchor have been studied. They are marked by the presence of a large variety of minerals: alkali-feldspar, nepheline, biotite, sapphire, hercynite, ilmenite, schorl, monazite, sodalite, apatite, zircon, eskolaite, graphite, native iron, analcite, goethite, etc.

Inclusions have been studied in sapphire, sodalite, nepheline and biotite. Largest inclusions (≤0.2-0.4 mm) were seen in a dark blue sapphire. Inclusions are of glassy, crystal-fluid and predominantly gaseous types. Shapes of most inclusions are negative crystal, Th = 1000°C. Pinkish sodalite bears mostly predominantly gaseous (gas 60-70%) and gas-liquid inclusions of rounded and elongated shapes and size ≤50-150 µm. Th = 400 to 520°C. Nepheline is particularly rich in inclusions constituting ≤3-5 vol.%, but inclusions are extremely small, hence Th ≈800°C are not sufficiently accurate. Nepheline and sodalite contain secondary hydrocarbon(?) inclusions of spherical, oval, rarely elongated shapes and few tens to few hundreds of µm in size, distributed along cracks of different orientation.

Results of these studies, combined with detailed mineralogical studies, reveal that pegmatites were formed from residual melts-solutions at ≈1000-700°C, with participation in subsequent stages of deep-seated fluids containing hydrocarbons, F, As and S. (From the authors' abstract)

GOSTYAEVA, N.M., 1985, Physico-chemical conditions of formation of metasomatic rocks of the Kirovograd block of the Ukrainian shield (fluid inclusion data): Summary of the Candidate of Science Dissertation (Doctorate), [Univ. of] Kiev, 26 pp. (in Russian).

Cited in Naumov, 1986 (this volume).

GOTTIKH, R.P. and PISOTSKIY, B.I. 1986, Migration of uranium and bituminous matter in hydrothermal solutions: Dokl. Akad. Nauk SSSR, v. 286, no. 4, p. 962-964 (in Russian). Authors at Sci.-Research Inst. Nuclear Geophys. & Geochem., Moscow, USSR.

The uranium-bearing bitumens commonly occur in terrigenous and carbonate rocks of the Irkutsk region; they were regarded as the final products of decomposition of the paleo-petroleum by oxidized waters bearing uranium. However, similar U-bearing bitumens were found in the rocks of the crystalline basement, commonly in zones of the higher permeability. Minerals of such zones bear water-hydrocarbon (HC) inclusions 3-10 μm in size, filled by LH_2O (80-90 vol.%) + G, LHC + G and LHC + LH_2O + G in various proportions, as well as by pure LCO_2 + GCO_2 and methane. Autoradiography proved the presence of uranium in the HC-bearing inclusions. Th of inclusions range from 258 to 88°C, but the LH_2O + LHC inclusions did not homogenize $\leq 260°C$, indicating heterogeneous trapping. By laser spectrography it was found that together with uranium, also Ti, Fe, Th, Zr, La, Y and Ce migrated in the hydrothermal HC-bearing solutions. (Abstract by A.K.)

GOU, X.M., COMET, P.A. and DOUGLAS, A.G., 1986, Origin of the bitumen in Derbyshire, England - An organic geochemical study (abst.): Terra Cognita, v. 6, no. 1, p. 23.

GRABCZAK, J. and ZUBER, A., 1986, A combined isotope and chemical approach to determining the origin of brines in salt mines: Freiberger Forschungshefte, no. 417, 1986, p. 105-115.

The paper presents a summary of isotope and chemical studies on the origin of brines in four Polish salt mines (three in Zechstein salt domes and one in a Miocene formation). Stable isotope content of brines encountered in mines depend on the origin of waters and on the processes of isotope exchange. These processes may be classified as primary, i.e., those occurring in the salt rock, and secondary, i.e., those occurring in a mine. The primary processes are dissolution of, and isotope exchange with hydrated salt minerals. The secondary processes are evaporation in a mine and molecular exchange with the water vapor in the mine air. The secondary processes may lead to great shifts of the original isotope contents, which make the identification of some brines ambiguous. Particular identification problems are encountered in mines with wet exploitation and/or in the case of leaks of a low flow rate at places of difficult access. The presented case studies prove that in spite of some ambiguities the isotope methods are very useful in solving the identification problems. (Authors' abstract)

GRABEZHEV, A.I., LEVITAN, G.M., VIGOROVA, V.G., CHASHCHUKHINA, V.A., NEYKUR, T.A. and YERSHOVA, N.A., 1986, Gold in orogenic granitoids of the Ural eugeosyncline: Izvestiya AN SSSR, Ser. Geologicheskaya, 1986, no. 4, p. 105-116 (in Russian; translated in Int'l. Geol. Review, v. 28, no. 4, p. 449-460, 1986).

Includes a table (p. 459) of Na/K ratios of fluid inclusions in quartz from 9 gold-ore and rare-metal deposits. (E.R.)

GRAHAM, D.W., JENKINS, W.J., KURZ, M.D. and BATIZA, R., 1986, Helium isotopic disequilibrium and geochronology of glassy seamount basalts (abst.): Terra Cognita, v. 6, no. 2, p. 191. First author at Dept. Chem., Woods

Hole Oceanographic Inst., Woods Hole, MA 02543.

We have used the isotopic disequilibrium of $^3He/^4He$ between He trapped in vesicles and dissolved in the glass phase of seamount basalts to determine (U + Th)/He ages. The $^3He/^4He$ in vesicles, extracted by crushing *in vacuo*, allows a correction to be made for the inherited component, in order to obtain the radiogenic [He]. The minimum detectable age for these seamount alkali basalts is less than 10,000 years.

We have analyzed a suite of glassy basalts from seamounts on young crust (<10 Ma) near the East Pacific Rise. Isotopic disequilibrium, with lower $^3He/^4He$ in the glass phase, occurs in all the alkali basalts; some transitional lavas also show disequilibrium. Both these rock types are degassed with respect to coexisting tholeiites and thus have high (U + Th)/He, making radiogenic ingrowth clearly detectable. Computed ages range from 10^3 to 10^6 years. The disequilibrium technique can be applied to rocks where phases of different (U + Th)/He are present, and has the potential for resolving the geochemical evolution of volcanic systems on time scales less than 10^4 years. (Authors' abstract)

GRAIZER, M.I. and IL'INSKAYA, Kh.G., 1986, Time of formation of the fold structures in the Patom Upland Sov. Geol., no. 2, 1986, p. 82-87 (in Russian). Authors at Inst. Litosf., USSR.

Fluid inclusions in blue quartz from metaconglomerate and granite are similar in phase composition, homogenization temperature, and phase transition sequence. (From C.A. 104: 171921w)

GRAMBLING, J.A., 1986, A regional gradient in the composition of metamorphic fluids in pelitic schist, Pecos Baldy, New Mexico: Contrib. Mineral. Petrol., v. 94, p. 149-164. Author at Dept. Geol., Univ. New Mexico, Albuquerque, NM 87131, USA.

Two metamorphic isograds cut across graphitic schist near Pecos Baldy, New Mexico. The southern isograd marks the first coexistence of staurolite with biotite, whereas the northern isograd marks the first coexistence of andalusite with biotite. The isograds do not record changes in T or P. Instead, they record a regional gradient in the composition of the metamorphic fluid phase. Ortega Quartzite, which contains primary hematite, lies immediately north of the graphitic schist. Mineral compositions within the schist change gradually toward the quartzite, reflecting gradients in $\mu(O_2)$ and $\mu(H_2O)$. The chemical potential gradients, locally as high as 72 cal/m in $\mu(O_2)$ and 9 cal/m in $\mu(H_2O)$, controlled the positions of the two mapped isograds. The staurolite-biotite isograd records where $X(H_2O)$ fell below 0.80, at $f(O_2)$ near 10^{-23} bars; the andalusite-biotite isograd records where $X(H_2O)$ fell below 0.25, at $f(O_2)$ near 10^{-22} bars. Dehydration and oxidation were coupled by graphite-fluid equilibrium.

The chemical potential gradients apparently formed during metamorphism, as graphite in schist reacted with hematite in quartzite. Local oxidation of graphite formed CO_2 which triggered dehydration reactions along the schist-quartzite contact. This process created a C-O-H fluid which infiltrated into overlying rocks. Upward infiltration, local fluid-rock equilibration and additional infiltration proceeded until the composition of the infiltrating fluid evolved to that in equilibrium with the infiltrated rock. This point occurs very close to the staurolite-biotite isograd. Pelitic rocks structurally above this isograd show no petrographic evidence of infiltration, even though calculations indicate that volumetric fluid/rock ratios may have exceeded 15 and thin, rare calc-silicate beds show extensive K-metasomatism and quartz veining. (Author's abstract)

GRANOVSKAYA, N.V., 1985, Genetic and prospecting-assessment information content of gas-liquid inclusions in barite of deposits in the Northwestern Caucasus (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 176-178 (in Russian; translation by Dorothy B. Vitaliano). Author at Rostov State Univ., Rostov-on-the-Don, USSR.

Gas-liquid inclusions in zoned barite crystals of different generations in crustification veins of the ore zones of the Belorechensk and Chernyy Shakhan deposits and in several vein barite prospects on the Belaya-Laba interfluve were studied. The inclusions were P, PS ("pseudoprimary" or "early secondary") and S ("late secondary"); they are mainly gas-liquid and liquid, sometimes with CO_2. The P inclusions are situated on zones of growth and azonally in undeformed crystals. The PS inclusions are confined to microfractures syngenetic with the growth of the crystal; they have equal phase ratios for minerals of the same age: gas-liquid (from 2:98% to 15:85%). The largest of the inclusions (up to 10 μm) are characteristic of barite of vein fillings; for the metasomatic varieties their size does not exceed 1-2 μm. No dms were found. The number of S inclusions, localized in post-genetic fracture zones and unrelated to processes of growth and regeneration of the enclosing crystal, generally falls off from the barite of the earlier to the later generations, and their size does not exceed 2 μm. Inclusions formed both at the time of growth of the large barite crystals and epigenetically are characterized by a necked-down shape, and also often by negative-crystal form, variable phase ratio, size up to 30 μm, and Th $\leqslant$300°C.

Study of the Th of the contents of normal (authigenic) P inclusions and the chemical composition of their solutions and gases showed that they can be used as indirect typomorphic criteria in distinguishing different generations of barite, in formulating the evolutionary series of the crystals, and in qualitative estimation of the erosion level of the barite veins and their potential.

For instance, for early and late productive generations of barite, there were established, respectively: Th of P inclusions -- 200-140 and 110-60°C; phase composition of inclusions (g:l,%) - (10-15):(90-85) and (5-7):(95-93); concentration of salts in the solutions in the inclusions (in NaCl equivalent) -- 11-14 and 7-8 wt.%; Ca/Na ratio in aqueous extracts -- 0.1-0.94 and 0.98-3.08; Td -- 100-200 and 40-100°C. In each generation of barite there is observed a positive correlation between the Sr content in the samples and the Th of its inclusions, i.e., a decrease in the content of that element as the mineral was deposited, with a general tendency toward its increase from the initial to the final phases of the process of barite formation. The evolution of the habit of the barite shows up to change in the crystals from a long prismatic habit with insignificant development of the faces of the pinacoid, to tabular and pinacoidal habit with corresponding decrease in Th of the P inclusions, situated zonally in the outer zones of growth of the crystal, from 180 to 60°C. For the gas composition of the inclusions, a content of CO_2 in the samples seems typomorphic, also a CO_2/H_2O ratio (from data of gas chromatography), the main variations in which are produced by the possibility of degassing of the mineralizing solutions as they move along the fracture and, as a result, by the morphological features of the veins themselves and of individual barites. In massive fractured barite from the thickest veins, the relative amount of CO_2 is 1-7%, and in the transparent crystals growing in cavities in relatively closed systems the CO_2 content increases to 20% of the total amount of gases.

Correlation of the results of the mineralogic and thermometric investigations indicates that most intensive crystallization of barite occurred in the 180-160° and 90-70°C ranges, with a sharp decrease in the relative amount of CO_2.

For standard [normal?] barite bodies explored at depth, a primary vertical zoning has been established, on the basis of which mineralogic-thermobarogeochemical prospecting indicators of barite veins that have not been deeply eroded have been determined: the presence of late generations of minerals and morphologic types of barite crystals of pinacoidal habit; low Th of P inclusions; maximum amount of Sr impurities in barite (>1%); maximum Ca/Na ratios in the solutions of the inclusions (>1), and also several other typomorphic criteria characterizing late generations of barite. (Authors' abstract)

GRANT, G.J. and RUIZ, Joaquin, 1986, Paragenesis and ore fluid evolution in the San Francisco Del Oro district, Chihuahua, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 620.

GRANT, J.A., 1986, Quartz-phlogopite-liquid equilibria and origins of charnockites: Am. Min., v. 71, p. 1071-1075. Author at Dept. Geol., Univ. Minnesota, Duluth, MN 55812, USA.

Published experimental data for quartz + K-feldspar + phlogopite + enstatite + liquid + vapor suggest that the liquid in the low-pressure invariant assemblage has less than 3 wt% H_2O, and that a thermal divide exists on the liquidus below 5 kbar. With addition of CO_2 to the system, the thermal divide persists to at least 15 kbar. The small but not negligible solubility of CO_2 in the silicate liquids apparently results in (1) a temperature range of 50-100 degrees over which quartz + K-feldspar + phlogopite + enstatite can coexist with liquid in the absence of vapor and (2) the possibility that influx of CO_2 into a solid-phase assemblage such as quartz + K-feldspar + phlogopite can initiate partial melting. Subsequent segregation of restite from liquid could lead to the formation of charnockite with a CO_2-rich vapor and biotite granite with an H_2O-rich vapor. (Author's abstract)

GRATIER, J.P., 1986, Experimental deformation of quartz and calcite by dissolution-precipitation: Effect of the nature of the fluid (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 84 (in French). Author at IRIGM, Un. de Grenoble, BP 68, 38402 St Martin d'Heres, France.

Natural deformation of rocks by dissolution-precipitation is a process of flow of the outer layer and occurs mostly when fluid-saturated rocks are subjected to small stress differences. Strain rates, although significant in natural situations (10^{-11} -$10^{-16}s^{-1}$), are very difficult to produce in laboratory experiments (where one is limited to $10^{-9}s^{-1}$). Using maximum values for T, P and stress difference (around 400°C, 200 MPa and 50 MPa respectively) just below the limits of plastic behavior, and very effective solvents (NaOH solutions for quartz and NH_4Cl solutions for calcite), one obtains deformations by dissolution-precipitation which are measurable after experimental runs of several weeks. The results give information on the limiting steps in the deformation process (reaction kinetics at the solid/liquid interface or mass transfer by diffusion) and on the driving force of this mass transfer: stress difference between the dissolution interface and the precipitation interface. (Author's abstract; translated by R. Kreulen)

GRATIER, J.P. and GUIGUET, R., 1986, Experimental pressure solution-deposition on quartz grains: The crucial effect of the nature of the fluid: J. Structural Geol., v. 8, no. 8, p. 845-856. Authors at IRIGM, Univ. Grenoble, B.P. 68, 38402 Saint-Martin-d'Hères, France.

Experimental deformation by P solution was performed on an aggregate of small grains subjected to deviatoric stress (50 MPa) for a long time (several weeks or months) at relatively high T and P in contact with various fluids (air, water, 0.1 to 1 N NaOH for quartz, water and 5% NH_4Cl for calcite). The change in shape of the grains by solution-deposition depended on the duration of the experiment (with the same fluid) and on the concentration of the solid in solution (with the same duration but various fluids). Significant shape changes were obtained for quartz grains, but only with both long duration and very good solvents (1 N NaOH). By comparison with previously obtained results on the change of shape of fluid inclusions (where the kinetics of dissolution was the rate controlling process), the limiting process of the deformation of the quartz grains was inferred to be the rate of diffusion along grain boundaries saturated with trapped fluid. (Authors' abstract)

GRATZ, J.F. and MISRA, K.C., 1986, Nature of ore-forming fluids for zinc deposits of the central Tennessee district, USA (abst.): Terra Cognita, v. 6, no. 3, p. 509. Authors at Dept. Geol. Sci., Univ. Tennessee, Knoxville, TN 37996-1410, USA.

There are three textural varieties of sphalerite (disseminated, massive, and vug-fill), but they are indistinguishable in terms of fluid inclusion data or composition (electron microprobe and atomic absorption analyses).

Fluid salinity remained essentially constant from early calcite through main-stage calcite deposition. The clustering of paired Th (avg. 115°C) and Tm (avg. -20.3°C) for fluid inclusions in sphalerite suggest its precipitation from one fluid rather than due to mixing of two or more fluids. Organic matter, abundant in mineralized zones and as inclusions in sphalerite, appears to have played a role in sphalerite precipitation. Precipitation of fluorite was probably caused by the slight decrease in T. Precipitation of barite and late-stage calcite, correlated with a slight decrease in T but a marked decrease in salinity, may have been caused by an influx of meteoric water, but this is not supported by our limited carbon and oxygen isotope analysis of calcite. (From the authors' abstract)

GRAYBEAL, F.T., SMITH, D.M., Jr. and VIKRE, P.G., 1986, The geology of silver deposits, in Handbook of strata-bound and stratiform ore deposits, Part IV, Vol. 14, Regional studies and specific deposits, K.H. Wolf, ed.: Amsterdam Elsevier Sci. Pub., p. 1-184.

Includes a discussion of literature data on inclusions at Providencia, Mayflower vein at Park City, Leadville, Wood River, and Encantada, and unpublished work of P.D. Proctor on Tintic, Utah, where Th of fluid inclusions in vein minerals decrease with increasing distance from the Silver City stock from about 350°C at the intrusion to 250°C in veins in siliceous sedimentary rocks adjacent to it, thence to 200°C in veins in carbonate rocks which host replacement ore at the Chief mine 11,000 ft to the north. (E.R.)

GREEN, H.W., II, 1985, Coupled exsolution of fluid and spinel from olivine: Evidence for O^- in the mantle?, in R.N. Schock, ed., Point Defects in Minerals, Geophys. Monograph 31, Mineral Physics 1: Am. Geophys. Union, Washington, DC, p. 226-232. Author at Dept. Geol., Univ. California, Davis, Davis, CA 95616.

At least some of the C in the earth's upper mantle is dissolved in the silicates. Recent experimental studies on olivine by Freund and coworkers have indicated C solubility of several hundred ppm at atmospheric P and very rapid diffusivities. I here consider the chemistry of composite fluid and solid precipitates in olivine from peridotite xenoliths in kimberlite pipes. The precipitates consist of hemispheres of CO_2-rich fluid and platelets of spinel. The two phases exsolved simultaneously, suggesting a link between the dissolution of carbon and the trivalent cations of the spinel. (From the author's abstract)

GREENLAND, L.P., 1986, Gas analyses from the Pu'u O'o eruption in 1985, Kilauea volcano, Hawaii: Bull. Volcanol., v. 48, p. 341-348.

GREGORY, R.G., 1986, An integrated approach to vein and fracture mapping using soil gases (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 10.

GREGORY, R.T., 1986, Oxygen isotope systematics of quartz-magnetite pairs from Precambrian iron formations: Evidence for fluid-rock interaction during diagenesis and metamorphism, in J.V. Walther and B.J. Wood, eds., Fluid-Rock Interactions during Metamorphism, New York, Springer-Verlag, p. 132-153.

GRETENER, P.E., 1986, Macrofractures and fluid flow: Bull. Swiss Assoc. Petrol.-Geol. & Engineers, v. 53, no. 123, p. 59-74. Author at Dept. Geol. & Geophys. Calgary, Calgary, Alberta, T2N 1N4, Canada.

Evidence is presented that fractures, in particular joints, play a much more significant role in subsurface fluid flow than is generally accepted. Fractures produce little porosity but increase permeability dramatically. Both field observations and theoretical considerations force upon us the conclusion that open fractures are a key element in facilitating subsurface fluid movements. (Author's abstract)

GRETENER, P.E. and FENG, Z.-M., 1985, Three decades of geopressures - Insights and enigmas: Bull. Ver. Schweiz. Petrol.-Geol. u.-Ing., v. 51, no. 120, p. 1-34.

GREW, E.S., 1986, Kornerupine at the Sar e Sang, Afghanistan, whiteschist locality: Implications for the role of water activity in the disappearance of tourmaline during high-grade metamorphism (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 621.

GRIB, Ye.N., 1985, Temperature conditions of crystallization of acid magmas of the region Uzon-Geyzernyi (results of studies of melt inclusions in minerals): Vulkanologiya i Seysmologiya, no. 5, p. 66-79 (in Russian).

Cited in Naumov, 1986 (this volume).

GRIGORIEVA, E.P. and MOROZOV, S.A., 1985, Thermobaric conditions of forming of gold mineralization in Pamirs (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 45-46 (in Russian; translation by I.V. Kulikov). Authors at IG AN Tadzh. SSR, Dushanbe, USSR.

Gold mineralization in Pamirs, which are still poorly investigated, could be classified into two formations: gold-quartz and gold-sulfide. Gold-bearing mineral associations in the Central Pamirs are gold-quartz, gold-arsenopyrite, gold-tungsten-tourmaline; and in the North Pamirs - it is the gold-tetrahedrite association.

Gold mineralization in the North Pamirs formed during three hydrothermal stages. First (pre-ore) stage silicified the rocks, yielded slight pyritization and formation of siderite-ankerite veins at high temperatures (>450°C), and 1.5-1.8 kbar. In the second stage quartz-carbonate veins were formed at 430-360°C and 0.7-.8 kbar. At the end of this stage T decreased to 300°C and P to 0.3 kbar. Formation of gold-tetrahedrite association occurred at comparatively low T (250-150°C) and P (0.35 kbar).

Gold mineralization in the Central Pamirs formed during a polystaged hydrothermal cycle. Native gold appeared in two periods: 1) in association with quartz, tourmaline, scheelite, and later with arsenopyrite (earlier type of gold); 2) in association with later sulfides (later type of gold). The first association was formed at 400°-350°C and 0.8-0.5 kbar, and the second association at 200-150°C and ~0.3 kbar.

Gold mineralization of Pamirs in Tadzhikistan are the youngest (Alpine), while all the others are Paleozoic. Still their thermobaric conditions of formation are similar in many features. (Authors' abstract)

GRINENKO, L.N., BOCHAROV, V.L. and KOTORGIN, N.F., 1986, Sulfur content and isotopic composition in the rocks of komatiite series: Geokhimiya, 1986, no. 9, p. 1245-1253 (in Russian; English abstract).

Determination of isotopic composition and contents of sulfur in the same samples of the rocks of komatiite series of Voronezh crystalline massif as well as Ukrainian and Baltic shields has been made. For the domestic samples of komatiite it has been done for the first time. A distribution of contents of sulfur and its isotopes along the vertical profile of komatiite flows was studied using a core of one of the drill-holes of Voronezh crystalline massif. Sulfur contents in komatiites from various areas vary from 0.04 to 077%, and average 0.11 ± 0.02%. Values of $\delta^{34}S$ vary from -1.4 to +4.2‰, on the average +1.6 ± 0.2‰. The dependence of $\delta^{34}S$ on the depth of sampling and in different flows of komatiite has not been observed. The lowest contents of sulfur ($n \cdot 10^{-2}\%$) and $\delta^{34}S$ values significantly different from meteoritic were determined in the samples of komatiites [that have] undergone intensive secondary alteration. A correlation between the sulfur content and sulfur isotopic composition has not been observed. Average contents of sulfur in the komatiites is estimated as 0.1 ± 0.91% and sulfur content in the komatiite magma, ~0.5%. Distribution of sulfur in komatiites is considered in relation with estimation of the ore-generating capacity of the ultramafic effusives. (Authors' abstract)

GROMOV, A.V., FORTUNATOV, S.P., KARSKI, B.E. and ZORIN, B.I., 1985, Concentration of CO_2 in pegmatite minerals and possibilities of its use in the evaluation of their mica-bearing capacity (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 25 (in Russian; translation by S. Jaireth). Authors at MGRI, Moscow Inst. Geol. & Explor., Moscow, USSR.

Study of GLI in minerals of mica-pegmatites from Mam-Chuai and Karelo-Klolski regions reveals that minerals (quartz, feldspars, mica) of commercially important mica-pegmatites, as compared to the barren ones, are highly enriched in CO_2, H_2O-CO_2 and CO_2-H_2O inclusions.

Gas-chromatography analysis reveals that concentration of CO_2 in quartz of barren pegmatites equals 0.46 to 2.19 mol/liter H_2O while in quartz of mica-pegmatites (commercial grade) it is 6.6 to 52 moles/liter H_2O.

There is a direct correlation (correlation coefficient 0.84) between concentration of mica in pegmatites and CO_2 concentration in the fluid inclusions.

Presence of CO_2-rich inclusions in minerals of commerical grade mica-pegmatites can be utilized to differentiate them from barren pegmatites and to evaluate mica-bearing capacity of pegmatites using gas-chromatography. (From the authors' abstract)

GROMOV, A.V., ZORIN, B.I., KARSKIY, B.Ye., FORTUNATOV, S.P., 1985, Main trends in the use of thermobarogeochemical methods in prospecting and evaluating mica-bearing pegmatites (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 253- 255 (In Russian; translation by Dorothy B. Vitaliano). Authors at MGRI, Moscow, USSR.

Five years' experience with work in the Mama-Chuya and Karelia-Kola regions makes it possible to determine the main trends in the practical use of the methods of thermobarogeochemistry in prospecting for and exploring muscovite deposits. Analysis of several thousand decrepitograms of rocks containing pegmatite bodies showed that the intensity of decrepitation in the low-T range (20-320°C) increases distinctly as the pegmatites are approached. This is related to the presence of a large number of water-CO_2 inclusions in the minerals of the host rocks.

Decrepitometric aureoles of several orders were brought out by work on different scales: from regional to narrowly local. They are related both to large zones of development of mica-bearing rocks, and to isolated mica fields, clusters of pegmatite veins, individual veins, pockets and even large crystals of muscovite. The decrepitometric anomalies of first order are brought out by traverse profiles on a small scale (1:100,000-1:50,000). They are related to high decrepitometric activity in the low-T interval of a substantial part of the rocks of the producing suite. Against a background of relatively uniform decrepitation of the nonproductive suites, the productive rocks are distinguished by uneven distribution of decrepitometric activity (coefficients of variation here reach 200-300%).

Anomalies of second order on a scale of 1:50,000-1:25,000, and of third order on a scale of 1:5000 are established by decrepitometric surveying. Decrepitation anomalies of fourth order are brought out around individual pegmatites at 1:1000 to 1:5000. Aureoles of fifth and sixth order around individual pockets and large muscovite crystals in large pegmatites can be brought out. It was also established that the muscovite content correlates well with the CO_2 concentrations (by gas chromatography) in inclusions of the mineralizing solutions in the quartz of the pegmatites.

Several problems remain which require in-depth treatment. The most acute is the problem of establishing reliable criteria for grading anomalies of different nature. More detailed study of the morphology and structure of aureoles of steaming and anomalies of different order is also needed. Wider use of the whole spectrum of methods of modern thermobarogeochemistry seems advisable in solving these problems: Th, cryometry, gas and gas-chromatographic analyses, the method of aqueous extracts, etc. (From the authors' abstract)

GROSHENKO, A.R., 1985, The relationship between the paleotemperature fields and productivity in the 'South' vein of the Arsen'yevo tin deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 130-131 (in Russian; translation by D.A. Brown). Author at Inst. Geol. Ore Deposits, Petrogr., Miner., & Geochem., Acad. Sci. USSR (IGEM), Moscow, USSR.

This deposit in the quartz-cassiterite-sulfide association consists of a series of subparallel, steeply-dipping quartzose veins, transecting chloritized terrigenous sequences. The most productive 'Yuzhnaya (South)' vein is about 2 km long and 0.5 km deep throughout its strike and on all shaft horizons. The vein contains in the main three mineral associations: quartz-cassiterite-chlorite-arsenopyrite, quartz-cassiterite-sulfide, and quartz-carbonate. More than 200 polished sections of quartz of different generations and about 100 monomineralic samples were examined. Th analyses were made on P inclusions, and most of the monomineralic samples were examined for Td; some were subjected to gas chromatography.

As a result, it appears that quartz precipitated as the T gradually fell: quartz-I at ~430-360°C, quartz-II at ~370-250°C, and quartz-III at ~270- 150°C. The Th and Td data are in good agreement. Construction of paleoisotherms shows that the T-fields during crystallization of quartz-I of the most productive phase were most extensive and wide, and in places had a complex outline, with a clearly-defined northward dip; when quartz-II precipitated, the fields were localized, with a mosaic distribution, although on the whole, they had a tendency to inherit the spatial arrangement of the high- and low-T fields.

Comparison between the T data and the amount of Sn in the vein shows that in the Sn-enriched zones, in contrast to the lean zones, Th and Td are higher, there is more CO_2, and essentially-G inclusions are present. The slopes of the paleo-T fields and those of Sn-isoconcentrations conform with the peculiarities of the geological environment (a volcanic center to the north of the deposit, supposedly associated with the mineralization), whereas the extended shape of the fields possibly reflects the flow direction of the jets of ore-forming solutions). (From the author's abstract)

GROVES, D.I. and HO, S.E., 1985, Fluid inclusions in quartz veins associated with Archaean gold mineralization: Clues to the nature and source of ore fluids and ore depositional conditions and significance to exploration (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 7. First author at Dept. Geol., The Univ. Western Australia, Nedlands, W.A., 6009, Australia.

Same as Ho et al., 1985, Fluid Inclusion Research, v. 18, p. 172-173; see also next item. (E.R.)

GROVES, D.I., HO, S.E., HOUSTOUN, S.M. and PHILLIPS, G.N., 1986, A review of gold deposits in the Archaean greenstone belts of western Australia: Proc. 13th Congress of C.M.M.I., Singapore, May 1986, p. . First author at Geol. Dept., Univ. Western Australia, Nedlands, Australia 6009.

The important regional- and local-scale characteristics of most gold deposits can be explained in terms of a metamorphic-replacement model. In this model, metamorphic H_2O-CO_2 fluids, focussed by faults and shear zones, infiltrated host rocks and deposit gold at 350 ± 50°C and 1-2 kb, largely in response to fluid-wallrock interaction. In many large deposits, gold precipitation was synchronous with sulphidation of Fe-rich host rocks, but the diversity and abundance of smaller deposits reflects the variety of reactions precipitating gold from ubiquitous, auriferous metamorphic fluids. Regional variations in abundance and size of deposits relate to factors such as tectonic setting, alteration styles and possibly source rocks. (From the authors' abstract)

See also Ho et al., 1985, Fluid Inclusion Research, v. 18, p. 172-173. (E.R.)

GROVES, D.I., MARCHANT, Trudi, MASKE, S. and CAWTHORN, R.G., 1986, Compositions of ilmenites in Fe-Ni-Cu sulfides and host rocks, Insizwa, southern Africa: Proof of coexisting immiscible sulfide and silicate liquids: Econ. Geol., v. 81, p 725-731.

GRUBESSI, Odino and MARCON, Renata, 1986, A peculiar inclusion in a yellow corundum from Malawi: J. Gemm., v. 20, no. 3, p. 163-165. First author at Dipart. di Sci. della Terra, Univ. degli Studi di Roma, Rome, Italy.

A good example of the necking down process. (E.R.)

GSTALTER, Nicole, 1986, Geochemical and thermobarometric study of glass inclusions in quartz from Southern Basse-Terre (Guadeloupe) (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 85 (in French). Author at Lab. Pierre Süe, Groupe des Sci. de la Terre, C.E.N. Saclay, 91191 Gif-sur-Yvette Cedex, France.

Physico-chemical conditions during the evolution of shallow magma chambers were obtained by microscopic, thermometric and chemical studies of silicate liquids trapped as inclusions in quartz, plagioclase, pyroxene and amphibole. Samples were obtained from Plinian-type eruption products and pumice flows of the Grande-Decouverte region. Crystallization of quartz occurred between 815 and 865°C and plagioclase An40 at 875°C; fluid P (pH_2O) was 1 to 1.5 kb. T zonation is correlated with small variations in the mineralogy of the volcanic products. A shallow reservoir model is proposed and discussed. (Author's abstract; translated by R. Kreulen)

GSTALTER, Nicole and METRICH, Nicole, 1986, Chlorine in rhyolitic magmas from Danois (Chaîne de Bouillante, Guadeloupe, Lesser Antiles). A melt inclusions study: C.R. Acad. Sc. Paris, v. 303, Ser. II, no. 11, p. 1009-1012 (in French; English abstract).

The pumices of Danois eruption (0.244 ± 0.018 M.y. B.P.) from Guadeloupe were investigated through study of melt inclusions in quartz crystals. Chlorine content of rhyolitic glass included is 3.070 ± 120 ppm. The bulk volatile concentration was estimated at 6% (wt.), using microprobe analysis. On a microscope heating stage, the melt inclusions were homogenized at 810°C ± 10. After heating experiments, using furnace (Adamel), at 810°C, during 90 min. then 12 hrs. the chlorine (or volatile elements) do not show significant variations. For runs of few days (28 and 30 days) chemical variations were observed, inferring exchange between liquid and host mineral. The chlorine (and volatile elements) decreases. But, no evidence of selective diffusion of chlorine through quartz structure exists. F (550 ± 120 ppm), S, Ba content is very low. In fact, water represents 90% (weight) of the dissolved fluids. The corresponding water pressure is 180 MPa. Using these results (H_2O content, temperature) the viscosity of the rhyolitic liquid, prior the eruption, was calculated 3.14×10^5 Po, before gas release. With 30% of minerals, the viscosity of the melt (liquid and crystals) becomes 1.15×10^6 Po. (Authors' abstract)

GÜBELIN, Eduard, 1986, The inclusions in peridot: Minde and Mineraux, no. 76, p. 28-29 (in French).

A summary of inclusions in peridot, taken from Gübelin et al., 1986 (this volume). (E.R.)

GÜBELIN, E.J. and KOIVULA, J.I., 1986a, Inclusions in quartz: Lapis, v. 9, p. 19-26 (in German).

A series of excellent photomicrographs. (E.R.)

GÜBELIN, Edward and KOIVULA, J.I., 1986b, Inclusions in opal: J. Gemm., v. 20, no. 3, p. 139-144. First author at Ratna Mahal, Benzeholzstrasse 11, CH-6045 Meggen LU, Switzerland.

Includes one photo of a large L/V inclusion in a rhombohedral cavity in opal (Fig. 10). (E.R.)

GÜBELIN, E. and KOIVULA, J.I., 1986c, Inclusions in amber: Z. Dt. Gemmol. Ges., v. 35, no. 3/4, p. 73-86 (in German).

Text identical to that in section on amber in Gübelin et al., 1986, p. 212-228 (next item), but some photos are different. One figure shows "gas (CH_4?) or air bubbles," and another a "two-phase inclusion, perhaps raindrops with a shrinkage bubble." (Abstract courtesy H.A. Stalder)

GÜBELIN, E.J., KOIVULA, J.I., MEYER, H.O.A., ROEDDER, Edwin and STALDER, H.A., 1986, Photoatlas of inclusions in gemstones: Zurich, ABC Edition, 532 pp. (in English and German editions).

Includes discussions of the origin of inclusions (Roedder), inclusions in diamond (Meyer), and the formation of quartz and its inclusions (Stalder), and hundreds of beautiful full-color photomicrographs of inclusions, solid and fluid, in various gemstones. (E.R.)

GUILBERT, J.M., 1986, Recent advances in porphyry base metal deposit research, in Geol. & Metallogeny of Copper Deposits, G.H. Friedrich et al., eds.: Springer-Verlag Berling Heidelberg, p. 197-208. Author at Univ. Arizona, Tucson, AZ 85721, USA.

A review including discussion of fluid inclusions. (E.R.)

GUILBERT, J.M. and PARK, C.F., Jr., 1986, The geology of ore deposits: W.H. Freeman & Co. Publ., New York, 985 pp.

Includes a 10-page review of fluid inclusion techniques (p. 252-261). (E.R.)

GULIY, V.N., 1985, Particulars of the composition of inclusions in apatite in the Precambrian rocks of the Aldan shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 160-161 (in Russian; translation by Dorothy B. Vitaliano). Author at Leningrad State Univ., Leningrad, USSR.

Apatite is extensively developed in the Precambrian rocks of the Aldan shield, where it occurs as an accessory mineral and less often, in economic concentrations. In the latter case the apatite is usually related to carbonate and pyroxene-bearing rocks, of which a few deposits are known. Economic contents of apatite have also been found in later veins and metasomatites.

Solid, liquid and gaseous inclusions have been found in the apatites. The solid inclusions are mainly P, single-phase and consist of minerals which form paragenetic associations with the apatite. (...) The use of data on the composition of the inclusions made it possible to establish that the apatite is later than the pyroxene in the pyroxene-bearing rocks and earlier than the other minerals in the carbonate rocks and metasomatites. In the apatites from the pyroxene-bearing rocks there were identified: pyroxene, phlogopite, less often sphene and sulfides, and in the apatites from the carbonate rocks, calcite, dolomite, quartz, and chlorite. A similarity in composition of the solid inclusions in the apatites from metasomatites and from the pyroxene-bearing rocks containing them is observed, which confirms the existence of paragenetic relationships between these formations.

The series of liquid and gaseous inclusions in apatite are irregularly distributed or else are oriented along [i.e., elongated parallel to?] the six-fold axis. Their size ranges from 0.01 to 0.09 mm. The shape of the vacuoles of the inclusions varies from isometric to tubular.

Due to the presence of very tiny post-genetic inclusions of iron oxide, many apatite grains are opaque and unsuitable for visual observations. For this reason preliminary sorting of the inclusions was carried out on the basis of the results of vacuum decrepitation. In so doing it was assumed that the decrepitation activity of the mineral would be the same for similar temperatures in the same geochemical setting. Analysis of the decrepitation curves showed that the decrepitation activity of apatites of similar genetic type very rarely agrees in intensity and temperature interval. At the same time, apatites from genetically different formations are similar in characteristics of the decrepitation curves.

In the composition of individual inclusions, CO_2, N_2, rare gases, and less often, H_2 and CO are observed. Fluctuations in the composition of individual inclusions are very considerable; for CO_2 and N_2 they amount to 0-100%, and for CO and H_2, 0-30%, with no qualitative difference in apatites of different genetic type. Thus the variability of the decrepitation curves is caused by qualitative and quantitative differences in composition of the inclusions and their different reaction to heating at the time the decrepitation effects were obtained.

High-temperature gas chromatographic analysis of the bulk composition of the inclusions also showed a considerable concentration of CO_2, which along with water is the main component of the inclusions. CO, CH_4, H_2 and N_2 are insignificant components.

For the gas-liquid inclusions, the temperature levels vary within limits of 250-300°C, 440-500°C and 550-650°C. (Author's abstract)

GURNEY, G.G., 1986, The interpretation of depositional environments and burial history in vertical sequences: An example from Lower and Middle Devonian carbonates in Cherry Valley, New York: M.A. thesis, Brooklyn College, City Univ. of New York, 109 pp.

GURNEY, G.G. and FRIEDMAN, G.M., 1986, Burial history of Cherry Valley carbonate sequence, from Cherry Valley, New York (abst.): AAPG Bull., v. 70, no. 8, p. 1066. First author at Brooklyn College of City Univ. New York, Brooklyn, NY.

Lower and Middle Devonian carbonates including the Helderberg Group and the Onondaga Formation as well as interbedded clastics near Cherry Valley, New York, compose over 300 ft of vertical section.

Fluid-inclusion analysis, stable isotope ratios, and vitrinite reflectance values suggest that the Cherry Valley sequence was buried to depths between 4.5 and 5.0 km, using 26°C/km as a previous geothermal gradient.

Data from vitrinite reflectance stable isotope ratios imply that the Helderberg Group was buried 0.5-1.0 km deeper than the Onondaga Formation. This difference in burial depth indicates that tectonic-related deposition and the subsequent erosion of thick sedimentary sequences occurred following Helderberg deposition and prior to the deposition of the Onondaga.

Stable isotope ratios, fluid-inclusion analysis, and petrographic evidence indicate that most of the Cherry Valley coarse calcite cements precipitated from saline brines in a deep burial setting. (Authors' abstract)

GURNEY, J.J., HARRIS, J.W., RICKARD, R.S. and MOORE, R.O., 1985, Inclusions in Premier mine diamonds: Trans. Geol. Soc. S. Africa, v. 88, no. 2, 1985, p. 301-310.

HAEFNER, R.J. and MANCUSO, J.J., 1986a Mississippi Valley type mineralization and dolomitization in the Trenton Formation, Wyandot County, Ohio (abst.): Abstracts, 32nd Ann. Inst. on Lake Superior Geology, Wisconsin Rapids, WI, April 29-May 4, 1986, p. 31. Authors at Dept. Geol., Bowling Green State Univ., Bowling Green, OH 43403.

See next item. (E.R.)

HAEFNER, R.J. and MANCUSO, J.J.,b 1986, Mississippi Valley-type mineralization and dolomitization in Trenton Formation, Wyandot County, Ohio (abst.): AAPG Bull., v. 70, no. 8, p. 1066-1067. Authors at Bowling Green State Univ., Bowling Green, OH.

Trace amounts of sphalerite, pyrite, and marcasite associated with abundant saddle and replacement dolomite and sparry calcite were examined in nine drill holes along a fracture zone in the Ordovician Trenton Formation in Wyandot County, Ohio. The Wyandot fracture zone consists of a series of anastomosing fractures, whose overall trend in N30°W and length is at least 8 mi.

The paragenetic sequence of mineralization as observed from the wall of the fracture is: (1) pyrite, marcasite, and saddle dolomite; (2) sphalerite; (3) coarse sparry calcite, commonly with inclusions of liquid hydrocarbons; and (4) anhydrite and gypsum. Fluid inclusion data from dolomite, sphalerite, and calcite indicate that these fracture-filling minerals were precipitated from warm, saline (~14.8-22.9 wt. % NaCl) brines. The decrease in Th (mean values for dolomite = 99.1°C, sphalerite = 82.9°C, and calcite = 60.1°C) indicates that the T of the solutions progressively decreased during precipitation.

Petrographic and cathodoluminescence analyses reveal compositional zonation in dolomite and calcite. The zones are most easily explained by the mixing of fluids. Geochemical constraints limit the transport of metals and sulfide in the same solution; therefore, sulfide precipitation probably resulted from mixing of two fluids - a warm brine carrying metals and a fluid bearing liquid hydrocarbons and H_2S.

We conclude that the paucity of Zn mineralization in the Wyandot fracture zone in the Trenton Formation is attributed to poor timing. Sulfur (as H_2S) was not available in sufficient quantities at the time the metal-bearing brines arrived in the fracture, since the calcite that hosts the hydrocarbon inclusions postdates the sphalerite mineralization. (Authors' abstract)

HAEFNER, R.J., MANCUSO, J.J., FRIZADO, J.P., SHELTON, K.L. and GREGG, J.M., 1986, Crystallization temperatures and stable carbon and oxygen isotopes of Mississippi Valley-type sulfides and associated carbonates, Trenton limestone (Ordovician), Wyandot County, Ohio (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 624. First author at Geol. Dept., BGSU, Bowling Green, OH 43403.

Trace sphalerite, pyrite and marcasite, along with replacement dolomite, saddle dolomite, and calcite cements were examined in 9 drill holes along a fracture zone in the Trenton Limestone in northwest Ohio. Fluid inclusion data from dolomite, sphalerite, and calcite indicate that these minerals were precipitated from warm, saline (14.8-22.9 wt% NaCl) brine. Decreasing homogenization temperatures (mean values for dolomite = 99°C, sphalerite = 83°C, and calcite = 60°C) indicate progressive cooling of solutions during precipitation. Mean carbon and oxygen isotope values (per mil PDB) for dolomite are: $\delta^{18}O = -8.2$ and $\delta^{13}C = -0.5$ ($n = 12$). These are similar to values obtained for late fracture related dolomites in the nearby Michigan Basin. Isotope values for calcite cements are: $\delta^{18}O = -9.2$ and $\delta^{13}C$ ranging from -3.8 to -26.6 ($n = 3$). The depleted carbon values are indicative of an organic source and consistent with observation of petroleum inclusions in these calcites.

Sulfides were precipitated by a metal-bearing brine derived from the Appalachian or Michigan Basin; possibly mixing with a locally derived H_2S-rich water. The paucity of economic amounts of sphalerite is attributed to either: 1) Metal-bearing brines, although rich in Mg and Fe, were poor in Zn. 2) Insufficient reduced sulfur was available for sulfide mineralization. (Authors' abstract)

HAGNI, R.D., 1986a Ore microscopy and paragenetic sequence of the ores in the southeast Missouri lead district (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 118.

HAGNI, R.D., 1986b Ore microscopy and mineral paragenetic sequence of the early bornite ores in the Viburnum Trend, southeast Missouri (abst.): Terra Cognita, v. 6, no. 3, p. 503-504. Author at Dept. Geol. & Geophys., Univ. Missouri-Rolla, Rolla, MO 65401, USA.

The mineralogical assemblage found in the bornite pods is highly unusual for Mississippi Valley-type deposits, but they are an integral part of the ore deposits in the Viburnum Trend and should be considered in modeling this type of deposit. The bornite ores were deposited from the earliest ore fluids at temperatures that were higher than those that deposited the subsequent lead-zinc ores at 137°C to 82°C and with a salinity of about 23 wt % NaCl equivalent. (From the author's abstract)

HAGNI, R.D., ed., 1986c, Process Mineralogy VI: The Metallurgical Soc., 631 pp.

Includes 8 papers on use of cathodoluminescence in geology, most of which are pertinent to its use for fluid inclusion studies. (E.R.)

HAHN, Raimund and IKRAMUDDIN, Mohammed, 1986, K/Tl ratio in precious metal exploration, fluid inclusion evidence (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 624. First author at 931 Forest Street, Reno, NV 89509.

It has been documented the K/Tl ratio decreases from unmineralized to mineralized rocks in the precious metal deposits at Carlin, NV, the Como mining district, NV, and Kendall mining district, MT. However, at the Acme mine, WA, the mean value of the ratio has remained unchanged and increased at Mt. Tolman, WA (Cu-Mo deposit). A reconnaissance fluid inclusion survey was conducted to determine the temperature of homogenization at the Acme, Como, and Mt. Tolman. The fluid inclusion survey shows decreasing temperatures have decreasing K/Tl ratios from unmineralized to mineralized rocks. The decrease in the values of this ratio is due to a greater Tl enrichment relative to K in the mineralized rocks. A sample of fluorite from the intrusive in the North Moccasin, away from the Kendall mine, has temperature of homogenization of 190-207°C. At the Kendall mine and Carlin the K/Tl ratios decreases by factors of 21.2 and 47.1 respectively. This further supports the use of K/Tl ratio as a geochemical pathfinder in exploration of sedimentary hosted and silicified (replacement) precious metal deposits. (Authors abstract)

	T°C	X	n	K/Tlx10^4 unmineralized	K/Tlx10^4 mineralized	Factor decrease
Mt. Tolman, WA	306-362	335	28	3.37	4.12	0.82
Acme, WA	203-316	275	18	4.16	4.15	1.00
Como, NV	223-274	237	23	13.1	2.83	4.63
North Moccasin, MT	190-207	201	17	.127	.006	21.2
Carlin, NV				1.32	.028	47.1

HALL, David, BOTH, R.A. and DAILY, Brian, 1986, Copper mineralization in the Patawarta Diapir, northern Flinders Ranges, South Australia: Bull. Proc. Australas. Inst. Min. Metall., v. 291, no. 7, p. 55-60. First author at North Broken Hill Ltd., Elura Mine, N.S.W.

The Patawarta Diapir, located in the northern Flinders Ranges (South Australia), has intruded into late Proterozoic Wilpena Group sedimentary rocks. The diapir contains disrupted blocks of wide variety of rock types, most of which can be correlated with the Lower Callanna Beds of Willouran age, in a matrix of predominantly carbonate and siltstone breccia. Mafic rocks in the diapir appear to predate intrusion of the diapir. As with many other diapirs in the Flinders Ranges, copper mineralization is present in the diapir and occurs as narrow veins consisting essentially of carbonate with chalcopyrite and pyrite that formed after diapiric intrusion.

Fluid inclusion studies demonstrate that the mineralizing fluid was a Na-Ca-K-Cl brine; probably derived by expulsion of interstitial water following emplacement of the diapir, with dissolution of evaporites within the Callanna Beds sediments and enrichment in copper by reaction with these sediments and associated basic igneous rocks. Mineral assemblages combined with fluid inclusion and geochemical data indicate a possible environment of vein formation of $T \simeq 165°C$, $pH \simeq 4.3 \pm 0.9$ and $\log fO_2 \simeq 47.3 \pm 0.5$. Sulphur isotope analyses indicate $\delta^{34}S(\text{fluid}) \simeq 10$ per mil, suggesting evaporites in the Proterozoic sediments as the major source of the sulphur but with some additional sulphur from an igneous source, possibly leached from the mafic rocks of the diapir. (Authors' abstract)

HALL, D.L. and BODNAR, R.J., 1986, Determination of isochoric P-T paths for fluid inclusions which decrepitate prior to homogenization (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 625. Authors at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

H_2O-CO_2 bearing fluid inclusions are common in a variety of geologic environments, and are characteristic of medium to high-grade metamorphic rocks. During microthermometric analysis, these inclusions often decrepitate prior to homogenization because the internal overpressures generated as a result of heating the sample exceed the strength of the host mineral, and this behavior has often precluded determination of homogenization temperatures and P-T trends of the isochores corresponding these fluid inclusions. However, because of the known relationship between fluid inclusion size and the internal pressures required to decrepitate fluid inclusions in quartz, the isochoric P-T trend of a given fluid inclusion can be approximated if the inclusion size (volume) and the decrepitation temperature are known. Furthermore, if compositional constraints can be placed on the inclusion by room temperature phase ratios and/or microthermometric behavior, the temperature at which the inclusion should have homogenized if it had not decrepitated may be estimated.

Utilizing this technique, the P-T trends for synthetic H_2O-CO_2 fluid inclusions of various compositions have been determined, and the results have been compared to known isochores for these inclusions. The experimentally determined isochores project through the known P-T formation conditions of these synthetic fluid inclusions, indicating that the isochoric trend of natural fluid inclusions can be approximated using this technique. In addition, the formation temperature or pressure for natural fluid inclusions can be determined if the complimentary parameter is known from an independent geothermometer or geobarometer. For example, inclusions containing 50 mole % CO_2 decrepitate over the range 126°-510°C. Internal pressures at decrepitation for these inclusions, calculated from the equation of Binns and Bodnar (1986, EOS, 67, (16), 399)*, show a good correlation between inclusion size and internal pressure and define an isochore which projects through the known formation P-T conditions of formation of 3 kbar and 600°C (Authors' abstract)

*Binns and Bodnar (1986) EOS 67 (16) 399.

HALL, D.L. and COHEN, L.H., 1986, Hydrothermal alteration in the Iron Hat iron-ore/skarn system, eastern Mojave Desert, San Bernardino County, California (abst.): EOS, v. 67, p. 389. First author at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24060.

Typical examples of Mojave Desert iron-ore and skarn deposits occur within the Marble Mountains, San Bernardino Co., CA. Three episodes of skarn formation in calcareous wallrocks adjacent to granitic intrusives were delineated. 1) Early contact skarn formation generated iron-poor garnet, pyroxene and minor vesuvianite, with retrograde epidote, actinolite, calcite, chlorite, and late-stage vein quartz ± specular hematite at temperatures ≤600°C and variable $X(CO_2)$, but generally below 0.1. Fluids were NaCl-$CaCl_2$-H_2O-rich, with maximum salinities of 50 wt. % NaCl equiv. Some prograde contact skarn growth was associated with boiling (or condensing) fluids. 2) Intermediate-age dike skarn formation produced epidotized felsic dikes with alteration envelopes of iron-rich garnet, pyroxene, minor wollastonite, and retrograde actinolite, chlorite, calcite, quartz and specular hematite. T <500°C are indicated by mineral equilibria calculations. 3) Magnesian-magnetite skarn formation resulted in structurally controlled clinohumite-magnetite-serpentine bodies at faulted contacts between dolomitic marble and granite. Fluids were enriched in CO_2 and KCl relative to contact skarn-forming solutions. Minimum T of 375°C are suggested by mineral equilibria.

Two distinct alteration signatures are recorded within the pluton. 1) Pervasive albitization of granite and felsic dikes, which caused large sodium enrichments and potassium depletions in igneous rocks, occurred syngenetically with contact skarn and dike skarn formation but prior to iron-ore deposition. Fluid inclusion and isotopic data suggest that the altering fluid was magmatic in origin. 2) Late-stage quartz ± specular hematite alteration affected all three skarn types, and all igneous rocks. T of 200-250°C, salinities of 0-22 wt. % NaCl equiv., and $NaCl-CaCl_2-H_2O$-rich fluids are indicated by fluid inclusion studies. Drastic whole-rock O^{18}-depletions associated with this event are consistent with a meteoric origin for the fluid. (Authors' abstract)

HALL, W.E., 1986, Relations of syngenetic and epigenetic base- and precious-metal deposits to the regional geology and tectonics of the central Idaho black-shale mineral belt, U.S.A. (abst.): Terra Cognita, v. 6, no. 3, p. 497. Author at U.S. Geol. Survey, M.S. 984, Menlo Park, CA 94025, USA.

The epigenetic Pb-Ag-Sb-Sn veins, which contain principally jamesonite, galena, tetrahedrite, and stannite, are localized in black shale near Tertiary plutons. $\delta^{34}S$ values of sulfide minerals, ranging from +2.2 to +15 per mil, indicate that the sulfur had a shallow crustal source. Radiogenic Pb-isotope ratios also suggest a shallow crustal source. Quartz gangue has a $\delta^{18}O$ value of +16 per mil, a value reasonable for hydrothermal fluids that reached equilibrium with the black shale. The δD values of inclusion fluids in ore and gangue minerals range from -110 to -120 per mil. The geologic, isotopic, and fluid-inclusion data are consistent with a model of convective hydrothermal meteoric-water systems in faulted Paleozoic rocks near plutonic masses. This environment permitted deep circulation of the hydrothermal fluids, which dissolved sulfur and syngenetic metals from the Paleozoic host and deposited ore in favorable structures. In two ore bodies, epigenetic Pb-Ab-Sb-Sn ore can be traced backward to stratiform Zn-Pb-Ag ore at the intersections with felsic plutons, a relation demonstrating that the epigenetic deposits were remobilized as Pb-Ag sulfantimonide complexes. The Pb-Ag-Sb-Sn vein deposits in the three favorable allochthons each have unique mineralogic and stable-isotope signatures. (From the author's abstract)

HALLIDAY, A.N., SHEPHERD, T.J., DICKIN, A.P., MacLAREN, F. and DARBYSHIRE, F., 1986, Sm-Nd dating and fingerprinting of the North Pennine fluorite deposits (abst.): Terra Cognita, v. 6, no. 2, p. 227. Authors at S.U.R.R.C., East Killbride, Glasgow G75 0QU, UK.

This classic $Pb-Zn-BaSO_4-CaF_2$ mineralization forms veins and replacement structures in Carboniferous limestones zoned above the buried 400 Ma Weardale Granite. This [work] accords with a fluid inclusion Rb-Sr isochron age of 206 ± 9 Ma for quartz from the Great Sulphur Vein and K-Ar data for clays. It is suggested that mineralization was episodic from Permo-Carboniferous to Cretaceous times and was triggered by tectonic events in the North Atlantic region. Most of the Nd and Sr came from Carboniferous sediments. The granite acted largely as a heat source. (From the authors' abstract)

HALLS, C. and ALLMAN-WARD, P., 1986, The role of decompressive shock and hydraulic decrepitation in the formation of hydrothermal breccias and composite lode structures: A discussion (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 11.

HALPERN, A.M. and LIN, M.-F., 1986, The liquid-vapor phase diagram of CO_2 near the critical temperature: J. Chem. Education, v. 63, no. 1, p. 38-39.

HAMILTON, D.L. and BEDSON, P., 1986, Carbonatites by liquid immiscibility (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 77. Authors at Dept. Geol., Univ. Manchester, England.

Experimental work at P from 1 to 8 kb and T from 900°C to 1250°C has shown the immiscible nature of phonolite and nephelinite melts with alkali-rich carbonate melts. The immiscibility gap widens with increasing P and falling T. (From the authors' abstract)

HAMILTON, D.L. and BEDSON, P., 1986, Carbonatites by liquid immiscibility (abst.): Mineral. Soc. Bull., no. 73, Dec. 1986, p. 3. Authors at Univ. Manchester.

Experimental work at P from 1 to 8 kbars and T from 900°C to 1250°C has shown the immiscible nature of phonolite and nephelinite melts with alkali-rich carbonate melts. The immiscibility gap widens with increasing P and falling T. In the above PT-range there is no immiscibility gap between CaO-rich carbonate melts and silicate melts so that sovite-type carbonatites either do not owe their origin to immiscibility or have lost their alkalies by fenitization before emplacement. Also there is no immiscibility gap between kimberlite melts and Ca-rich carbonate melts at crustal P.

The partitioning of Cr, Mn, Cu, Zr, Ba, La, Ce, Sm, Eu, Gd, Yb, Lu, Hf and Ta between immiscible carbonate and silicate melts has been determined. The distributions, in general, agree with those measured in the Oldoinyo Lengai carbonatite-phonolite lavas. (Authors' abstract)

HAMILTON, J.M. and SHAW, D.R., 1986, Evolution of source fluid and resulting deposits during genesis of the Sullivan ore body, Kimberly, B.C., Canada (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 626.

HAMLYN, P.R. and KEAYS, R.R., 1986, Sulfur saturation and second-stage melts: Application to the Bushveld platinum metal deposits: Econ. Geol., v. 81, p. 1431-1445.

HANEL, I.V., BEANE, R.E., WALSH, J.F. and KESLER, S.E., 1986, Characterization of hydrothermal fluids associated with Archean gold mineralization, carbonate alteration, and greenschist metamorphism, Timmins, Ontario, Canada (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 626. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Microthermometric fluid inclusion analyses of hydrothermal quartz-carbonate veins from the Timmins, Ontario, vicinity were used to characterize fluids associated with Archean gold mineralization (Pamour No. 1 Gold Mine), carbonate alteration of an ultramafic body (Canadian Magnesite deposit), and unmineralized, unaltered (metamorphic?) quartz veining (Regional). Three distinct fluid types identified were: (1) dilute aqueous fluids (avg. salinity = 4.3 eq.wt.% NaCl, avg. homogenization temperature = 192°C) are found in all three hydrothermal environments; (2) saline aqueous fluids (avg. salinity = 22.1 eq.wt.% NaCl, avg. homogenization temperature = 143°C) are common at the Canadian Magnesite and Pamour deposits, but are rare in the Regional samples; and (3) carbonaceous aqueous fluids (avg. salinity = 58 eq.wt.% NaCl, avg. homogenization temperature = 280°C, XCO_2 = 0.02-0.12 and 0.30-0.80) are found in all areas. Methane is negligible in veins from the Canadian Magnesite and Regional samples, but is abundant at Pamour (XCH_4 = 0.01-0.40 in the CO_2 phase). The methane may have been derived from the metagraywacke which hosts the Pamour veins, directly, or by wall-rock reduction of fluid CO_2. Abundant evidence for CO_2 effervescence was detected only at the Pamour Mine. Different CO_2 pressures in the three hydrothermal areas may be due to variations in solution pH as a result of different fluid wallrock reactions. Because similar fluid types are associated with three distinct geologic environments, variations in hydrothermal alteration/mineralogy may be due, in large part, to differences in wallrock composition, rather than fluid composition. (Authors' abstract)

HÄNNI, H.A., 1986, Corundum from Umba valley, Tanzania: Z. Dt. Gemmol. Ges, v. 35, p. 1-13 (in German; English abstract).

Many solid inclusions (of various phases), and some negative crystals (fluid?). (E.R.)

HANOR, J.S., 1986, Evidence for large-scale vertical overturn of pore fluids in the Louisiana Gulf Coast (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 627.

HANOR, J.S. and WORKMAN, A.L., 1986, Distribution of dissolved volatile fatty acids in some Louisiana oil field brines: Applied Geochem., v. 1, p. 37-46.

HARDER, V.M., 1986, Fluorite: A new fission track age dating mineral (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 628.

HARLOW, G.E., 1986, Jadeitites and their fluid inclusions from Rio Montagua, Guatemala (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 119. Author at Dept. Min. Sci., American Museum of Natural History, New York, NY 10024-5192.

Jadeite rock (jadeitite) occurs as blocks in tectonized serpentinite.

Particularly important questions relative to jadeitite petrology are the conditions of formation and metastability, both with respect to intrinsic parameters, P + T, and to the chemical activities of fluids, Na^+, SiO_2, etc. A potentially useful indicator is abundant fluid inclusions in coarse jadeite from Guatemala. Preliminary results show the following: 1) The inclusions are usually 2-phase (fluid + smaller gas bubble, constant ratio), usually elongated along the c-axis, and appear to be a mix of P, PS, and S. 2) All inclusions freeze at -5.6° to -5.7°C which yields a NaCl equiv. solute concentration in H_2O of 8.7 wt.%. If the fluid is related to sea water involved in serpentinization, these data give slightly more than twice the original fluid salinity and suggest a low local water to rock ratio ($\approx$1:1). The fluid composition is consistent with a Na-rich metasomatic/hydrothermal origin for jadeitization. 3) Th range from 260° to 283°C, which can define a lower limit of an envelope in which jadeitization occurs. Using the constructions of isochores of Bodnar and Roedder[sic] (1980), extrapolation for the observed inclusions to 500°C (an upper limit used by some authors) yields a minimum bracketing P between 2.0 and 2.6 kbar (compared to a minimum 14 kbar for eq. 1, 8.5 kbar for eq. 2 and 11 kbar for eq. 3).

A low T and P model for jadeitization must be scrutinizned seriously. Fluid inclusion measurement on jadeitite albite and regional albitites are underway to attempt to constrain their formational conditions and relationship to jadeitites. (From the author's abstract)

HARRIS, Chris, 1986, A quantitative study of magmatic inclusions in the plutonic ejecta of Ascension Island: J. Petrology, v. 27, Part 1, p. 251-276. Author at Dept. Geochem., Univ. Cape Town, Rondebosch 7700, South Africa.

Plutonic blocks in the volcanic and pyroclastic rocks of Ascension Island contain a variety of silicate melt and fluid inclusions, mainly in the intermediate (monzonite-syenite) and granite types. The silicate melt inclusions consist of trapped granitic melt with a small contraction bubble.

The fluid inclusions are: (i) highly saline (40 to >67 wt. per cent NaCl) aqueous inclusions; (ii) low density CO_2 + H_2O inclusions, predominantly vapor and (iii) high density approximately pure H_2O inclusions. Mixed silicate melt-saline aqueous fluid inclusions also occur showing that the original magma became saturated with respect to saline aqueous fluid and a magmatic origin is thus indicated for the saline fluid inclusions. Microprobe analysis of the silicate melt inclusions suggests that the original magma may have contained greater than 5 wt. per cent H_2O before saturation was reached and Th show the trapping of the silicate melt took place between 715-790°C. Separated amphiboles from the granites have δD values which are significantly different from the whole rock δD values of the dry but otherwise chemically similar obsidians. Sheppard & Harris (1985) interpret this difference as reflecting a sea water source for the water in the granites. Qualitative and quantitative study of the fluid inclusions (extending the earlier work of Roedder & Coombs, 1967) suggests that at least one episode of fluid immiscibility (into aqueous liquid + vapor, i.e., "boiling") occurred. This resulted in a loss of H_2O via the vapor and increased the salinity of the remaining liquid. The initial fluids belonged to the system H_2O-CO_2-NaCl-KCl and the CO_2 was strongly partitioned into the vapor phase during fluid unmixing, hence $X(CO_2)$ decreased as the fluid evolved. A suite of gabbroic blocks from Dark Slope Crater contain pure CO_2 fluid inclusions of just higher than critical density. Assuming a trapping temperature of 1000-1200°C the pressure must have been >1·8 kb - 2·8 kb or 7-11 km in depth, i.e., well below the base of the Ascension Cone. The pure CO_2 inclusions in this suite of gabbros and the fluids in the H_2O-CO_2-NaCl-KCl system would seem to require entirely different origins and it may be significant that these gabbros show a different isotopic Pb signature than do the volcanics and other blocks. (Author's abstract)

HARRIS, J.W. and SPEAR, P.M., 1986, Systematic studies of nitrogen in diamonds (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 398-400.

HARWOOD, A., 1985, Tungsten-tin mineralization at Chojlla in the Taquesi batholith, Cordillera Real, Bolivia, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 549-561. Author at Dept. Geol. & Applied Geol., Univ. Natal, Durban, South Africa.

The Chojlla W-Sn mine (lat. 16°24'S; long. 67°47'W) is located in the Sud Yungas Province in the central part of the Cordillera Real, northeast of La Paz. The mineralization is contained within an en-echelon series of quartz-filled veins which are associated with an apophysis of the Mesozoic Taquesi batholith.

Fluid inclusions in quartz, cassiterite, fluorite and siderite obtained from mineralized veins were studied in order to determine temporal and spatial trends in Th during formation of the paragenetic sequence. The salinity showed an initial rise followed by a fall during the early and main vein stages. Some boiling is evident in the greisen and early vein stages.

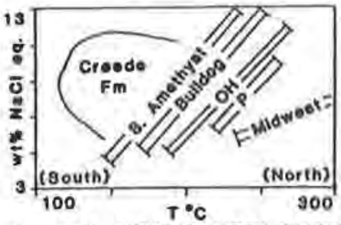
Sulphur isotope compositions have been interpreted to show that the sulphur in the sulphide minerals was derived from magmatic sources, either from the mantle or from large volumes of homogenized crustal material. (From the author's abstract)

HASELTON, H.T., Jr. and D'ANGELO, W.M., 1986, Tin and tungsten solubilities (500-700°C, 1 kbar) in the presence of a synthetic quartz monzonite (abst.): EOS, v. 67, p. 388.

HAYBA, D.O., 1986, District-wide fluid mixing during precious/base-metal epithermal mineralization at Creede, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 632. Author at U.S. Geol. Survey, MS 959, Reston, VA 22092.

Examination of several worker's measurements from >3500 fluid inclusions from 5 major veins and the Creede Formation in the district reveals heretofore unrecognized trends when these data are plotted on temperature-salinity diagrams (fig. shows gross trends). The fluid inclusion data for most of these veins, taken individually, show a general north-to-south (and upward) decrease in both temperature and salinity, suggesting that the hydrothermal solutions usually cooled by mixing with overlying ground water. Evidence for boiling, however, is also common.

In contrast to the individual veins, a general district-wide north-to-south increase in salinity and decrease in temperature is observed when the veins are considered collectively. The southerly decrease in temperature indicates (in agreement with the mineral zoning pattern) that the center of the upwelling hydrothermal plume was located beneath the northern part of the district. The district-wide north-to-south increase in salinity can best be explained by mixing of two different source fluids in variable ratios. One possible source was brine that originated in the closed shallow basin in which the Creede Formation was deposited. This brine, having salinities in excess of 13 wt.%, fed the hydrothermal cell at depth from the south, while fluids with more typical epithermal salinities (<2 wt%) entered the system at depth from the north. The deep mixing of these two fluids below the ore zone, plus the late effects of boiling and shallow mixing with ground water, account for the broad range of temperature and salinities found in the fluid inclusions from across the Creede district. (Author's abstract)



HAYBA, D.O., FOLEY, N.K. and HEALD-WETLAUFER, P., 1986, Characteristics that distinghish types of epithermal deposits (abst.): J. Geochem. Explor., v. 25, p. 231.

HAYMON, R.M. and KASTNER, Miriam, 1986, The formation of high temperature clay minerals from basalt alteration during hydrothermal discharge on the East Pacific Rise axis at 21°N: Geochimica Cosmo. Acta, v. 50, p. 1933-1939.

HAYNES, F.M., 1986, Geologic and geochemical controls for sphalerite mineralization, Mascot-Jefferson City zinc district, east Tennessee: PhD dissertation, Univ. of Michigan, 278 pp.

The Mascot-Jefferson City (MJC) district of east Tennessee is the largest of several Appalachian-style Mississippi Valley-type (MVT) ore fields in the Lower Ordovician carbonate rocks of eastern North America. As products of the natural evolution of sedimentary basins, MVT deposits provide critical information on the history of the host basin and associated continental margins. This dissertation sought to 1) characterize the mineralizing fluid(s) in the MJC district, 2) define the physical and chemical conditions leading to sphalerite deposition, and 3) determine the relation of mineralizing event(s) to the Paleozoic history of the southern Appalachians.

Chloride brines attending mineralization were Na(2.4-3.3 m)-, Ca(0.3-0.8 m)-rich with subordinate K(0.15-0.30 m) and Mg(0.04-0.12 m) and contained 0.4 to 1.5 mole % CO_2 as indicated by SEM/EDA of inclusion-derived decrepitates and gas chromatography. Equilibrium solubility calculations for sphalerite and dolomite are consistent with single solution transport of zinc and reduced sulfur in these fluids at a pH near 4.0. Collapse breccias hosting ore apparently formed when these brines dissolved, dolomitized and silicified limestone units of the Upper Knox. Ore-matrix breccia bodies surround and post-date unmineralized breccias which contain appreciably more "recrystalline" dolostone and have undergone less vertical collapse. Sphalerite deposition in ore-matrix breccias may have been induced by T decrease, perhaps triggered by a release of "abnormal" fluid pressure generated during basin development. Barren breccia cores are interpreted to result from fluid/carbonate reaction prior to P release when equilibrium was achieved chiefly by pH-independent dolomitization and not by dissolution. (From the author's abstract)

HAYNES, F.M., KESLER, S.E. and BEANE, R.E., 1986, Sphalerite deposition by CO_2 pressure release and acid neutralization, east Tennessee zinc district (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 632. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Fluid inclusion compositional data from sphalerite of the Mascot-Jefferson City district of east Tennessee and equilibrium solubility calculations for dolomite and sphalerite are consistent with a model involving single solution transport of Zn and sulfide S in Ca(0.3-0.8 m)-, Mg(0.04-0.10 m)-, CO_2(0.4-1.5 mole %)-rich brines having a pH near 4 and at a temperature of 125-150°C. Solution collapse breccias hosting mineralization apparently formed when these brines dissolved, dolomitized, and silicified limestone units of the upper Knox Group. Mass balance calculations indicate that ZnS in ore-matrix breccia can be concentrated efficiently by a decrease in the partial pressure of CO_2. A 50% drop in CO_2 pressure (from 120 to 60 bars) and consequent increase of 0.15 pH units could reduce zinc solubility by as much as 15 ppm, which is sufficient to provide the observed ZnS abundances from reasonable solution volumes. Ore-matrix breccia bodies surround and post-date unmineralized rock-matrix breccias which contain appreciably more "recrystalline" dolostone and have undergone less vertical collapse. The barren breccia cores are interpreted to result from collapse. The barren breccia cores are interpreted to result from fluid/carbonate reaction prior to CO_2 release when equilibrium was achieved chiefly by pH-independent dolomitization and not by wholesale limestone dissolution. Silicification in the early breccias reflects the elevated CO_2 pressures (and thus lower H_2O activity) attending their formation. It is proposed that reductions in CO_2 pressure occurred when "abnormal" fluid pressures generated during sedimentary basin evolution were released, most likely in the Devonian-Mississippian when the Knox was deeply buried but as yet undeformed by Alleghenian faulting. Sphalerite banding suggests either that the degassing was accomplished in several, discrete steps or that CO_2-charged, pregnant solutions were introduced episodically into the district. (Author's abstract)

HE, Zhili, 1986, Main achievements in the study of inclusion mineralogy in China (abst.): Abstracts of Posters, VII IAGOD Meeting, Lulea, Sweden, 18-22 Aug., 1986 (unpaginated). Author at Dept. Geol., Beijing Univ. of Iron & Steel Tech., Beijing, China.

The study of inclusion mineralogy started in the beginning of the sixties in China. Now, there are about 80 organizations in this field of science spreading all over the country. Our inclusion mineralogists are focussing on the following topics:

1. The physical-geochemical conditions of postmagmatic deposit formation.

2. The search for the postmagmatic deposits based on the theory of inclusion mineralogy.

3. The composition and properties of fluid inclusions.

Four symposia in this field of science have been held in China since 1977: the first, on inclusions, held in Quanzhou, Guanxi Zhuang Autonomous Region, 1977; the second, on [inclusion] composition, held in the Third Institute in Beijing, 1980; the third, on decrepitation methods, held in Beijing University of Iron and Steel Technology, 1981; the fourth, on homogenization and freezing methods, held in Nanchang, Jianxi province, 1983; and the fifth, on inclusions, will be held in 1987.

Some methods for measuring temperature and pressure, or determining the composition of inclusions, have been widely used. However, inclusions from sedimentary and metamorphic paragenesis have hardly been studied. Much attention has been paid to the application of inclusion mineralogy to the genesis of deposits. Primary steaming-through haloes, salt haloes, and gas haloes were found around some Fe, W-Sn, W, Au, and polymetallic deposits. All this research work suggests some useful inclusion mineralogical parameters for setting up deposit models. (Author's abstract)

HEARN, P.P., Jr., SUTTER, J.F. and BELKIN, H.E., 1986, Use of authigenic K-feldspar as an indicator of fluid-migration events associated with orogenic activity (abst.): Terra Cognita, v. 6, no. 2, p. 119. Authors at U.S. Geol. Survey, Reston, VA, USA.

Once considered to be a geologic rarity, large concentrations of authigenic K-feldspar are now known to occur commonly in Cambrian and Ordovician carbonate rocks along the entire length of the Appalachian basin. Analysis of fluid inclusions in overgrowths indicate precipitation from a hot (150°-200°C) and saline (18-21 wt% NaCl equiv) non-boiling brine. These results strongly suggest that the K-feldspar formed from hot basinal brines mobilized during the Hercynian-Alleghanian Orogeny. (From the authors' abstract)

HEDENQUIST, J.W., 1986a, An interpretive framework for gases extracted from fluid inclusions (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 251-254. Author at Geothermal Res. Centre, Wairakei, Taupo, NZ.

The gas composition of a geothermal fluid generally reflects thermal and chemical equilibria. Therefore, the gas composition of fluid inclusions from epithermal and other ore deposits may give us detailed information on the chemistry of the ore fluids, if the following conditions are met: (1) Thermal and chemical equilibria is 'frozen in' at or near the conditions of inclusion trapping, (2) there are no changes to the inclusion (e.g., diffusion of gases in or out), (3) there are no gases produced or altered during crushing or decrepitation and (4) the analysis of the released gases is accurate (there is no absorbtion of gases onto surfaces, etc.).

This paper provides a framework for (1) an assessment of the validity of analytical data for gases in fluid inclusions and (2) the interpretation of composition data of gases in epithermal systems in terms of thermal and chemical equilibria as well as boiling and gas loss or two phase entrapment. The latter information assists in determining the chemistry of the hydrothermal fluid, necessary to realistically model metal transport and deposition. (The author's Introduction)

HEDENQUIST, J.W., 1986b, Geothermal systems in the Taupo volcanic zone: Their characteristics and relation to volcanism and mineralization, in I.E.M. Smith, ed., Late Cenozoic Volcanism in New Zealand: The Royal Soc. of New Zealand, Bulletin 23, p. 134-168. Author at Geothermal Res. Center, Dept. Sci. & Industrial Res., Chem. Div., Wairakei, Taupo, NZ.

A thorough review of pertinence to geothermal systems in general. (E.R.)

HEDENQUIST, J.W., 1986, Precious metal vein systems in the National district, Humboldt County, Nevada - A discussion: Econ. Geol., v. 81, p. 1020-1023. Author at Dept. Sci. & Industrial Res., Chem. Div., Wairakei, Private Bag, Taupo, New Zealand.

A discussion of a paper, The problems of interpretation of fluid inclusion data from epithermal deposits by Vikre (1985) (Fluid Inclusion Research, v. 18, p. 435-436, 1985). See reply by Vikre (this volume). (E.R.)

HEILMANN, Gabriela and HENN, Ulrich, 1986, On the origin of blue sapphire from Elahera, Sri Lanka: The Australian Gemmologist, v. 16, p. 2-4. First author at Inst. Edelsteinforschung, Univ. Mainz, West Germany.

Chemistry and inclusions of light blue sapphire from Elahera (Sri Lanka) are described. Biotite inclusions verify that the sapphires are formed in garnetiferous gneisses. (Authors' abstract)

HEINRICH, C.A. and EADINGTON, P.J., 1986, Thermodynamic predictions of the hydrothermal chemistry of arsenic, and their significance for the paragenetic sequence of some cassiterite-arsenopyrite-base metal sulfide deposits: Econ. Geol., v. 81, no. 3, p. 511-529.

HELGESON, H.C., 1986, Effects of complex formation on the hydrothermal solubilities of minerals as a function of fluid pressure at high temperature (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 633.

HEMINGWAY, M.P., NORMAN, D.I. and ROBINSON, R.W., 1986, Epithermal mineralization resulting from mixing of ore solutions: Southern Amethyst vein system, Creede, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 634. First author at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Previous studies of the southern Amethyst vein system indicated mineralization resulted from mixing of solutions. A detailed mineralogic study over a 375 vertical section indicates mineralization occurs both as disseminations within the country rock and in finely-laminated quartz veins. Sulfides are fine-grained and exhibit replacement textures indicating sequential replacement in the order sphalerite to galena to chalcopyrite to acanthite to sulfosalts to covellite. Sequential bands of sulfides exhibit the same replacement sequence. Pb and Zn grades are lowest at the base of the system where Ag occurs as solid solutions within galena and copper minerals. Ag is highest in the upper elevations coinciding with increasing abundance of acanthite and agentiferous sulfosalts. Replacement of galena by acanthite at 200°C indicates Pb/Ag = 11 in ore solutions, and this value is near the Pb/Ag ratios in the veins.

Geochemical calculations indicate that the sulfide replacement sequence results from a simultaneous decrease in temperature and increase in fO_2 in the ore solutions. Mineralization is best explained by the presence of a stacked-cell convection system wherein cool, oxygenated surface waters convected in a cell overlying the circulating ore fluids. The cyclical nature of the mineralization could have resulted from repeated vertical movements of the mixing zone.

Similar replacement sequences have been reported in other epithermal deposits suggesting that fluid mixing may be common in epithermal systems. This specific replacement sequence may be useful as an indicator of solution mixing and formation of bonanza-type ores. (Authors' abstract)

HEMLEY, J.J., CYGAN, G.L. and d'ANGELO, W.M., 1986, Effect of pressure on ore mineral solubilities under hydrothermal conditions: Geology, v. 14, p. 377-379. Authors at U.S. Geol. Survey, Reston, VA 22092.

Experimental studies were conducted at elevated P and T on the combined solubilities of iron, zinc, and lead sulfides in chloride solutions buffered in pH by a silicate assemblage of quartz monzonite composition plus added muscovite, and buffered in fS_2 and fO_2 by the assemblage pyrite-pyrrhotite-magnetite. Major controls on base metal concentration are T, total chloride, and P. Higher T and higher chloride concentration favor higher metal solubilities as expected, but the P effect is opposite to that generally expected and is of considerable importance to the problem of ore mineral transport. At 500°C, 0.5 kbar, and 1 m total chloride, Fe, Zn, and Pb solubilities were 8500, 4300, and 8700 ppm, respectively, whereas at 1 kbar they were 4200, 2400, and 2600 ppm, and at 2 kbar, 1700, 800, and 1200 ppm. The experimental results thus indicate that the metals could be carried over long distances on a decreasing P gradient so long as the T decreases were not sufficient to significantly offset the P effect. Such a condition could be approximated by a near-adiabatic transport cooling path. Such a condition is probably common geologically, especially for hydrothermal processes involving fairly deep-seated sources of heat and mineral components. (Authors' abstract)

HENRY, D.J., TONEY, J.B., SUCHECKI, R.K. and BLOCH, Salman, 1986, Development of quartz overgrowths and pressure solution in quartz sandstones: Evidence from cathodoluminescence/backscattered electron imaging and trace element analysis on the electron microprobe (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 635. First author at Louisiana State Univ., Baton Rouge, LA 70803.

To enhance our understanding of porosity-reducing processes, such as pressure solution and the development of quartz overgrowths in sandstones, we have employed an electron microprobe imaging technique that utilizes a combination of cathodoluminescence (CL) and backscattered electrons. This technique reveals textural features that cannot be easily resolved with traditional optical and CL microscopy. Using these images as guides, detailed electron microprobe analyses of trace elements (minimum detection limits of 40 ppmw) in quartz establish the nature and distribution of the trace elements between detrital quartz and its overgrowth.

Application of this approach to quartzose sandstones reveals several noteworthy features. (1) Pressure solution develops not only among detrital grains but also at contacts among quartz overgrowths. (2) Complex oscillatory or disrupted zoning is common in many overgrowths, although homogeneous quartz overgrowths are equally common. (3) The quartz overgrowths are generally Al-rich, typically containing more than 600 ppmw Al_2O_3, and Fe-, Ti-, Na-, K-poor. An inverse relationship between the Al content and the CL intensity is observed. The relatively Al-rich overgrowths provide a substantial sink for Al, because of the large volume of overgrowth in some sandstones (>20%), and imply a mobilization of Al in the fluid phase during overgrowth development. (4) The fracturing and healing of detrital quartz revealed by CL gives insight into the stress history of the rock during burial. In addition, the relative temporal relationships of fracturing and entrapment of fluid inclusions can assist in the assessment of the early diagenetic fluids. (Authors' abstract)

HERBERT, H.K., ed., 1985, Abstracts of Conference on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, 73 pp.

Contains abstracts (and papers) of many presentations of pertinence to fluid inclusion studies, only the most pertinent of which are abstracted in this volume of Fluid Inclusion Research. (E.R.)

HERRINGTON, T.M., ROFFEY, M.G. and SMITH, D.P., 1986, Densities of aqueous electrolytes $MnCl_2$, $CoCl_2$, $NiCl_2$, $ZnCl_2$, and $CdCl_2$ from 25 to 72°C at 1 atm: J. Chem. Eng. Data, v. 31, p. 221-225.

HERSHEY, J.P., FERNANDEZ, Marino, MILNE, P.J. and MILLERO, F.J., 1986, The ionization of boric acid in NaCl, Na-Ca-Cl and Na-Mg-Cl solutions at 25°C: Geochimica Cosmo. Acta, v. 50, p. 143-148.

HERVIG, R., DUNBAR, N., WESTRICH, H. and KYLE, P., 1986, Direct determination of initial H_2O and F content of rhyolitic magmas by ion microprobe (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 636. First author at Dept. Chem., ASU, Tempe, AZ 85287.

Water (as H) and F were measured by ion microprobe in rhyolitic glass inclusions in phenocrysts from Taupo Ultraplinian (TU) tephra and tephra associated with Obsidian Dome (OD), Long Valley.

Standards were: F, an A-type granite glassed in the piston cylinder with 1200 ppm F; H, three rhyolite glasses with 0.2, 1.62 and 3.62 wt% H_2O, by TGA. Positive ions from 20 μm areas were analyzed. Estimated errors: ±0.5 wt% for H_2O and ±50 ppm for F.

H_2O ranges from 1.9 to 5.8 wt% in 7 inclusions representing 3 TU hypersthene crystals. The mean of 4.7 ± 1 wt% (n = 6, discarding the low value) is considered a good estimate of pre-eruptive water content. F from the same inclusions ranges from 400-810 ppm, averaging 590 ± 160 ppm (n = 7). Electron probe analyses for Cl in inclusions from the same eruption show a small variation (1710-1890 ppm, mean = 1780 ± 60, n = 6). Inclusions were analyzed in the following hosts from OD tephra: 2 plag crystals (H_2O = 2.2, 3.2 wt%; F = 475, 155 ppm), alkali feldspar (3.5; 800). Inclusions in amphibole and pyroxene were too small for precise analyses, but indicated >2 wt% H_2O. An inclusion in mica had the same water content as the glass rim (1 wt%) and may have outgassed.

Previous estimates of pre-eruption water contents of rhyolites (1.5-4.5 wt%) agree with the present analyses of Long Valley inclusions (mean of 3 = 3 wt%). We find the relatively high water content of the catastrophic TU eruption significant. Homogeneity of Cl and major elements in TU inclusions contrasts with the wide range in trace F and LIL elements indicated by the ion probe. (Authors' abstract)

HESS, Jennifer, BENDER, M.L. and SCHILLING, J.-G., 1986, Evolution of the ratio of strontium-87 to strontium-86 in seawater from Cretaceous to present: Science, v. 231, p. 979-984.

A detailed record of the $^{87}Sr/^{86}Sr$ ratio in seawater during the last 100 million years was determined by measuring this ratio in 137 well-preserved and well-dated fossil foraminifera samples. Sample preservation was evaluated from scanning electron microscopy studies, measured Sr/Ca ratios, and pore water Sr isotope ratios. The evolution of the Sr isotopic ratio in seawater offers a means to evaluate long-term changes in the global Sr isotope mass balance. Results show that the marine Sr isotope composition can be used for correlating and dating well-preserved authigenic marine sediments throughout much of the Cenozoic to a precision of ±1 million years. The $^{87}Sr/^{86}Sr$ ratio in seawater increased sharply across the Cretaceous/Tertiary boundary, but this feature is not readily explained as Sr input from a bolide impact on land. (Authors' abstract)

HEYMANN, D., BURKE, E. and TOURET, J., 1986, A qualitative laser-Raman study of graphitic carbon in Allende (abst.): Lunar & Planet. Sci. XVII, p. 339-340, Lunar & Planet. Inst., Houston.

HICKMAN, S. and EVANS, B., 1986, Diffusional crack healing in NaCl in the presence of a saturated brine solution (abst.): EOS, v. 67, p. 1202-1203. Authors at Dept. Earth, Atmos. & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

In order to examine in detail the effect of pore fluids on the crack healing process we have initiated an experimental study of crack healing in NaCl. Cracks were introduced into single crystals of synthetic NaCl and initial crack apertures were determined using sodium interferometry. Samples were annealed in a heated microscope stage containing saturated NaCl solution at temperatures ranging from 5° to 90°C, and crack tip regression distance and crack aperture were continuously recorded during the course of these experiments using both transmitted light photomicrographs and sodium interferograms. The crack tip regression velocity was observed to decrease exponentially with the initial crack aperture. In a sample annealed at 50°C, for example, the healing velocity decreases from approximately 1×10^{-1} μm/sec near the tip of the crack (initial aperture ≈ 0.1 μm) to 1×10^{-4} μm/sec at points far removed from the tip (initial aperture ≈ 1.2 μm). A considerable increase in aperture occurs immediately ahead of the moving crack front, however, and suggests that mass transport during healing is much more localized than previously thought. As expected, the crack healing velocity increases with temperature and further experiments are in progress in order to better constrain this dependence. Finally, we observed a transition in the mode of crack healing from one in which geometrical instabilities at the healing front lead to the production of residual porosity to a mode of crack healing in which no such instabilities occur and the crack heals as one continuous front. This transition occurs with decreasing healing velocity and provides a possible explanation for a variety of observations made by other investigators. (Authors' abstract)

HIGGINS, K.L. and STEIN, C.L., 1986, Micro-Raman spectroscopy of fluid inclusions in a hopper crystal in halite: Microbeam Analysis, Proc. 22nd Ann. Meeting of Microbeam Anal. Soc., Aug. 10-15, 1986, Albuquerque, N. Mexico, p. 31-34.

Fluid inclusions in Permian halite from the Delaware Basin, southeastern New Mexico, were analyzed for dissolved sulfate using laser Raman microscopy. The sample contained portions showing primary or chevron growth zonation, as bands containing extremely small fluid inclusions (~1 to 10 μm on an edge). Four larger inclusions (~100 μm) were also analyzed. Sulfate values ranged systematically from approximately 13.5 parts per thousand at the exterior face of the primary crystal structure down to approximately 2 to 3 parts per thousand toward the interior. Sulfate values in the larger fluid inclusions ranged from ~5 to ~10 parts per thousand. These results are consistent with formation of chevron salt in a very shallow evaporite basin; the data also suggest that halite recrystallization can occur with extremely localized fluid movement. (Abstract provided by C. Stein)

HIGGINS, N.C., 1985, Moderately depleted ^{18}O of waters from magmatic hydrothermal systems: The effect of CO_2 (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 32-33. First author at Bureau Min. Resources, G.P.O. Box 378, Canberra, A.C.T., 2601, Australia.

See Higgins, 1985, Fluid Inclusion Research, v. 18, p. 171-172. (E.R.)

HILDEBRAND, R.S., 1986, Kiruna-type deposits: Their origin and relationship to intermediate subvolcanic plutons in the Great Bear magmatic zone, northwest Canada: Econ. Geol., v. 81, p. 640-659. Author at Geol. Survey of Canada, 588 Booth St., Ottawa, Ontario K1A 0E4, Canada.

Separation of iron phosphate and silicate melts by liquid immiscibility is not supported, [but] all available data are compatible with a deuteric origin. It is concluded that high T, low initial water content, and shallow-level emplacement by intermediate plutons are necessary for the development of Kiruna-type deposits. (From the author's abstract)

HILL, P.I., 1986, Emplacement and hydrothermal alteration of the St. Austell granite (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 12.

HILTON, D.R., OXBURGH, E.R. and O'NIONS, R.K., 1985, Fluid flow through a high heat flow granite: Constraints imposed by He and Rn data, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 135-142.

HIRAI, Hisako and ARAI, Shoji, 1986, Relic fluid inclusions in Alpine-type peridotite (abst.): [Abstract Volume], 1986 Annual Meeting of Geol. Soc. of Japan, p. 437 (in Japanese; translated by M. Sasada).

The serpentine-brucite inclusions in olivine from mantle dunite from Iwanaidake are H_2O-relic fluid inclusions (RFI). Water is assumed to have been supplied to the dunite at the mantle (Arai and Hirai, 1985). In order to understand the stage and place at which the fluid was supplied to the inclusions, we examined the inclusions in olivine from Higashiakaishi and Horoman ultrabasic rocks [optically and with] an analytical electron microscope.

The inclusions are not present in neoblasts but are in porphyroclasts in the dunite from Higashiakaishi. Prismatic inclusions elongated in a certain direction are present on curved surfaces in olivine from the Horoman dunite and in the olivine porphyroclasts from Higashiakaishi. In the Horoman dunite euhedral carbonate minerals occur in large and irregular inclusions which grade into serpentine veins.

Observation under analytical electron microscope and by electron diffraction reveal serpentine, talc and magnesite(?) in pseudohexagonal inclusions completely enveloped by olivine in the Higashiakaishi dunite. Similar-shaped inclusions containing serpentine and brucite are present in Horoman dunite.

Since RFI are not present in neoblasts but are found in porphyroclasts in the Higashiakaishi dunite, the fluid was supplied before the Sambagawa metamorphism, perhaps while still in the upper mantle. In the case of Horoman, various kinds of fluid may have been supplied at several stages while the dunite was in the upper mantle and the crust. When we consider only the inclusions in which the fluid was supplied before the dunite intruded the crust, the H_2O/CO_2 ratio of the fluid in the Horoman dunite is higher than that in Higashiakaishi dunite. A wedge of mantle above a subduction zone is a reasonable place where such CO_2-H_2O fluids are easily supplied. The H_2O/CO_2 ratio of the supplied fluid is assumed to correlate with the depth of the subduction. Hence RFI may provide constraints on the source of the enclosing peridotite. (Authors' abstract)

HIRSCH, P.B., HUTCHISON, J.L. and TITCHMARSH, J., 1986, Voidites in diamond: Evidence for a crystalline phase containing nitrogen: Phil. Mag. A, v. 54, no. 2, p. L49-L54. First author at Dept. Metal. & Sci. of Materials, Univ. Oxford, Parks Rd., Oxford OX1 3PH, England.

Small octahedral bubbles ('voidites'), 10-100 Å in diameter, occur in some type Ia diamonds. In a study of one such specimen, electron diffraction and moiré fringe analysis have been used to demonstrate that the bubbles contain a crystalline cubic phase. Energy-dispersive X-ray microanalysis on the 20 Å scale provides evidence that the phase contains nitrogen. The cell constants derived from the electron diffraction data are consistent with X-ray and compressibility data for solid ammonia, although the possibility of a hitherto unreported phase of solid N_2 cannot be ruled out. (Authors' abstract)

HITZMAN, M.W., 1986, Geology of the Abbeytown mine, Co. Sligo, Ireland, in Geology and genesis of mineral deposits in Ireland, C.J. Andrew et al., eds.: Irish Assoc. Econ. Geol., p. 341-353. Author at Chevron Resources Co., P.O. Box 7147, San Francisco, CA 94120-7147, USA.

Mineral textures indicate a complex sequence of precipitation and dissolution. Fluid inclusions in sphalerite suggest Tt of 88°-170°C. Calcite-pyrite breccias were formed during the last major mineralizing event, and the calcite in these breccias yields fluid inclusion Tt of 140°-175°C. The textures, temperatures and late timing of the mineralization relative to host-rock deposition suggest that Abbeytown should be classified as a replacement-style, Mississippi Valley-type deposit. (From the author's abstract)

HITZMAN, M.W., 1986, Geology of the Ruby Creek copper deposit, southwestern Brooks Range, Alaska: Econ. Geol., v. 81, p. 1644-1674. Author at Chevron Resources Co., P.O. Box 7147, San Francisco, CA 94120-7147.

At Ruby Creek, Alaska, a 1-km-diameter body of hydrothermal dolostone cuts through over 500 m of Middle to Late Devonian carbonate sediments and contains in excess of 100 million tons of 0.2 percent copper. Fluid inclusion studies indicate decreasing T in the veins outward from the core of the system. Deep veins yield T $\leq$215°C whereas veins on the periphery of the system give T ~125°C. Zones of massive copper sulfides formed at T between 100° and 120°C. (From the author's abstract)

HIYAGON, H. and OZIMA, M., 1986, Partition of noble gases between olivine and basalt melt: Geochimica Cosmo. Acta, v. 50, p. 2045-2057. First author Dept. Physics, Univ. California, Berkeley, CA 94720, USA.

The distribution coefficients (K_i) of noble gases were determined for synthesized olivine-basalt melt pairs. Seven samples (BH-series) were synthesized at 1370 ~ 1300°C under a one atmospheric pressure (~10^5 Pa) noble gas mixture, and four samples (HPP- and HPG-series) at 1360-1050°C at high pressures (0.2-1.5 GPa). The two different experiments gave consistent results with each other. Some BH-series olivine samples were apparently contaminated with gas-rich inclusions or the glass phase, and the effects of such interferences on the calculated distribution coefficients were evaluated.

The possible ranges of the distribution coefficients of noble gases thus obtained are: $K(He) \leq 0.07$, $K(Ne) = 0.006\text{-}0.08$, $K(Ar) = 0.05\text{-}0.15$, $K(Kr) \leq 0.15$, and $K(Xe) \leq 0.3$. These show remarkable features compared to solid element distribution coefficients: the distribution coefficients of noble gases are rather insensitive to, or even positively correlated with the atomic size of noble gases. The striking contrast between the partition of noble gases and that of solid elements may be attributed to the electrical neutrality of noble gases and the increasing electronic polarizability from He to Xe. (Authors' abstract)

HO, S.E., GROVES, D.I. and PHILLIPS, G.N., 1985, Fluid inclusions in quartz veins associated with Archaean gold mineralization: Clues to ore fluids and ore depositional conditions and significance to exploration: Special Publ., Geol. Soc. of Australia, Proc. of the Int'l. Conference on Stable Isotopes and Fluid Processes in Mineralization, Brisbane, July 1985, p. . First author at Dept. Geol, Univ. Western Australia, Nedlands, W.A. 6009, Australia.

See same authors, Fluid Inclusion Research, v. 18, p. 172-173.

HOEFS, J., 1986, Isotope geothermometers, in Paleogeothermics; evaluation of geothermal conditions in the geological post, Buntebarth, G. and Stegena, L., eds., Paleogeothermics; 18th Gen. Assemb. of Int'l. Union of Geodesy & Geophys., Hamburg, Germany, FRG, Aug. 15-27, 1983: Springer-Verlag, Germany, pt. 5, p. 45-52.

Indexed under fluid inclusions. (E.R.)

HOLDAWAY, M.J., DUTROW, B.L., BORTHWICK, James, SHORE, Patrick, HARMON, R.S. and HINTON, R.W., 1986, H content of staurolite as determined by H extraction line and ion microprobe: Am. Min., v. 71, p. 1135-1141. First author at Dept. Geol. Sci., Southern Methodist Univ., Dallas, TX 75275, USA.

H_2O analyses for 31 staurolites, determined using H-isotope extraction-line and ion-microprobe techniques, range from 1.43 to 2.26 wt%. The two techniques are consistent with each other. Whereas H_2O contents determined using the H-isotope extraction line are more precise, the ion microprobe has the advantage of eliminating the H_2O contributed from contaminating phases. (From the authors' abstract)

HOLLISTER, L.S., 1986, Review of Shepherd et al., Fluid Inclusion Studies: Am. Min., v. 71, p. 1284.

A very unfavorable review. (E.R.)

HOLLISTER, V.F., ed., Case histories of mineral discoveries, Volume 1, Discoveries of epithermal precious metal deposits: Soc. Mining Engrs. of Am. Inst. Mining, Metal. & Petrol. Engrs., Inc., publ. New York, NY, 165 pp.

Fourteen districts are in individually authored chapters, but there is no entry for "fluid inclusions" in the index. (E.R.)

HOLLOWAY, J.R., CLEMENS, J.D., NEKVASIL, H., RUSHMER, T., VIELZEUF, D. and WEBSTER, J.D., 1986, Experimental constraints on the H_2O contents of silicic magmas (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 127.

HOLLOWAY, J.R. and JAKOBSSON, Sigurdur, 1986, Volatile solubilities in magmas: Transport of volatiles from mantles to planet surfaces: Proc. of 16th Lunar & Planet. Sci. Conf., Part 2, J. Geophys. Res., v. 91, no. B4, p. D505-D508.

HOLMES, H.F. and MESMER, R.E., 1986, Thermodynamics of aqueous solutions of the alkali metal sulfates: J. Solution Chem., v. 15, no. 6, p. 495-518.

HONDA, M., EPSTEIN, S., McCONVILLE, P., REYNOLDS, J. and ROEDDER, E., 1986, Noble gases in terrestrial diamonds (abst.): Terra Cognita, v. 6, no. 2, p. 104. First author at Dept. Physics, Univ. California, Berkeley, CA 94720.

Slightly different than Honda et al., 1985, Fluid Inclusion Research, v. 18, p. 176. (E.R.)

HONDA, M., McCONVILLE, P., REYNOLDS, J.H. and ROEDDER, E., 1986, Solar-like noble gases in terrestrial diamonds: Lunar Plan. Sci. XVII, p. 348-349. First author at Dept. Physics, Univ. California, Berkeley, CA.

It is suggested that the noble gases (He, Ne, Ar, Kr, Xe), together with N_2, are trapped in platelets and/or "vesicles." The highest and lowest values for $^3He/^3He$ (1.6×10^{-4} and $<4.5 \times 10^{-8}$) came from colorless and yellowish diamonds, respectively, both from the same Australian pipe; these and other data obtained indicate strong heterogeneity in the mantle. The He and Ne in some diamonds may be of solar origin. (E.R.)

HORIBE, Y., KIM, K.-R. and CRAIG, H., 1986, Hydrothermal methane plumes in the Mariana back-arc spreading center: Nature, v. 324, p. 131-133. First author at Scripps Inst. Oceanography, La Jolla, CA 92093, USA.

Submarine hydrothermal vents were first unequivocally detected by measurement of $^3He/^4He$ ratio anomalies coupled with deviations from ambient T-S relationships on the Galapagos spreading center. Since then the existence of hydrothermal vents along the entire length of the East Pacific Rise has been demonstrated by shipboard observations of ^3He, methane, and manganese in the effluent plumes. We have extended our studies of vent fields at mid-ocean-ridge spreading centers to search for effluent plumes in back-arc basins, which are also thought to be active regions of seafloor spreading where new oceanic crust is formed, and thus where rifting and fissuring along the axis of extension should provide similar opportunities for the downward penetration of sea water and the development of active hydrothermal systems. We have detected large plumes of methane-enriched water in the Mariana Trough back-arc basin and also in the summit crater of Loihi Seamount at the present site of the Hawaiian hotspot, thus establishing the widespread existence of 'off-ridge' hydrothermal vents in the ocean. However, although the Loihi vents produce plumes enriched in both ^{3}He and methane, we find that, surprisingly, the Mariana vents are enriched in methane without a corresponding enrichment in ^{3}He. This is the first time such a 'decoupling' of these two effluent plume tracers has been observed. (Authors' abstract)

HORITA, Juske and MATSUO, Sadao, 1986, Extraction and isotopic analysis of fluid inclusions in halite: Geochem. J., v. 20, p. 261-272. Authors at Dept. Chem., Tokyo Inst. Tech., O-okayama, Meguro-ku, Tokyo 152, Japan.

Basic technique for the extraction and isotopic analysis of fluid inclusions in halite was investigated using synthetic single crystals of halite and three natural halite samples from China.

Vacuum ball-mill, vacuum decrepitation and vacuum melting methods were examined for the extraction of fluid inclusions. Results of analyses on δD and δ^{18}O of the water in fluid inclusions extracted by the ball-mill method from synthetic single crystals agreed with those of the mother solution from which the single crystals were formed. Although the δ^{18}O value of the water extracted by the melting method agrees well with that of the mother solution, the δD value was about 7‰ more negative than that of the mother solution.

There was a great difference in both δD and δ^{18}O of the water extracted by the two methods applied to the identical natural halite samples; the melting method gave consistently more negative values for both δD and δ^{18}O compared with those by the ball-mill method. The difference was interpreted as a result of the hydrolysis of NaCl with H_2O combined with the formation of oxides of alkaline-earth elements in brine inclusions in natural halite samples in the process of the melting method.

Although the melting method has an advantage of complete recovery of volatiles in halite samples, the chemical and isotopic compositions of volatiles cannot be retained owing to a variety of thermal reactions which occur at high temperatures. It was concluded that the ball-mill method is much superior to the melting method in order to obtain isotopic and chemical information on fluid inclusions in halite, though the recovery of fluid inclusions by the ball-mill method is not 100%, and high concentrations of Mg^{2+} and Ca^{2+} in fluid inclusions require correction for the δD and δ^{18}O values of the water. (Authors' abstract)

HORSÁK, Ivan and SLÁMA, Ivo, 1986, Densities of aqueous electrolyte solutions. A model for a data bank: J. Chem. Eng. Data, v. 31, p. 434-437.

HOWARD, K.W. and HANOR, J.S., 1986, Compositional zoning in the Fancy Hill stratiform barite deposit, Ouachita Mtns., Arkansas (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 641. First author at USGS, M.S. 959, Reston, VA 22092.

Mineralizing fluids at Fancy Hill were probably typical subsurface brines having elevated Ba, Sr, and Ca concentrations and negligible concentrations of metals. Most barite precipitated when these brines migrated upward to the sea floor and mixed with marine bottom waters. (From the authors' abstract)

HUA, Renmin, 1985, Ca-rich feature of the ore-forming fluid and it's genetic significance to Jinduicheng Mo deposit: Geol. & Prospecting, v. 21, no. 12, p. 22-26 (in Chinese).

Includes histogram of Th(?) value (<100 to >300°C), and SEM photos of dms? (E.R.)

HUANG, Dianhao, WANG, Yichang, NIE, Fengjun and JIANG, Xiujie, 1986, Type, origin and rhenium distribution of the Huanglongpu molybdenum (lead) deposit in Shaanxi Province (China): Zhongguo Dizhi Kexueyuan Kuangchan Dizhi Yanjiuso Sokan, v. 16, p. 1-129 (in Chinese).

Indexed under fluid inclusions. (E.R.)

HUANG, H.F. and GOFF, Fraser, 1986, Hydrogeochemistry and reservoir model of Fuzhou geothermal field, China: J. Volcan. & Geotherm. Res., v. 27, p. 203-227.

HUANG, Minzhi, WU, Gongbao, CHEN, Yuchuan and TANG, Shaohua, 1986, Mineralogical study of the franckeite from the Dachang cassiterite-sulphide polymetallic ore field, Guangxi: Acta Geol. Sinica, 1986, no. 2, p. 164-175 (in Chinese; English abstract). Authors at Inst. Min. Deposits, Chinese Acad. Geol. Sci.

Uniform T of calcite ranges from 128°C to 326°C with a mean T of 221°C. The $\delta^{13}C$ value is -8.3‰ the $\delta^{18}O$ value is +15.1‰, and the $\delta^{18}O(H_2O)$ is +4.93‰. Td of franckeite is 180°C, the $\delta^{34}S$ value is -3.1%[sic].

The ore-containing fluid represents a moderate- to low-temperature hydrothermal solution formed by mixing post-granitic-magmatic hot water with meteoric water. The ore-containing elements such as Pb and S came from a mixed source of magma and surrounding rocks. (From the authors' abstract)

HUANG, W.-L. and WYLLIE, P.J., 1986, Phase relationships of gabbro-tonalite-granite-water at 15 kbar with applications to differentiation and anatexis: Am. Mineral., v. 71, p. 301-316.

HUBERT, P., BENY, C., OUSTRIERE, P. and TOURAY, J.-C., 1986, Geochemistry of fluid phases associated with the gold mineralization of Sanoukou (Kenieba district, Mali) (abst.): Colloq. PIR SEM, "Facteurs de Concentration des metiers premiers minerales," Montpellier, 29-30 Sept. 1986 (in French).

See next item. (E.R.)

HUBERT, P., BONNEMAISON, M., DOMMANGET, A., OUSTRIÈRE, P. , RANKIN, A. and TOURAY, J.C., 1986, The use of geochemistry of the fluid phases to characterize gold-bearing quartz from W-Africa (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 93 (in French). First author at BRGM, BP 6009, 45060 Orléans Cédex, France.

Fluid inclusions were studied in Au-bearing and sterile quartz from shear zones in W-Africa. Results are used to characterize the evolution of fluids, conditions of formation of the deposits, and to determine relations between chemical composition of the fluids and trace element contents of the samples. Apart from the usual nondestructive techniques (microthermometry and Raman-spectrometry) the fluid inclusions were analyzed by ICP spectrometry and gas chromatography for Na, K, Ca, Sr, Ba, Li, S, CO_2, CH_4, C_2H_6, (C_3, C_4). The results of these analyses are in good agreement with those obtained by microthermometry and Raman-spectrometry. It was possible to distinguish high-T carbonic inclusions (type C) poor in CH_4, and low-T (<200°C) aqueous inclusions (type L) with variable but high salinities (<15% eq. NaCl). Fluids in samples with high Au concentrations seem to be characterized by low gas contents (CO_2/Na low), enrichment of methane (CO_2/CH_4 low) and T around 180°C (Na-K and Na-K-Ca geothermometers). (Authors' abstract; translated by R. Kreulen)

HUBERT, Pascal, 1986, Textures and fluid inclusions of gold-bearing quartz. Application to the Cros-Gallet deposit (Haute-Vienne, France) and to the prospecting area of Sanoukou (Kenieba district, Mali): Ph.D. dissertation, Univ. d'Orleans, France (in French; English abstract).

Chronologic and genetic relations between gold, associated minerals, quartz assemblages and fluid phases have been studied on two gold shear-zone deposits which show similar structure and mineralogy: the deposit of Cros-Gallet (Haute-Vienne, France) and the prospect area of Sanoukou (Kenieba district, Mali). This study established the best conditions and environments for this type of gold deposit and determined useful measures for prospecting.

Gold is related geochemically and/or mineralogically, in both deposits, to microcrystalline quartz assemblages. These result from local silica remobilization during brittle (cataclasis) or semi-ductile deformation (deformation-recovery-recrystallization) which modifies an already silicified structure. These assemblages form a trap for the gold-bearing mineralization, mainly arsenopyrite and native gold.

This early mineralization results from a fall in P in the shear-zone system, initially at high P (1.8-2 kb) and T (300-400°C). This P drop is accompanied by the arrival of carbon dioxide vapor which mixes mechanically with the pre-existing solutions. Later, this early mineralization is enriched through remobilization by low-T (<300°C) lead-bearing fluids with a minor CO_2 content.

This later mineralization is characterized by the crystallization of clear quartz in small vugs. The formation of economic concentrations of gold in the two studied deposits occurred during this stage. The study of Sanoukou was completed by bulk fluid inclusion analysis and trace element data.

A correlation [was found to] exist between gold content and certain parameters of the fluid chemistry (K/Na, Li/Na, CO_2/Na and to a lesser extent CO_2/CH_4. (From the author's abstract)

HULEN, J.B. and NIELSON, D.L., 1986, Hydrothermal alteration in the Baca geothermal system, Redondo dome, Valles caldera, New Mexico: J. Geophys. Res., v. 91, no. B2, p. 1867-1886.

HUNZIKER, J.C., FREY, M., CLAUER, N., DALLMEYER, R.D., FRIEDRICHSEN, H., FLEHMIG, W., HOCHSTRASSER, K., ROGGWILER, P. and SCHWANDER, H., 1986, The evolution of illite to muscovite: Mineralogical and isotopic data from the Glarus Alps, Switzerland: Contrib. Mineral. Petrol., v. 92, p. 157-180.

HUTCHEON, Ian, 1986, Mineral reactions in a sand-shale sequence with specific reference to an over-pressured zone (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 84. Author at Dept. Geol. & Geophys., Univ. Calgary, Calgary Alberta, T2N 1N4, Canada.

The toplogy of these reactions in terms of T and the mole fraction of CO_2 in the system CO_2-NaCl-H_2O implies that at a specific T, P and NaCl concentration the solubility of CO_2 in an aqueous liquid will be exceeded and CO_2-rich vapor will be produced. (From the author's abstract)

HYMAN, D.M., 1982, Methodology for determining occluded gas contents in domal rock salt: DOI/Bureau of Mines Rept. of Investigations 8700, 11 pp. Author at Pittsburgh Res. Center, Bureau of Mines, Pittsburgh, PA.

Ballmilling and dissolution were used. Of the two, the dissolution method appears to be more versatile because it can be performed in situ. The relevance and applicability of data on the occluded gas contents of rock salt are dependent on sample size, sample collection method, geologic context of the sample, and the correlation with gas emissions that occur as a result of mining-induced fractures and pressure differentials. (From the author's abstract)

Louisiana Gulf Coast domal salt and Polish domal salts were analyzed; the former showed a maximum of 8-10 cm^3 CH_4/100 g rock, plus lesser quantities of other gases. Popping salt gave 0.6-10 cm^3. Other domes yielded high CO_2. Polish salt yielded high N_2 values. (E.R.)

IGNAT'YEVA, I.B., SEROVA, L.S., NOSIK. L.P., REKHARSKIY, V.I., 1985, (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 239-240 (In Russian; translation by Dorothy B. Vitaliano). Authors at IGEM, Acad. Sci. USSR, Moscow USSR

At the present time, in studying the gas component in mineral vacuoles, much attention is being paid to hydrocarbons contained both in the vacuoles and in defects in crystal structure of the minerals. When samples of minerals are heated, carbon is given off in the form of CO_2 and to a lesser extent, of CO, CH_4 and other hydrocarbons.

Liberation of CO_2 is recorded in the form of three maximums corresponding to different forms of carbon -- CO_2, CO_3^{2-}, and reduced C (table 1). The isotopic composition of carbon of the individual maximums does not contradict our earlier data on the existence of different forms of carbon in minerals.

Table 1. Isotopic composition (%) and CO_2 content (tor. cm^3) [sic] in minerals of the Kalmakyr deposit

Minerals	500°C		900°C		1100°C	
	$(PV_{CO_2})_{CO_2}$	$\delta^{13}C_{CO_2}$	$(PV_{CO_2})_{CO_3^{2-}}$	$\delta^{13}C_{CO_3^{2-}}$	$(PV_{CO_2})_C$	$\delta^{13}C_C$
K-feldspar	48.6	-18.4	222.0	-15.5	258.5	-25.5
	270.0	- 4.7	324.0	- 7.4	126.0	-29.6
Quartz	126.0	- 4.7	21.0	- 7.5	333.6	-24.8
	272.4	-10.4	54.0	-15.0	204.0	-29.3

When minerals of different fractions are heated, hydrocarbons are given off in addition to CO_2 (table 2). Grinding of minerals to <0.01 leads to loss of CH_4 in the low-T region, which suggests its presence in the vacuoles in the minerals.

Table 2. Kinetic liberation of methane from a different fraction of quartz

Fraction(mm)	PV_{CH_4} (tor.cm^3) at various temps., °C						
	200	400	500	600	800	900	1000
1.5 to 0.5	0.05	1.00	0.20	0.80	0.60	0.30	0.20
<0.01	0.20	0.30	0.10	0.85	0.63	0.38	0.10

The high content of CH_4 at 600-800°C may be related to the liberation of hydrocarbons from defects in the crystals or of hydrocarbons formed on the active surfaces of crystals in the course of diffusion of C and H. Experiments on repeated heating of samples, first held in a H_2 atmosphere at 400°C, indicates the possibility of formation of CH_4 at that T (table 3).

Table 3. Kinetic liberation of CH_4 from quartz (<0.01 fraction) upon repeated heating

Temp., °C	400	500	600	800	900	1000
PV CH_4 (tor.cm^3)	0.06	0.08	0.25	0.20	0.08	0.03

The results obtained should be taken into account in studying the main forms of carbon in minerals and in judging the physiochemical conditions of their formation. (From the authors' abstract)

IKEYA, M., DEVINE, S.D., WHITEHEAD, N.E. and HEDENQUIST, J.W., 1986, Detection of methane in geothermal quartz by ESR: Chem. Geol., v. 56, p. 185-192. First author at Tech. College, Yamaguchi Univ., Ube, Yamaguchi, Japan.

In an ESR study of New Zealand rhyolite from geothermal drill holes, quartet signals with intensity ratio of 1:3:3:1 appeared after γ-irradiation which proved to be due to the presence of methane trapped in the primary quartz or slightly altered quartz. The signals are stable for periods of months at room temperature, which is extremely long. The produced defects give signals which anneal at temperatures only 50°C higher than the temperature of the samples as measured in the drill holes and this is shown to support the idea of a signal origin in an altered surface layer. The technique shows promise of being a sensitive and non-destructive technique for analysis of trapped methane. Another unidentified signal and its calculated durability leads to the conclusion that the rhyolite is much younger than 7 Ma and the signal itself could prove useful in future geothermal dating after more investigation. (Authors' abstract)

IKORSKIY, S.V. and FANYGIN, A.S., 1986, Zonal distribution of hydrocarbon gases at the apatite deposit Oleniy Ruchey in the Khibiny massif: Dokl. Akad. Nauk SSSR, v. 290, no. 3, p. 683-686 (in Russian). First author at Geol. Inst. of Kola Div. of Acad. Sci. USSR, Apatity, USSR.

Methane is the main component of gases present in fluid inclusions and in the systems of microfractures in the minerals from the Khibiny ijolite-urtite massif. The subordinate gas components consist of the hydrocarbons C_2-C_5, H_2, He, sometimes CO and CO_2. The deposit Oleniy Ruchey (Reindeer Creek) bears apatite bodies in the ijolite-urtite rock. The study of gases was performed for samples from drill cores, sample weight 250-600 g, sampling step 5-10 m; directly after the coring the samples were put into special air-tight containers. Gases from microfractures were released by vacuum pumping at 80-90°C, gases from fluid inclusions by powdering under vacuum. Composition of the both kinds of gases was the same (in vol. %): CH_4 83-98.5, C_2H_6 0.25-7.8, H_2 0.3-13.9, He up to 1-2, hydrocarbons heavier than C_2H_6 very subordinate. The absolute contents range from 0.16 to 130 ml/kg of rock. The direct relation between the amouns of CH_4 in inclusions and in microfractures was found (correlation coefficients +0.54 to +0.83). Rocks with higher G content from continuous zones around the apatite ore bodies, the parts richest in gases occur under ore bodies; there also these zones are thickest. All rock varieties present at the deposit occur within such zones, except apatite thus [there is] no petrographic control on the gas distribution. The origin of the gas-rich zones is connected most probably with the tectonic phenomena accompanying formation of the apatite ore bodies. (Abstract by A.K.)

IKORSKIY, S.V., PRIPACHKIN, V.A., FANYGIN, A.S., 1985, Microinclusions of gas as a prospecting-appraisal criterion of apatite mineralization at Khibiny (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 255- 256 (In Russian; translation by Dorothy B. Vitaliano). Authors at Geochem. Inst., Kola Affil., Acad. Sci. USSR.

From the beginning of the 1930's to the present time, the apatite deposits in the Khibiny massif have been the main source of raw material for phosphate fertilizer in the USSR. All known apatite deposits in the Khibiny are spatially and genetically related to rocks of an ijolite-urtite complex. The rocks containing the ijolite-urtite intrusion are agpaitic nepheline syenites. A typical feature of the rocks of the ijolite-urtite complex and nepheline syenites is their enrichment in microincluded gases of hydrocarbon composition, the main component of which is CH_4.

More than a hundred boreholes were studied and thousands of core samples were analyzed for gas content. The gases were extracted in a vacuum mill and analyzed by gas chromatography.

The established regularities consist of the fact that in the exocontacts of the apatite occurrences, a marked increase in content of microincluded hydrocarbon gases is observed in the enclosing rocks of the ijolite-urtite complex -- up to tens or hundreds of milliliters per kilogram of rock. Generally the aureoles of high gas content consist of two zones, super-ore and sub-ore. Usually the sub-ore zone is thicker and better expressed. The thickness of the gas-saturated zones is tens or a few hundred meters.

On the basis of the established data, the following prospecting-appraisal criteria are proposed: a) the appearance in the section of the ijolite-urtite complex of zones of high gas content, and especially the presence of gas-rich rocks in its footwall, should be considered a favorable sign for prospecting for concealed apatite bodies above it in the section, even when the first holes drilled through the productive sequence did not detect them; b) the ore zone -- that is, the part of the section of the productive thickness where apatite ores might be found -- can be considered penetrated over its whole depth if the holes enter (or better, cross) a zone of gas-rich rocks.

The nature of the zonal distribution of microincluded gases apparently is related on the one hand to limitation of the formation of microinclusions to the postmagmatic stage of development of the ijolite-urtite complex, and on the other, to tectonic movements accompanying the formation of the apatite bodies in their present form. (From the authors' abstract)

ILCHIK, R.P., 1986, Metal associations in hydrothermal ore deposits and implications about transport complexes (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 2, p. 119.

ILTON, E.S. and EUGSTER, H.P., 1986, The exchange of Zn, Mn, Cd, Cu and Fe between magnetite and a supercritical aqueous chloride solution (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 643.

INGRIN, J. and POIRIER, J.P., 1986, Transmission electron microscopy of ejecta from the XVIth century eruption of the Soufrière, Guadeloupe; microscopic evidnece for magma mixing: J. Volcan. & Geotherm. Res., v. 28, p. 161-174. Authors at Inst. Phys. du Globe de Paris, 4 Place Jussieu, 75230 Paris Cedex 05, France.

Pyroclastic products of the XVIth centrury eruption of the Sourfriere of Guadeloupe were examined in transmission electron microscopy. Features smaller than one micrometer inside the pyroxene and plagioclase phenocrysts were analyzed and provided information to constrain the mechanism and the chronology of the eruption. The observations support a mechanism of triggering by injection of a hot andesitic magma into a chamber containing partly differentiated dacitic magma. The analysis of the dusty zones in plagioclase phenocrysts suggests that the basic magma was about 200°C hotter than the resident magma. The eruption probably had a very low chlorine yield and ended with a pyroclastic flow contemporaneous with the emplacement of the present dome. (Authors' abstract)

Involves study of silicate glass inclusions. (E.R.)

IRVING, A.J., 1986, Polybaric magma mixing in alkalic basalts and kimberlites: Evidence from corundum, zircon and ilmenite megacrysts (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 262-263. Author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195, USA.

Megacryst phases enclosed in basanite, minette and kimberlite magmas provide a record of polybaric magmatic evolution during ascent of mantle-derived magmas. Evidence from trace element, isotopic and phase equilibrium data implies that some megacrysts (e.g., Al-augite, pyropic garnet in basanites) could be cognate with the host magma, whereas other (e.g., corundum, zircon, anorthoclase in basanites) must be exotic to their hosts. A variety of megacryst species including corundum, zircon, anorthoclase, magnetite, ilmenite and pleonaste spinel occur within numerous Tertiary basaltic plugs in the Rubyvale region of central Queensland, Australia. The corundum megacrysts (commonly 1-2 cm across) show very distinctive fluid inclusions. They form planar arrays of two main types. Type 1 is pure CO_2 (liquid + vapor), as in sapphires from minette at Yogo, Montana. More common and associated with the first type are multi-phase inclusions composed of subequal amounts of CO_2 (liquid + vapor) and H_2O containing halite, sylvite and other unidentified daughter minerals. Dissolution studies of the halide salts imply a high total salinity in the H_2O phase (~35% NaCl and a similar value for KCl). These Type 2 inclusions remain unhomogenized $\leq$685°C. Taken together the growth zoning, CO_2-rich inclusions, and high Th suggest a high T (and P) magmatic origin for the corundum megacrysts. (Abbreviated from the author's abstract by E.R.; references deleted.)

ISHIYAMA, Daizo and MATSUEDA, Hiroharu, 1986, Mode of occurrences and chemical compositions of dolomite and kutnahorite related to manganese mineralization at the Jokoku mine, southwestern Hokkaido, Japan: J. Jap. Assoc. Min., Pet. & Ec. Geol., v. 81, p. 205-217 (in Japanese; English abstract).

Epithermal vein-type manganese deposits of the Jokoku mine occur in Pre-Tertiary sedimentary and Tertiary acidic pyroclastic rocks of southwestern Hokkaido, Japan. Formation T of the minerals associated with kutnahorite in metasomatic dolomite is estimated to be about 200°C, based on Th of fluid inclusions etc. Based upon the chemical compositions and mode of occurrences of kutnahorite in metasomatic dolomite at the Jokoku mine, it is suggested that the hydrothermal solutions having low $(m\ Mg^{2+}/m\ Mn^{2+})_{aq}$ would replace dolomite. (From the authors' abstract)

ISMAILOV, M.I. and BALAKINA, A.S., 1985, Decrepitation typomorphic peculiarities of quartz from the skarn-tungsten-molybdenum deposits of Western Uzbekistan: Zapiski Uzbekistan. Otdel. Vses. Mineral. Obshch., no. 38, p. 59-61 (in Russian).

Cited in Naumov, 1986 (this volume).

ITALIANO, F., NUCCIO, P.M. and VALENZA, M., 1984, Geothermal energy release at the Solfatara of Pozzuoli (Phlegraean Field): Phreatic and phreatomagmatic explosion risk implications: Bull. Volcanol., v. 47, no. 2, p. 275-285 (published 1986). First author at Istituto di Geochimica dei Fluidi, C.N.R., Palermo, Italy.

The H_2O, CO_2 and H_2S outputs at the Solfatara of Pozzuoli have been measured and a map of the exhaling areas has also been made. The energy released at the surface by the fluids has been estimated to be 10^{19} ergs/day.

The presence of aquifers at Phlegraean Fields increases the phreatic and phreatomagmatic explosion risk.

Our results suggest that even if an uprising magma may interact with water at depth, an explosion could occur only at the shallow levels of a few hundred meters. Since the transfer of energy toward the surface is favored by the presence of fractures, a detailed analysis of the deep fracture network would help to evaluate the risk levels of the various areas of Phlegraean Fields. (Authors' abstract)

IVANOVA, G.F. and NAUMOV, V.B., 1985, Geochemical inter-relations of rare-metal ore mineralization with granites, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 155-162. Authors at V.I. Vernadsky Inst. Geochem. & Anal. Chem. of USSR Acad. Sci., Moscow, USSR.

Includes new(?) data on the H_2O concentrations and pressures in Li-F-, alkaline-, and "standard" granites, from melt inclusion studies (p. 158), and a review of data in Naumov and Sokolov, 1981 (Fluid Inclusion Research, v. 14, 1981, p. 144) and Naumov and Ivanova, 1980 (Fluid Inclusion Research, v. 13, 1980, p. 171). (E.R.)

IVANOVA, G.F., NAUMOV, V.B. and KOPNEVA, L.A., 1986, Physico-chemical parameters of formation of scheelite in the deposits of various genetic types: Fluid inclusions study: Geokhimiya, 1986, no. 10, p. 1431-1442 (in Russian; English abstract).

Based on fluid inclusion study, the physico-chemical parameters of formation of scheelite have been considered on the example of more than 40 scheelite-bearing deposits of various genetic types from an extremely broad range of deposition of scheelite in natural conditions. Th of fluid inclusions in scheelite varied from 600 down to 150°C. Analysis of T-P relations gives evidences of significant range of P for solutions from which scheelite was deposited: from 1600 to 200 bar. Study of T-X dependence permits distinguishing two broad groups of scheelite-bearing associations different in the mentioned parameters. The first group corresponds to early scheelites of skarns, Au-scheelite deposits and some explosive pipes. They were deposited at high T (600 to 300°C) and high concentration of the solutions (75 to 30 wt. % of NaCl equiv.). The second group includes association with scheelite from the vein-greisen, vein and stockwork deposits formed from weakly-mineralized solutions (14 to 2 wt. % of NaCl equiv.) and a lower T (mainly, 340 to 200°C). (Authors' abstract)

IVANYUK, B.O., KARAVAYEV, I.B. and KARAVAYEVA, V.A., 1985, The thermobarometry and geochemistry of the ore-forming fluids in the cassiterite-quartz deposits of Chukotka (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 126-128 (in Russian; translation by D.A. Brown). First author at Magadan Br. of the Khar'kov [?Khabarovsk] Polytechnic Inst., Magadan, USSR.

The T-P and geochemical features of mineral-forming fluids have been studied in topaz, quartz, cassiterite, beryl, and fluorite from the Iul'ta, Svetloye, Solnechnoye, Snezhnoye, and other deposits of the cassiterite-quartz association in Chukotka. These deposits occur in Upper Permian, and Lower and Middle Triassic sedimentary rocks, less commonly in gabbroids of the Triassic intrusive complex, and in Late Cretaceous granites, which have a spatial-genetic connection with the mineralization. The quartz veins in these deposits consist of topaz-muscovite, arsenopyrite-cassiterite-wolframite-muscovite with beryl and fluorite, and stannite-chalcopyrite-galena-molybdenite mineral associations.

Th studies on topaz have revealed that the P authigenic GLIs of homogeneous trapping with a capture coefficient (KZ) [degree of fill?] = 0.6-0.7, homogenize into the liquid phase at 370-330°C. In quartz-I, crystallofluidal multiphase and differently-filled two-phase inclusions of homogenous and heterogeneous capture (KZ = 0.4-0.6) are present with Th = 500-400°C. They homogenize into the liquid phase, and less commonly into the gas phase with critical phenomena. The P two-phase authigenic GLIs (KZ = 0.5-0.6) of tubular shape in beryl homogenize into the liquid phase at ~440-410°C. In cassiterite-I, GLIs (KZ = 0.5-0.6) are normal, but less commonly they have a solid phase ($\leq$15 vol.%) which homogenizes into the liquid and gas phases at ~450-420°C.

Quartz-II most commonly has water-CO_2 inclusions of complex composition (CO_2 <60 wt.%), and two-phase GLIs (KZ = 0.6-0.8), with Th = ~400-230°C. In quartz-II, 75% of the inclusions examined display a homogeneous (liquid) aggregate state for the hydrothermal fluid, and 25%, a heterogeneous state (gas + liquid). In fluorite, the authigenic two- and multiphase inclusions with solid inclusions (platelets of muscovite <50 vol.%) homogenize into the liquid phase at Th = ~380-320°C. P authigenic two-phase (KZ = 0.6-0.7) inclusions, with Th = ~360-300°C, have been noted in cassiterite II.

These data indicate that the deposits were formed at ~500-230°C. The minerals studied are marked by a narrow range of Te conditions and quartz alone is a 'through' [ubiquitous?] mineral, which crystallizes over a greater T range. In this case, some T rise has been recorded in mineral-formation from the topaz-muscovite to the arsenopyrite-cassiterite-wolframite-muscovite association, with its subsequent fall towards the later associations. A Th study of the inclusions in quartz and cassiterite along the dip of the ore veins has shown that the most exposed Iul'ta and Svetloye deposits have a T-gradient based on quartz of 14-18°C/100 m, and on cassiterite, 18-20°C/100 m. Pc of the minerals studied, calculated by V.A. Kalyuzhnyi's method, lies in the range of 100-40 MPa, whereas the gradient obtained in the direction of the granite dome is 8-10 MPa/100 m.

An analysis of the aqueous extracts and gases has shown that the ore-forming solutions were essentially aqueous; amounts (wt.%) of H_2 are 65-85, gases 5-27, salts 7-10. The gases include H_2S, CO_2, CO, NH_3, CH_4, H_2, N_2, and Ar; the salts include Na, K, NH_4, Ca, Mg, Fe^{++}, CO_3, SO_4, Cl, I, F, H_2SiO_3, and HBO_2. A characteristic feature of the fluid solutions is the presence of high concentrations (g/kg of solution) of CO_2 70, SO_4 37, H_2S 25, Cl 16, Na 16, and K 10. Along the dip of the veins, there is variation in the amounts of H_2O, CO_2, and SO_4, the total light gases, and CO_3, K, Na, and Cl decrease insignificantly, and H_2S increases by almost four times. (Authors' abstract)

JACOBS, R.S., FODOR, R.V. and BAUER, G.R., 1986, Alkalic magmatism on Kahoolawe Island, Hawaii: Ba-, Sr-, S-, Y-, and REE-bearing phases in basalt (abst.): EOS, v. 67, p. 390.

JADHAV, G.N., PANCHAPAKESAN, V. and SAHU, K.C., 1986, Fluid-melt inclusion studies of pegmatites in and around Dhab, Hazaribagh district, Bihar, India (abst.): Terra Cognita, v. 6, no. 3, p. 510. Authors at Dept. Earth Sci., Indian Inst. Tech., Powai, Bombay-400076, India.

Inclusion studies were performed on quartz, beryl and tourmaline. Lollingite from fracture zones in mica-rich pegmatites was also used for inclusion studies.

Melt inclusions consisting of gas + melt ± quartz crystals show a range of Th from 500°C to 1020°C. Fluid inclusions are more abundant than melt inclusions. They are either biphase or polyphase and each of these is either liquid-rich or gas-rich. Halite, sylvite and anhydrite are the common dms, and monazite needles were recorded in polyphase fluid inclusions. The range of Th in the four different classes studied are as follows: biphase, liquid-rich, 145°C to 410°C; biphase, gas-rich, 270°C to 500°C; polyphase, liquid-rich, 205°C to 390°C; and polyphase, gas-rich, 290°C to 470°C. All types of inclusions are observable in these pegmatites thereby indicating a wide range of crystllization T. However, predominance of any particular type is well correlated with mineralogical types within different pegmatites, as illustrated by statistical data. (From the authors' abstract)

JAHODA, R., FOSTER, R.P. and ANDREWS, J.R., 1986, Gold-bearing hydromagmatic breccia systems in Asturias, north-west Spain: A petrographic investigation (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 13.

JAIRETH, S. and SHARMA, M., 1986, Physico-chemical conditions of ore deposition in Malanjkhand copper sulphide deposit: Proc. Indian Acad. Sci. (Earth Planet. Sci.), v. 95, no. 2, p. 209-221. Authors at Dept. Earth Sci., Univ. Roorkee, Roorkee 247 667, India.

Heating and freezing studies on fluid inclusions in quartz from mineralized quartz-feldspar reef reveal the presence of type A CO_2-H_2O (H_2O>50% by volume), type B CO_2-H_2O (H_2O<50% by volume), type C pure CO_2 and type D pure aqueous inclusions. Types A, B and C are P and/or PS inclusions while type D are S. Types A and B homogenize on heating into different phases at similar T ranging between 307 and 476°C, indicating entrapment from boiling hydrothermal solutions. Type D inclusions homogenize into a liquid phase between 88 and 196°C. Boiling of hydrothermal solutions led to the formation of a CO_2-rich phase of low density and salinity that coexisted with another dense and saline aqueous phase with very little CO_2 dissolved in it. Ore and gangue mineral assemblages of primary ores indicate that ore deposition was characterized by log fO_2 = -34.4 to -30.2 atm, log fS_2 = -11.6 to -8.8 atm and pH = 4.5 to 6.5. (Authors' abstract)

JAKOBSSON, S.P. and MOORE, J.G., 1986, Hydrothermal minerals and alteration rates at Surtsey volcano, Iceland: Geol. Soc. Am. Bull., v. 97, p. 648-659.

JAMBON, Albert, WEBER, Hartwig and BRAUN, Otto, 1986, Solubility of He, Ne, Ar, Kr and Xe in a basalt melt in the range 1250-1600°C. Geochemical implications: Geochimica Cosmo. Acta, v. 50, p. 401-408.

JAMES, L.P., 1986, Geochemical and geological exploration of gold-copper deposits in southern Luzon, the Philippines (abst.): J. Geochem. Explor., v. 25, p. 241. Author at James Geoassociates, Box 226, Golden, CO 80402, USA.

One quartz-pyrite-chalcopyrite-gold system, rich in cobalt and bismuth tellurides, and low in silver, arsenic, lead, and zinc was drilled and sampled. Fluid inclusion, ore microscopy, and trapped gas analyses to date show ony partial similarities to known models. (From the author's abstract)

JANECKY, D.R., 1986, Massive sulfide deposits and hydrothermal solutions - Incremental reaction modeling of mineral precipitation and sulfur isotopic evolution (abst.): Terra Cognita, v. 6, no. 3, p. 546.

JAQUES, A.L., SHERATON, J.W., HALL, A.E., SMITH, C.B., SUN, S.S., DREW, R. and FOUDOULIS, C., 1986, Composition of crystalline inclusions and C-isotopic composition of Argyle and Ellendale diamonds (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 426-428.

JAVOY, M. and PINEAU, F., 1986, The volatile record of a "popping" rock from the Mid-Atlantic Ridge at 15°N: Concentrations and isotopic compositions (abst.): EOS, v. 67, p. 410. Authors at Lab. Géochimie des Isotopes Stables, UER des Sci. Phys. de la Terre, Univ. Paris VII, 2, Place Jussieu - 75251 Paris Cedex 05, France.

The popping rock dredged at 15°N by the ship Academik B. Petrov contains the highest content of gas so far reported in MORB = 1.41 cc $STPg^{-1}$. These gases consist mainly of CO_2 (78%) and H_2O (21.9%). Incondensible gases (0.11%) consist of N_2 (94.5%) He (2.86%) Ar (1.76%) and very small amounts of CO, H_2 and CH_4. The main component ratios are: CO_2/N_2 = 732; CO_2/He = 24 190; N_2/Ar = 53.7. From the argon isotopic composition the combined atmospheric and sea water contamination is estimated to less than 5% of the nitrogen.

The sample contains additionally 191 ppm of dissolved carbon and 0.512% of dissolved H_2O. ^{13}C is - 3.64‰ in the gas and - 6.78 in the glass, ($^{13}C_T$ = -4.45). D is - 25‰ in the gas and - 69‰ in the glass, (D_T = 68) ^{15}N is -2.6/ATM.

The hydrogen isotopic composition is very similar to those reported before. The carbon isotopic composition is significantly heavier than those of other Mid-Atlantic MORB. The nitrogen is markedly depleted in ^{15}N relative to the atmosphere.

Most of the chemical and isotopic characteristics can be assigned to the high gas content. However chemical ratios such as CO_2/N_2 and CO_2/He are very similar to those found in other MORB vesicles either in popping or non-popping rocks suggesting that the latter may have had, prior to their partial alteration, similar gas contents. (Authors' abstract)

JÉBRAK, M., TOURAY, J.C. and GIRET, P., 1986, Fluorite deposits from Morocco: Geochemical characteristics in relation to their genesis (abst.): Terra Cognita, v. 6, no. 3, p. 515. First author at BRGM, BP 6009, 45060 Orléans Cédex, France.

The El Hamman vein, the main fluorite producer in North Africa located in a major shear zone, is related to an active geothermal system developed during the late cooling of a crustal granite intrusion during Autunian time. Ore-forming solutions were Ca-rich brines with variable T from 100°C to 250°C. In the district, there is a regional variation of the REE pattern for fluorite, related to the more or less proximal character of the veins with respect to the granite. A precipitation model, involving mostly cooling, may be involved. (From the authors' abstract)

JENSENIUS, J., 1986, Fluid inclusions in Danish Palaeozoic sediments (abst.): Geol. Soc. Newsletter, v. 15, no. 2, p. 55.

JENYON, M.K., 1986, Salt with a pinch of water: Nature, v. 324, p. 515-516. Author at Seismograph Service (England) Ltd., Holwood, Keston, Kent BR2 6HD, UK.

A brief review of the importance of fluid inclusions in salt on nuclear waste isolation in salt, based on a paper by Urai et al. (1986, this volume). (E.R.)

JIN, Qingming, 1986, Marine volcanic exhalative Pb-Zn-Ag ore deposit Yidun Island-arc zone, China: Geological features and metallogenic model (abst.), in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 101. Author at Nanjing Inst. Geol. & Mineral Resources, Nanjing, China.

Includes Rb/Sr, Pb, and S data, plus an estimated mineralization T (from inclusions?) of 100-150°C. (E.R.)

JIN, Ronglong, 1986, S and Pb isotopic composition and mineral inclusion feature[s] of the major Pb-Zn deposits in south Hunan and their application in evaluation of ore potential: Geol. & Prospecting, v. 22, no. 12, p. 29-35 (in Chinese).

JOANNY, J.-F. and GENNES, P.-G., 1986, Nucleation under conditions of complete wetting: C.R. Acad. Sci. Paris, v. 303, Ser. II, no. 5, p. 337-340.

JOHAN, Z. and WATKINSON, D.H., 1986, Fluid rich in Na-Cl-C-H-O-N and their role in concentrating platinum-group elements and chromite: Example of the critical zone of the Bushveld complex (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 99 (in French). First author at GIS BRGM-CNRS, 1A, rue de la Férollerie, 45071 Orléans Cedex 2, France.

Study of the "upper critical zone" between chromitite UG 1 and the

Bastard reef shows pronounced cryptic variations at the level of the reefs, which include Cr spinels with the highest XMg and the lowest YFe^{3+} (with the exception of the Merensky reef). Plagioclases in the Cr and PGM-enriched levels are rich in Na; inclusions of a Na equivalent of phlogopite occur frequently in the chromitites. In the postcumulus, phlogopite is rich in Cl (up to 1%), F (up to 3%) and Ti, particularly between the reefs where loveringite is found. The composition of the cumulative phases and of the postcumulus are in chemical equilibrium, which argues against accumulation over a long distance. Fluid inclusions in quartz and plagioclase are rich in CO_2, CH_4 and N_2. The presence of inclusions of laurite in the chromite shows that at least part of the precipitation of Os, Ir, Ru is independent of base metal sulfides. Pt an Pd were transported by a magma rich in volatiles and Cl and deposited in pegmatoids, chromitites and the Merensky reef. Associated with the Pt and Pd are Se, Te, Sn, Ge, As, Sb, Bi, elements which occur typically in volatile-rich environments. fO_2 fluctuations affecting the solubility of S in the magma are responsible for the precipitation of sulfides (Fe, Ni, Cu) and PGM in the Merensky reef. A high partial P of water allows the formation of olivine at this level of the "upper critical zone." (Authors' abstract; translated by R. Kreulen)

JOHANNES, W., 1986, Melting in quartz-feld rocks at varying H_2O activities (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 135.

JOHANSSON, Åke, 1985, The Dalslandian sulphide-bearing quartz veins of Dalsland and Värmskog, southwest Sweden: Sveriges Geol. Undersokning, Ser. C., no. 809, p. 1-48.

Quartz veins containing sulphides, sulphosalts, carbonates and occasionally fluorite, barite, chlorite, sericite, magnetite and/or hematite are found in Dalsland and Värmskog (southwest Värmland) in southwest Sweden. The Dalsland veins are hosted by rocks of the Amal Complex and the Dalsland Group and the Värmskog veins by gneisses of the southwest Swedish gneiss complex (western 'Pregothian' unit) on the east side of the Gillberga synform. Geological and lead isotope evidence indicates a late Dalslandian age of around 1000 Ma for both vein groups, and a metamorphic or magmatic contribution to the ore-forming fluid may be indicated by the presence of CO_2 in fluid inclusions in quartz and sphalerite from the Vegerbol deposit in Värmskog. Fluid inclusion data indicate quartz deposition at a minimum temperature (no pressure correction added) of +190 to +330°C from a weakly saline (c. 4 eq. wt% NaCl) CO_2-bearing hydrothermal solution, while the temperature of sphalerite deposition is more uncertain. (From the author's abstract)

JOHANSSON, Ake, 1986, The geology and genesis of lead-zinc veins in Sweden (abst.): Abstracts of Posters, VII IAGOD Meeting, Lulea, Sweden, 18-22 Aug., 1986 (unpaginated). Author at Lab. för Isotopgeologi, Naturhistoriska Riksmuseet, S-10405 Stockholm, Sweden.

The geology and genesis of Pb-Zn-bearing vein deposits in Sweden have been studied through investigations of their geological setting, vein and alteration mineralogy, wall rock geochemistry, lead and sulfur isotope composition and sphalerite composition, and through thermometric measurements on fluid inclusions from selected veins. The investigated deposits include Subjotnian veins from Alvdalen, Dalslandian veins from Dalsland and Varmskog, Caledonian quartz and calcite veins, Devonian deposits in the Siljan Ring structure, and Variscan veins in SE Scania. Based on their dominating gangue mineral, they may be divided into calcite veins and quartz veins.

The calcite veins have a simple Mississippi Valley-type mineralogy, and probably formed at rather low T (around 100-150°C) from saline brines. The ore-forming solutions may have been brought up rapidly from depth by hydraulic fracturing in connection with deep faulting. The faulting was related to distant orogenic movements (the Caledonian and Variscan orogenies), to basin subsidence, magmatism and incipient rifting (in the Scanian/ Variscan case), or, in the case of the Siljan astrobleme, to a Devonian meteorite impact.

The quartz veins have a more complex mineralogy and probably formed at higher T (around 200-300° C). The Dalslandian Vegerbol quartz vein in Varmskog was deposited from a weakly saline, CO_2-bearing water solution. The Dalslandian quartz veins formed in connection with late-tectonic block faulting and hydrothermal activity related either to late-stage metamorphism or the intrusion of Bohus-type granite. The Caledonian quartz veins formed in connection with late thrusting and faulting, the hydrothermal activity possibly being related to the loading and movements of the nappes. The Subjotnian Alvdalen veins formed in relation to faulting and anorogenic magmatism. (From the author's abstract)

JOHNSON, C.A. and SEIDEMANN, D., 1986, Mineralogic and stable isotopic evidence for a metamorphic fluid at the Sterling Hill deposit, Sussex Co., NJ (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 647.

JOHNSON, J.W. and NORTON, D., 1986, Transport and chemical consequences of critical phenomena in magma-hydrothermal systems: A preliminary assessment (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 647.

JOHNSSON, M.J., 1986, Distribution of maximum burial temperatures across northern Appalachian Basin and implications for Carboniferous sedimentation patterns: Geology, v. 14, p. 384-387.

JOLLIFF, B.L., PAPIKE, J.J. and SHEARER, C.K., 1986, Tourmaline as a recorder of pegmatite evolution: Bob Ingersoll pegmatite, Black Hills, South Dakota: Am. Mineral., v. 71, p. 472-500.

JONES, A.P., 1986, A new technique for studying melts at crustal pressures: "Carbonatite glass" (abst.): Mineral. Soc. Bull., no. 73, Dec. 1986, p. 3. Author at Kingston Polytechnic.

Precise P to 60,000 psi at T $\leq$1200°C can be achieved for small diameter samples (1-2 mm) in a new gas P vessel. Developed by conversion of a standard "Tuttle Bomb," the unit, now called a "Haskel Miniclave" is inexpensive and several can be run side by side on a bench. Gas (Ar) P is provided by a small intensifier and heating by a platinum wound furnace. Run T are reached within a few minutes and fast quench rates approach those typical of solid media apparatus. The apparatus is being used to produce carbonate glasses, quenched from melts which are being studied in IR spectroscopy to determine melt structure and volatile speciation. Immediate geological applications to the origins of carbonatites are intended, but intrinsic properties of the glasses themselves are also being investigated. (Author's abstract)

JONES, A.P. and WYLLIE, P.J., 1986, Solubility of rare earth elements in carbonatite magmas, indicated by the liquidus surface in $CaCO_3$-$Ca(OH)_2$-$La(OH)_3$ at 1 kbar pressure: Applied Geochem., v. 1, p. 95-102.

JONES, M.T. and CHIVAS, A.R., 1985, The origin of gold mineralization in the Wau district, Papua New Guinea (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 35-36. First author at Gold Fields Explor. Pty. Ltd., P.O. Box 590, Fyshwick, A.C.S., 2609, Australia.

Pliocene epithermal gold mineralization in the Wau district of the Morobe gold field in Papua New Guinea is related to maar-diatreme volcanism and related dacite porphyry endogenous domes (Sillitoe et al., Ec. Geol., 1984). Continued next page.

Two broad styles of primary gold mineralization can be recognized at Wau: 1) shallow-dipping carbonate lodes, locally brecciated, overlain by quartz-carbonate stockworks and associated with only minor kaolinite and sericite alteration; and 2) quartz-pyrite-arsenopyrite veins and stockworks in intensely sericitized dacite porphyries.

The first type is well displayed at the Upper Ridges mine where low fineness (500-600) gold occurs in a hydrothermally brecciated remnant of the tuff ring formed by initial maar volcanism. High-grade (10-30 g/t Au) mineralization occurs in sub-horizontal calcite-manganocalcite-quartz infilled tension fractures, 0.1 to 10 m in thickness, at or near the base of the hydrothermal breccia. Primary dawsonite-bearing fluid inclusions in the quartz yield Th of 233-224°C; $\delta^{18}O$ qtz. of 4.7 per mil, indicates mineralization formed from a fluid with $\delta^{18}O$ of -5.3 per mil, i.e., essentially meteoric. Bulk mineable mineralization at Upper Ridges largely overlies the main lodes and has the form of quartz-carbonate stockworking and vein fragments within the breccia. Inclusions in the quartz stockwork are similar to those in the lodes but oxygen measurements indicate a slightly less depleted fluid with $\delta^{18}O$ of -2.8 per mil.

The vein-style mineralization at Upper Ridges is similar to the more steeply dipping veins at Upper Edie Creek, some seven kilometres to the southwest; these are for the most part hosted by chloritic schists of the Kaindi Metamorphics and are more silver-rich.

The Wau diatreme is localized by a regional fault zone which hosts the somewhat deeper level, second type of mineralization expressed by the occurrence at the Ribroaster mine. Quartz-sulphide veinlets, carrying gold of approximately 750 fineness, are accompanied by intense sericite alteration of the host dacite porphyry. Halite-bearing fluid inclusions in the early vein quartz indicate deposition from a boiling, saline ore fluid at a temperature around 330°C. Oxygen isotope measurements on the quartz indicate an ore fluid with $\delta^{18}O$ of 1.3 per mil. Later vuggy quartz deposited at temperatures of 290-263°C in association with gold of lower fineness (about 500) from a fluid with $\delta^{18}O$ of -3.8 per mil. Recent exploration has located a further center of mineralization some ten kilometres south of Wau, again apparently related to a diatreme, with quartz-pyrite-arsenopyrite stockwork development in a sericitized dacite porphyry similar to that at the Ribroaster mine. (Authors' abstract)

JONES, R.M., ZENG, R.R. and MACKENZIE, W.S., 1986, Phase relations in the undersaturated part of the system nepheline-kalsilite-anorthite-quartz at $P(H_2O)$ = 5 kb (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 136.

JOWETT, E.C., 1986, Genesis of Kupferschiefer Cu-Ag deposits by convective flow of Rotliegende brines during Triassic rifting: Econ. Geol., v. 81, p. 1823-1837. Author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Cu solubilities of 1000 mg/kg in 20-30% Ca-Na-Cl brines can form these deposits in $\leqslant$10 my. (E.R.)

KALINICHENKO, A.M., PASAL'SKAYA, L.F., MATYASH, I.V., PROSHKO, V.Ya, 1985, Investigation of the composition of the fluid phase of inclusions by the methods of PMR and gas chromatography (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 231-232. (In Russian; translation by Dorothy B. Vitaliano). Authors at IGIM, Acad. Sci. Ukrainian SSR, Kiev, USSR.

The methods of PMR (proton magnetic resonance) and gas chromatography were used to study quartz and feldspars from granitoids and pegmatites of the Ukrainian shield.

The PMR parameters indicate that the main intensity of the spectrum is related to molecules of vacuole fluid water. It is suggested that this non-destructive method be used for quantitative determination of the water.

The distribution of volatiles between two zones of growth of a huge crystal of morion was studied. It was established that high-T "honeycomb" quartz contains: 0.11 H_2O and 0.012 CO_2 [in units of "mas. doley %"*] and 20 H_2 and 104 cm^3/kg CH_4; post-inversion α-quartz contains 0.03 H_2O 0.05 CO_2, [in units as above] and 20 H_2, 27 CH_4, 119 cm^3/kg CO. The water content in the quartz correlated with the amount of visually observable inclusions. No correlation was found for the other volatiles.

Water and CO_2 are liberated to the air from "honeycomb" quartz in the same T range of 600-800°K, which indicates they occur together in the inclusions. When the character of distribution of the fluid components in coexisting feldspars and quartz in the granites was investigated, it was ascertained that the feldspars contain more water and CO_2. The H_2O/CO_2 ratio decreases from quartz to feldspar (table).

For the other volatiles, no clear-cut regularities were established. It is suggested that the decrease in the amount of H_2O and CO_2 and change in the H_2O/CO_2 ratio reflect the order of separation of these minerals [sic] from the melt, as according to the scheme of A.A. Marakushev, CO_2 separates from a melt before H_2O. It was determined that quartz in the granitoids containing ore mineralization, pegmatites and metasomatites, contains several times more H_2O than quartz in the barren granites. It was ascertained that in the quartz of the Perzhansk metasomatites with ore mineralization, the H_2O content and H_2O/CO_2 ratio are several times higher than those from the barren granites. Probably this can bring out information on the transfer of ore material into formations of this type. (From the authors' abstract)

* [A "dolya" is a unit of weight of 44.435 mg.]

H_2O/CO_2 ratio for the minerals of the granites

Body	Quartz	Albite	Micro-cline	Plagio-clase	Order of crystallization
Anadol'sk	9	7	6	1.5	Pl→Mi→Ab→Q
Rybal'sk	6	-	-	1.5	Pl→Q
Mokromoskovsk	15	16	17	-	together
Demurinsk	8.3	8.6	-	-	together

KALOGEROPOULOS, S.I. and SCOTT, S.D., 1986, On the genesis of barite-associated with volcanogenic massive sulfides, Fukazawa mine, Hokuroku district, Japan, in Geol. & Metallogeny of Copper Deposits, G.H. Friedrich et al., eds.: Springer-Verlag Berling Heidelberg, p. 370-388. First author at Inst. Geol. & Min. Explor., 70 Messoghion St., Athens 608, Greece.

Fourteen inclusions in barite showed constant salinity (4.6 ± 0.4) equiv. wt. % NaCl and highly variable Th (131-302°C) presumably from necking down. (E.R.)

KALYUZHNYI, V.A., KRASNOZHINA, Z.B., ZINCHUK, I.N. and NAUMKO, I.M., 1985, The composition of the mineralizing fluids of the tin deposits of the Bazar Dara district (southwestern Pamirs) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 138-139 (in Russian; translation by Dorothy B. Vitaliano). First author at IGGGI, Acad. Sci. Ukrainian SSR, L'vov.

1. Tin deposits are associated with the hypabyssal Upper Cretaceous Bazar Dara intrusion of plumasitic leucogranite, in the apical part of which there are bodies of Li-F granite with protolithionite and zinnwaldite.

The deposits are localized in the contact zone and farther from the intrusion, in aluminosilicate and carbonate rocks. The interaction of the mineralizing solutions with the anisotropic host medium produced the appearance of different types of syn-ore metasomatites -- topaz-muscovite greisens, quartz veins, quartz-chlorite, quartz-fluorite-tourmaline-chlorite and feldspar metasomatites and amphibole-siderophyllite-chlorite-fluorite metasomatites after skarns. In the ores localized in aluminosilicate rocks, crystals of cassiterite occur in association with wolframite and arsenopyrite; in the hydrothermally altered skarns and in zones of mylonitization, collomorphic radial cassiterite is deposited along with scheelite and sulfides of zinc, iron and copper.

2. The composition of the mineralizing solutions forming the ores of the main stage (from aqueous extracts) is alkaline-F-Cl. The average concentration of the main components, in mol/kg H_2O is: 0.3 Na^+, 0.25 K^+, 0.35 Cl^-, 0.11 HCO_3^-, 0.25 F^-. The Cl concentration and the F/Cl ratio in the aqueous extracts are comparable to those of the quartz-cassiterite deposits. The F concentration decreases as temperature falls. The relatively low F probably results from simultaneous crystallization of topaz, cassiterite and fluorapatite, which follows from the mineralogic observations and low Th. The fluorine content in topaz reaches extreme values, according to the NMR data. The absence of Ca in the inclusions makes it possible to attribute the measured F content to uncomplexed F, as its equilibrium concentration above Al-bearing fluoride for 300°C is $n \cdot 10^{-1}$ mol/kg H_2O (Ryzhenko, 1981).

3. Cryometry on inclusions in cassiterite suggests a low concentration of the solutions (9.5-12 wt.% NaCl equiv.). However, in the topaz and fluorite of these veins numerous inclusions containing halite crystals were found, which may indicate that both low- and highly concentrated F, produced by the Li-F granite intrusive, took part in the formation of the tin mineralization.

4. Signs of heterogenization of the solutions were found in quartz and fluorite from the tin bodies, which occur in sharply different structural-tectonic positions: quartz-chlorite breccia with cassiterite in argillized rocks and essentially fluoritic greisens after carbonates from zones where the contact between granite and marmorized limestones is cut by a quartz-wolframite vein. In both cases syngenetic inclusions of CO_2 fluid and gas-liquid, essentially aqueous inclusions are observed. Heterogenization of the solutions was the result of various processes: a sharp drop in pressure in the first case, and removal of CO_2 during interaction of F-bearing solutions and limestones and fixing of Ca, in the second.

5. Variations in the content of gases in the composition of the volatile components of the mineralizing fluids are considerable. On the basis of the composition of the gas phase, the minerals studied are separated into several groups: a) cassiterite and wolframite, in the gas phase of which CO_2 predominates; b) topaz, the composition of the gas phase of which is distinguished by the presence of CH_4 and N_2; c) cassiterite from quartz-chlorite breccia, in the gas phase of which CH_4 predominates; d) low-temperature fluorite and calcite of the final stages of mineralization, which contain comparable amounts of CH_4, N_2, and CO_2. The evolution of the gas composition of the fluids corresponds to the variation in acidity and redox potential at various precipitating geochemical barriers. (Authors' abstract)

KALYUZHNYI, V.A., KULIKOV. I.V., TELEPKO, L.F. and BOYARSKAYA, R.V., 1985, Particulars of the material and phase composition of the fluids of the final stage of ore genesis in the Tyrny Auz deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 156-157 (in Russian; translation by Dorothy B. Vitaliano). First author at IGGGI of the Acad. Sci. Ukrainian SSR, L'vov, USSR.

1. The final stage of formation of the Tyrny Auz skarn deposit (Northern Caucasus) is characterized by intensive manifestation of high-temperature hydrothermal mineralization in all structural zones of the deposit. Minerals deposited throughout the whole stage are fluorite and garnet. Fluid inclusions in fluorite of different generations, and also in garnet, calcite and quartz, indicate complex changes in the material and phase composition of the environment of ore formation.

2. Equilibrium fluid phases (aqueous solution and steam) of the boiling environment of crystallization are accompanied by a multitude of solid xenogenic mineral microparticles. Fluid and solid phases [i.e., solid inclusions] which simultaneously found their way into cavities of the inclusions complicate the possibilities of correct reconstruction of the parameters of the process. Using X-ray and electron microscopy in conjunction with microdiffraction, optical microscopy, macroscopy and other methods, authigenic [i.e., dms] and xenogenic minerals that are known and some that are new for fluid inclusions were identified in the cavities of the inclusions in fluorite.

3. Study of the composition and physicochemical properties of the fluid inclusions, the relative time of formation of which was established on the basis of crystallogenetic criteria (confinement to zones of growth of crystals, refilling phenomena, etc.) makes it possible to assert that: a) the aggregate state and concentration of the environment of crystallization varied in time, from highly saturated with saline fluids similar to the melts, to slightly concentrated essentially aqueous solutions; a state of boiling was maintained in all stages of the process; b) the temperature conditions of crystallization of the minerals of the association studied corresponded to a broad interval -- from 650-500°C to 250-150°C. The order of crystallization was: fluorite (650-250°C), calcite (500-150°C), quartz (400-150°C), garnet (300-150°C); c) among the nonvolatile salt components, $CaCl_2$ usually predominates, NaCl and KCl to a lesser degree; the pH of the solution of the inclusions corresponds to 3.0-3.5 (in fluorite) and 3.4-4.0 (in calcite); d) the volatile components of the fluids (not counting water) consist mainly of an N_2-CH_4 mixture plus CO_2.

4. A decrease in the overall concentrations and temperatures, and an increase in CO_2, of the fluids from the lower to the higher horizons of the thousand-meter section of the deposit are recorded by the inclusions. (Authors' abstract)

KALYUZHNYI, V.A., NAUMKO, I.M. and LEMISHKO, R.A., 1985, Study of fluid inclusions in terrigenous topaz from alluvial deposits of northwest Ukranian shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 27-29 (in Russian; translation by S. Jaireth). First author at IGGGI, Inst. Geol. & Geochem. of Fuels, Acad. Sci., Ukraine, USSR.

Fluid inclusions have been studied in topaz from panning samples collected from alluvial deposits of the Pripyat river basin on the NW slope of Ukranian shield with an aim to decipher physico-chemical conditions of its crystallization and thereby to reveal primary source of this important typomorphic mineral.

Sulach river: Polyphase inclusions (L + G + B* = 65 + 20 + 15%) have elongated forms and size ≤80 μm, solid phase-isotropic with sharp cubic shape, Tm of solid = 260-265°C, ThL-V(L) = 400-415°C.

Liquid-gaseous (L = 30%) spherical inclusions with regular cavity boundaries (sometimes have crystal shapes) are 50-70 μm in size. ThL-V(V)

*Notation B is not defined.

= 404-415°C, rarely 420-425°C.

Gas-liquid (L = 75%), flat inclusions with elongated cavities are <75 µm in size. ThL-V(L) = 340-365°C.

Stokhod river: Polyphase inclusions (L + G+ B* = 60 + 25 to 28 + 12 to 15%) have different shapes (mostly regular) and sizes <100 µm. Tm of isotropic, cubic solid is 245°C, ThL-V(L) = 440°C.

Spherical liquid gaseous (L = 30%) inclusions distributed mostly along healed fracture planes have regular shapes and size of 10 to 30 µm. ThL-V(V) of two groups are 420-425°C and 395°C.

Lake Lubaz: In addition to other types, polyphase inclusions (L + G + B* = 65 + 23 to 35 + 10 to 12% and 25 to 28 + 20 + 3 to 5%) with spherical, isometric shapes and size <60 µm have been observed. ThL-V for the first type = 465-470°C with Tm of isotropic solid = 200°C.

Topaz from all areas contain rounded inclusions of a mineral (probably cryolite) with refractive index << topaz.

All topaz grains contain similar types of inclusions: polyphase, liquid-gaseous and gas-liquid. Small differences in Tm of isotropic solid and Th of polyphase inclusions can be explained by variation in the salinity of fluids generated in various parts of topaz-bearing rocks. All inclusions show high Th (<400°C). Aqueous phase has sodium chloride composition with salinity of 27 to 30 wt.%. Polyphase inclusions in topaz from "zanorysch" type pegmatites (Korostensk pluton in western part of Ukranian shield), contain, apart from NaCl, sylvite, chlorides of Al and Zn, elpasolite, caracolite and other dissovled salts (Kalyuzhnyi, 1958) and have a salinity of 58-60 wt.%. Topaz from these pegmatites also contain inclusions with liquid CO_2 (Voznyak, 1971, Kalyuzhnyi 1971; Naumko, Kalyuzhnyi, 1981). These inclusions in topaz from alluvial sediments are very different from inclusions in topaz from various zones of zanorysch type pegmatites of Volnyn. They are similar to inclusions in topaz from coastal sands of Lake Pechannai (Kalyuzhnyi et al., 1983). (From the authors' abstract)

KAMENETSKIY, Vadim, SOBOLEV, Alexander, CLOCCHIATTI, Roberto and METRICH, Nicole, 1986, First estimation of water content in etnean magma (1669 Monti Rossi eruption) by fluid and melt inclusion studies: C.R. Acad. Sci. Paris, v. 302, Ser. II, no. 17, p. 1069-1074 (in French; English abstract). First author at Vernadsky Inst. Geochem. of USSR Acad., 9, Shosse Kosyguina 47 A, Moscow, USSR.

The melt and fluid inclusions in salitic crystal-lapilli from Monti Rossi (1669) were investigated. In the fluid inclusions and in shrinkage bubble of melt inclusions, pure water was detected using cryometric and microthermic data. Melt inclusion studies give a T range of crystallization from 1070 to 1100°C and a melt trapped of hawaiitic composition. The partial P of water estimated from fluid inclusions and shrinkage bubble varies from 85 to 185 bars; the calculated water content of the melt trapped is close to 1 ± 0.2 wt.%. The total fluid P during the salite phenocryst crystallization was from 800 to 1000 bars with a pH_2O/pCO_2 ratio close to 0.1-0.2. Before the crystallization process, in the basaltic parent magma of the 1669 eruption, the minimum content of water was estimated close to 0.6%. (Authors' abstract)

KAMILLI, R.J., 1986a Genesis and evolution of the Baid al Jimalah tungsten deposit, Kingdom of Saudi Arabia: USGS Open-File Report 86-0588, 54 pp.

The Baid al Jimalah W deposit (lat 25°09'N., long 42°41'E.) is a swarm of steeply dipping, sheeted, W-bearing quartz veins. It is spatially, temporally, and genetically associated with a 569 Ma, highly differentiated, porphyritic granite that intrudes late Proterozoic, immature sandstones of the Murdama group.

The bulk of the vein constituents came from hydrothermal fluids exsolved from a granite cupola at a depth of about 3.1 km during a single cycle of magma intrusion and hydrothermal mineralization. Hypogene mineralization can be divided into 3 main periods: early quartz-molybdenite stockwork veins, wolframite- and scheelite-bearing greisen veins, and late, barren veins. Each of the three periods can be divided into several stages that are transitional to each other. The greisen veins, in particular, show replacement of earlier mineral assemblages by later ones. The veins at Baid al Jimalah East, approximately 1.5 km to the east of the Baid al Jimalah W deposit, are genetically related to it and probably formed while the greisen mineralization was being deposited.

Early stockwork mineralization was formed near magmatic T (580°-700°C) from low salinity fluids (1-2 wt% NaCl eq.). Two fluids were present, one low density and CO_2-rich, the other high density and H_2O-rich. Greisen mineralization was formed from fluids in the liquid state between 390° and 430°C with salinities between 4.5 and 10.9 wt% NaCl eq. Late, barren mineralization formed from liquids with salinities between 0.5 and 3.0 wt% NaCl eq. and at least as low as 238°C. The veins at Baid al Jimalah East formed from liquids between 0 and 4.2 wt% NaCl eq., largely between 300° and 375°C. Depth of mineralization was greater than 3.1 km. The T given above have been corrected for P assuming this depth, and are 75-80°C higher than the fluid inclusion Th. Important volatile constituents of the hydrothermal fluids were CO_2 and CH_4, in addition to H_2O and HF.

Baid al Jimalah is similar in character and origin to other W-Sn greisen deposits in the world, especially the Hemerdon deposit in Devon, England. It is also analogous to Climax-type Mo deposits, which contain virtually identical mineral assemblages, but with the relative intensities of the Mo and W mineralization reversed. (Author's abstract)

KAMILLI, R.J., 1986b Genesis of the Proterozoic Baid al Jimalah tungsten deposit, Kingdom of Saudi Arabia (abst.). Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 650-651. Author at U.S. Geol. Survey Saudi Arabian Mission, APO New York, 09697-7002.

The Baid al Jimalah tungsten deposit, located in the northeastern Arabian Shield, is a swarm of steeply-dipping, sheeted, tungsten-bearing quartz veins. It is associated with a 569 Ma-old, highly differentiated, peraluminous, porphyritic granite that intrudes late Proterozoic immature sandstone metamorphosed to greenschist grade.

Most of the vein constituents came from hydrothermal fluids exsolved from a granite cupola at a depth greater than 3.1 km during a single cycle of magma intrusion and hydrothermal activity. Mineralization can be divided into 3 periods: early quartz + molybdenite stockwork veins; wolframite ± scheelite greisen veins; and late quartz + carbonate veins.

The early stockwork veins formed at temperatures greater than 580°C in the presence of H_2O-rich liquid and CO_2-rich vapor while the magma was still crystallizing. The greisen mineralization formed from an aqueous liquid between 390° and 430°C after the magma had crystallized. Late veins formed at temperatures below 340°C. All fluid inclusion salinities are less than 11 equivalent weight percent NaCl. CO_2 and CH_4 were important constituents of the hydrothermal fluid; C_2H_6 and C_2H_8 were also identified.

This deposit is similar in character and tectonic setting to the Permian Hemerdon deposit in Devon, England. More importantly, it is analogous to the Tertiary Climax-type molybdenum deposits in Colorado, which contain mineral assemblages virtually identical ot those of Baid al Jimalah, but with the relative intensities of the molybdenum and tungsten mineralization reversed. It is clear that all these deposits are not only genetically associated with highly differentiated granites, but also share a similar sequence of hydrothermal events. (Author's abstract)

KAMINSKIY, F.V., KULAKOVA, I.I. and OGLOBINA, A.I., 1985, Polycyclic aromatic hydrocarbons in carbonados and in diamond: Doklady Akad. Nauk SSSR, v. 283, no. 4, p. 985-988 (in Russian). First author at Sci.-Research Geol.-Prospecting Inst. of Base & Precious Metals, Moscow, USSR.

Hydrocarbons extracted from two Brasilian carbonados by n-hexane and next by chloroform solvent were studied by means of low-T luminescence spectroscopy, and carbon isotopes in hydrocarbons and in carbonado samples were determined. Organic substance is slightly enriched in heavier C isotope when compared with carbonado, but this enrichment is too small for genetic considerations. Hexane and chloroform leachates were mixed and dried. Polycyclic aromatic hydrocarbons (PAH) comprised 0.002-0.004 wt.% of carbonado, giving a value roughly 100 times higher than PAH in single crystal diamond in other kimberlite minerals: olivine and pyrope, and in lherzolites, and 10 times higher than in kimberlites and alkaline basaltoids. PAH consist mostly of homologues of naphthalene (70-90%), homologues of phenantrene and pyrene are present in lower amounts, 4-11 and 6-19 wt.% respectively. The authors suggest that PAH in carbonado are essentially syngenetic with this mineral, like in single crystal diamond. (Abstract by A.K.)

KANANA, Ya.F. and MATVEEV, A.K., 1986, Determination of the paleotemperature of sedimentary beds: Byull. Mosk. O-va Ispyt. Prir., Otd. Geol., v. 61, no. 4, p. 110-121 (in Russian).

Indexed under fluid inclusions. (E.R.)

KANAORI, Y., 1986, A SEM cathodoluminescence study of quartz in mildly deformed granite from the region of the Atotsugawa fault, central Japan: Tectonophysics, v. 131, p. 133-146. Author at Civil Engrg. Lab., Central Res. Inst. of Electric Power Industry, 1646 Abiko, Abiko City, Chiba 270-11, Japan.

Cathodoluminescence (CL) images of quartz in granite distributed around the Atotsugawa fault in central Japan were observed by SEM and compared to optical microscope observations of the same crystals. Narrow or wide dark bands or dots were commonly recognized in the CL images. Almost all dots or narrow bands correlate with isolated bubbles or semi-planar bubble arrays along healed cracks, respectively. Some wide bands correspond to cracks filled with other minerals (chlorite, calcite, mica, etc.) or can be distinguished as zones with an extinction differing from that of surrounding areas in quartz (crushed zones composed of healed crack arrays). Other wide bands are healed cracks where quartz is precipitated in optical continuity. The quartz CL images displayed overall textures, composed of mineral-filled cracks, bubble arrays along healed cracks and crushed zones, more clearly than normal optical images. Healed cracks containing quartz precipitated in optical continuity with the enclosing grains were distinctly revealed as dark bands in CL images. The abundance of these minor deformation structures, as revealed in CL images, increases with proximity to the fault. Therefore, CL textures of quartz are an important aid in examining brittle deformation textures and understanding the tectonic processes that produce them. (Author's abstract)

KANEOKA, Ichiro, TAKAOKA, Nobuo and UPTON, B.G.J., 1986, Noble gas systematics in basalts and a dunite nodule from Réunion and Grand Comore Islands, Indian Ocean: Chem. Geol. (Isotope Geosci. Sec.), v. 59, p. 35-42. First author at Geophys. Inst., Fac. Sci., Univ. Tokyo, Bunkyo-ku, Tokyo 113, Japan.

Noble gas isotope data are reported for olivine crystals in: (a) three basalt samples and one dunite nodule from Réunion; and (b) from one basalt sample from Grande Comore.

Although the three Réunion basalts were selected to cover different phases of the volcanism, the data reveal rather similar $^3He/^4He$ ratios ($1.8 \cdot 10^{-5}$-$2.1 \cdot 10^{-5}$; 13-15 R_A) but variable $^{40}Ar^{36}Ar$ ratios (430-1900). The dunite has a $^{40}Ar/^{36}Ar$ of ~3000. The $^3He/^4He$ ratios from Réunion are distinctly higher than those for MORB whereas the $^{40}Ar/^{36}Ar$ ratios of the Reunion basalts are lower than MORB values. Such noble gas isotopic signatures are similar to those reported from Hawaiian and Icelandic basalts.

The Grande Comore sample, by contrast, showed a $^3He/^4He$ value slightly below that for MORB, with a relatively low $^{40}Ar/^{36}Ar$ of ~380.

On the basis of these data we conclude that the Réunion and Grande Comore magmas may have originated from hot-spot mantle sources with distinctly different noble gas isotopic compositions. (Authors' abstract)

KATZ, M.B., 1985, Review of the geology of the gemstones of Sri Lanka, in Proc. of 20th Int'l. Gemmological Conference; Part 1; Sydney, NSW, Australia, Sept. 29-Oct. 4, 1985: The Australian Gemmologist, May 1986, v. 16, no. 2, p. 52-56.

Indexed under fluid inclusions. (E.R.)

KAZAHAYA, Kohei, 1986, Isotopic and chemical studies on hydrothermal solutions: PhD dissertation, Dept. Chem., Tokyo Inst. Tech., Tokyo, 185 pp.

The paper includes the results of experimental studies on the fractionation of D/H and $^{18}O/^{16}O$ in NaCl aqueous solution-vapor systems at temperatures between 100° and 345°C, development of a new ball-mill method for extraction of fluid inclusions from minerals, and application of the method to chemical and isotopic studies of fluid inclusions from hypothermal tungsten deposits.

The new ball-mill consists of an upper valve head and lower sample container made of Pyrex glass, and an alumina ball (32 mm in diameter). The sample (4-8 g of 6-10 mesh) is crushed in vacuum by shaking the mill for 30-60 min. The recovered gases were H_2O, CO_2, CH_4, N_2, H_2 and noble gases. Extraction of water and gases from fluid inclusions by stepwise heating was also carried out in order to compare the results with those of the ball-milling. The ball-milling method has some advantages as compared with the decrepitation method.

The method was applied to the study of mineralization of hypothermal tungsten deposits in Japan. Quartz samples from the Kaneuchi wolframite-scheelite-quartz veins were mainly used, and gas composition, D and ion concentration of fluid inclusions were analyzed. A positive linear relationship is found between NaCl equivalent concentration and $CO_2 + CH_4/H_2O$ mole ratio. From the results, it is assumed that the ore-forming fluids were a mixture of magmatic water, local ground water and boiled magmatic water. Changes of T, P, pH and $f(O_2)$ of ore-forming fluids during the mineralization are discussed.

The results of fluid inclusions, Na-K-Ca and carbon isotopic geothermometry are compared. In quartz samples, the Na-K-Ca T generally agree with the range of Th, but in some samples the former is higher than the later, indicating that the fluid P were about 1200 bars. Quartz-calcite carbon isotopic T are variable. P at the time of formation of veins are estimated to be between 250 bars and 1200 bars from Th and Na-K-Ca T. As it is shown that the change of $\delta^{13}C$ value of CO_2 and CH_4 is not remarkable during the cooling of fluid inclusions, it is presumed that CO_2 and CH_4 in fluid inclusions retain their original contents in the case of quartz. The $f(O_2)$ calculated from CO_2 and CH_4 contents ranges from 10^{-32} bars at 340°C to 10^{-38} bars at 260°C under the total P of 250 bars, which is nearly parallel to the Ni-NiO buffer curve. A model of the formation of W-bearing quartz veins of the Kaneuchi deposit is proposed on the basis of the analytical results of fluid inclusions and the origins of water and carbon species are suggested. It is suggested that the general condition for the W mineralization is the presence of a large amount of CO_2, high T, and low $f(O_2)$. (Abstract courtesy S. Takenouchi)

Obtained data
NaCl eq. molality 0.2-0.8 m

Gas comp.	CO_2+CH_4/H_2O	CH_4/CO_2	$\delta^{13}C(CO_2)$	$\delta^{13}C(CO_2+CH_4)$
Stage I	0.018-0.051	0.08-0.24	-10.6 - -7.1	-14.3 - -10.7
Stage II	0.037-0.054	0.13-0.44	-11.2 - -8.9	-18.5 - -12.1
Stage III	0.010-0.020	0.60-2.60	- 4.1 - +1.0	-23.0 - 015.1

KAZAHAYA, K. and MATSUO, S., 1986, D/H and $^{18}O/^{16}O$ fractionations in NaCl aqueous solution-vapor systems at elevated temperatures (abst.): Terra Cognita, v. 6, no. 2, p. 262.

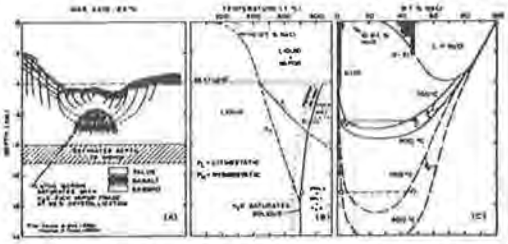
KELLEY, D.S. and DELANEY, J.R., 1986a Fluid inclusion evidence for multiple fracturing events in gabbros from the Mid-Atlantic Ridge, 23°N (abst.): EOS, v. 67, no. 44, p. 1283. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195.

Microthermometric analyses of fluid inclusions in relatively fresh to highly altered olivine, pyroxene, and hornblende gabbros from the Mid-Atlantic Ridge, 23°N, indicate penetration by seawater derived fluids at uncorrected temperatures of 300° and 400°C as well as a hydrothermal event at >700°C. Complex planar arrays of plagioclase-hosted, microcrack-bound fluid inclusions are present in all samples studied; less commonly inclusions occur in apatite, epidote, and pyroxene. Corresponding heating and freezing measurements of liquid-dominated inclusions in plagioclase and apatite indicate homogenization temperatures of 300°C and equivalent salinities of 0.7-7 wt% NaCl. Vapor-dominated inclusions in apatite and augite homogenize in the vapor phase at temperatures of 380-430°C and contain NaCl equivalent salinities of 1-2 and 5-6 wt%, respectively. Some epidote-hosted inclusions, which contain salinities of 3.5-6.5 wt% homogenize in the vapor phase, others in the liquid phase, and many exhibit 'pseudocritical' behavior at 390°-430°C. The variable homogenization behavior is interpreted to indicate fluid entrapment, in epidote, under near critical conditions. Temperature-compositional relationships of the secondary fluid inclusions are interpreted to indicate fluid entrapment during 2 to 3 deep-seated fracturing events in an evolving submarine hydrothermal system. Fluid inclusions which exhibit salinities 40% of seawater may represent entrapment of a condensed vapor phase. Fluid salinities two times seawater may be the result of hydration reactions under upper-greenschist to lower-amphibolite facies conditions. (Authors' abstract)

KELLEY, D.S. and DELANEY, J.R., 1986b Supercritical two-phase separation and brittle failure at temperatures of 700°C in Mid-Atlantic Ridge gabbros (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 653. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195.

Apatite-hosted, microcrack-bound fluid inclusions in gabbros recovered from the axial valley walls of the Mid-Atlantic Ridge, near the Kane Fracture Zone, remain unhomogenized at temperatures up to 700°C and contain salinities greater than thirteen times that of seawater. The high temperature, liquid- and vapor-dominated inclusions, which contain halite, ± sylvite and opaque daughter minerals, coexist with vapor-dominated, low salinity

(1-2 wt% NaCl) fluid inclusions. Spatial, compositional and temperature relationships recorded by the two populations of secondary inclusions may be accounted for by two-phase separation of a magmatically derived aqueous fluid phase (X-X') or of highly-modified seawater. Intersection of the two-phase curve for the system $NaCl-H_2O$ and the solidus for a late-stage melt of tonalitic composition may be used to estimate the phase relationships for an exsolved aqueous phase. Temperature-compositional relationships require that phase separation took place at pressures of 100-110 MPa, which under lithostatic load (P_L) correspond to depths of 1.5-2.0 km beneath the axial valley floor of the MAR. The presence of fluid inclusions occurring along healed microcracks, which remain unhomogenized at temperatures up to 700°C, provide evidence that brittle failure in the oceanic crust occurs at temperatures in excess of 700°C. (Authors' abstract)



KELLEY, S., TURNER, G., BUTTERFIELD, A.W. and SHEPHERD, T.J., 1986, The source and significance of argon isotopes in fluid inclusions from areas of mineralization: Earth & Planet. Sci. Letters, v. 79, p. 303-318. First author at Physics Dept., Sheffield Univ., Sheffield, UK.

Argon isotopes in fluid inclusions in quartz veins associated with granite-hosted tungsten mineralization in the southwest and north of England have been investigated in detail by the $^{40}Ar-^{39}Ar$ technique. The natural argon is present as a number of discrete components which can be identified through correlations with ^{39}Ar, ^{38}Ar and ^{37}Ar induced by neutron bombardment of potassium, chlorine and calcium. The potassium-correlated component arises principally from in situ decay of potassium in solid phases in the inclusions. In the case of the Hemerdon tungsten deposit of southwest England the phases responsible are small (~25 μm) captive authigenic micas which are shown to have been deposited from a fluid 268 ± 20 Ma ago, shortly after the emplacement of the host granite. The chlorine-correlated component is present in the brines which constitute the fluid phase of the inclusions. The argon in these hydrothermal fluids is made up in part of "parentless" or "excess" ^{40}Ar, leached from surrounding crustal rocks, and in part of dissolved ancient atmospheric argon. Absolute concentrations of both atmospheric and excess components in the brine can be estimated from ($^{40}Ar/Cl$) ratios and independent determinations of the salintiy of the inclusions. The absolute concentrations of the atmospheric argon are close to those found in modern meteoric water, while those of the excess component can be interpreted in terms of the degree of interaction between the circulating fluids and country rock. A calcium-correlated component, with a much higher ratio of excess to atmospheric argon than that in the brine, was found to be a dominant phase in one sample from the Hemerdon deposit, indicating the presence of a solid phase (probably a $CaSO_4$ daughter mineral). Inclusions of this composition represent fluids which have had a more prolonged interaction with crustal rocks. The results obtained from this study provide a systematization and a framework for future multi-component argon studies of fluid inclusions, together with an indication of the wide range of information which can be inferred. (Authors' abstract)

KELLEY, S., TURNER, G. and SHEPHERD, T., 1986, Multicomponent sources for argon in fluid inclusions from tin-tungsten deposits (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 15. First author at Dept. Physics, Univ. Sheffield, Sheffield, S3 7RH, UK.

See previous item. (E.R.)

KELLY, W.C., RYE, R.O. and LIVNAT, Alexander, 1986, Saline mine waters of the Keweenaw Peninsula, northern Michigan: Their nature, origin, and relation to similar deep waters in Precambrian crystalline rocks of the Canadian Shield: Am. J. Sci., v. 286, p. 281-308. First author at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

Stagnant pockets of Ca-Na-Cl brine occur at depth in many, if not all, native copper mines of the Keweenaw Peninsula. The brines are characterized by high salinities (200 g/l or more), high Ca/Na ratios (5:1 - 7:1), low K and Mg contents, and δD (-17 to -21 per mil) and δ^{18}O (-7.3 to -7.6 per mil) values which plot well above the global meteoric water line. Similar saline waters are now known to be widespread in the Canadian and other shields.

In the Keweenaw Peninsula, several origins can be precluded. Fluid inclusions in the Keweenaw copper deposits are chemically similar to the mine waters, but their δD values increase systematically with sample depth, indicating contamination by surface waters, probably in Precambrian time. Furthermore, there is no viable mechansim for collecting these inclusion waters into large quantities of brine with salinities as high as 30 wt percent.

This paper advocates a basinal water model involving several stages: (1) initial evolution of the waters as Paleozoic-hosted formation waters, (2) deep infiltration, reaction, and "self-sealing" of these brines in basement rocks under conditions of relatively high temperature and W/R ratios, (3) removal of Paleozoic cover and back-reaction of the waters, chemically and isotopically, under new conditions of low temperature and W/R ratios, and (4) subsequent and variable mixing with fresh meteoric waters. In the Keweenaw Peninsula, stages (1) and (2) must have occurred by Late Jurassic time while a Paleozoic cover still existed. Viewed in this framework, the brine pockets are essentially large "fluid inclusions" in which the liquid phase is evolved basinal water and the host a grouted silicate rock. Like most inclusion liquids in oxygen-bearing minerals, these brines have, upon cooling, back-exchanged with their host over a prolonged period of time. Implications of the model with respect to subsurface fluid waste disposal and to the genesis of Mississippi Valley-type ore deposits are briefly discussed. (From the authors' abstract)

KENNEDY, S.F., 1986, Seiko synthetic emerald: J. Gemm., v. 20, no. 1, p. 14-17. Author at The British Gem Testing Lab. of the London Chamber of Commerce & Industry.

The solid crystalline inclusions in these emeralds are useful in differentiating between natural and synthetic stones. (E.R.)

KEPEZHINSKAS, P.K., BAKUMENKO, I.T. and USOVA, L.V., 1986, Crystallization of anhydrous andesite melts as inferred from study of magmatic inclusions in minerals: Doklady Akad. Nauk SSSR, v. 286, no. 6, p. 1487-1490 (in Russian). First author at Inst. of Lithosphere of Acad. Sci. USSR, Moscow, USSR.

Crystallization conditions of calc-alkaline melts were studied using an example of the Cenozoic andesites of the volcanoclastic complex of the Pakhacha Ridge in the continental frame of the Comandor Deep. The andesites have a hyalopilitic or more rarely cryptocrystalline matrix (of pyroxene-plagioclase + glass composition), with phenocrysts (up to 50 vol.%) of labradorite-bytownite, bronzite, and diopside; titanomagnetite and olivine are much rarer. Plagioclase bears abundant melt inclusions (glass + G ± dms), especially in central parts; melt inclusions were also studied in bronzite. Th were as follows (°C): Pakhacha Ridge, plagioclase (pl.) 1210-1385, orthopyroxene (opy.) >1300, Khayryuzovo massif (Kamchatka), pl. 1200-1280, opy. >1400, clinopyroxene (cpy.) 1190-1300, Avachinskiy volcano (Kamchatka) pl. 1160-1340, cpy. 1200-1250, volcano Mendeleev (Kunashir Island), pl. 1290-1380, volcano Bezymyannyi (Kamchatka), pl. 1345-1350, volcano Karym (Kamchatka), pl. 1280-1340. Separation of high-Ti magnesium-type melts connected with immiscibility [Table 1 gives one example with TiO_2 1.85 wt.% and MgO 14.2 wt.%, another analysis of inclusion glass with SiO_2 79.8 wt.%, TiO_2 30.11 wt.%(sic), and Al_2O_3 14.44 wt.%, and total thus equal 131.61 wt.% must bear at least a misprint, A.K.] and ultracid low-alkali melts [from Table 1: SiO_2 >75 wt.%, Na_2O 0.11 wt.%, K_2O 0.32 wt.%?; the authors do not indicate directly any pertinent analysis, A.K.] are the essential tendencies. The latter formed due to deep near-liquidus differentiation of the primitive melt in the magmatic chamber. This process is typical of orogenic magmas, but the alkali content is lower than in volcanic rocks of the active continental margins. PH_2O during formation of dry andesite magmas was estimated as <1 kbar (~2 wt.% in melt). Problem of generation of dry high-T andesite magmas is briefly discussed. (Abstract by A.K.)

KERRICH, R., 1986, Fluid transport in lineaments: Phil. Trans. R. Soc. Lond., v. A317, p. 219-251. Author at Dept. Geol., Univ. Western Ontario, London, Ontario, Canada N6A 5B7.

A detailed review of data from: Abitibi Greenstone Belt, Yellowknife, Grenville Front, Lagoa Real (Brazil), and Picacho Cordilleran metamorphic complex (AZ). (E.R.)

KERRICH, R. and HYNDMAN, D., 1986, Thermal and fluid regimes in the Bitterroot lobe-Sapphire block detachment zone, Montana: Evidence from $^{18}O/^{16}O$ and geologic relations: Geol. Soc. Am. Bull., v. 97, p. 147-155. First author at Dept. Geol., Univ. Western Ontario, London, Ontario N6A 5B7, Canada.

In granite and pegmatite mylonites, quartz ($\delta^{18}O$ = 10.4 to 11.1) and coarse muscovite (8.4‰) yield isotopic T of 550 ± 50°C, interpreted as the T of ductile deformation, and would have involved fluids of 9.5 ± 0.5‰, which is close to the magmatic or high-T metamorphic range. K-feldspar (7.4 to 1.3‰), fine muscovite (8.3 to 6.8‰), and biotite (2.0 ± 0.2‰) have been shifted by variable magnitudes to low $\delta^{18}O$, which reflects post-mylonite, meteoric-water incursion resetting, less retentive minerals, an effect also observed in underformed precursors to mylonites. Mylonitic metasedimentary rocks 25 km from the Bitterroot Lobe have not been isotopically disturbed by exchange with meteoric water but retain isotopic concordancy for coexisting quartz, k-feldspar, and muscovite, corresponding to estimated T of 450 to 500°C the ambient conditions of ductile deformation.

In chloritic breccias, quartz and feldspar have undergone shifts of about -10‰ relative to their values in mylonitic granites and exhibit disequilibrium fractions (Δ = 5.3 to 9.6‰), due to preferential exchange of feldspar down to lower T. Albite and chlorite yield T of 370°C (Δ = 4.5‰) to 250°C (Δ = 6.3‰), and calculated $\delta^{18}O$ of fluids in equilibrium with albite is -7 (370°C) to -11.8 (250°C). This T range is corroborated by fluid-inclusion data.

High deduced T and fluid isotopic compositions in the mylonites are commensurate with a pluton roof-zone environment at near magmatic conditions, providing enhanced ductility in mylonites. The chloritic breccia is regarded as a structural domain that accommodated late movement of the overlying rocks subsequent to removal of the main cover and provided conduits for incursion of low-T meteoric waters.

The structural sequence reflects the change from high-T ductile deformation of mylonites, under conditions of crust-equilibrated fluids at low water/rock ratio, to a regime of brittle fracturing at diminished T and lower confining stress. In the latter structural environment, hydrological communication to the surface promoted elevated water/rock ratios in the domains of fracturing. (From the authors' abstract)

KERRICH, R., STRONG, D.F., ANDREWS, A.J. and OWSIACKI, L., 1986, The silver deposits at Cobalt and Gowganda, Ontario. III: Hydrothermal regimes and source reservoirs--evidence from H, O, C, and Sr isotopes and fluid inclusions: Can. J. Earth Sci., v. 23, p. 1519-1550. First author at Dept. Geol., The Univ. Western Ontario, London, Ont., Canada N6A 5B7.

This is full paper for abstract by Strong and Scott, Fluid Inclusion Research, v. 17, p. 335, 1984. (E.R.)

KERRIDGE, J.F., SHIPP, Ruth and CHANG, Sherwood, 1986, Deuterium exchange during acid-demineralization: Lunar Plan. Sci. XVII, p. 414-415.

KERSTING, A.B., ARCULUS, R.J. and ESSENE, E.J., 1986, Pressure-temperature-time path calculated for peridotite xenoliths from Ichinomegata Crater, Japan (abst.): EOS, v. 67, p. 394. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Ichinomegata Maar in northwest Honshu, Japan, represents one of the few island arc localities where peridotite xenoliths have been found. The locality is also unusual due to the presence of H_2O-bearing fluid inclusions in the xenoliths.

Several different two-pyroxene geothermometers applied to the peridotite nodules record an increase in equilibrium temperature from the spinel lherzolite at 900-1000°C to the symplectite at 1000-1100°C. Corresponding pressures for the symplectite assemblages range from 7-10 kbars. This temperature difference has been interpreted to represent heating during entrapment of the xenoliths in the rising host magma prior to eruption. There is as yet no clear-cut relationship between the polybaric episodes of fluid inclusion entrapment and the major equilibration events reported here. (From the authors' abstract)

KESLER, S.E., HAYNES, P.S., CREECH, M.Z. and GORMAN, J.A., 1986, Application of fluid inclusion and rock-gas analysis in mineral exploration, in C.E. Nichols, ed., Exploration for Ore Deposits of the North American Cordillera: J. Geochem. Explor., v. 25, p. 201-215. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

Gases are known to form haloes around presently active geothermal systems and might be useful in exploration for older, extinct hydrothermal systems. Gases from such extinct hydrothermal systems can be liberated for analysis from fluid inclusions in hydrothermal minerals by thermal decrepitation or they can be desorbed from alteration mineral surfaces by heating. The most abundant of these gases, besides H_2O, are usually CO_2, CH_4, CO and N_2. We have used a gas chromatograph to analyze these gases in fluid inclusions in jasperoid around the Pueblo Viejo gold-silver deposit, in vein minerals from the Creede silver-lead-zinc deposit, and from clays in the alteration cap overlying veins at Creede to test for gas haloes useful in exploration. At Pueblo Viejo CO_2 abundances in the jasperoid range from less than 1 mole percent (with respect to the system CH_4-CO_2-CO-N_2-H_2O) in the ore zone to as much as 6 mole percent in surrounding, barren jasperoid. Fluid inclusion analyses at Creede suggest that a drop in the CO_2 content of the fluid may relate to ore deposition and clay directly above veins has large amounts of adsorbed CO_2. These results suggest that primary gas abundances exhibit patterns in and around hydrothermal ore deposits that can be used in mineral exploration. (Authors' abstract)

KESTIN, J. and SENGERS, J.V., 1986, New international formulations for the thermodynamic properties of light and heavy water: J. Phys. Chem. Ref. Data, v. 15, no. 1, p. 305-320.

KETTLER, R.M., MEYERS, P.A., KESLER, S.E., STEININGER, R.C. and GLASER, Alan, 1986, Aliphatic hydrocarbons in Pilot Shale adjacent to the Alligator Ridge gold deposit, Nevada: Indicators of ore-forming processes (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 656. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Extractable aliphatic hydrocarbons have been analyzed from samples of Pilot Shale in and adjacent to the disseminated gold deposit at Alligator Ridge, Nevada. Soxhlet extraction and chromatographic separation yielded 0.2 to 4.5 mg of aliphatic hydrocarbons from 30 gm samples. The distributions of n-alkanes exhibit systematic variations related to distance from the Vantage ore bodies. Between 1.9 and 0.5 km from the ore bodies samples exhibit unimodal n-alkane distributions with a maximum of nC_{15}, closer samples display a depletion of short chain n-alkanes and a unimodal n-alkane distribution. Concentrations of n-alkane and total aliphatic hydrocarbons increase from values of 0.3 mg/gm organic carbon (OC), and 0.9 mg/gm OC, respectively, 1.9 km from the ore bodies to 16 mg/gm OC and 26 mg/gm OC, respectively, 500 m from the Vantage II pit and drop to 1.7 mg/gm OC and 3.8 mg/gm OC in mineralized shale. The yields and n-alkane distributions are independent of the type of sample (diamond drill core, rotary percussion drill cuttings or exposure in the Vantage II pit). These data outline two geochemical halos around the Vantage ore bodies. The first is defined by the variations in the concentrations of n-alkane and total aliphatic hydrocarbons, and may reflect an increase in thermal maturity proximal to the ore bodies. The second is defined by the decrease in the proportion of short chain n-alkanes and may reflect either oxidation or water washing of hydrocarbons, both consistent with hydrothermal activity. (Authors' abstract)

KHAN, M.A. and RAZA, H.A., 1986, The role of geothermal gradients in hydrocarbon exploration in Pakistan: J. Petrol. Geol., v. 9, no. 3, p. 245-258. First author at Min. Petrol. & Natural Res., Government of Pakistan, P.O. Box 1308, Islamabad, Pakistan.

Subsurface geothermal gradients play a significant role in oil exploration. Based on a synthesis of bottom-hole temperatures recorded in electric logs from 74 exploratory and development wells in various parts of Pakistan, a study of geothermal gradients was undertaken to delineate the temperature regimes and to identify the oil window in various areas. Case-histories of known accumulations are given to substantiate the results. The first-ever iso-geothermal gradient map of Pakistan is presented. A regional correlation of the oil window, superimposed with stratigraphy, is attempted for the first time, providing a unique exploration tool. Several indications, based on geothermal gradients, are given for the regional prospects of oil and gas. (Authors' abstract)

KHARAKA, Y.K. and CAROTHERS, W.W., 1986, Oxygen and hydrogen isotope geochemistry of deep basin brines, in P. Fritz and J.Ch. Fontes, eds., Handbook of Environment Isotope Geochemistry, Vol. 2, The terrestrial environment, B: Elsevier Publ., p 305-360.

KHASANOV, A.Kh. and ZEVAKIN, N.N., 1985, Temperature regime of formation of the amethyst of the Selbur deposit in the Southern Gissars (abst.):

Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 172-173 (in Russian; translation by Dorothy B. Vitaliano). Authors at Tadzhik State Univ., Dushanbe, USSR.

Geologic-structural analysis suggests that the amethyst-bearing veins are localized in the supra-intrusive zone, 300-500 m from the granitoid intrusion. The amethyst mineralization is controlled by roughly north-south trending faults, mainly in the metamorphosed tuffs and tuff-sandstones, which are associated with zones of crushing, silicification and orthoclasization. In the crush zones, quartz cements fragments of the country rocks and forms individual veinlets. The quartz was formed in three stages and ended with amethyst formation. Both in the quartz and in the amethyst, an abundance of GLIs is found. They are essentially liquid or gas-liquid and homogenize to the liquid phase. Most of the inclusions are two-phase, rarely three- and multiphase. According to the data of thermometric investigations, the formation of the quartz veins began at 400-370°C with deposition of fine-grained milky quartz. Columnar and drusy semitransparent quartz was deposited on the walls of cavities at 160-130°C. The process of formation of the amethyst veins ended with crystallization of amethyst at 120-100°C. Thus a tendency toward a gradual decrease in T in the course of formation of the amethyst-bearing zones is observed.

Cryometric investigations of GLIs in quartz and amethyst showed that higher values of supercooling are typical of the transparent varieties of amethystine quartz. This indicates that the amethyst-forming solutions contained [only] a small amount of impurities which could serve as centers of crystallization. Lower values of supercooling characterize the columnar and drusy quartz, which indicates that they formed from more mobile[?] solutions, containing a large amount of impurities. The amethyst crystallized later in a more quiet setting, from purer solutions of low concentration. (From the authors' abstract)

KHEANG, Lao and KUMARAPELI, Stephen, 1986, Low salinity aqueous fluids of Acton Vale, Upton and Lord Aylmer carbonated-hosted base metal deposits, Eastern Townships, Quebec (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 89. First author at Dept. Génie Minéral, Ecole Polytech., Montral, Quebec, H3C 3A7, Canada.

Gangue minerals (calcite, quartz, barite) and sphalerite contain relatively abundant P fluid inclusions. They are aqueous and liquid-rich with vapor/liquid ratios generally less than 10% in volume. Some inclusions contain carbonate crystals with the fluid phase. Salinity of the fluids range from 1 to 6 wt% eq NaCl. Their Th are generally from 100 to 130°C. Semiquantitative chemical analyses of inclusion residues in calcite show the following modes: Na/(Na + K) = 0.51, Cl/(Na + K) = 0.50 and S/(Na + K) = 0.20.

Thermo-chemical data of fluid inclusions allow us to draw the following conclusions: (1) the ore-bearing fluids were low T (100-130°C) aqueous solutions, (2) the fluid salinity is low (2% for Acton Vale and 3.5% for Upton and Lord Aylmer), (3) K in the fluid is as abundant as Na and (4) Cl in the fluid is low.

The fluid from Acton Vale, Upton and Lord Aylmer deposits are comparable in T to those of Mississippi Valley type deposits (generally 90 to 150°C) but their salinity and Na and Cl abundances are distinctly different. Their low salinity is comparable to that of modern sea water (3.5%). (Authors' abstract)

KHEANG, Lao, PERRAULT, Guy and GAUMOND, Andre, 1986, Metamorphogenic fluid of New Pascalis gold deposit, Val d'Or, NW Quebec (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 89. First author at Dept. Génie Minéral, Ecole Polytech., Montral. Quebec, H3C 3A7, Canada.

Primary fluid inclusions in quartz-tourmaline-sulphide subvertical veins from New Pascalis are carbonic (54%), aquacarbonic (28%) and aqueous (18%). Salinity of aqueous and aquacarbonic inclusions varies from 2 to 6 wt.% eq. NaCl: their Th are generally between 240 and 360°C. Microprobe analyses of inclusion residues provide the following modes: Na/(Na + K) = 0.40, S/(Na + K) = 0.63, Ca/(Na + K) = 0.07 and Cl/(Na + K) <0.05.

In subhorizontal and 45° dipping veins, fluid inclusions are carbonic (55%), aquacarbonic (34%) and aqueous (11%). Their average salinity (4 wt.% eq. NaCl) and Th (330°C) are similar to that of subvertical vein inclusions. Chemically, they are characterized by a large variation in Na/(Na + K) ratios from 0.20 to 0.98; S/(Na + K) <0.10 and Cl/(Na + K) >1.0.

Thermo-chemical data on fluid inclusions lead us to the following conclusions: (1) the New Pascalis mineralizing fluid is rich in CO_2; (2) its salinity is generally low and comparable to that of sea water (3.5%); (3) Th are about 325°C; (4) S and K are more abundant in subvertical veins, while Cl is very abundant in subhorizontal and 45° dipping veins. The high content of S and K in the fluid of subvertical veins is explained by a hydrodynamic model dominated by condensation of S-rich vapor-phase. Finally, the New Pascalis mineralizing fluid with its low salinity and high CO_2 content is similar to the fluid found in many aurifereous veins, generally accepted to be metamorphogenic. (Authors' abstract)

KHETCHIKOV, L.N., KOTEL'NIKOVA, Z.A., RUB, M.G. and RUB, A.K., 1986, Composition of inclusions in quartz of Precambrian granites of the northern Priladozhia: Dokl. Akad. Nauk SSSR, v. 288, no. 6, p. 1462-1468 (in Russian).

See Rub, M.G. et al., 1986, this volume. (E.R.)

KHETCHIKOV, L.N. and POLENKOV, A.I., 1984, Some distribution patterns of inclusions of mineral-forming media in minerals of Precambrian rocks of different age: Dokl. Akad. Nauk SSSR, v. 279, no. 1, p. 431-433 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., v. 279, p. 50-51, 1986). Authors at Inst. Lithosphere, USSR Acad. Sci., Moscow, USSR.

Abstract in Fluid Inclusion Research, v. 17, p. 163, 1984. (E.R.)

KHETCHIKOV, L.N., POLENKOV, A.I., DOROGOVIN, B.A., 1985, Inclusions of the mineralizing medium in the minerals of Precambrian rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 189-190 (In Russian; translation by Dorothy B. Vitaliano). First author at ILSAN, Moscow, USSR.

1. Inclusions of the mineralizing medium in minerals of Precambrian rocks of different age from the Aldan shield, Mama-Chuya area of East Siberia, Patom upland, Karelia, the Kola Peninsula, the Kursk Magnetic Anomaly and, in small amounts, from Africa and Antarctica, were studied.

2. In the minerals from the Precambrian rocks, 8 varieties of inclusions with CO_2 (L_{CO_2}; $L_{CO_2}+G_{CO_2}$; $L_{CO_2}+K$; $L_{CO_2}+G_{CO_2}+K$; $L_{CO_2}+L_{H_2O}$, etc.), single-phase water inclusions (L_{H_2O}), inclusions containing solid phases and water-salt solution ($L_{H_2O}+K$) and water-salt inclusions with diverse phase relations were established; this is consistent with the data of A. A. Tomilin and V. P. Chupin (1983).

3. As illustrated by the Aldan shield, the Mama-Chuya region, Karelia and other areas, the features of the composition of the inclusions as a function of age of the rocks are demonstrated. For the minerals

from Archean rocks, formed under conditions of various facies of metamorphism, single-phase inclusions of liquified CO_2 (L_{CO_2}) and two-phase CO_2 inclusions ($L_{CO_2}+G_{CO_2}$) are typical. In the upper parts of the sections of Archean rocks, in addition to CO_2 inclusions, single-phase water inclusions (L_{H_2O}) appear, which are especially typical of Proterozoic rocks. The features of composition of inclusions in different periods of the Precambrian history of the earth are determined by the evolution of the composition of the mineralizing fluids in time -- by the predominance of CO_2 in their composition in the Archean, with low activity of water.

4. In other periods of earth history, single-phase CO_2 inclusions (L_{CO_2}) could be formed under very high T and P conditions in local sectors where ultrametamorphism occurs. In this case, if the rocks melt, the process of differentiation of fluids occurs -- water is dissolved in the melt and CO_2 is removed from it, forming a CO_2 front of metamorphism of the rocks. In this case, near large enough centers of melting, inclusions of L_{CO_2}, then of $L_{CO_2}+G_{CO_2}$ and still later of $L_{CO_2}+G_{CO_2}+L_{H_2O}$ are observed in the minerals of the metamorphic rocks.

5. At each stage of its manifestation, metamorphism is characterized by CO_2 inclusions and water-salt inclusions with various phase relationships, often containing a variable amount of solid phases.

6. Inclusions containing CO_2 and a variable amount of solid phases are formed in metamorphic minerals at high P and T, under the action of a highly concentrated fluid. In this case, judging from paleopeographic data, original rocks of saline sequences contained in the section possibly affect the composition and concentration of the fluid.

7. The data obtained make it possible to propose a procedure for age subdivision of Precambrian metamorphic sequences on the basis of inclusions in minerals, and to recommend study of inclusions for prospecting and appraising deposits of some mineral resources, for instance ferruginous quartzites and mica-bearing pegmatites. (Authors' abstract)

KHITAROV, D.N., KANDINOV, M.N. and ARMAN, O.P., 1985, Present-day state and development of methods of studies of composition of inclusions of mineral-forming media: VIMS, Moscow, 50 pp. (in Russian).
Cited in Naumov, 1986 (this volume).

KHITAROV, D.N. and SHMAROVICH, Ye.M., 1985, Relative characteristics of solutions responsible for the formation of different ore deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 36-38 (in Russian; translation by S. Jaireth). Authors at MINGEO, Ministry of Geol., Moscow, USSR.

1. The literature is full of cases in which geologists a priori associated differences in the metallogenetic specialization of ore provinces only with favorable sources of ore-forming components rather than with the specificities of the ore-forming solutions. This indicates that physico-chemical factors which determine principle possibility of selective ore transportation and deposition were not given due importance. A number of studies based on the analysis of data on the composition and structures of altered rocks in hydrothermal deposits show that the solutions responsible for the formation of various ore deposits were sufficiently specific in their physico-chemical parameters. This assumption was verified by using thermobarogeochemical data on the ore-forming solutions in various deposits.

2. Fluid inclusions have been studied in U (hydrothermal), fluorite, polymetallic (stratiform), Hg, Sb, Pb, Zn, Ag, Cu, Bi, Au, W and Mo deposits. Th was used to determine minimum Tt. Composition (qualitative) of

liquid and gaseous phases was determined using leachate and gas-chromatographic analysis respectively.

3. Results support presence of specific characteristics of hydrothermal solutions responsible for the formation of ore deposits and their mineralogical-genetic types. Based on the obtained data, hydrothermal solutions are divided into 8 groups: (1) medium to low T carbonate type U deposits; (2) medium to low T, weakly saline, alkali-chloride type - fluorite deposits; (3) hydrocarbon-bearing chloride brines - stratiform polymetallic and younger fluorite deposits; (4) low T sulfur-bearing chloride type - Sb and Hg deposits; (5) medium T sulfur-bearing chloride types - Pb, Zn, Cu, Ag and Bi deposits; (6) high T sulfur-bearing chloride type - Cu porphyry deposits; (7) high T sulfur-bearing chloride carbonate type - Au deposits; (8) high T chloride carbonate type - W and Mo deposits.

4. Above mentioned results which help to classify ore deposits on the basis of types of ore-forming solutions, are significant in solving problems of ore genesis and geological prospecting. (From the authors' abstract).

KHNYAZEVA, S.N., DOROFEYEVA, V.A. and SUSHCHEVSKAYA, 1985, Variations in the gas composition of fluids of the productive stage of two tin deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 135-136 (in Russian; translation by Dorothy B. Vitaliano). Authors at Vernadsky Inst. Geochem. & Anal. Chem. (GEOKHI), USSR Acad. Sci., Moscow, USSR.

On the basis of the data on two economic deposits (tourmaline-type cassiterite-silicate formation) in the Komsomol' tin region, the dependence of the distribution of the gaseous components in the ore-forming solutions on the intensity of Sn-W and Sn-Cu mineralization was investigated. For this purpose, the composition of inclusions in a series of samples of quartz of the quartz-cassiterite stage, statistically characterizing the ore (workable) and non-ore (unworkable) parts of the mineralized crush zones, at different levels, were analyzed. Gas chromatography, with thermal decrepitation of the inclusions was used, with preliminary sample preparation to eliminate to some extent the effects of admixture of carbonate and organic material.

From the study of the inclusions, the solutions correspond to the interval of deposition of the main mass of tin ore. For all the cases studied, the distribution of the gaseous components is characterized by the same type of concentration sequence, $CO_2 > N_2 \geqslant CH_4 \geqslant CO \geqslant H_2$. The variations in concentration are considerable: for CO_2 they lie within half an order of magnitude (1-5m)[sic]; for the other components they are more than an order. Differences in the concentrations of the gaseous components for places differing in intensity of mineralization are not statistically significant. Calculated data on the variation in pH in the equilibrium systems quartz-aqueous salt solution and aluminosilicate rock-solution, brought in to explain this conclusion, show that the pH of the solutions depends to a greater extent on the variation in proportions of rock and solution than on the variation of CO_2 in the system.

Apparently, use of the relationship of the gas composition of the fluids to the productivity of the ore bodies (Kalyuzhnyy and Matviyenko, 1978; Vynar et al., 1980; and others) is possible only when it is known that the variation in CO_2, or other gases or their proportions, in the process in question is the main factor in ore deposition, or depends on it unequivocally. The formation of hydrothermal tin mineralization of cassiterite-silicate and cassiterite-sulfide types depends on two main factors, pH and $f(O_2)$, which precludes the existence of a simple clearcut correlation between the intensity of mineralization and concentration of

CO_2 in the fluid depositing it. (Authors' abstract)

KHOLIEF, M.M. and BARAKAT, M.A., 1986, New evidence for a petroleum source rock in a Miocene evaporite sequence, Gulf of Suez, Egypt: J. Petrol. Geol., v. 9, no. 2, p. 217-226.

Anhydrite, gypsum and halite evaporites of Middle Miocene age occurring in the Gulf of Suez area constitute more than 50% of the total rock components. They are intercalated mainly with shales and also subordinate carbonate and sandstone layers. Examination of several evaporite samples under both binocular and petrographic microscopes reveals the presence of inclusions of various types hosted by gypsum crystals. Solid inclusions are composed mainly of minute calcareous particles, fine pyrite crystals and residual organic matter, while liquid inclusions, which are most frequent, exist in a uniphase or biphase state. A light hydrocarbon in the form of oil or gas constitutes one of these phases, while the other is a brine. Most of these inclusions are of primary origin and have been developed during the growth of the hosted minerals.

Based on the assemblage of these inclusions, it can be assumed that the evaporitic environment of deposition, with its reducing condition and high salinity, is favorable for the generation of oil from accumulated organic matter. Also, the presence of a carbonate mineral trapped by gypsum indicates the possible mixing of marine water with a brine of restricted occurrence. (Authors' abstract)

KIEFERT, L. and SCHMETZER, K., 1986, Pink and violet sapphires from Nepal: Z. Dt. Gemmol. Ges., v. 35, no. 3/4, p. 113-125 (in German; English abstract).

Small platelets of mica, which are partly observable in three-phase inclusions, are the most significant inclusion types of samples from the new locality. (From the authors' abstract)

KIEFFER, S.W. and HENLEY, R.W., 1986, Flow of H_2O-CO_2 mixtures in geothermal wells: Prediction of calcite deposition (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 656-657.

KING, C.-Y., 1986, Preface: J. Geophys. Res., v. 91, no. B12, p. 12,157, Nov. 10, 1986. Author at U.S. Geol. Survey, Menlo Park, CA.

This section of the Journal of Geophysical Research contains a special collection of 22 papers derived from a symposium entitled "Gas Geochemistry of Volcanism, Earthquakes, Resource Exploration, and Earth's Interior," convened by M. Sato of the U.S. Geological Survey and S. Matsuo of the Tokyo Institute of Technology at the 1984 International Chemical Congress of Pacific Basin Societies in Honolulu, Hawaii, on December 19 and 20, and from contributions from authors in response to a postmeeting call for papers for this collection. It includes discussions of the various gases (CO_2, SO_2, H_2O, HCl, HF, H_2S, N_2, H_2, CH_4, He, Ar, Rn, etc.), use of Rn and $^3He/^4He$ in earthquake prediction, etc. (E.R.)

KINNAIRD, J.A., BATCHELOR, R.A., WHITLEY, J.E. and MacKENZIE, A.B., 1985, Geochemistry, mineralization and hydrothermal alteration of the Nigerian high heat producing granites, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 169-195. First author at Dept. Geol., Univ. St. Andrews, Fife, Scotland.

Fluid inclusion data indicate that the fluids responsible for early metasomatic alteration were highly saline, F-rich and were trapped at >500°C. Loss of CO_2, which occurred during sodic metasomatism, was important for the deposition of U. Major cassiterite deposition took place between 300-380°C in greisen, often from fluids that were boiling. Major sulphide deposition was in the range 240-380°C from more dilute fluids. Changes in P were important in controlling the type of alteration process and the style of mineralization. (From the authors' abstract)

KIRILO, M.V. - See KURILO, M.V.

KISIN, A.Yu. and TALANTSEV, A.S., 1986, Formation characteristics of chondrodite-carbonate-tremolite veins in marbles from the area of the Kocharsk granite intrusion (USSR): Zap. Vses. Mineral. O-va, v. 115, no. 1, p. 93-99 (in Russian). Authors at Obed. "Uralkvartssamotsvetei," Sverdlovsk, USSR.

Veins in calcite-dolomite marbles can be clearly subdivided into (1) tremolite, (2) carbonate with fluorite, and (3) chondrodite-calcite zones, in center-to-edge order. Carbonate mineral compositions and fluid-inclusion studies indicate these formational temperature-pressure conditions: (1) chondroditic metasomatism of marbles at 570-610° and 2.0-2.3 kbar; (2) crystallization of fluorite and carbonates on fissure walls at 500-560° and 1.9-2.0 kbar; and (3) crystallization of tremolite and filling of interstices with carbonates at 480-500° and 1.2-1.4 kbar. (C.A. 104: 171682u)

KLAGISH, B.D., KOVALISHIN, Z.I., KALYUZHNYI, V.A. and HARBUT, G.B., 1985, Fluid inclusions in quartz and cassiterite in the tin-bearing deposits of Chukotka as additional prediction-assessment criteria (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 128-130 (in Russian; translation by D.A. Brown). First author at Soyuzmorinzhgeologiya, Riga.

The commonest types of ores of the quartz-cassiterite association in the Pyrkay and Billing ore lodes and ores of the cassiterite-silicate-sulfide association of the Pevek and Kuyvieyem-Gyrgychan ore lodes, have been examined. The highest-T fluid inclusions occur in early pre-ore smoky quartz. The fluid inclusions in the cassiterite and quartz of the productive phase, in contrast to the ores of the cassiterite-quartz association, are smaller, and rarely encountered. For the most part, these are PS inclusions, confined to sealed fissures. Frequently, such P[sic] inclusions are arranged along the growth zones in the cassiterite crystals. The L/G ratio is 3:1.

Multiphase inclusions are widely distributed in quartz from the cassiterite-tourmaline-quartz veins in the Kuyviveyem-Gyrgychan ore lode. Along with the L and G phases, they contain several solid phases, consisting of halite and isometric ore minerals. The G/L/S ratio is 1:1.5:1.5 [2:3:3].

The mass-spectrometer shows that the gas phase in the inclusions in the cassiterite-quartz association had a CH_4-CO_2 composition. The amount of CO_2 varies from 84.6 to 94.2 vol.%, and of CH_4, from 4.2 to 10.2 vol.%. Aqueous extracts from this material are distinguished by the high alkali concentration as compared with those from the cassiterite-silicate-sulfide association. Quartz from the ores of the cassiterite-silicate association in the Kuyviveyem-Gyrgychan ore lode occupies an intermediate position. The anion composition of the extracts is marked by increased amounts of chlorine and sulfate. The quantity of gas from inclusions in the cassiterite-silicate-sulfide and cassiterite-silicate associations is significantly smaller. The quantity of CO_2, as compared with that in quartz from the quartz-cassiterite association is somewhat diminished and ranges from 67.9 to 85.5 vol.%, and that of H_2 from 2.9 to 21.6 vol.%. An increased amount of N_2 has been noted ($\leq$12.2 vol.%).

Data on the mineral-forming media have shown that they are different for each type, and at the same time they have certain common features and continuity of composition, which is not refuted by the geological and mineralogical data.

Hence, the fluid inclusions examined may turn out to be an essential aid in resolving various problems on their origin, and may also be used as additional prediction-assessment criteria. (From the authors' abstract)

KLATT, Ekkehard, 1980, Serial distribution, mineral facies and composition of fluid inclusions in the Precambrian rock units of Northern Lapland: PhD dissertation, Christian-Albrechts-Univ., Kiel, 125 pp. (in German; abstract courtesy Johann Gieb).

Deals with geologic and petrographic studies of the above mentioned series in order to elucidate the prevailing metamorphic conditions. In order to obtain a timing of the intergranular fluid phases also fluid inclusion studies of quartz in veins and in the rocks have been completed.

Polymetamorphic Precambrian (oldest rocks 2.85 Ga) granulites situated 25°30' to 26°20'E and 69°22' to 69°45'N display high grade amphibolite to granulite facies overprinting. Petrological P-T-data correlated with isochores of high density CO_2-inclusions formed during prograde metamorphism, indicate the last overprinting during Carolian orogeny (2.1-1.9 Ga) at 800 ± 50°C and 7 ± 1 kbar. Lower density CO_2-inclusions are attributed to retrograde metamorphism (compare Figs. 28 and 29, p. 114). Th and resulting densities of fluid inclusions in both quartz varieties are given (Fig. 3, p. 78).

See also Klatt and Schoch, 1984, in Fluid Inclusion Research, v. 17, 1984, p. 167-168. (E.R.)

KLEIN, H., WANDERS, K. and BECKER, F., 1986, Density distribution near gas/liquid critical points under reduced gravity: Naturwissenschaften, v. 73, p. 374-375. First author at Inst. für Raumsimulation, DFVLR, D-5000 Köln, FRG.

Experimental studies of SF_6 in a tube (0.25 cm x 6 cm I.D.) under microgravity show that gravity induces growing density inhomogeneities in a fluid near the critical point. (E.R.)

KLEMM, Werner, 1986a Contribution to the analytical geochemistry of gas-fluid inclusions in hydrothermal minerals: Dissertation B, Bergakademie Freiberg, GDR (in German).

In addition to a review of the fundamentals of inclusion methods, a system of analytical techniques for the determination of Na, K, Li, Ca, Mg, Sr, Cu, Zn, Cl, HCO_3, SO_4, F, H_2S, N_2, CH_4, CO_2 and H_2O is given and methods for the analysis of the isotopic composition of H_2O and CO_2 are tested. The following techniques suitable for the chemical analysis of fluid inclusions are used: atomic emission spectrometry: Na, K, Li; atomic absorption spectrometry: Ca, Mg, Sr, Cu, Zn; spectrophotometry with mercuric thiocyanate and iron alum: Cl; titration with sulphuric acid: HCO_3; direct potentiometry by means of F^- and S^{2-} ion-selective electrodes: F, H_2S; turbidimetry with barium chloride: SO_4; nuclear magnetic resonance: H_2O (in inclusions); gas chromatography: N_2, CH_4, CO_2, H_2O; mass spectrometry: isotopes of H, O and C.

New chemical analyses of fluid inclusions (bulk analysis) in quartz, fluorite, barite, calcite, cassiterite, wolframite, sphalerite and galenite from G.D.R. deposits show material connections between the chemism of the solutions and the formation of deposits, thus yielding numerous conclusions for fundamental geological research and for the geological practice [i.e., exploration]. (Abstract courtesy R. Thomas)

KLEMM, Werner, 1986b A survey of chemical analysis of gas-fluid inclusions: Freiberger Forschungshefte, v. C402, p. 49-68 (in German). Author at the Bergakademie Freiberg, 9200 Freiberg/Sa., Schließfach 47, GDR.

This paper gives a general review of the techniques for the analysis of the composition of fluid inclusions in minerals (cation and anion analysis, volatiles, solid phases). In addition to brief comments on the many modern techniques, the crush-leach methods and the leachate analysis for cations (Na^+, K^+, Li^+, Ca^{2+}, Mg^{2+}, Sr^{2+}, Cu^{2+}, Zn^{2+}) and anions (Cl^-, F^-, HCO_3^-/CO_3^{2-}, SO_4^{2-}, S^{2-}) chosen by the author are presented and discussed in detail. Model experiments with quartz regarding the degree of extraction were carried out. Results obtained by leachate analysis of fluorites from the G.D.R. were presented and compared with data from the literature. (Abstract courtesy R. Thomas)

KLEY, D., FREYER, H.D. and GEISS, H., 1986, The variability of $^{13}C/^{12}C$ in atmospheric CO_2 as derived from historic records - implications for climate (abst.): EOS, v. 67, p. 881. First author at Inst. for Chem., KFA Jülich, FRG.

The $^{13}C/^{12}C$ carbon isotope ratio of atmospheric CO_2 is affected by processes occurring on a variety of time scales.

The principal atmospheric sources of CO_2 are biospheric respiration, release from the sea and fossil fuel combustion. These are balanced by photosynthesis, uptake by the sea and changes of atmospheric CO_2 mixing ratio. Respiration/photosynthesis has a strong seasonal effect. During summer with a high photosynthetic activity, CO_2 mixing ratios are lower than during winter. The time constant for the seasonal change is one year. Since plants discriminate against the heavier isotope during photosynthesis, the atmospheric $^{13}C/^{12}C$ ratio must increase in summer, causing a seasonal modulation of the $^{13}C/^{12}C$ ratio.

CO_2 from the fossil fuel consumption is depleted in ^{13}C compared to the ^{13}C content of atmospheric CO_2. Therefore, on a secular time scale, the atmospheric $^{13}C/^{12}C$ ratio of CO_2 is decreasing.

Historic records of atmospheric CO_2 isotope ratios have been preserved in carbon of tree wood and air bubbles trapped in polar ice. We have compared the records and find, after subtraction of the secular trend, that a globally significant signature emerges as residuals with a typical time constant of about 30-50 years. This time is long enough so that the temperature dependence of exchange equilibria of atmospheric CO_2 with reservoir carbon (oceans, soil) will influence the atmospheric $^{13}C/^{12}C$ ratio.

The analysis of the isotope records allows conclusions about past global temperature fluctuations and suggests predictions about future ones. (Authors' abstract)

KLINKHAMMER, G., EDMOND, J.M., ELDERFIELD, H. and GREAVES, M., 1986, A comparison of REE data for hydrothermal fluids from the MAR and EPR (abst.): EOS, v. 67, p. 1021.

KNAUTH, L.P., 1986, Stable isotope variations of deep basin brines reexamined (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 659. Author at Dept. Geol., Arizona State Univ., Tempe, AZ 85287.

The conventional interpretation of δD, $\delta^{18}O$ variations in deep basin brines is that meteoric waters have flushed out connate fluids and become enriched in ^{18}O by isotopic exchange with calcite. While this interpretation explains in a general way the ^{18}O enrichments, the approach has never satisfactorily explained the δD variations or their covariance with $\delta^{18}O$.

Because of the hooked evaporation trajectory on a δD-$\delta^{18}O$ diagram, sea water evaporite brines have negative δD values and $\delta^{18}O$ values which range from negative to positive. Many deep basin brines which have chemical compositions similar to sea water evaporite brines also have the same isotopic composition as evaporated sea water. Mixing of meteoric waters with evaporite brines can account for the observed isotopic variations of brines in many sedimentary basins, including the large changes in δD and details of the $\delta^{18}O$ variations.

Assuming that δD is basically conservative for parts of the basin above 100°C where isotopic exchange with clay minerals is minimal, plots of δD versus individual chemical species allow mixing trends to be separated from the more complicated chemical variations arising from fluid/rock interactions. These plots reveal the probable presence of an evaporated sea water component in several ancient sedimentary basins, including the Michigan and Palo Duro basins. Horizons and areas that have been least disturbed by meteoric waters can be determined with this combined chemical and isotopic approach. Deep basin brines containing a major component of evaporated sea water associated wtih, or expelled from, evaporite sequences may be more common than previous interpretations of isotopic data have indicated. (Author's abstract)

KNAUTH, L.P. and BEEUNAS, M.A., 1986, Isotope geochemistry of fluid inclusions in Permian halite with implications for the isotopic history of ocean water and the origin of saline formation waters: Geochimica Cosmo. Acta., v. 50, p. 419-433. First author at Dept. Geol., Arizona State Univ., Tempe, AZ 85287, USA.

δD and $\delta^{18}O$ values have been determined for fluid inclusions in 45 samples of Permian halite. The inclusions are enriched in ^{18}O relative to the meteoric water line but are depleted in D relative to ocean water. Inclusions with the more positive δ-values coincide with the isotopic composition expected for evaporating sea water which follows a hooked trajectory on a δD-$\delta^{18}O$ diagram. Inclusions with more negative δ-values may represent more highly evaporated sea water but probably reflect synsedimentary or diagenetic mixing of meteoric water with evaporite brines. The isotope systematics in these inclusions are sufficiently similar to those of a modern evaporite pan to indicate that Permian sea water was isotopically similar to modern sea water.

Connate evaporite brines can have negative δ-values because of the probable hooked isotope trajectory of evaporating sea water and/or synsedimentary mixing of evaporite brines with meteoric waters. Subsurface formation waters composed of mixtures of remnant primary evaporite brines and later meteoric waters may be more common than previous isotopic evidence has suggested. (Authors' abstract)

KOGARKO, L.N., COSTOGLIANI, C. and RYABCHIKOV, I.D., 1986, Geochemistry of the reduced fluid of alkaline magmas: Geokhimia, 1986, no. 12, p. 1688-1695 (in Russian; English abstract).

Using microanalytic technique based on the Raman spectroscopy it has been found that CH_4, H_2 and N_2 are the predominant components of gas micro-inclusions captured by eudialytes from Lovozersky massif of agpaitic nepheline syenite. Thermodynamic calculations show that gases of such composition could be generated as a result of dehydration of water fluids formed in the equilibrium with igneous rock at $T \approx 400°C$ and $P = 0.5$-1 kbar. The dehydration may be a result of a hydration of rock-forming minerals and decomposition of the fluid into gas and liquid along with the T decrease. (Authors' abstract)

KOGARKO, L.N. and LAZUTKINA, L.N., 1986, Typomorphic characteristics of eudialite and the genetic problem of zirconium mineralization in alkalic rocks, in Typomorphism of minerals and mineral associations, Petrovskaya, N.V., ed.: Izd. Nauka, p. 125-131 (in Russian).

Includes some discussion of inclusions in eudialite. (E.R.)

KOGARKO, L.N. and ROMANCHEV, B.P., 1986, Geochemical criterion of ore-bearing capacity of alkaline magmas: Geokhimiya, 1986, no. 10, p. 1423-1430 (in Russian; English abstract).

Microprobe analysis of inclusions in minerals was made. Based on contents of P, Zr, Nb and Ce in the inclusions which have been homogenized into glasses the cotectic contents of these elements necessary for crystallization of apatite, loparite and eudialyte from the nepheline-syenite melts have been determined. A degree of saturation of the initial melts in relation to apatite, eudialyte and loparite have been determined by comparison of cotectic contents of the elements with their average contents in the intrusives. (Authors' abstract)

KOGARKO, L.N., ROMANCHEV, B.P., CHAUNINA, G.N. and KRIGMAN, L.D., 1985, Parameters of ultraagpatic alkaline pegmatite formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 21-22 (in Russian; translation by S. Jaireth). Authors at GEOKHI, Inst. Geochem. & Anal. Chem., Moscow, USSR.

Ultraagpatic pegmatites associated with the nepheline-syenite massif of Lovozero are characterized by the presence of some unique minerals. The studied pegmatite (Lesser Punkaruev Hill) is composed of three zones: 1st, outer zone - large 7 cm crystals of eudialyte, hackmanite, and smaller crystals of aegirine and ramsayite [lorenzenite]; 2nd, intermediate zone - aegirine, neptunite, ussingite, murmanite; 3rd, central zone - mostly ussingite with traces of epistolite, steenstrupine, villiaumite, chkalovite, belovite.

As most of the studied minerals are translucent a special heating stage with a three-dimensional heating element of nichrome foil was fabricated. This stage allowed use of standard objectives (9 x and 20 x) without cooling.

Primary inclusions were studied in eudialyte and hackmanite (1st zone), neptunite and ussingite (2nd zone), ussingite (3rd zone). Eudialyte bears crystal-fluid inclusions with Th = 765-645°C, neptunite and ussingite of 2nd zone, crystal fluid inclusions, Th = 610-560°C, ussingite of 3rd zone - gas-liquid inclusions, Th = 305-165°C. Following are the main conclusions: (1) eudialyte crystallized from alumosilicate melt enriched in H_2O and salts, (2) hackmanite existed in equilibrium with two immiscible melts - silicate and saline, (3) neptunite and ussingite of 2nd zone crystallized from predominantly saline melt enriched in volatiles, (4) ussingite of central zone crystallized from solutions, (5) pegmatite was formed during evolution of residual melt with participation of magmatic, magmatic-liquation and hydrothermal processes, (6) a gradual transformation of melt into solution occurred in the presence of high concentrations of soluble volatiles. (From the author's abstract)

KOIVULA, J.I., 1986a Carbon dioxide fluid inclusions as proof of natural-colored corundum: Gems & Gemology, v. 22, p. 152-155. Author at Res. Dept., Gemological Inst. America, Santa Monica, CA.

The question of how to identify natural-colored from heat-treated corundum has long puzzled the gemological community. One important clue is now provided by carbon dioxide fluid inclusions. Because such inclusions cannot survive heat treatment, their existence intact and unruptured in rubies and sapphires is conclusive proof that no heat treatment has occurred. (Author's abstract)

KOIVULA, J.I., 1986b Solution coloration of smoky quartz: J. Gemm., v. 20, no. 4, p. 208-209. Author at Dept. Research, Gemological Inst. Am., Santa Monica, CA, USA.

This paper discusses the possible coloration of smoky quartz by naturally occurring radioactive hydrothermal fluids. The smoky brown color of the quartz crystals described here is confined to a surface layer only a few millimeters in thickness. The greatest depth of color is concentrated around surface solution cavities and near-surface fluid inclusion chambers. (Author's abstract)

KOIVULA, J.I., 1986, Three-phase inclusions in "Regency" synthetic hydrothermal emerald: Z. Dt. Gemmol. Ges., v. 35, no. 3/4, p. 97-99.

Three-phase inclusions were found in Vacuum Ventures "Regency-Created" hydrothermal synthetic emeralds. The solid daughter crystals are birefringent and display the habit of phenakite. (From the author's abstract)

KOIVULA, J.I. and FRYER, C.W., 1986, Blue-green zircon in Pakistani beryl: Z. Dt. Gemmol. Ges., v. 35, no. 3/4, p. 101-103.

Euhedral crystals of translucent blue-green zircon are identified for the first time as inclusions in a crystal of pale blue aquamarine derived from a pegmatite located in northen Pakistan. (Authors' abstract)

KOKORIN, A.M. and KOKORINA, D.K., 1985, Prediction of tin mineralization from thermobarogeochemical data (as exemplified by deposits in the south of the Soviet Far East region) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 132-133 (in Russian; translation by D.A. Brown). First author at Far Eastern Geol. Inst. of Far Eastern Sci. Center of Acad. Sci. USSR, Vladivostok, USSR.

Tin deposits of the cassiterite-quartz, cassiterite-silicate, and cassiterite-sulfide associations are widely distributed in the southern part of the Soviet Far East. The second association currently occupies the leading role.

Formation of deposits of the cassiterite-quartz association took place at T = 550-70°C. The successive contiguous deposition of the mineral associations was completed from pneumatolytic-hydrothermal $NaCl-CO_2-H_2O$ solutions with salt concentrations of 3-5 to 50-60 wt.% (calculated as NaCl) and the amount of CO_2 ranged from 75-85 to 5-7 mole %; pH was 5-7. Pf (calc.) varied from 850-1100 to 30-40 bars. With a vertical extent of the ore bodies down dip of 800-1200 m, the T-gradient was about 25°C/100 m.

Formation of deposits of the cassiterite-silicate association was completed at T ranging from 500-530 to 50-60°C from CO_2-enriched solutions (40 mole %) and/or those enriched in alkali-chlorides (45 wt.%) at pH = 5.5-8.5. The minerals crystallized mainly when the solutions boiled during P changes from 1000 to 1 bar. The optimal T for the successive mineral associations, representing contemporaneous facies of differing depth, are: quartz-tourmaline-muscovite (early and deepest), 530-350°; quartz-cassiterite, 470-330°; quartz-chalcopyrite-pyrrhotite, 400-300°; galena-sphalerite, 350-250°; and quartz-carbonate (latest), 280-100°C. As T dropped through time (ore-deposition process) and space (along the rise of the ore bodies), there occurred condensation of the gas solutions, increase in their alkalinity, and a significant change in their concentration, especially during intervals of repeated fluctuations [in P ?]. With the vertical extent of the ore bodies of 1000-1500 m, the Tc of cassiterite dropped from 450-480 to 330-350°C, with an average T-gradient of 15°C/100 m.

Formation of the deposits of the cassiterite-sulfide association in the sector of 1 km depth examined, took place at T ranging from 450-460 to 40-50°C, mainly from relatively low-concentration hydrothermal solutions (CO_2 8-10 mole %, and NaCl 15-20%). The most recent data show that in deposits of this group, mineralization may be traced over greater depths, and in this case, a change in facies of the mineralization with an increase in ore-quality takes place simultaneously with a rise in T and directional changes in the solution composition. With an established T-gradient of 10°/100 m, the vertical extent of mineralization may reach 2+ km.

The derived thermobarogeochemical parameters for the origin of the commerical ores have been successfully used in reassessing a number of deposits in the cassiterite-quartz association in the Khingan, Badzhal'sk, and Arminsk ore regions; as a basis for discovering a second (deep) stage of mineralization in the Komsomol'sk region; for predicting commerical ore bodies in deep horizons of cassiterite-sulfide deposits (Pionersk, Dal'netayezhnoye, Levitskoye, Vstrechnoye, etc.). (From the authors' abstract)

KOKSHAROV, V.A. and MYSNIK, A.M., 1985, The water content and thermobarometric peculiarities of the ore-forming fluids during massive-sulfide - polymetallic mineral-formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 106-108 (in Russian; translation by D.A. Brown). First author at Inst. Geol. Sci., Acad. Sci. Kazakh SSR, Ust'-Kamenogorsk, USSR.

Numerous studies of the compositions of volatile components extracted by thermo-vacuum decrepitation from massive-sulfide - polymetallic and gold-polymetallic associations in the Rudny (Ore) Altay show: H_2O, H_2S_2[sic], CS_2, SO_2, NH_3, Cl_2, H_2S, CO_2, SiF_4?, N_2O?, HCl, HF, SiH_4?, NO, S, and H_2SO_4 and similar indeterminate gases (N_2, H_2, CO, CH_4, and noble gases). In most of the analyses, the proportion of water is less than the total concentration of the other volatiles, that is, the bulk compositions of the mineral-forming media indicate their 'dry,' pneumothermal, and not hydrothermal nature. Only in isolated analyses does H_2O dominate over the remaining volatiles, reaching 70 and even 100 vol %. During determination of Th (in liquid) of various GLIs distinguishable under the microscope, and during cryometric observations, there is usually no doubt about the predominantly aqueous content of these GLIs, that is, about the hydrothermal nature of the mineral-forming systems.

In order to clarify the apparent contradiction between these phenomena, the authors carried out thermo-vacuum decrepitation of inclusions in a large number of monomineralic samples of ore-forming minerals in 3-9 T ranges (up to 500-560°C). A study of the compositions of the gas mixtures released in this case at different T has revealed the following changes in water concentration:

a) at relatively low Td (<100, <250, and ≤300°C), the proportion of water in the ore-forming fluids is maximal and comprises 100, 75-50, and <50 vol %;

b) at Td ≤450°C, the content of water in only individual cases reaches 50 vol %; and

c) at Td >450°C, the proportion of water is a few percent and rarely exceeds ~20-28%.

These data indicate the complex evolution of the composition, T, and the aggregate state of the fluid systems, which generated the deposits of the massive-sulfide - polymetallic association. The ore process is characterized by wide T ranges for mineral-formation and marked changes in the concentration of water and other volatiles. These phenomena were evidently dependent on the polyphase nature of the ore-generating processes, the overall trend of which may follow the sequence set out below.

1. Mineral-formation in the most productive stages takes place at high T and is generated by 'dry' pneumothermal systems, which may be regarded as the principal ore-forming systems. The relicts of these fluids are preserved in numerous ultramicroscopic, and therefore invisible inclusions. The content of water in the fluids is minimal, and the other volatiles and ore elements comprising them are transported in the gas phase.

2. Transformation of the ore system has primarily been controlled by lowering of T, as a result of increase in the role of H_2O in association with its condensation or the ingress of vadose waters. Simultaneously,

the more mobile volatiles of the gas system are displaced from the system. Under the influence of the qualitatively new aqueous-gaseous and aqueous solutions, partial solution of the earlier-precipitated ores, their retrograde metamorphism, recrystallization, and transfer of ore material may take place, with the formation of new associations and generations of minerals. The latter include the extremely large, essentially aqueous GLIs. These are evidently the objects of studies of GLIs by methods of homogenization, cryometry, etc. The difference in the present ore system (that of ore transformation) is in the hydrothermal nature of the mineral-formation.

3. Thermobarometry of GLIs, based on visual methods of study, describes the temperature and salt regime of only a part of the ore-generating processes, since it does not fully take account of a large number of ultramicroscopic inclusions in minerals of the early high-T and most productive stages. This feature must be taken into account during thermobarogeochemical studies of polyphase deposits. (From the authors' abstract)

KOLODIY, O.N., LYAKHOV, Yu.V. and the late MISNIK, Yu.F., 1985, Zonation of mineralization in the Baley region of Eastern Transbaikalia based on mineralothermobarogeochemical data (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 95-96 (in Russian; translation by D.A. Brown). First author at L'vov State Univ., L'vov, USSR.

New thermobarogeochemical studies verify the pneumatolytic-hydrothermal mineralization of the moderately-sulfide-rich, medium-depth association. They also support the truly hydrothermal origin of the shallow-depth, sulfide-poor association, represented in the form of stockwork and vein zones. The principal gold parageneses were formed, independent of the depth of mineralization, in the mid-T range (300-200°C) by Mg-Ca bicarbonate solutions with significantly increased concentration of the alkali elements and CO_2 (as compared with the non-productive phases).

Dome-like plutonic and volcanic-plutonic structures, 12-15 km in diameter, are, as a rule, associated with fields of predominant development of the medium-depth association, whereas the calderas are associated with the shallow-depth category. The established vector-gradients of regular T lowering (25-30°C to 4-6°C/100 m) (towards the upper horizons and from the center to the periphery), are correlated with changes in the thermoelectric fields[sic], and, as a rule, coincide with radial (horizontal) and conical (vertical) elements of structures of the central type.

The identification of the radial-ring structure of the ore fields and nodes has enabled us to discern the concentric arrangement of monotypical ore-shows along arcs of a single radius. The highest-T mineralization (molybdenite and tourmaline) has been developed close to the central plutons, being regularly replaced towards the periphery by a relatively low-temperature form (pyrrhotite-arsenopyrite, polysulfide, and fluorite-antimonite).

The endogenic-mineralization zonation revealed on the basis of correlation between mineralothermobarogeochemical and structural data has been used as a basis for prediction on various scales. (From the authors' abstract)

KOLPAKOVA, I.N. and MANACHURIANTS, B.O., 1986, Concentration of antimony, gold and hydrogen sulphide in hydrothermal solutions forming gold-stibnite ore (on the data on fluid inclusions) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 64 (in Russian). Authors at GEOHI, AN SSSR & IMGRE, Moscow, USSR.

The studied deposit is of gold-stibnite type. The main minerals are quartz, stibnite, berthierite; subsidiary minerals are pyrite, arsenopyrite, ferrous dolomite, muscovite and paragonite.

Detailed mineralogical and thermobarogeochemical studies show that the deposit was formed in two stages, quartz and stibnite, which were close in time to each other. Mineral associations of the first stage formed at 250-350°C and P = 1600-800 bar; of the second stage 250-170°C and P = 1000-600 bar. Ore-forming solutions have high concentrations of CO_2 (5-15 mole of CO_2 per 1 kg of H_2O).

Concentrations of H_2S in inclusions, established by a potentiometric method, average $\sim 10^{-2}$ M. Maximum concentrations of H_2S are characteristic for gold-stibnite stage. The content of antimony in inclusions of quartz is 10^{-2} to 10^{-3} M. For the quartz of the barren zones the concentrations of H_2S and Sb are low: $10^{-3.5}$ and 10^{-4} M respectively.

High concentrations of ore components and H_2S indicate that antimony and gold were transported in near-neutral solutions as hydro-sulfide complexes. Gold was transported also in the form of heteropoly nuclear complexes of the type of HA[sic] and SbS^-_3. (From the authors' abstract, translated by I.V. Kulikov)

KOMISSAROV, V.A., TRIFONOV, B.A., KOLOSKOV, V.P., KOLEDA, A.Ya. and PETROVA, N.N., 1985, Genetic model of formation of deposits of the gold-sulfide formation with temperature decrease in the areas of ore precipitation: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 2, p. 138-139 (in Russian).

Cited in Naumov, 1986 (this volume).

KONNERUP-MADSEN, Jens, 1986, A fluid inclusion study of the metamorphosed Fe-Zn-Pb massive sulphide ores of the Black Angel mine, central west Greenland (abst.): Abstracts of Posters, VII IAGOD Meeting, Lulea, Sweden, 18-22 Aug., 1986 (unpaginated). Author at Inst. Petrology, Univ. Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen, Denmark.

The stratabound massive Fe-Zn-Pb sulphide ore bodies of the Black Angel Mine, central west Greenland, occur in the lower Proterozoic Marmorilik Formation, which comprises a sequence up to 1200 m thick of carbonates with minor, intercalated fine-grained clastics and which overlies basement gneisses unconformably. The sulphide sheets have been interpreted as a sabhka-type deposit which was subsequently metamorphosed and deformed under middle greenschist facies conditions. During deformation, 3 types of ore tectonite developed: (D1) massive and banded ore, (D2) porphyroclastic ore, and (D3) remobilized ore.

Fluid inclusions, primarily in quartz from the various ore tectonites have been studied in order to establish the general characteristics of fluids associated with metamorphism and remobilization of the sulphides. Three main types of fluid inclusions were observed: (1) aqueous inclusions, (2) CO_2-CH_4 inclusions, and (3) mixed aqueous - CO_2-CH_4 inclusions. Aqueous inclusion fluids vary in salinity from about 1 to 45 equiv. wt % NaCl and have total Th and densities between 175° and 300°C and up to 1.19 grams/cm^3, respectively. CO_2-CH_4 inclusions vary in composition of the carbonic fluid from pure CO_2 to more than 80 mole % CH_4. Molar volumes vary between 40 and 50 cm^3/mole, irrespective of the CO_2/CH_4 ratio. Aqueous - CO_2-CH_4 inclusions have CO_2-CH_4 compositions similar to the pure CO_2-CH_4 inclusions but slightly higher molar volumes of the CO_2-CH_4 fluid. Total Th occurs up to 320°C, at calculated P generally around 2.5 kbar.

The compositional characteristics of the different fluid inclusion types together with their spatial distribution suggest the simultaneous existence and entrapment of a highly saline aqueous fluid (low in carbonic component) and a CO_2-CH_4-dominated fluid during metamorphism, deformation and remobilization of the ore. General conditions of 300-400°C and about 2.5 kbar are indicated, but higher fluid pressures and more CH_4-rich carbonic fluids may have prevailed during stages of shearing and porphyroclastic deformation of the ores and may have been influential in overthrusting of the ore bodies. The CO_2/CH_4 ratio of the fluids may have been governed by reactions between the sulphides in the ore. (Author's abstract)

KONONOV, V.V., 1983, Temperature conditions of formation of the pyrite mineralization of the Kunashir Island, in Ore deposits of the Far East, p. 84-88, Vladivostok (in Russian).
Cited in Naumov, 1986 (this volume).

KOPTELOVA, O.M. and TALANTSEV, A.S., 1985, Primary gas-liquid inclusions in amethyst of the Vatikha deposit (Central Urals) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 170-171 (in Russian; translation by Dorothy B. Vitaliano). Authors at Inst. Geol. & Geochem. Ural Sci. Center, USSR Acad. Sci., Sverdlovsk, USSR.

In amethyst crystals from the Vatikha deposit in the Central Urals, large P GLIs (up to 2-3 mm^3) of complex shape are encountered, with oriented development during crystallization and clearly expressed growth cones, indicating that there has been no post-trapping transformation of their form. In faintly colored varieties of amethyst they are two-phase (L_w+G) or have small amounts of liquid CO_2 phase, but in the quality amethyst raw material three-phase predominate (L_w+LCO_2+G); but in addition to these, two-phase CO_2 are common (LCO_2+G). Usually they are solitary; groups of syngenetic GLIs with sharply mainfested difference in filling are much rarer, and mainly in the faintly colored crystals. Usually such groups are located around planes of abrupt reduction in color in the crystal. S GLIs are rare in healed fractures.

Crystallization of the amethyst in fracture cavities was accompanied by crystallization of carbonates (calcite and ankerite). This feature of the mineralization in cavities permitted a detailed study of the PT conditions of crystallization of the amethysts by the methods of carbonate thermobarometry.

It turned out that regardless of the intensity of the color of the amethyst, crystallization of the amethyst "sceptres" (i.e.,both intensively and very slightly colored) began at 170°C and ended at 110°C. In contrast to this, the pressure in the mineralizing medium was essentially different in the crystallization of the varieties with different intensity of color: in faintly colored ones it was ≤120-160 bar, while the brightly colored ones crystallized at ≥300-400 bar. On the whole, it should be concluded from the results obtained that the fracture systems in which the amethyst formed were natural analogs of thermal-gradient autoclaves. With their relatively closed character, the quality amethyst crystals were formed under conditions of high pressures and CO_2 concentrations, with some decrease in intensity of the color from top to bottom; where CO_2 escaped under the influence of tectonics and the pressure in the system dropped, faintly colored varieties crystallized.

P GLIs in brightly colored amethysts yielded Th that was clearly too high. Such systematic exaggeration of Th compared to the T of mineralization, determined by the carbonate thermobarometer, is caused by the fact that the mineralizing medium preserved in the inclusions was heterogeneous right from the beginning.

In contrast to this, in series of P inclusions in faintly colored amethyst crystals, T ranges of mineralization in good agreement with the data of carbonate thermobarometry were obtained on the basis of the principle of picking the minimum Th in each series. Statistically, for each quarter of the investigated GLIs, a Th value was obtained which corresponded to these data. Let us mention that in this case, the Th of all the inclusions with separate CO_2 phase at room temperature turned out to be too high.

If we had only the data on Th of P GLIs at our disposal, it would be logical to conclude that the faint-colored amethysts crystallized at a lower T than the bright-colored. But as we have seen, that is incorrect. This is caused by the fact that in the vast majority of cases the three-phase (L_w+LCO_2+G) P inclusions have a Th substantially above the Tt. This feature should always be taken into account in genetic formulations. (From the authors' abstract)

KORMUSHIN, V.A., KUDRYASHOV, A.V., DARBADAYEV, A.B. and LIPOVA, Z.M., 1985, Model composition of the ore-forming solutions of the greisen-quartz vein deposits of Central Kazakhstan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 220-221 (in Russian; translation by Dorothy B. Vitaliano). Authors at Inst. Geochem. Sci., Kazakh Acad. Sci., Alma-Ata, USSR.

In Central Kazakhstan a group of greisen-quartz vein rare metal deposits has been distinguished. It comprises three main ore formations: W-Mo (Akchatau and Karaoba), W (Baynazar) and Mo (Seltey). The main genetic and compositional features of their affinity are: spatial and genetic relationship to acid and peracid granite intrusions of the late stage of the Hercynian tectonomagmatic cycle; concentration of ores in greisen bodies, veins and veinlet filling; typical metasomatic and ore zoning; characteristic set of ore and volatile components and trace elements.

W-Mo type: 1. Akchatau - subparallel accumulations of en-echelon veins localized in the endo- and exocontact of a peracid granite massif. Two main stages (after G.N. Shcherba, 1960) are distinguished in the mineral formations: 550-320° and 480-190°C. Tf of the main ore-bearing quartz veins were 380-280°C, the P 100-80 MPa. The total concentration of the solutions was 397 kg/m^3 (salts, 209 kg/m^3; gases, 188 kg/m^3). The model composition was established [as given in table].*

2. Karaoba consists of radial and concentric veins in the inner intrusive zone of the granite massif. Three main ore stages are distinguished: 550-350°; 470-250°; and 430-180°C. The main W-quartz veins were formed at 395-250°C and P of 70-50 MPa. The total concentration of the solutions was 166.8 kg/m^3, of salts 126.2 kg/m^3, and of gases 46.6 kg/m^3. Model composition [given in table].

			Concentrations (kg/m^3)														
Deposit	T (°C)	P (MPa)	H_2O**	Na	K	Ca	Mg	Cl	HCO_3	F	SO_4	CO_2	CO	CH_4	H_2O**	H_2	H_2S
Akchatau	380-280	~100-80	627	54.8	15.2	8.0	0.2	116	11.2	2.9	0.6	158	17	9	3	0.8	--
Karaoba	380-350	~70-60	637	28.2	10.9	3.0	2.4	27.5	36.8	11.9	5.4	31.5	--	5.0	--	--	4.2
Baynazar	350-270	~100-50	679	13.1	23.4	5.8	0.2	74.8	(16.3)	4.5	1.8	193	3.5	15.1	--	--	29.9
Seltey	380-320	~100-80	657	17.5	31.4	0.5	0.5	49.6	42.6	5.8	2.6	107	6	--	0.8	--	4.8

*The distinction between the two values for H_2O is not made in the text. (Ed.)

Tungsten type. Baynazar -- a stockwork, linear type, localized in the supraintrusive zone of the granite massif. Pre-ore stage 335-300°, ore stage 450-200° (P from 120 to 40 MPa) and post-ore stage 240-100°C. The main W-quartz veins and veinlets were formed at 350-270° and 100-50 MPa. The total concentration of the solution was 381.5 kg/m^3, including

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*The compositons were originally given in a typographically awkward format; they have been reformatted into a table. (Ed.)

salts 140 and gases 241.5 kg/m^3. Model composition [given in table].

Molybdenum type. Seltey -- vein-stockwork zones situated in the endo- and exocontact of a massif of microgranite porphyry. Pre-ore ~500°C; in the ore stage two rhythms are distinguished: 475-355° and 455-300°C. The P ranged from 200-40 to 10 MPa. The main ore formations are quartz veinlets of the second rhythm; the model composition [is given in table].

The results of thermobarogeochemistry and the model compositions obtained indicate that these data depend on the depth of development of the parent intrusion and erosional truncation of the deposit. The K/Na ratio is most informative; it is taken from the model composition of the solutions. It can be used as an indirect criterion of the preservation of ores in the body. (Authors' abstract)

KOROTAYEV, M.Yu., MATVEYEVA, S.S. and VALYASHKO, L.M., 1985, Fluid regime of the greisenization process (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 218-219 (in Russian; translation by Dorothy B. Vitaliano). Authors at Moscow State Univ., Moscow, USSR.

The variation in composition of the hydrothermal solutions in the zoning of the greisens is estimated from of the variation in PTX parameters of fluid inclusions and from the behavior of the elements in the course of greisenization. The pseudomorphic structure of quartz-muscovite greisens is emphasized by the zonal structure of the quartz grains, each zone corresponding to a specific set of fluid inclusions which differ in morphology and composition of the solutions. Metasomatic quartz syngenetic with the muscovite of the greisens is characterized by the presence of P crystal-fluid inclusions with bulk concentration of dxls, mainly NaCl and KCl, of up to 50-70 vol.%, in addition to gas (G) and GLIs. Analysis of the proportion of crystal-fluid and GLIs shows that the relative amount of G and GLIs increases in the interior zones of the metasomatic column and upper parts of the greisen body. (From the authors' abstract)

KORTEMEIER, C.P., 1986, Geology and mineral deposits of the Tip Top district Yavapai County, Arizona: Ariz. Geol. Soc. Digest, v. 16, p. 468-472. Author at Ariz. State Univ., Tempe, AZ 85287.

Reconnaissance fluid inclusion studies indicate that the veins are epithermal. Ag mineralization took place in the interval between 205°C and 255°C. Intermittent fluid boiling may have helped localize ore shoots.

The Tip Top district is a Ag end member epithermal deposit characterized by a low-sulfur mineralogy, a low-sulfur alteration assemblage, and a distinct geochemical assemblage. (From the author's abstract)

KORTEMEIER, W.T. and BURT, D.M., 1986, Evidence for the magmatic origin of ongonite and topazite dikes in the Flying W Ranch area, Tonto Basin, central Arizona (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 661.

KORYTOV, F.Ya., KUDRIN, V.S., PROKOF'YEV, V.Yu. and RYABENKO, S.V., 1984, Genesis of cryolite: Dokl. Akad. Nauk SSSR, v. 279, no. 6, p. 1464-1467 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., v. 279, p. 187-189, 1986). First author at Inst. Mineral., Geochem. & Crystal Chem. of Rare Elements, All-Union Res. Inst. of Mineral Products, Moscow, USSR.

Abstract in Fluid Inclusion Research, v. 17, p. 172, 1984. (E.R.)

KORYTOV, F. Ya., PROKOF'YEV, V. Yu., and MEL'NIKOV, F.P., 1985, Conditions of formation of the rhodonite deposits of the Urals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 183-185 (In Russian; translation by Dorothy B. Vitaliano). First author at Inst. Min. Geochem. and Crystallochemistry of Rare Elements, Moscow, USSR.

The rhodonite deposits in the Urals have been known for a long time and have attracted the attention of many investigators. Despite that fact, fundamental problems of their origin still remain controversial. According to the most popular point of view, these deposits were formed by metamorphism of originally sedimentary manganese ores (Fersman, 1920; Betekhtin, 1948; and others).

To ascertain the conditions of formation of the rhodonite ores of the Urals, the authors used the methods of thermobarogeochemistry. Samples of rhodonite ores for the investigations were taken from the main occurrences of the Malo Sedel'nikovo deposit, the largest in the Urals. The deposit is located in the southeastern exo-contact of the Sedel'nikovo granite massif, localized in the inner part of a ring structure about 15 km in diameter.

In the deposit there are several lenticular occurrences of rhodonite, in Silurian siliceous shale [shist?]. In conformable and crosscutting ore bodies, in addition to rhodonite there are present garnet, bustamite, quartz, rhodochrosite, calcite and other minerals. Sr, Ti, Ag, Au, Pb, Mo, and other trace elements are present in the rhodonite. In the country rocks (shales, etc.) high concentrations of W and Sn have been found (up to 0.01%).

In the minerals of the ores (rhodonite, bustamite, quartz), the authors were the first to find P and S GLI. They are in the form of negative crystals, 3 to 15 μm in size, and have Th 180-360°C. The highest Th inclusions (280-360°C) were established for quartz from quartzite-like rocks. These inclusions contain two immiscible liquids and gas. Partial homogenization of these inclusions occurs at 15-18°C. The ice melts [$TmCO_2$?] at -56.8 to -57.2°C, which indicates the presence of pure CO_2. The gas hydrates dissolve at +9.0°C. P at Th is 1.6-2.2 kbar. In this same quartz there are S GLI with Th 200-210°C. Homogenization of the P GLI to the liquid phase occurs at 180-280°C, and in bustamite, at 240-270°C.

Inclusions in the rhodonite contain an aqueous solution which freezes at -35 to -40°C. The beginning of melting of ice [Te?] is recorded at -26 to -25°C, which indicates that Na and K chlorides predominate in the solution. Tm ice occurs at -1.4 to -2.0°C, which is typical of solutions of low concentration (2-3 wt.% NaCl-equiv.).

It was established that quartz was the first to crystallize, from medium to low T water CO_2 solutions, forming lenses and veins of quartzite-like rocks. Later, rhodonite, bustamite, spessartite and other manganese minerals were formed from manganese-bearing chloride solutions, by filling of open cracks in the quartz and its metasomatic replacement. In the final stage, rhodochrosite, calcite and sulfides crystallized out of the hydrothermal solutions at relatively low temperature (<200°C). The process of mineralization occurred under decreasing P and a change in composition of the hydrothermal solution.

Thus, the data obtained indicate a medium to low T hydrothermal metasomatic origin for the rhodonite deposits of the Urals. From this standpoint, the prospects for finding new deposits of rhodonite in the Urals, and primarily in deep horizons of the marginal zone of the Sedel'nikovo ring structure, are considerably enhanced. (Authors' abstract)

KORYTOV, F.Ya., PROKOF'EV, V.Yu. and NAUMOV, V.B., 1985a Genesis of fluorite in cap rocks of salt domes of Taymyr: Doklady Akad. Nauk SSSR, v. 280, no. 2, p. 435-4384 (in Russian). First author at Inst. Mineral., Geochem. & Crystallochem. of Rare Elements, Moscow, USSR.

In the Taymyr metallogenic province, E. part of the Khatang rift structure filled by Mesozoic sediments, the salt domes of the mountains: Belaya, Nordvik, Kozhevnikova, Seraya and Ledovka, are known; deposits of oil and gas are related to some of the domes. Cap rocks of these domes achieve thickness up to 200 m. Anhydrite-gypsum cap rocks contain unique cubic and rarer octahedral transparent crystals of fluorite. The studied fluorite from the domes Belaya and Nordvik forms crystals up to 4-5 cm of cube edge, occurring in nests and veinlets in gypsum-anhydrite rock; in addition to fluorite also quartz, danburite, prehnite, hematite, actinolite, epidote, chlorite, native sulfur, etc. occur there. All fluorite crystals bear P inclusions containing LH_2O, LCO_2, GCO_2 and halite crystals. Te ranges from -65 to -51°C indicating presence of Ca salts in solution (Te of inclusion in halite from Sol'-Iletsk and Nordvik domes -38 to -36°C, in parentheses further data on halite from this dome), disappearance of gas hydrate -40 to -26.2°C (-33 to -2.4°C), dissolution of halite crystal 170-330°C (-3.8 to -1.6°C), partial LCO_2 + GCO_2 homogenization 21.0 to 28.3°C (--), Th 280-330 (Belaya) and 80-100°C (Nordvik), (104-280), P kbar 1.0-2.5, total salt concentration 30-36 wt.%. The data indicate the endogene origin of solutions which formed cap rocks. (Abstract by A.K.)

KORYTOV, F.Ya., PROKOF'YEV, V.Yu. and NAUMOV, V.B., 1985b, Ore-salt-dome formation: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 1, p. 38-39 (in Russian).

Cited in Naumov, 1986 (this volume). See previous item. (A.K.)

KORZHINSKIY, A.F., KOVALISHIN, Z.I. and PLATONOVA, E.L., 1985, Physicochemical conditions of formation of the Kholtoson rare-metal deposit in Transbaikalia based on a study of inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 96-98 (in Russian; translation by D.A. Brown). First author at IGGGI of Acad. Sci. Ukrain. SSR, L'vov, USSR.

The Kholtoson [Kholtason in this text] tungsten deposit has been spatially and genetically associated with the injection of a small Mesozoic granite-porphyry intrusion at the contact between a Caledonian quartz-diorite massif and a Cambrian sedimentary-volcanic sequence. It consists of large quartz veins, containing hübnerite and fluorite, and less commonly, scheelite and polymetals (sphalerite, galena, chalcopyrite, tetrahedrite, etc.). As a result of the activity of HF-bearing hydrothermal solutions, the quartz-diorite around the veins has been converted into a fluorite-sericite greisen, impregnated with pyrite. The veins display a distinct zonation: 1) quartz-diorite, propylitized with the appearance of epidote, chlorite, and calcite; 2) a fluorite-sericite-quartz greisen with pyrite segregation (width of zone 0.5 m in the footwall, and 1 m in the hanging wall of the vein); 3) a gilbertite selvedge (width 1-2 cm), being replaced by fluorite lenses; and 4) a vein-quartz rock of grayish-white color, containing hüebernite and fluorite, which ususally congregate towards the vein selvedges.

The inclusions of mineral-forming fluids in quartz of two generations, in hüebnerite, and in fluorite of two generations have been examined. Both primary (with zonal arrangement, and regular negative form) and early-secondary (arranged along the fissures) inclusions have been found. Along with gas-liquid inclusions in quartz-I (Th = 265-295°C), there are syngenetic inclusions with liquid CO_2 (d = 0.56). In the drusy quartz (II), syngenetic with the polymetal sulfides, the primary gas-liquid inclusions are 70-75% filled with liquid (Th = 265°C). The thermometric characteristics of the fluids of quartzes I and II are very similar. This is indicated by the closely similar pH values for the individual inclusions (pH = 7.2).

Fluorite was precipitated over a long interval, and in this instance under markedly different conditions. Besides syngenetic generations with hüebnerite and sulfides, colorless or greenish fluorite crystals occur in the vein and fissure cavities. Inclusions with liquid CO_2 have been found in the fluorite. Partial homogenization has been observed at T = 28°C, and they completely homogenize at 140-145°C (pH = 5.4).

The maximum quantity of gases (160.5 mL/kg) has been found in a drusy quartz-II. The gas phase (volume %) consists of 58.9 CO_2, 36.3 H_2, 1.7 CH_4, and 3.1 N_2. We have also examined the gas from the quartz-diorite, greisen, quartz-sulfide rock, and the white coarse-grained vein quartz.

Na and K are present in water extracts from vein quartz I and II, and Cl and HCO_3; Na>K, Cl>HCO_3. The same ions are present in a water extract from fluorite I, but K>Na, and HCO_3>Cl. Thus, the mineral-forming fluids in the Kholtoson rare-metal deposit were initially enriched in Na and Cl ions, but towards the end of the process the concentrations of K and HCO_3 had increased. Increased amounts of CO_2 are typical in the mineral-forming solutions. (From the authors' abstract)

KORZHINSKIY, M.A., 1985, Diopside-wollastonite equilibrium in a supercritical chloride fluid: Geokhimiya, no. 10, p. 1430-1440 (in Russian; translated in Geochem. Int'l., v., 23, no. 3, p. 143-153, 1986).

KOSUKHIN, O.N., BAKUMENKO, I.T. and CHUPIN, V.P., 1984, Magmatic stage of formation of the granitic pegmatites: Trudy Inst. Geol. & Geophysics, v. 476, ed., Yu.A. Dolgov, 136 pp., Siberian Branch of "Nauka" Publ. House, Novosibirsk (in Russian). (See Translations)

KOSTYRKO, A.A. and NAUMOV, V.B., 1985, Fluid inclusions in minerals from Kola-series rocks: Geokhimiya, no. 12, p. 1795-1799 (in Russian; translated in Geochem. Int'l., v., 23, no. 5, p. 159-163, 1986). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Includes data on the gross chemical composition, Tm[CO_2?], Th, density, and pressure [calculated] for 8 rocks. See next item. (E.R.)

KOSTYRKO, A.A., NAUMOV, V.B. and PETROV, V.P., 1985, Investigations of fluid inclusions in minerals of the metamorphic rocks of the Kola Peninsula (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 197-199 (in Russian; translation by Dorothy B. Vitaliano). Authors at Vernadsky Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

On the Kola Peninsula (eastern part of the Baltic shield), Archean supracrustal formations are represented by two large complexes: the Kola series and the Ponoy-Lebyazh'ye complex (PLC), which differ sharply from one another both in composition and in degree of metamorphism. The rocks of the Kola series consist of gneisses and schists, metamorphosed under amphibolite and granulite facies conditions. They are metamorphosed sedimentary and volcanogenic-sedimentary formations. The development of charnockites is related to the epoch of granulite metamorphism. The PLC consists of volcanics of basaltic, andesitic, dacitic and rhyolitic composition, metamorphosed under conditions of the epidote-amphibolite facies. The PLC lies on microcline-plagioclase granites of the basement and is overlain by aluminous shales [schists?] of the Keyvyy suite.

In quartz, cordierite, kyanite and garnet of the rocks of these complexes, in the shales of the Keyvyy suite, and in the granites of the basement of the PLC, the following types of fluid inclusions have been found: 1 - CO_2, 2 - CH_4, 3 - H_2O. A predominance of inclusions of type 1 is typical of the rocks of the granulite facies, and of type 3 of the rocks of the amphibolite and epidote-amphibolite facies. CH_4 inclusions occur in some samples of rocks of the granulite facies. In the quartz of the charnockites, crystallized melt inclusions were observed.

Th of inclusions of type 1 vary: in the rocks of the Kola series, from -5.4 to +20.3°C (amphibolite facies) and from -27.5 to +15.9°C (granulite facies); in the Keyvyy shales from -26.0 to +3.2°C; and in the granites of the basement of the PLC from -25 to +20°C. The use of PVT data for CO_2 gives the following ranges of values (in kbar): for rocks of the Kola series, 2.2-4.8 (T = 500-650°C) and 3.4-6.8 (T = 680-750°C), for the Keyvyy shales 2.1-5.3 (T = 500-550°C), and for the granites 2.4-5.3 (T = 500-550°C). The Tm CO_2 varies from -56.6 (pure CO_2) to -58.8°C, which may be caused by the presence of CH_4, the molar amount of which is 0.05 in this case. Th(L) CH_4 occurs at -87.5 to -91.0°C, which corresponds to a high density (0.24-0.26 g/cm^3). With T of metamorphism of 680-750°C, the CH_4 pressure reached 2.2-2.6 kbar.

The Th of aqueous inclusions in the rocks of the Kola series falls in the interval 125-190°C. Cryometric investigations and observations of Tm halite made it possible to estimate the concentration of the solution: 10-30 (wt.%). Low Te (to -47°C) indicate the presence of substantial amounts of Ca and Mg in the solution.

In the basement of the PLC there are microcline-plagioclase granites containing water inclusions with low Te (to -48°C). Inclusions of CO_2 are absent in this type of granite. In the gneisses and amphibolites of the PLC, the aqueous inclusions have Te from -18.8 to -40°C, and concentrations of 5-20 wt.%. In the gneisses from the zone of contact with the alkaline granites of the Ponoy massif, S inclusions with Te of -2.6 to -14°C appear. In the quartz of the alkaline granites of this massif, which intrudes the PLC, aqueous inclusions were found which had Te from -2 to -9.4°C and low concentration of the solution (1.7-5 wt.%). (Authors' abstract)

KOTEL'NIKOV, A.R., 1986, Study of stability of the sulfur-bearing scapolite in hydrothermal conditions: Geokhimiya, 1986, no. 7, p. 787-996 (in Russian; English abstract).

Synthesis of the sulfur-bearing scapolite has been made an T = 600 to 800°C, P(fl) = 2 kbar and CO_2/SO_3 ratio in the fluid controlled by the calcite-anhydrite buffer. (From the author's abstract)

KOTELNIKOV, A.R. and SHCHEKINA, T.I., 1986, Experimental study of kinetics of interaction of plagioclases wtih water-salt fluid at 500°C and $P_{fl} = 1$ kbar: Geokhimiya, 1986, no. 9, p. 1233-1244 (in Russian; English abstract).

A partition of Ca and Na between plagioclase and 1 M solution ($CaCl_2$ + NaCl) at 500°C and 1 kbar was under study. It has been shown that the character of approach to equilibrium is complex: first, an equilibrium has been reached between the homogeneous plagioclase solid solution and the water-salt fluid (in 60 days), then, as a result of increase of duration of experiments up to 80-100 days an exsolution of plagioclase solid solution has occurred. So a rather long time (90-100 days) is necessary to reach equilibrium of reaction plagioclase-solution in the case when plagioclase subsolidus transformation occurs. Boundaries of immiscibility fields are An(10±5) - An(35±10) and An(50±7) - An(85±10). It was shown that at 500°C and 1 kbar plagioclase has more Ca than the solution if $X_{Ca}^{Pl} > 0.15$ and vice versa, if $X_{Ca}^{Pl} < 0.15$. (Authors' abstract)

KOTEL'NIKOVA, Z. A., KOTEL'NIKOV, A. R., 1985, Gas regime in metamorphism of the Khankay massif, according to data of study of fluid inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 228-229. (In Russian; translation by Dorothy B. Vitaliano). Authors at ILS, USSR Acad. Sci., Moscow, USSR.

In the Precambrian metamorphic sequence of the Khankay massif, rocks of the garnet-cordierite and orthoclase-biotite-sillimanite facies of the Iman series (Lower Proterozoic) have been studied in detail. Study of the composition of the rock-forming minerals made it possible to calculate the PT parameters of metamorphism: 750-675°C (garnet-cordierite facies) and 680-470°C (orthoclase-biotite-sillimanite facies) and 5.8-2.0 kbar (total P). The composition of the metamorphic fluids was studied by cryometry and gas chromatography and yielded the following results.

Cryometric measurements of inclusions of solutions (type L or L+G) indicate the presence of NaCl, $MgCl_2$ and $CaCl_2$. The very small size of the inclusions precluded studying in detail the phase transitions at low T and determining the quantitative relationships of the components. The concentrations determined as NaCl equiv. range from 12.0 to 16.5%.

Inclusions of dense liquid CO_2 were found. The fluid P was determined by Dolgov's method (1967). The average Th vary from -17 to 0°C and the corresponding specific volumes from 1.00 to 1.10 cm^3/g. Thus for the garnet-cordierite facies P of the order of 7.0-4.8 kbar were obtained, and 6.3-3 kbar for the orthoclase-biotite-sillimanite.

Six samples of carbonate-silicate and high-alumina rocks were selected for gas-chromatographic analysis. Carbonates were removed by washing in hydrochloric acid, then the sample was dried at 105°C for 10 minutes. The two successive portions of gas liberated when the samples were heated for 10 minutes at 500°C and then at 700°C were analyzed. The main components of the fluids were water (78-88 vol.% for the low-T fraction and 30-40 vol.% for the high T) and CO_2 (4-6 vol.% for the low and 12-52 vol.% for the high-T fraction). In addition, N_2, CH_4, and H_2 were found in small amounts. The composition of the high-T fraction of the gases is more reduced than that of the low-T fraction. (From the authors' abstract)

KOTELNIKOVA, Z.A., KOTELNIKOV, A.R. and SAMOVAROV, Yu.V., 1986, Evolution of metamorphism of Khankaysky massif: Study of fluid inclusions and geothermobarometry: Geokhimiya, 1986, no. 8, p. 1101-1112 (in Russian; English abstract).

A study of fluid inclusions in the Early Proterozoic rocks of Khankaysky massif led to their classification into several types. Density varying from 1.05 to 0.87 g/cm^3 was determined for the liquid CO_2 inclusions. The water inclusions have Th of 105 to 411°C and contain solutions of Na, Ca and/or Mg chlorides. The essentially gaseous inclusions are composed of methane and nitrogen. According to gas-chromatography data the main components of fluid were water and CO_2. From mineral equilibria [the] P-T conditions and composition of fluid phase were calculated and the trend of their changing in the metamorphic process was determined. A correction of the P-T trend was made from comparison of studies of fluid inclusions and mineral equilibria. Retrograde metamorphism occurs at 910 to 540°C and 7.7 to 3 kbar. (Authors' abstract)

KOTOV, Ye.I., TIMOFEYEV, A.V., MEL'NIKOV, I.V. and KRYLOVA, T.L., 1985, Temperature conditions of formation of hydrothermal uranium oxides in different epochs of ore formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 157-158 (in Russian; translation by Dorothy B. Vitaliano). First author at Inst. Geol. Ore Dep., Petrog., Min. & Geochem., USSR Acad Sci., Moscow, USSR.

It was established that deposition of U oxides and formation of mineralization of various mineral types occurred at different temperatures.

The uraninites from the ores of the Karelian epoch were deposited at 400-350°C with an overall temperature range of mineral formation of 500-200°C.

In the Caledonian, Hercynian and Kimmeridgian epochs, hydrothermal mineralization occurred at 350-300 to 100-80°C. Pitchblende, the main U mineral of the ores of these epochs, was deposited in the 220-180°C interval. Th of primary gas-liquid inclusions in calcite of the main U paragenesis of the Hercynian calcite-sulfide-pitchblende ores showed that this paragenetic association was deposited in a somewhat broader interval -- 240-180°C.

The Alpine calcite-marcasite-pitchblende mineralization is characterized by lower temperatures of formation: pitchblende deposited in the 150-110°C interval, with an overall range of 250-80°C.

A general lowering of temperature of U mineralization from the Karelian to the Alpine epoch is observed, although during the Paleozoic and Mesozoic the temperature conditions of deposition of pitchblende and formation of U mineralization were rather similar.

The formation of U mineralization of all the enumerated mineral types and ages occurred against a background of a decrease in T of the hydrothermal solutions and was characterized by T inversions at the boundaries of the stages of mineral formation. (From the authors' abstract)

KOVALENKER, V.A., NAUMOV, V.B., PROKOF'EV, V.Yu. and BORTNIKOV, N.S., 1986, New data on the chemistry and temperature of ore-forming solutions of low-depth gold-silver ore mineralization: Dokl. Akad. Nauk SSSR, v. 291, no. 3, p. 672-676 (in Russian). Authors at Inst. Geol. Rudn. Mestorozhd. Petrogr. Mineral. Geokhim., Moscow, USSR.

Epizonal (low-depth) Au-Ag ore deposits, with primary sulfides <2-3 wt.%, developed in 3 stages of mineralization. The productive stage had varied sulfide mineralogy, including chalcopyrite, sphalerite, Se-containing sulfoantimonites of Ag, freibergite, tetrahedrite, etc. Thermometric and cryometric studies of fluid inclusions in minerals showed that the early productive stage occurred at 330 to <50°; most of the Au-containing parageneses with sulfosalts and tellurides formed at 190 to 100°. The post-productive barite and quartz derived from cold (<70°) aqueous solutions. Eutectic temperatures (T) suggest 2 types of ore-forming solutions; the early productive stage is attributed to solutions with NaCl>KCl (with T -21 to -27°). The major productive stage had solutions containing NaCl + KCl + $CaCl_2$ + $MgCl_2$ (with T -39 to -50°). (C.A. 106: 53433g)

KOVALENKER, V.A., NOVGORODOVA, M.I. and NOSIK, L.P., 1985, Redox conditions of formation of minerals of the commercial-ore stages of gold-ore deposits from data of gas-liquid inclusion studies: Degassing of the Earth and geotectonics: Abstracts of papers of the II All-Union Symp., Moscow, "Nauka," p. 58-59 (in Russian).

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KOVALENKO, I.V., DOROGOVIN, B.A. and SVIRIDENKO, A.F., 1985, On the question of the physicochemical conditions of jadeite formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 222-223 (in Russian; translation by Dorothy B. Vitaliano). Authors at VNIISIMS, Aleksandrov, USSR.

In bodies with jadeite mineralization, metasomatic formations are common. On the basis of geologic mapping and study of mineral parageneses the following order of formation on metasomatites (from early to late) was established: albitites and albite-amphibole rocks, quartz-bearing rocks with monomineralic segregations of "icy" quartz and jadeitite. The jadeitites were formed in two stages: in the first, white and gray rock-forming jadeite crystallized; in the second, green (jewelry and ornamental) pyroxenes.

Thermobarometric investigations of gas-liquid inclusions (≤10 μm) were made on the albitites, albite-amphibole and quartz rocks and jadeitites. The pressure was determined from inclusions containing CO_2. The Itmurundy deposit in the Balkhash area was formed in three stages: stage I, manifested in albitization of feldspathic rocks -- 480-520°C, 3.5-4 kbar; stage II, accompanied by deposition of quartz in albitites and amphibole-albitite rocks -- 330-370°C, 1 kbar; stage III, substage 1, leading to the formation of rock-forming jadeite -- 490-550°C, 4.5-5 kbar; substage 2 (ore), during which the green pyroxene was deposited -- 320-365°C, 1.5 kbar. The concentration of NaCl in the solutions in the inclusions in amphibole from the albitite is 30-35%, in quartz from the quartz-bearing rock, 3-8%, in gray jadeite, 12-28%, and in the green pyroxene, 10-15%.

These investigations indicate the evolutionary character of the development of the mineralizing medium. The presence of graphite and native lead in the jadeitites and wall rocks indicates the reducing character of the medium during jadeite formation. (Abbreviated by E.R. from the authors' abstract)

KOVALENKO, N.I., RYZHENKO, B.N., BARSUKOV, V.L., KLINTSOVA, A.P., VELYUKHANOVA, T.K., VOLYNETS, M.P. and KITAYEVA, L.P., 1986, Experimental study of cassiterite dissolution in solutions of HCl, HCl + NaCl(KCl) at T = 500°C, P = 1000 atm and fixed redox conditions: Geokhimiya, 1986, no. 2, p. 190-205 (in Russian, English abstract; translated in Geochem. Int'l., v., 23, no. 7, p. 1-16, 1986). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

A conclusion was made that transport of tin by the supercritical fluids at the postmagmatic stage is realized predominantly by hydroxochlorine-complexes of bivalent tin. (From the authors' abstract)

KOVALENKO, V.I., NAUMOV, V.B. and BOGATIKOV, O.A., 1986, Natural silicate and salt melts, fluids, and associated mineralization: Geologiya i Geofizika, v. 27, no. 7, p. 52-55 (in Russian; translated in Sov. Geol. & Geophys., p. 27, no. 7, p. 41-43).

The chemical and phase composition and regime of fluids in magmas of basic acid composition and the associated mineralizing systems are discussed, mainly according to data from analyzing inclusions in minerals. (Authors' abstract)

KOVALENKO, V.I., SOLOVOVA, I.P., NAUMOV, V.B., RYABCHIKOV, I.D., IONOV, D.A. and TSEPIN, A.I., 1986, The mantle mineral-formation with participation of carbon dioxide-sulfide-silicate fluid: Geokhimiya, 1986, no. 3, p. 289-303 (in Russian, English abstract; translated in Geochem. Int'l., v., 23, no. 7, p. 66-79, 1986). First author at Inst. Ore-Deposit Geol., Petrogr., Min. & Geochem., Acad. Sci. USSR, Moscow, USSR.

The unique samples of the mantle-derived xenoliths from alkaline-basalt volcano Shavaryn-Tsaram in Mongolia are described: a druse of large faceted crystals of clinopyroxene and garnet, growing on the usual spinel lherzolite, and "bubbled" megacrysts of clinopyroxene containing numerous large voids lined in fine-grained aggregate of glass, sulfides and other phases. Under study was a composition of P and PS inclusions which were subdivided into four types, including sulfide-silicate-fluid having the immiscibility character. Composition of the main minerals and dms in microinclusions of both the druse and the megacrysts are practically the same. Their origin is related with formation from fluid. The fluid was evidently an emulsion of the high-density CO_2 (~70 vol.%) with suspended drops of sulfide-silicate melts (~30 vol.%). High-potassium residual melt after crystallization of silicate material can be a source of alkaline magmas. (Authors' abstract)

KOVALENKO, V.I., TSEPIN, A.I., IONOV, D.A. and RYABCHIKOV, I.D., 1985, Garnet-pyroxene druse - example of fluid crystallization in mantle: Doklady Akad. Nauk SSSR, v. 280, no. , p. 449-4534 (in Russian). Authors at Inst. Geol. Ore Deposits, Petrogr., Mineral. & Geochem. of Acad. Sci. USSR, Moscow, USSR.

This paper bears no inclusion data but it gives the detailed characteristics of the probably mantle-origin garnet-pyroxene druse from Shavaryn-Tasaram (Mongolia), next thoroughly investigated for fluid inclusions, see Solovova et al., 1985, Fluid Inclusion Research, v. 18, p. 391. (A.K.)

KOVALISHIN, Z.I. and VISHTALYUK, S.D., 1985, Composition of ore-forming fluids of the northwestern part of the Marmarosh massif: Mineral. Sbornik L'vov. Univ., v. 39, no. 2, p. 76-80 (in Russian).

Cited in Naumov, 1986 (this volume).

KOVALISHIN, Z.I., VISHTALYUK, S.D. and STEPANOV, V.B., 1985, The genetic characteristics of quartz-vein formations in one of the Transcarpathian ore-shows (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 92-93 (in Russian; translation by D.A. Brown). Authors at IGGGI AN Ukr. SSR, L'vov, USSR.

In the area examined, mineralization is confined to the upper Proterozoic and Paleozoic metamorphic rocks. Ore minerals occur in insignificant amounts (up to 1% of the mineral mass of the rock) and are mainly confined to the quartz veins which are almost monomineralic, except for traces of plagioclase, carbonate, and mica. Four varieties of quartz veins are distinguished: light-gray, spotted, gray, and white.

The quartz contains three types of inclusions, P, early S[sic], and late S. The first are rare, have no connection with cracks, and occur in growth zones in gray and white quartz with pyrite and pyrrhotite. Th(L) is 315-380°C.

Quartz containing ore mineralization (light-gray and spotted varieties), also contains early-secondary inclusions. They are confined to wedging-out cracks, their shape is laminar and tubular, and they measure up to 0.02 mm; they occur in the form of broken chains and have Th = 240-275°C. Segregations of idiomorphic, zoned pyrite plus sulfides of copper, lead, and zinc, and tellurides of lead, and other metals, are confined to such cracks. The most widespread are the late-secondary inclusions, occurring in all the varieties of quartz and confined to the cross-cutting cracks; Th = 120-160° and 180-240°C. (From the authors' abstract)

KOZERENKO, S.V., BARANOVA, N.N., KOLPAKOVA, N.N., DAR'INA, T.G. and GORIACHEV, N.A., 1986, Antimony, gold, and hydrogen sulphide contents in mineral-forming solutions of some gold deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 65-66 (in Russian). Authors at GEOHI AN SSSR, Moscow, USSR.

1. By the methods of thermobarogeochemistry a number of gold-ore deposits were studied, including the gold-sulphide, gold-rare metal and gold-silver types. Methods for establishing concentrations of antimony, gold and hydrogen sulphide in fluid inclusions of quartz were developed.

2. The following features were recognized for rare metal type deposits: relatively high general salinities of solutions, dominance of sodium over other cations, narrow limits of concentration variations for gold and

hydrogen sulphide, and high content of CO_2.

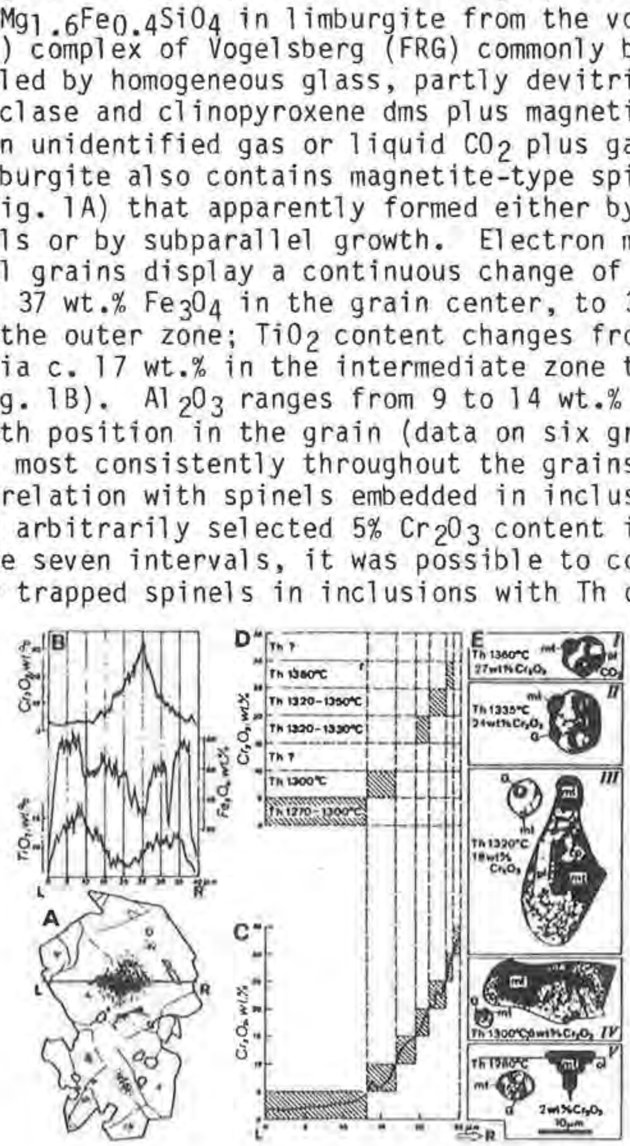
3. For deposits of the gold-sulphide type: generally lower salinity, dominance of potassium over other cations, broad interval of concentration variations in hydrogen sulphide, and low contents of CO_2. The highest contents of hydrogen sulphide were found in fluid inclusions of quartz of late sulphide mineral association of one of the gold-sulphide deposit ($n \cdot 10^{-1}$ - $n \cdot 10^{-2}$ M), and substanitally lower ($n \cdot 10^{-3}$ M - $n \cdot 10^{-4}$ M) in inclusions of quartz from gold-rare-metal deposits; and, finally, the lowest contents were discovered for gold-silver deposits ($n \cdot 10^{-5}$ M).

4. The assumption is made that gold was transported in solution in the form of hydro-sulphide complexes of gold for gold deposits, while for gold-rare-metal and gold-silver deposits it was rather transported as complex hydro-oxide-chloride and chloride compounds of gold.

5. Highest contents of antimony (for gold-sulphide deposits) were found in quartz inclusion of the late sulphide association ($10^{-0.23}$ M). Hetero-poly nuclear gold-antimony complex compounds are assumed to occur in nature. (From the authors' abstract, translated by I.V. Kulikov)

KOZŁOWSKI, A. and METZ, P., 1986a Cr-Tl-Fe spinels in melt inclusions in olivines (abst.): Terra Cognita, v. 6, no. 3, p. 510. First author at Inst. Geochem., Warsaw Univ., al. Zwirki i Wigury 93, 02-089 Warsaw, Poland.

Olivines $Mg_{1.6}Fe_{0.4}SiO_4$ in limburgite from the volcanic (basaltoid-trachyte, etc.) complex of Vogelsberg (FRG) commonly bear polyphase melt inclusions filled by homogeneous glass, partly devitrified glass, crystal phases (plagioclase and clinopyroxene dms plus magnetite-type trapped and/or dms), and an unidentified gas or liquid CO_2 plus gas bubble (see Fig. 1E, I-V). Limburgite also contains magnetite-type spinel grains in the rock matrix (Fig. 1A) that apparently formed either by agglomeration of several crystals or by subparallel growth. Electron microprobe analyses of these spinel grains display a continuous change of composition, from 33 wt.% Cr_2O_3 and 37 wt.% Fe_3O_4 in the grain center, to 3 wt.% Cr_2O_3 and 62 wt.% Fe_3O_4 in the outer zone; TiO_2 content changes from c. 7 wt.% in the grain center via c. 17 wt.% in the intermediate zone to c. 10 wt.% in the outer zone (Fig. 1B). Al_2O_3 ranges from 9 to 14 wt.% without any distinct correlation with position in the grain (data on six grains). Since Cr_2O_3 content varies most consistently throughout the grains, it was used in an attempt at correlation with spinels embedded in inclusions or directly in olivine, using arbitrarily selected 5% Cr_2O_3 content intervals (Fig. 1C). For five of the seven intervals, it was possible to connect the composition of daughter or trapped spinels in inclusions with Th of the adjacent melt

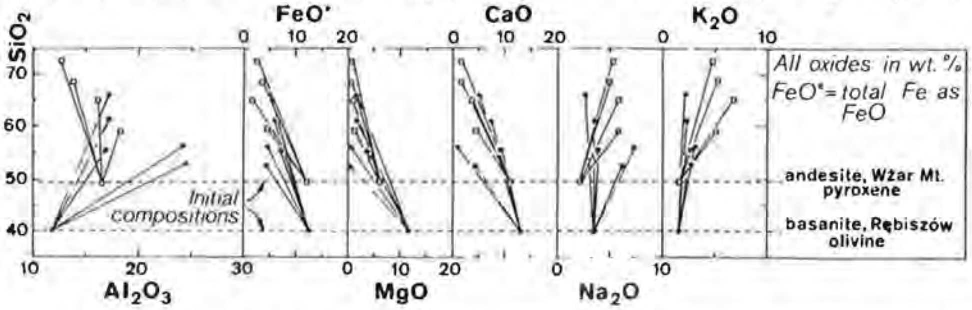


inclusions in the same growth zone of olivine, and subsequently to correlate these data with zones in spinel phenocrysts (Fig. 1D). The Th values of 31 melt inclusions in olivine, obtained by the quenching method, range from 1360 to 1280°C. Examples of their relationships to Cr_2O_3 content in spinels are presented in Figure 1E. The proposed procedure may be used for indirect estimation of crystallization T of spinels using melt inclusions.

Fig. 1. Spinel grain in rock matrix, drawn from the backscattered electron image (A), oxide contents in this spinel along the L-R profile (B), selection of the arbitrary Cr_2O_3 content intervals (C), correlation of Cr_2O_3 contents with Th of melt inclusions (D) and examples of melt inclusions in olivines (E). (Authors' abstract)

KOZŁOWSKI, A. and METZ, P., 1986, Fractionation of melt inclusions by natural partial crystallization: Fortschritte der Mineralogie, v. 64, no. 1, p. 84.

Melt inclusions rarely preserve the initial phase state, in which they were trapped at high temperatures, with the formation of glass only during natural quenching. Usually various parts of the melt crystallize as a layer of the host mineral on the inclusion walls as well as a number of daughter minerals inside the inclusion. This crystallization strongly influences the composition of the remaining melt, and such natural fractionations may be traced with electron microprobe analyses. Previous studies showed melt inclusions with an evolution starting at the composition of an alkali basaltoid to a phonolite (Bazarova et al., 1982), from basaltic andesite to rhyolite (Vavilov et al., 1984) and from basalt to basaltic andesite (Anan'ev, Shnyrev, 1984) as well as an evolution within the rhyolite field (Naumov et al., 1983). This report presents data of inclusion studies in olivines and pyroxenes of basaltoids and andesites from 35 locations in W. Germany and Poland. The initial composition of the melts were found by analysis of homogenized inclusions. Crystallization of olivine, pyroxene and plagioclase in the inclusions causes a change in the chemical composition of the melts (see fig.) e.g., in the following sequences:



basalt → trachyte → alkali rhyolite; sodic foidite → mugearite → shoshonite → benmoreite → andesite → dacite. The crystallization of enstatite from a basanite melt leads to a potassic foidite, and the lack of plagioclase nucleation (only olivine and pyroxenes) leads to highly aluminous melts (up to 27 wt.% Al_2O_3) of tephriphonolite, shoshonite or latite type rocks (all names after TAS diagram, Le Maitre, 1984). Such melt inclusion studies may be of help in the recognition of large scale magmatic differentiation. (Authors' abstract)

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KOZŁOWSKI, A., METZ, P. and ESTRADA JARAMILLO, H.A., 1986, Contrary conditions of the origin of emeralds from Somondòco, Columbia, and varieties of beryl from Lower Silesia, Poland: Fortschritte der Mineralogie, v. 64, no. 1, p. 85.

Colombian primary deposits of emeralds (Muzo, Coscuez, Somondòco, Gachala, Chivor) from E-Cordillera occur in metasomatites and veins developed in Paleozoic siltstones, sandstones and carbonates, as well as in Cretaceous carbonaceous shales and sandstones. The emerald-bearing bodies consist of albite, oligoclase, quartz, dolomite, calcite, barite, pyrite and fluorite (Johnson 1961, Feininger 1970, Escovar 1979). First studies of inclusions in emeralds from Chivor and Muzo showed that they contain a brine with minor liquid CO_2. These inclusions decrepitated before the homogenization took place and the probable Th was evaluated as "well in excess of 355°C" (Roedder 1982). The present study of emeralds from Somondòco yields a Th of 470-570°C, a T of dissolution of daughter halite ranging from 280 to 370°C (see fig.), and a eutectic temperature of about -55°C. These values suggest the presence of $CaCl_2$ in the solution and also minor but variable amounts of CO_2. The total salt concentration (assuming $CaCl_2$ + NaCl) would be about 40 wt.%. The pressure correction for Th is not exactly known but an estimation from the overburden thickness is in the range of 150°C. Thus, the studied emeralds were formed from dense brines at high T and P conditions. The origin of these brines used to be connected with adjacent salt beds. The opposite mode of beryl formation is represented by the origin of aquamarine and pale green beryl from granitoid pegmatites in Lower Silesia. The Th values are much lower: primary inclusions in aquamarine at 315-373°C in L phase, and at 393-410°C in G phase, whereas in pale green beryl at 300-350°C in L phase and in secondary inclusions at 150-240°C. The total salt concentration in L solutions ranges from 5.5 to 7.3 wt.% NaCl equiv. The presence of alkalies and other minor elements in beryls will also be discussed. (Authors' abstract)

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Escovar, R.R.: Bol. Geol. 22, 117-153 (1979).
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Johnson, P.W.: J. Gemmology 8, 126-152 (1961).
Roedder, E.: Inst. Gemol. Symp. Proc., 479-502 (1982).

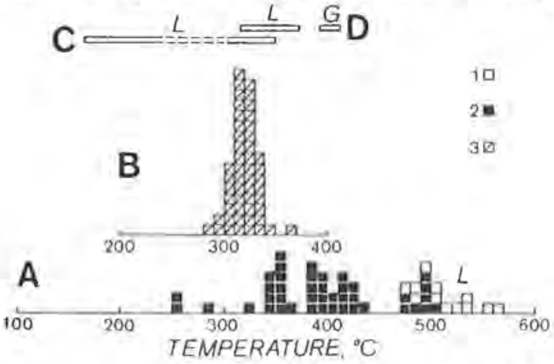


Figure. Th of inclusions in emeralds of Somondòco (A), beryl (C) and aquamarine (D) from Lower Silesia. T of halite dissolution in inclusions in Somondòco emeralds (B). 1-inclusion homogenized, 2-decrepitated, 3-salt dissolved. One square = one measurement. L-homogenization in liquid phase, G-in gas phase.

KOZ'MENKO, O.A., PESHCHEVITSKIY, B.I. and BELEVANTSEV, V.I., 1985, The solubility of bromellite in solutions of hydrogen fluoride: Geokhimiya, no. 11, p. 1614-1620 (in Russian; translated in Geochem. Int'l., v., 23, no. 4, p. 162-169, 1986).

KRASNOV, S.G., 1986, Types of the ore-forming hydrotherms in recent ocean: Dokl. Akad. Nauk SSSR, v. 290, no. 4, p. 924-928 (in Russian). Author at All-Union Sci.-Research Inst. of Geol. & Mineral Resources of the World Ocean, Leningrad, USSR.

The paper discusses the composition and other features of the present-day active submarine hydrotherms, essentially on the basis of the literature data. (A.K.)

KRĂSTEVA, M. and GADŽEVA, T., 1986, Gas-liquid inclusions in quartz, sphalerite, fluorite and carbonate from the deposits in Ermareka sector of Madan ore region: Geochem., Mineral. & Petrol., v. 22, p. 54-68 (in Russian; English abstract).

In the southern part of Madan ore region, around Ermareka, the ore mineralizations are of two genetic types: vein - in fault structures, and metasomatic - in the marble horizon. The paper presents results of thermal studies of gas-liquid inclusions in minerals of the two types of mineralizations: in quartz, sphalerite and carbonate from ore veins of 10 deposits, and in quartz, sphalerite, carbonate and fluorite from 5 structural bore-holes which drilled the metasomatic ore mineralization. Th were reported in a "Koffler" thermochamber with a mercury thermometer.

The studied minerals are rich in gas-liquid inclusions, mainly S and PS, which show a very irregular distribution. The Th data indicate that the crystallization of the minerals occurred at high to low T: 500-40°C. The gas-liquid inclusions in the carbonates, formed after skarns from the metasomatic bodies show the highest Th - ~450-400°C. Th of inclusions in quartz from the quartz-pyrite stage are from 370 to 80°C, in quartz from the polymetallic stage - from 350 to 90°C and in some deep horizons of the deposits - from 370 to 360°C, and in quartz from the quartz-carbonate stage - from 270 to 80°C. Th in sphalerite are from 280 to 85°C and in cleiophane - from 250 to 78°C. In carbonates from the quartz-carbonate stage Th are from 300 to 40°C. Fluorite and quartz from the late quartz veinlets of the metasomatic ore mineralizations show lowest Th - from 225 to 115°C and from 130-80°C respectively. In general the maximum Th of gas-liquid inclusions in metasomatic ore bodies are about 10°C lower than the maximum T in the ore veins. (Authors' abstract)

KREITLER, C.W., FISHER, R.S., SENGER, R.K., HOVORKA, S.D. and DUTTON, A.R., 1985, Hydrology of an evaporite aquitard: Permian evaporite strata, Palo Duro Basin, Texas: Int'l. Assoc. Hydrogeologists, Memoires, v. 17, Part 1, Proc. Hydrogeology of Rocks of Low Permeability, Tucson, Arizona, Congress, p. 150-162. Authors at Bureau of Econ. Geol., The Univ. Texas at Austin, Austin, TX 78713.

Permian evaporite strata of the Palo Duro Basin, Texas Panhandle, are considered to have low permeabilities, but are capable of some leakage. Cross-sectional and areal modeling of regional ground-water flow in the Palo Duro Basin indicates leakage from the Upper aquifer through the Evaporite aquitard that contributes approximately 30 percent of the water in the underlying Deep-Basin Brine aquifer. The regional estimate of permeability of the aquitard ($\approx 10^{-4}$ md) is in general agreement with laboratory testing of salt permeability. Oxygen and hydrogen isotopic composition and the Cl/Br ratio of the deep-basin brines also suggest leakage through the aquitard. Isotopically nonequilibrated meteoric waters are found to depths of 8,000 ft.

Leakage through the aquitard may occur as either matrix or fracture flow. According to petrographic and geochemical studies of the evaporite strata, halite dissolution and minor recrystallization occurred predominantly during Permian time. Post-Permian waters may have altered the top of the Evaporite aquitard. Fracturing is prevalent in the rock strata in the basin; the greatest density of fracturing occurs in areas with tectonic deformation. The potential for leakage may be greatest in these areas. (Authors' abstract)

KREWEDL, D.A. and CARISEY, J.-C., 1986, Contributions of the geology of uranium mineralized breccia pipes in northern Arizona: Ariz. Geol. Soc. Digest, v. 16, p. 179-186. First author at Pathfinder Mines Corp.

Includes some Th data on gypsum, anhydrite, calcite, sphalerite and barite, credited to "Landais" [i.e., G. Landis?]. Th = 54-125, avg. ~90°C. (E.R.)

KRONENBERG, A.K., KIRBY, S.H., AINES, R.D. and ROSSMAN, G.R., 1986, Solubility and diffusional uptake of hydrogen in quartz at high water pressures: Implications of hydrolytic weakening: J. Geophys. Res., v. 91, no. B12, p. 12,723-12,744. First author at Center for Tectonophysics, College of Geosci., Texas A&M Univ., College Station, TX.

Attempts to introduce molecular water into dry, natural quartz crystals by diffusive transport and thus weaken them hydrolytically at T = 700°-900°C and $P(H_2O)$ = 400-1550 MPa have failed. Infrared spectroscopy of hydrothermally annealed single crystals of natural quartz reveals the diffusive uptake of interstitial hydrogen (resulting in hydroxyl groups) at rates similar to those previously proposed for intracrystalline water at high water pressures. The solubility of interstitial hydrogen at these conditions is independent of temperature and pressure; instead, it depends upon the initial aluminum concentration by the local charge neutrality condition $[H_i] = [Al_{Si}']$. The rate of interstitial hydrogen diffusion parallel to $\underline{c}$ is given by an Arrhenius relation with $D_o = 1.4 \times 10^{-1}$ m^2/s and $Q = 200 \pm 20$ kJ/mol, in close agreement with H diffusivities reported for much lower pressures ($P(H_2O)$ = 2.5 MPa). Deformation experiments following hydrothermal annealing show no mechanical weakening, and the lack of any detectable broadband absorption associated with molecular water shows that the diffusion rates of structural water are much lower than those of hydrogen. These results are consistent with the available oxygen diffusion data for quartz and with the failure to observe weakening in previous studies of quartz deformation at pressures of 300-500 MPa; they call into question the rapid rates of diffusion originally suggested or the hydrolytic weakening defect. It is suggested that the observed weakening in many previous experiments was complicated by microcracking processes in response to nonhydrostatic stresses and low effective confining pressures. Extensive microcracking may provide a mechanism for molecular water to enter quartz and allow local plastic deformation to occur. It does not appear that molecular water can diffuse far enough into uncracked quartz to allow hydrolytic weakening over annealing times that are feasible in the laboratory. (Authors' abstract)

KROPOTKIN, P.N., 1985, Degassing of the Earth and the origin of hydrocarbons: Byul. Mosk. Obshch. Ispyt. Prirody, Otdeleniye Geologii, v. 60, no. 6, p. 3-18 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 11, p. 1261-1275). Author at Geol. Inst., USSR Acad. Sci., Moscow, USSR.

Author has long been a leading proponent of the inorganic origin of petroleum, a theory which has had a continuous tradition of support in Russia and the Soviet Union, and a recent revival in the United States and western Europe. (From the author's abstract)

KUCHA, H. and PAWLIKOWSKI, M., 1986, Two-brine model of the genesis of strata-bound Zechstein deposits (Kupferschiefer type), Poland: Mineral. Deposita, v. 21, p. 70-80. Authors at Inst. Geol. & Mineral Deposits, 30-059 Krakow, Av. Michiewicza 30, Poland.

These Kupferschiefer deposits were probably formed as a result of a mixing of two brines. The upper cold brine is an unmineralized brine rich in Na, Ca, Cl and SO_4, with a pH >7 and originate from evaporites overlying the metal-bearing Zechstein rocks. The lower hot brine, rich in Mg, K, Cl, SO_4 and CO_3 with a pH $\leqslant$ 7 formed in sediments in the central part of the Zechstein basin at a depth of 7,000 m. (From the authors' abstract)

KUEHN, C.A. and ROSE, A.W., 1986, Temporal framework for the evolution of fluids at the Carlin gold mine, Eureka County, Nevada (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 663.

KUKUL'YAN, M.A., 1985, Geological structure and conditions of formation of the Mardzhan polymetal deposit (Armenian SSR): Geol. Rudn. Mestorozhd., no. 2, p. 52-62 (in Russian).

Cited in Naumov, 1986 (this volume).

KULIKOV, I.V., 1986, The influence of unstable origin conditions on the properties of fluorite crystals from Tyrnyauz deposit: Morphology & Phase Equilibria of Minerals - IMA 1982, p. 171-180 (in English). Author at Moscow Geol.-Prosp. Inst., Moscow, USSR.

The sharp changes in crystallization regime (pressure drops, volatile loss, solution oversaturation) under conditions of tectonic movement in Tyrnyauz region, and, as a consequence, mineral growth acceleration, are strongly reflected in fluorite crystallomorphology and in fluid inclusion character (their dimensions, filling pattern and distribution inside the crystals). This is also registered by a 1-2 order of magnitude increase in the concentration of admixture and point defects as well as line defects in the fluorite structure. Flotation properties of fluorite are dependent on the latter. (The author's Conclusions)

The fluid inclusion Th ranges from 400°C (at altitude 2800 m) to 700°C (at 2000 m). (E.R.)

KULIKOV, I. and STOYNOVA, M., 1986, Fluid inclusions and rare earth elements in fluorite from the Yugovo X mineral deposit in the northern Rhodopes: Ann. of the Higher Inst. of Mining & Geol., (1985-1986), Sofia, v. 32, Part II, p. 127-135 (in Bulgarian with English abstract). First author at MGRI, Moscow, USSR.

The assay values of rare elements in fluorite from this small vein-type deposit have been determined by means of instrumental neutron-activation analysis. Variation curves for the distribution of rare earth elements have been plotted. On the basis of these curves the presence not only of primary but also of redeposited fluorite has been found. Part of the fluorite exhibits high Th of gas-liquid inclusions (300-365°C). The considerable content of rare earth elements in fluorite from the Yugovo mineral deposit indicates that the solutions causing the mineralization exhibit a deep-seated character. The amount of rare earth elements as well as the high Th of fluid inclusions are a sign that presence of economic concentrations of Mo, Cu, Pb and W are to be expected. (Authors' abstract, modified by I. Kulikov)

KULINICH', V.V., MUKANOV, K.M., URAZOVA, I.A., 1985, Thermobarogeochemical investigations of barite of deposits of Atasuy type (Central Kazakhstan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 179-180 (In Russian; translation by Dorothy B. Vitaliano). Authors at

Inst. Geol. Sci., Acad. Sci. of the Kazakh SSR, Alma-Ata, USSR.

1. Barite of different generations and mineral types from deposits of Atasu type (Zhayrem, Bestobe, Ktay, Karagayly, etc.) were investigated by homogenization (V. A. Kormushin's apparatus, Inst. of Geol. Sci., Acad. Sci. Kazakh SSR) and decrepitation (decrepitometer designed by V. Ye. Bocharov, Kazakh Sci. Research Inst. of Mineral Raw Materials). The composition of the inclusions was determined using aqueous extracts, and the gas phase was analyzed on a serially-produced [assembly line?] chromatograph.

2. The syngenetic barite (stage 1) was formed from Cl-CO_3-Fe-K-Na solutions with low CO_2 content. The volatiles are represented by water and gases (H_2S, CO_2, N_2, CH_4, with N_2 (65 cm^3/kg) and O_2 (16 cm^3/kg) predominant. The environment of mineralization was slightly alkaline. Very small single-phase liquid inclusions occur in the barite. Th is 80-40°C.

3. Hydrothermal-metasomatic barite (stage 2), which is of main economic value and associated with polymetals, is distinguished by higher Th (250-80°C). Two kinds of inclusions were found in the barite. The first are irregularly angular in shape, ~4 μm in size. The gas phase occupies 15 vol%. Th is 190-180°C. The second type are located along healed fractures. The vacuoles are oval, with a linear dimension of ~2 μm. The gas bubble constitutes 5-7 vol.%. Th is 100-80°C. The composition of the solutions is Cl-CO_3 with a high content of Cl^- (50.44 wt.%), with K (13.5%) and Mg (3 wt.%). N_2 (69.85 cm^3/kg) and H_2 ($51.18 \cdot 10^{-4}$ cm^3/kg[sic]) predominate in the gas mixture; H_2O, CO_2, H_2S, CH_4, O_2, He and others are recorded in minor amounts. The environment of barite formation was slightly alkaline.

4. The composition of the ore-forming solutions which formed the hydrothermal barite veins (stage 3) was CO_3-SO_4, Fe-Ca-Na (chalcopyrite-barite mineralization) and CO_3-SO_4 and calcic with silicic acid (quartz-barite mineralization). The volatiles included H_2O, H_2S, CO_2, N_2, and Ar. The T range of mineralization was from 330°C (quartz-barite) to 170°C (barite-hematite association).

5. Hydrothermally recrystallized barite contains S as well as P inclusions. The P are single-phase or two-phase; they are 80-85% full. The S are mostly essentially liquid, situated along cleavage cracks. They were formed in the course of recrystallization of earlier-deposited barite under the influence of superposed hydrothermal activity. Cl-CO_3 and K-Na solutions with Cl predominant (31 wt.%) and up to 15 wt.% CO_2 content took part in the recrystallization. Ca (22.5 wt.%) and Na+K (16.5 wt.%) are observed in high amounts. Barite of this type has the highest contents of N_2 and O_2 (75 cm^3/kg and 20.63 cm^3/kg, respectively) in the gas mixture. The T range of formation was 180-160°C. The pH of the medium of mineralization was close to 7.0.

6. Outside the deposits, a substantial amount of small monomineralic barite veins occur which are of no economic value. The barite of these veins was formed CO_3-Cl and Na-K solutions with some content of Ca (23.4 wt.%) and Cl (24 wt.%) and a very high content of K and Na ($Na^+ + K^+ = 19$ wt.%). A fairly low content of hydrocarbons is typical of the gas mixture ($CH_4 = 2.27 \cdot 10^{-4}$ cm^3/kg). The barite abounds in small (1.5-2 μm) P gas-liquid inclusions of oval shape, 90% full. The T range of barite formation was 260-100°C.

7. The observed features of the composition of the mineralizing solutions for the barites of different type and T range of formation are consistent with the data of geological and geochemical investigations and can be used in prospecting for and exploring barite deposits and related mineralization. (Authors' abstract)

KUMANN, Rolf, 1985, Tectonic and paragenetic study of tin lodes in the Ehrenfriedersdorf area: Dissertation A, Bergakademie Freiberg, GDR (in German).

On the results of the tectonic analysis, ore microscopy, and investigation of fluid inclusions in various minerals (quartz, cassiterite, topaz, beryl) the evolutionary stages of the tin-tungsten association have been derived. Some analytical results are also presented and discussed. In all samples the inclusion fluids always contain K, Na, Ca, F, Cl and HCO_3^-. There is a direct relationship between Th of P fluid inclusions and the salinity of the inclusion fluids. Microthermometry and leachate analysis show temperature and matter pulsation during the deposition of the tin-tungsten association. (Abstract courtesy of R. Thomas)

KUMAR, Anil, 1986a Densities and apparent molal volumes of aqueous concentrated calcium chloride solutions from 50 to 200°C at 20.27 bar: J. Solution Chem., v. 15, no. 5, p. 409-412.

KUMAR, Anil, 1986b Densities and apparent molal volumes of aqueous KCl-$CaCl_2$ mixtures at 298.15 K: J. Chem. Eng. Data, v. 31, p. 21-23.

KUMAR, Anil, 1986c Prediction of densities of concentrated brines by Pitzer theory: J. Chem. Eng. Data, v. 31, p. 19-20.

KUO, L.-C., LEE, J.H., ESSENE, E.J. and PEACOR, D.R., 1986, Occurrence, chemistry, and origin of immiscible silicate glasses in a tholeiitic basalt: A TEM/AEM study: Contrib. Mineral. Petrol., v. 94, p. 90-98. First author at Explor. Res. & Dev. Div., Conoco Inc., Ponca City, OK 74603, USA.

The occurrence and chemistry of immiscible silicate glasses in a tholeiite mesostasis from the Umtanum formation, Washington, were investigated with transmission electron microscopy and analytical electron microscopy (TEM/AEM). TEM observation reveals isolated, dark globules (2.1 micron or less in diameter) randomly distributed in a transparent matrix glass interstitial to plagioclase laths. The globules less than 0.3 micron and larger than 0.8 micron fall beyond the linear relationship defined by the 0.3-0.8 micron globules in a plot of the logarithm of number versus size. Large globules (0.7 micron or larger in diameter) range from homogeneous to heterogeneous in optical properties and chemistry. Homogeneous globules are completely glassy, whereas heterogeneous globules contain crystalline domains. AEM analyses show that the globules have high Si, Fe, Ca, and Ti with subordinate Mg, Al, P, S, Cl, K, and Mn, which gives high normative fa, px, il, and ap. The matrix glass consists dominantly of Si with low Al and minor Na and K, yielding a high normative qz, or, ab, and an.

It is proposed that the silicate liquid immiscibility occurs by reaction of network-modifying cations (NMCs) with dominantly chain-like anionic units in the parental melt to form less polymerized, NMC-bearing units and highly polymerized, Si-rich units. The globules nucleated metastably under supercooled conditions, and medium-size globules become either larger or smaller at lower temperatures. Internal nucleation of NMC-rich phases occurred in some larger globules upon cooling. (Authors' abstract)

KUPENKO, V.I., PANOV, B.S. and KUDRYAVTZEV, S.B., 1985, The origin of hydrothermal solutions based on thermobarogeochemical data (as exemplified by the Donbass mercury mineralization) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 120-121 (in Russian; translation by D.A. Brown). First author at DIP, Donetsk, USSR.

As a result of geological-structural, mineralogical, and thermobarogeochemical studies it has been established that mercury mineralization took place during two productive phases. Cinnabar of the first productive phase is associated with arsenopyrite, marcasite, dickite, carbonates, and quartz. The principal minerals are accompanied by a dispersed segregation of galena, sphalerite, chalcopyrite, and sulfosalts. The second productive phase is marked by a simple mineralogical composition: cinnabar, antimonite, quartz, and dickite.

The minerals of the first productive phase formed at ~130-165°C. Quartz from the second productive phase crystallized at ~110-150°C. Carbonates from the gangue veinlets contain inclusions homogenizing at ~60-95°C.

The O-isotope composition of the mineralizing solutions, in equilibrium with quartz and carbonates at T of crystallization mineral, has been calculated. For quartz, the $\delta^{18}O(H_2O)$ values range from +4 to +12% , the hydrotherms of the productive phases having been enriched in the heavy O-isotope up to +8 to +12% . The range of variation in $\delta^{18}O(H_2O)$ in the carbonates is +2 to +14% . The most typical values of +7 to +10% are found in magmatic waters.

Earlier studies on quartz and carbonates from other ore parageneses in the Donbass region have shown the wide involvement of water, close in isotope composition of oceanic (0%), in the hydrothermal process. Some uncertainty in interpreting the 'heavy' isotope composition of the mineral-forming solutions has been associated with possible isotope exchange with the country rocks. However, it is well-known that the formation waters in the Paleozoic sediments of the Dnepr-Donets Basin, occurring at depths of 1.9 to 4 km with T >100°C, have not undergone an oxygen shift (Vetshteyn, 1973). In this respect, it is most likely that juvenile waters of those with lighter isotopic composition have been widely involved in the formation of the Donbass mercury deposits. This water has been involved in circulation at extremely great depths. (From the authors' abstract)

KUPREISHVILI, K.A., AREVADZE, D.B. and YAROSHEVICH, V.Z., 1985, Conditions of formation and sources of material of the Tekhut porphyry copper deposit (Armenian SSR) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 154-155 (in Russian; translation by Dorothy B. Vitaliano). Authors at Caucasian Inst. Min. Raw Materials, Tbilisi, USSR.

The Tekhut deposit is located in the Somkhit-Karabakh structural-formational zone of the Lesser Caucasus. The mineralization, of stockwork type, is related to exo- and endocontact parts of quartz diorite porphyries and tonalite porphyries, cutting a Lower Cretaceous intrusive body of quartz diorite in the Shnokh-Kokhb massif. The main ore minerals are chalcopyrite, pyrite, and molybdenite; gangue minerals are quartz, anhydrite and calcite.

As a result of integrated thermobarogeochemical investigations (Th, Td, cryometry, laser microanalysis, analysis of salts and gases by the methods of aqueous extraction and chromatography), we established:

1. The typomorphic thermobarogeochemical features of the porphyry copper deposits are: a) the quartz of the veinlets and metasomatites has many fluid inclusions; b) multiphase fluid inclusions containing authigenic chlorides, sulfates and ore-mineral daughter minerals (chalcopyrite, pyrite, hematite) are present in the minerals of the productive associations; c) necking down is extensive.

2. Hydrothermal ore formation in the Tekhut deposit occurred in a wide range of T-X parameters: a) early quartz-molybdenite, quartz-anhydrite-molybdenite-chalcopyrite and early quartz-pyrite asociations formed at 420°C to 220°C from relatively highly mineralized fluids of Na-K-HCO_3-Cl

composition with a salinity of <40 wt.% NaCl. The fluids were characterized by high concentrations of metals and sulfide sulfur; b) the pressure in the productive stage of mineralzation did not exceed 1000 bars; in that case no boiling of the fluids is observed.

The main gas component of the fluid throughout the whole process of hydrothermal mineralization was CO_2, the concentration of which in the quartz reached 2-4, rarely 8-12% by volume[sic]. The total gas content of the fluid from the high- to the low-T stage dropped from 6-10 to 1-2% by volume.

3. On the basis of the results of isotopic investigations of the H of the water in the fluid inclusions, and the O, S, and C in the minerals, the sources of the hydrothermal fluids were at subcrustal depths. In the late low-T stages of the hydrothermal system this magmatogenic fluid, with a high content of deep-seated sulfide sulfur and relatively low CO_2 content was greatly diluted by meteoric waters containing carbon of crustal (sedimentary) origin. (Authors' abstract)

KURILO, M.V., 1986, Characteristics of distribution of vein carbonates of the Donets Coal Basin and relation with ore formation: Dokl. Akad. Nauk SSSR, v. 291, no. 1, p. 202-206 (in Russian).

See next item. (E.R.)

KURILO, M.V., GALABURDA, Yu.A. and DOBRYANSKII, L.A., 1986, Results of thermobarogeochemical studies on authigenic minerals from coal-bearing deposits of the Donets Basin: Litologiya i Poleznye Iskopaemye, no. 2, p. 68-72 (in Russian; translated in Lithology and Mineral Resources, v. 21, no. 2, p. 164-169, 1986). Authors at Inst. Min. Geochem. & Physics, Acad. Sci. USSR, Kiev, USSR.

Results of systematic studies are presented for gas-liquid inclusions in quartz and calcite from the coal-bearing deposits of the Donets Basin, which have undergone various stages of post-diagenetic alteration (catagenesis and metagenesis). These data attest to the regional character of the authigenic mineralization; in this regard, it is proposed that thermobarogeochemical methods of investigation be used for maturation analysis of sedimentary rocks, mineralogic prediction, prediction of the grade of coals, and reconstruction of paleohydrologic conditions. (Authors' abstract)

KURODA, Yoshimasu, KIDA, Yoshiharu, WATANABE, Koji, OBA, Takeshi and MATSUO, Sadao, 1986, D/H study on clay minerals from the Iwami Kuroko deposit, Shimane Prefecture, Japan: J. Japan. Assoc. Min. Petr. Econ. Geol., v. 81, p. 302-311. First author at Dept. Geol., Shinshu Univ., Matsumato, 390, Japan.

The δD value of the water extracted from fluid inclusions in quartz from the ore-veins is -58 to -59‰, which is different from those estimated for the hydrothermal solution during the formation of chlorite and sericite. This may indicate that there was a time difference between formation of chlorite-sericite clay and quartz. (From the authors' abstract)

KURODA, Y., YAMADA, T, KOBAYASHI, H., OHTOMO, Y., YAGI, M. and MATSUO, S., 1986, Hydrogen isotope study of the granitic rocks of the Ryoke belt, central Japan: Chem. Geol. (Isotope Geosci. Sec.), v. 58, p. 283-302.

KURSTEINER, P. and SOOM, M., 1986, Chobelwald - a new fluorite occurrence in Alpstein, Switzerland: Schweizer Strahler, v. 7, no. 5, p. 205-218 (in German and French).

A new fluorite occurrence is described. Some fluid inclusions in fluorite crystals have been studied by microthermometry: Tm decreases from -3°C (P incl.) to -1.5°C (S incl.). The fluid inclusions leak on heating; Th are not reproducible, they increase from 160°C continuously to Td (over 172°C). (Abstract by H.A. Stalder)

KURZ, M.D., 1986a Cosmogenic helium in terrestrial basalts (abst.): Lunar & Planet. Sci. XVII, p. 1001, Lunar & Planet. Inst., Houston. Author at Woods Hole Oceanographic Inst., Woods Hole, MA 02543.
See next item. (E.R.)

KURZ, M.D., 1986b In situ production of terrestrial cosmogenic helium and some applications to geochronology: Geochimica Cosmo. Acta, v. 50, p. 2855-2862. Author at Chem. Dept., Woods Hole Oceanographic Inst., Woods Hole, MA 02543, USA.

The concentrations of cosmogenic ^{3}He have been measured in a series of basaltic drill core samples from Hawaiian volcanoes Haleakala and Mauna Loa. The ^{3}He concentration in the surface of a radiocarbon dated Mauna Loa flow (20,000 years) gives reasonable agreement with a theoretical production rate of 140 atms $g^{-1}yr^{1}$, and suggests that the uncertainty in this rate is roughly 10%. The results illustrate the feasibility of using ^{3}He to measure exposure ages of young basaltic lava flows and for measuring erosion rates. Erosion rates calculated from the three Haleakala cores range from 7 to 11 meters/million years. The drill core data demonstrate that accurate depth control is crucial to the use and evaluation of cosmogenic helium. Depth profiles from several of the older cores display a non-exponential depth dependence of ^3He_c below 170 $g \cdot cm^{-2}$, which is attributed to the contribution from ^{6}Li(n, α)T, where the neutrons are from stopped muons. This has important implications for depth dependence of cosmogenic ^{3}He because muons are weakly attenuated compared to the nucleonic component that produces spallation. (Author's abstract)See previous item.

KURZ, M.D. and GURNEY, J.J., 1986, Helium isotopic heterogeneity within single diamonds from the Orapa kimberlite pipe (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 401-402. First author at Dept. Chem., Woods Hole Oceanographic Inst., Woods Hole, MA 02543, USA.

The large helium isotopic variability within single diamonds has important implications. First, it suggests that much of the isotopic variability is caused by ingrowth of radiogenic ^{4}He, and that Th and U are zoned within single diamonds. Therefore, helium may possibly be used to date individual diamonds. In addition, if the explanation for the heterogeneity given here is correct, the highest $^3He/^4He$ ratios may be found in those diamonds with the fewest defects. (From the authors' abstract)

KUSAKABE, Minoru, HORI, Mika and MATSUHISA, Yukihiro, 1986, Primary mineralizaton-alteration of the El Teniente and Rio Blanco porphyry copper deposits, Chile. Stable isotopes, fluid inclusions and $Mg^{2+}/Fe^{2+}/Fe^{3+}$ ratios of hydrothermal biotite: Technical Report of Inst. for Study of the Earth's Interior, Okayama Univ., ISSN 0910-9900, Ser. A, no. 5, 40 pp.
Full paper for abstract given in next item. (E.R.)

KUSAKABE, M., NAKAGAWA, Seiko, HORI, M., MATSUHISA, Y., OJEDA, J.M. and SERRANO, L., 1985, Primary mineralization-alteration of the El Teniente and Rio Blanco porphyry copper deposits, Chile: Stable isotopes, fluid inclusions and Mg(2+)/Fe(2+)/Fe(3+) ratios of hydrothermal biotite (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 41-42. First author at Inst. Thermal Spring Res., Okayama Univ., Misasa, Tottori 682-02, Japan.

The anhydrite-chalcopyrite sulphur isotope geothermometer indicates that the mineralization temperature decreases from 460°C in stage I, through 420-410°C in stages II and III, down to 360°C in stage IV. A lower temperature of 300°C is indicated for stage IV by the chalcopyrite-galena geothermometer. Th of P fluid inclusions in quartz are in good agreement with the above temperatures if pressure corrections are made for the assumed emplacement of porphyry stocks at depths of 2 to 3 km in the crust . Mg(2+)/Fe(2+)/Fe(3+) ratios of hydrothermal biotite are consistent with the above temperatures. Similar results are obtained for the Rio Blanco deposit.

With these temperatures, the oxygen isotopic data of quartz and anhydrite, the $\delta^{18}O$ value of the hydrothermal fluids is calculated to be virtually constant at 6 per mil, for all the stages, suggesting that magmatic fluids, or fluids of meteoric origin which had extensively interacted with wall rocks, might have been repeatedly incorporated during the primary mineralization-alteration processes. The δD values of -30 to -50 per mil, much higher than those for present-day meteoric waters of the areas, are estimated for the hydrothermal fluids from hydrogen isotope analysis of hydrous minerals.

Provided that anhydrite and sulphide minerals were precipitated from the fluid of a closed system containing SO_4 and H_2S as the main sulphur species, the $\delta^{34}S$ value of total sulphur in the fluid is computed to be +4.5 per mil and +7.6 per mil for the El Teniente and Rio Blanco deposits, respectively, based on a material balance calculation. These values are in good harmony with the reported $\delta^{34}S$ values of rock sulphur in nonmineralized granitoids that are associated with the porphyry copper deposits of the area. This may indicate that during cooling of the magmatic fluid rich in SO_2, SO_4 and H_2S are produced by disproportionation reaction of SO_2 and H_2O. Chemical characteristics of the hydrothermal fluids are discussed based on the above information. (From the authors' abstract)

KUZNETSOV, A.G., 1985, Thermobarogeochemical prediction of productive ore zones in the Sadon polymetallic deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 114 (in Russian; translation by D.A. Brown). Author at Simferopol' State Univ., Simferopol', USSR.

Thermobarogeochemical sampling has been carried out during a detailed exploratory survey of the Sadon polymetallic deposit in Northern Osetia, with the object of predicting productive mineralization. Quartz samples for thermobarogeochemistry have been taken in the field galleries, crosscuts, and rising and exploratory blocks from the polymetallic ores and surrounding quartz-bearing rocks across the strike of the ore bodies at 1-3, 8-10, 40-50, and 100-125 m spacing and in longitudinal sections through each at 10-25 m spacing. From these data, transverse and longitudinal profiles of the deposit have been compiled, with thermobarogeochemical contours (Th and Td, concentration and composition of the aqueous extracts from the quartz, etc.). A three-dimensional thermobarogeochemical description of the "steaming-out" halo of the country rocks has been obtained.

It has been shown that the thermobarogeochemical parameters regularly and successively change their values as one approaches the ore bodies. Th of the inclusions in quartz increase from 242-254°C to 308-320°C; Td of quartz from 225-260°C to 380-425°C; P from 20-38 to 85 MPa; calcination loss of quartz from 0.3-0.5 to 3.8-8.4%; number of inclusions per 0.1 mm^2 from 40-300 to 3500; concentration of salts in solutions from 3-6 to 8-13%, etc. A more distinct and sharper increase in the thermobarogeochemical indices has been noted as one approaches the thicker ore bodies with increased overall amounts of Pb and Zn, which is of prospecting value.

The regular pattern of change in the thermobarogeochemical conditions have been used for predicting the most productive zones in the deposit and for estimating the prospects of Pb-Zn mineralization at depth. (From the author's abstract)

KUZNETSOV, Yu.A., 1985, The temperature regime for the formation of new kind of mineralization in the Donbass region (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 121-123 (in Russian; translation by D.A. Brown). Author at Inst. Geochem. & Phys. Min., Acad. Sci., Ukrainian SSR, Kiev, USSR.

An earlier-unknown morphogenetic kind of segregated-veinlet mineralization with Cu-, Mo-, Te-Bi-, Pb-Zn-, As-, and other ore-minerals, has been examined in the SE part of the Donbass, at 50 km from the Nagol'nyy Ridge on the Kerchik River.

Thermometric studies have been made gangue veinlets of quartz and quartz-carbonate veinlets and their country rocks. Th measurements have been done on P-GLIs (600 analyses) in quartz, feldspars, carbonates, and sphalerite. Most inclusions homogenize into the liquid phase, and an insignificant portion of the highest-T varieties, into the gas phase. Statistical treatment of the results has shown that all groups of vein formations belong to the highest-T category in the Donbass.

The T range for mineral crystallization is as follows (in °C): 1) in the ore-bearing veinlets among the metasomatites after sedimentary rocks and andesites, respectively 440-140 and 400-140; 2) in gangue veinlets from metasomatites after sedimentary rocks and andesites, 480-220 and 400-220; and 3) in the country rocks, 490-200. It is important to note that in spite of the significant T variation throughout the phases of mineral-formation, the main crystallization in all groups lies within the 380-280°C range (70-80% of measurements). At the same time, a study of the metamorphic quartz-carbonate veins from this same Carboniferous coal sequence remote from the ore-bearing structures indicates their substantially lower Tt (280-80°C, with a predominant interval of 140-80°C) (80% of 106 measurements).

It is well-known that the origin of the ore-bearing veins on the Nagol'nyy Ridge is disputed, because a direct link between mineralization and magmatism is there absent, as has been observed in the Kerchensk area. It should be noted that the T of trapping of the veins and veinlets on the Nagol'nyy Ridge are also contrasted (by 150°C), and are distinguished by their higher values as compared with those of the metamorphic gangue veins of the coal-bearing sequence.

Thus, the results emphasize the most important role of T studies in resolving genetic problems of ore-formation. (From the author's abstract)

KUZNETSOVA, S.V. and KULIK, Zh.V., 1986, Chlorohydrocarbons in mineral-forming solutions: Doklady Akad. Nauk SSSR, v. 290, no. 3, p. 709-710 (in Russian). See Translations.

KVENVOLDEN, K.A., MORTON, J.L. and HOLMES, M.L., 1986, Hydrothermal petroleum associated with polymetallic sulfides, Escanaba Trough, offshore northern California (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 663.

KWAK, T.A.P., 1986, Fluid inclusions in skarns (carbonate replacement deposits): J. Metamorphic Geol., v. 4, p. 363-384. Author at Dept. Geol. La Trobe Univ., Bundoora, Australia 3083.

Fluid inclusions in ore skarn minerals reflect the physicochemical nature of the solutions present during the skarn-forming process. Because of the dense nature of skarn minerals and the dynamic processes operative during skarn genesis, sufficient primary fluid inclusions are usually present. Ore skarn solutions, as opposed to metamorphic skarn or ore vein solutions, have much higher $CaCl_2$ contents and usually very high formation temperatures (>500°C) and salinities (>40 wt % T.D.S.). Temperatures and salinities generally decrease away from the solution source, both in time and space. The gradients found at greater distances from the source in distal (far from contact) skarns tend to be less (e.g., 210-350°C) for a particular skarn stage to that in proximal (near contact) skarns (e.g., 400-650°C). This information is useful for delineating the parts of such a hydrothermal system. Temperatures also tend to decrease with time, which is reflected by the superimposition of various overprinting, retrograde mineral stages. In a few areas (e.g., Naica, Mexico) intermittent boiling of ore solutions occurs, periodically elevating both temperatures and salinities, but commonly boiling only occurs early in skarn genesis just after an early, commonly lower temperature, phase.

Most fluid inclusions represent a mix of 'exhaust' or reacted solutions with minor unreacted or new (pre-) ore solution components. Limited data on the distribution of elements present in fluid inclusions that do not normally take part in skarn genesis (Na, K and Cl) indicate that their proportions reflect the nature of the associated pluton. High KCl contents are found in skarns adjacent to high K granitoids, whereas high NaCl contents are found in skarns adjacent to calcic granitoids.

In many examples, daughter minerals present in minor proportions in opened fluid inclusion cavities reflect the metal characteristics of the ore solution. Small rare-earth metal, tungsten, zinc and copper daughter(?) minerals have been identified. The temperature and (or) salinity data for skarns of different metal or geological type is not particularly useful to delineate whether a skarn locality is part of a more complex, as yet unexplored system. Solutions in Pb-Zn skarns tend to be lower-temperature (150-400°C) and more dilute (<30 wt % T.D.S.) than in other skarn types, but exceptions occur. (Author's abstract)

KWAK, T.A.P., BROWN, W.M., ABEYSINGHE, P.B. and TAN, T.H., 1986, Fe solubilities in very saline hydrothermal fluids: Their relation to zoning in some ore deposits: Econ. Geol., v. 81, p. 447-465. First author at Dept. Geol., La Trobe Univ., Bundoora, Victoria 3083, Australia.

The Fe concentrations in fluids present in very saline fluid inclusions from the King Island W skarn, hole 16, F-Sn-W deposit and the Mary Kathleen U-rare earth element skarn have been determined using the phase deposit volume method. Fe-bearing dms include magnetite, pyrite, amarantite ($Fe^{+3}(SO_4)(OH)\cdot 3H_2O$), and hydrated ferrous chloride. The fluid inclusion liquid compositions are inferred from a combined analysis of [Te values], dm identification by scanning electron microscopy in conjunction with an energy dispersive X-ray analyzer, and relevant published experimental salt solubilities. Maximum Fe solubilities show an exponential increase to 9 wt % Fe with increasing total anion content of the fluid, especially in the 20 to 30 wt % interval. Fe solubility is mainly dependent on total chloride contents, with fluoride contributing very little to increasing the Fe solubility. T, fO_2 and fS_2 appear to have a minor influence on the total Fe solubilities.

Some of the samples contain solid Fe-bearing crystals which coexisted with the fluid inclusions and probably buffered Fe at the appropriate a(Fe) values during genesis, but the Fe contents of most fluids were probably undersaturated with respect to Fe-bearing minerals. Over the range for which the total anion content of the fluid is 25 to 35 wt %, the apparent maximum Fe content of fluid tends to decrease in the following order when the Fe-bearing dxls are present: magnetite > pyrite > hydrated ferrous chloride > amarantite, although anomalies to this trend occur.

The Fe solubility data are used to explain some Fe mineral overprints (stages II and III) of skarns, the magnetite-Fe chlorite-cassiterite veins in tin granites, and the zonal pattern present in porphyry copper systems.

The Fe data suggest that the highly saline, Fe-bearing solutions present in the cores of porphyry systems and other near-contact deposits are not a result of increased salinity of hydrothermal fluids due to boiling of meteoric solutions but are inherent from an orthomagmatic source. (Authors' abstract)

KYLE, J.R. and GUTIERREZ, G.N., 1986, Origin of sandstone- and carbonate-hosted lead deposits, Indian Creek district, southeast Missouri, USA (abst.): Terra Cognita, v. 6, no. 3, p. 560-561. Authors at Dept. Geol. Sci., The Univ. Texas at Austin, Austin, TX 78713, USA.

The Indian Creek district is the northernmost mineralized zone within Upper Cambrian strata on the flanks of the Ozark Dome in southeastern Missouri. Economic sulfide concentrations are related to sedimentary facies tracts that developed during the Late Cambrian marine transgression over a rugged basement topography resulting from an extensive period of late Proterozoic erosion. Fluid inclusion data for sphalerite from the Indian Creek mine indicate that the mineralizing fluid was a Na-Ca-Cl brine ranging from 100 to 120°C. The Lamotte served as the aquifer that channeled the metalliferous brines into the Bonneterre carbonates and that was locally mineralized near depositional pinchouts. (From the authors' abstract)

KYLE, J.R. and PRICE, P.E., 1986a Metallic sulphide mineralization in salt-dome rocks, Gulf Coast, U.S.A.: Trans. Instn. Min. Metall. (Sec. B: Appl. Earth Sci.), v. 95, p. B6-B16. First author at Dept. Geol. Sci., Univ. Texas-Austin, Austin, TX.

The fine-grained nature of the sphalerite at Hockley and some other cap-rock deposits has prevented direct fluid-inclusion investigation of the nature of the ore-forming fluids for the main stage of sulphide mineralization. Barite crystals in late vugs are the only materials that have provided information that is at all relevant to the main stage of mineralization; limited data for these fluid inclusions suggest precipitation over the range 120-130°C from solutions that ranged from 3 to 12% NaCl equivalent. The low salinities of these inclusions by comparison with those of many basinal brines probably indicate a late stage of mineralization, in which mixing with shallow meteoric waters may have played a part. Some late calcites also contain low-salinity, single-phase fluid inclusions, which suggest precipitation at less than 60°C. Although considerable scatter is found in the limited data, sulphur isotopic fractionation for galena-sphalerite pairs is compatible with sulphide precipitation between 110 and 180°C under equilibrium conditions. (From the authors' text)

KYLE, J.R. and PRICE, P.E., 1986b Salt dome metallic mineralization in Mesozoic rift basins in the Gulf Coast (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 663.

LABUTIN, A.N. and NAUMOV, V.B., 1985, Conditions of formation of the cassiterite-feldspar deposit Butugychar: Geokhimiya, no. 9, p. 179-185 (in Russian).

Cited in Naumov, 1986 (this volume).

LADIEVA, V.D., MONAKHOV, V.S., PASAL'SKAYA, L.F., STUL'CHIKOV, V.A. and SEMENENKO, N.P., 1986, Gaseous components in sedimentary-volcanic formations of the Ukranian Shield: Geokhim. Rudoobraz., v. 14, p. 11-14 (in Russian).

Indexed under fluid inclusions. (E.R.)

LAMB, W.M., VALLEY, J.W. and BROWN, P.E., 1986, Fluids and granulite genesis: CO_2-rich fluid inclusions from low-CO_2 granulites (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 92. Authors at Dept. Geol. & Geophys., Univ. Wisconsin, Madison, WI 53706.

Samples from throughout the granulite facies of the Adirondack Mountains, New York, may contain several generations of fluid inclusions. These include CO_2-rich, mixed CO_2 + H_2O and H_2O-rich. This investigation has focused primarily on the CO_2-rich inclusions, as their presence is frequently interpreted to indicate the important role which CO_2 may play in the formation of granulites (e.g., CO_2-infiltration). The data from the most dense fluid inclusions include:

Sample	Th	D	Tm	T(META)	P(META)	P(FI)	log fO_2	XCO_2
SR-31	8.5	0.88		715	7.8	4.0	-17.3	<0.02
MM-13	-11.8	0.99	-56.7	690	7.8	5.5	-17.7	<0.03
N-5	3.7	0.91	-58.5	710	7.5	4.6	-16.8	<0.10
TP-5	-4.0	0.95	-56.5	730	7.5	5.3	-16.0	<0.60
TP-11	-16.0	1.02	-57.4	720	7.5	6.1	-16.1	<0.80
IN-10	-17.9	1.03	-57.4	730	7.3	6.3	-15.9	<0.70
LB-1	-15.6	1.01		655	6.8	5.5	-18.2	<0.15
GVR-274	8.5	0.88	-56.8	645	7.0	3.7	-19.9	<0.004
GVR-275	14.6	0.82	-56.6	670	7.0	3.2	-18.1	<0.05
GVR-276	-2.2	0.94		744	7.0	5.3	-15.7	<0.70
GVR-64	-34.1	1.09	-57.2	735	7.0	7.6	-14.6	<1.0

[Th = CO_2 liquid-vapor Th, D = CO_2 density, Tm = CO_2 triple point, T(META) = T (magnetite + ilmenite), P(FI) = P calculuated from D and T(META)].

These inclusions are in samples which contain coexisting magnetite and ilmenite (Bohlen et al., 19880). Fluid calculations in the C-O-H system place an upper limit on the fugacity of CO_2 in these rocks (Lamb and Valley, 1984, 1985), and they show that some samples are too reducing to be compatible with a CO_2-rich peak metamorphic fluid. This indicates that at least some CO_2-rich, high density, fluid inclusions were formed after the peak metamorphism. (Authors' abstract)

LAMB, W.M., VALLEY, J.W., BROWN, P.E. and MORRISON, Jean, 1986, Fluid inclusion constraints on retrograde P-T-t paths and post-metamorphic fluid compositions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 664. Authors at Dept. Geol., Univ. Wisconsin, Madison, WI 53706.

Quartz from the Willsboro and Lewis wollastonite mines, N.E. Adirondack Mts., N.Y., contains several compositionally distinct types of fluid inclusions. These inclusions are 5 to 40 microns in diameter and include: 1) H_2O-rich (with variable salinity), 2) CO_2-rich (no visible H_2O), and 3) mixed H_2O-CO_2 varieties. Many of the CO_2-rich inclusions homogenize at temperatures (Th (L-V)CO_2) from -20 to -46°C; corresponding to CO_2 densities of 1.03 to 1.14 gm/cc. Although densities of ~1.05 to 1.1 are consistent with entrapment of CO_2 at peak metamorphic P-T, wollastonite is not stable in the presence of a CO_2-rich fluid under these conditions. This shows that entrapment of CO_2 occurred after the peak of regional granulite-facies metamorphism.

Many of the mixed inclusions contain small amounts of CO_2 (1-5 vol. %) with Th (L-V)CO_2 ~16 to 24°C. Final melting of H_2O-CO_2 clathrates ranges from ~6 to 10°C, corresponding to salinities up to 7.5 equivalent wt. % NaCl. Attempts to homogenize the H_2O-CO_2 in these inclusions resulted in decrepitation and demonstrate that entrapment occurred at T >225°C. Isochores for these inclusions pass from ~225°C, 3 kb to ~500°C, 7 to 8 kb. These isochores, in conjunction with the isochore for the most dense CO_2-rich inclusions (1.14 gm/cc), indicate the initial cooling of the terrane was nearly isobaric with a maximum decrease in pressure of ~2.5 kb occurring during the first 300°C of cooling. This suggests that many of the inclusions which contain >60 vol. % CO_2 (ρCO_2 = 0.6-0.9) must have reequilibrated at lower P and T along a P-T-t path that is concave towards the temperature axis. These results support studies of garnet zoning in Adirondack granulites that also indicate isobaric cooling (Bohlen, 1986).

Preliminary isotopic analyses of the CO_2 in fluid inclusions collected via stepwise heating and thermal decrepitation suggest the C has $\delta^{13}C$ values of -3 to -11‰ (PDB). The $\delta^{13}C$ of the calcite is 0.8‰, while carbonaceous material, which occurs included in the calcite, has a value of $\delta^{13}C$ ~-21‰.

The measured $\Delta(CO_2\text{-}Cc)$ of $\sim$-4 to -12 are not consistent with equilibrium at metamorphic temperatures and further support a post-metamorphic origin for the fluid in the inclusions. (Authors' abstract)

LAMBERT, I.B., DONNELLY, T.H., SOUTHGATE, P.N., ETMINAN, H. and WESTE, G., 1986, Isotopic and fluid inclusion studies of Cambrian paleoenvironments, eastern Officer Basin, south Australia (abst.): Terra Cognita, v. 6, no. 2, p. 223. First author at Baas Becking Lab., GPO Box 378, Canberra ACT 2601, Australia.

Evaporation in arid Lower Cambrian epeiric sea environments resulted in deposition of a thick carbonate-evaporite sequence in the Officer Basin. Isotopic and fluid inclusion studies have been conducted to obtain further information on paleoenvironmental conditions. Sr, C, and O isotope data on minerals were determined.

^{18}O-enrichment occurred during evaporation of ground and surface waters entering the lake system. The larger pseudomorphs of sodium carbonate minerals are characterized by significantly lower $\delta^{18}O$ values, concentrated between 19 and 22.5% and fluid inclusions with variable salinities and homogenization temperatures up to ca. 110°C. These features imply that the trona and shortite were dissolved and pseudomorphosed as a result of extensive influx of heated waters that mixed to varying degrees with the relatively saline interstitial brines. (From the authors' abstract)

Similar abstract in Eighth Australian Geol. Conv., Geol. Soc, of Australia, "Earth Resources in Time and Space," Feb. 16-21, 1986, Flinders Univ., Adelaide, Abstracts, no. 15, p. 117. (E.R.)

LAMBERT, I.B. and ETMINAN, Hashem, 1986, Diagenetic and mineralizing processes in Devonian carbonates, Canning Basin, W.A. (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 172. Authors at Baas Becking Lab., G.P.O. Box 378, Canberra, 2601, Australia.

Isotopic compositions of early cements from unmetamorphosed carbonate complexes of the Canning Basin indicate extensive marine cementation. Later carbonate cements have slightly more variable C- and O-isotopic compositions and generally higher $^{87}Sr/^{86}Sr$ ratios; fluid inclusions within them exhibit a range of salinities from around that of seawater to very high, and Th between 40 and 110°C. The strong brines were derived from basinal strata and they contain appreciable Ca^{2+} and/or Mg^{2+} in addition to Na^{+}. Carbonate spars from the vicinities of Pb-Zn mineralization exhibit relatively wide ranges of isotope compositions; also fluid inclusions in these spars and associated sphalerite have higher mean Th, salinities and hydrocarbon contents than observed in carbonates from unmineralized areas. Evidently the Pb-Zn mineralizing fluids formed relatively deep in the basin sequence, contemporaneously with hydrocarbon generation.

Color alteration in conodont fossils and annealing of fission tracks in detrital apatites can be used as indicators of thermal alteration. Both techniques have been applied to host rocks for Pb-Zn deposits and permeable strata along which metalliferous and dolomitizing fluids migrated, and they indicate that these strata have not been heated above ca 70°C for long enough to be recorded by these indicators. This constraint, together with widespread evidence for zoning of sphalerite and associated carbonates, implies that there were multiple short-lived pulses of heated brines.

Sulfur isotope compositions indicate that sulfide was formed by sulfate reduction under varying conditions, apparently involving thermochemical and biological processes, and that some iron sulfides formed at different times from closely associated ore minerals. (Authors' abstract)

LAMBERT, I.B., KNUTSON, J., DONNELLY, T.H. and ETMINAN, H., 1986, The diverse styles of sediment-hosted copper deposits in Australia, in Geol. & Metallogeny of Copper Deposits, G.H. Friedrich et al., eds.: Springer-Verlag Berling Heidelberg, p. 540-558.

For Olympic Dam, Th on fluorite and quartz associated with sulfides are 110-265°C and salinities are 0.5 to 14.3% NaCl equiv. (E.R.)

LAND, L.S., 1986, Saline brines, Frio Formation, south Texas: Contribution from basement exhalation? (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 665.

LANDAIS, P., 1986, Geochemical analyses of the organic matters associated with the breccia pipes in the Grand Canyon area (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 389. Author at Cogema, BP 4, 78141 Velizy-Villacoublay Cedex, France.

Geochemical analyses (rock-eval pyrolysis, C, H, O, N analysis, thermovaporization, gas chromatography) of the organic material associated with the breccia pipes in the Grand Canyon area have been used to characterize the nature and the maturation of the kerogens as well as the different alteration and migration processes.

All the breccia pipes investigated contain organic material: kerogens, fluid oils, oil impregnations, solid black bitumens and fluid inclusions containing hydrocarbons.

Oil and bitumens are more or less altered. Both waterwashing and biodegradation phenomena have been proven. Drastic bacterial degradation formed the highly insoluble bitumens associated with sulfides. This was caused by hydrocarbon oxidizing and sulphate reducing bacteria as well as the effect of two types of fluids: a brine and a meteoric water, which have been analyzed in fluid inclusions. Similar processes have been demonstrated in the Lodeve uranium deposit, France.

Calculations based on time-temperature relationships reveal that the most probable age of oil migration ranges between 100 Ma and 160 Ma. The inferred temperatures fit well with the Th of aqueous fluid inclusions trapped in carbonates (70-90°C).

These geochemical results provide evidence in favor of a low T model for the uranium and sulfide mineralization in the breccia pipes. (From the author's abstract)

LANDAIS, Patrick and CONNAN, Jacques, 1986, Source rock potential and oil alteration in the uraniferous basin of Lodève (Hérault, France): Sci. Géol., Bull., v. 39, pt. 3, p. 293-314 (in French; English abstract). First author at Centre de Recherches sur la Géol. de l'Uranium, PB 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

Major uraniferous mineralizations (post-fault ore) of the Permian from the Lodeve Basin are associated with migrated organic matter in reservoir facies (faults, joints, silts, cinerites). The kerogen of the dolomitic black shales is oil-prone (mixed to sapropelic type) and has reached the threshold of intense oil genesis.

Oil shows have been found in the karstic Cambrian basement as well as in the grey Autunian. Oil-to-source rock correlation has been demonstrated in the St Privat barite deposit by using sterane and terpane distribution patterns analyzed by computerized GC-MS analyses.

Oils associated with sulfidic and sulfatic mineralizations are often biodegraded and may have been partly transformed [to] chloroform insoluble bitumen. It is the case in the St Privat barite deposit where the intense biodegradation of oils has affected both stearanes and αβ hopanes entailing a correlative enrichment of tricyclic terpanes including the extended terms (C_{20}-C_{40}).

The study of Autunian oils shows that original oils may be altered by different processes: extensive biodegradation with intense attack of alkanes and aromatics (oxidizing pathway), genesis of a chloroform insoluble phase without obvious biodegradaton (non-oxidative pathway). This chloroform insoluble organic fraction may represent more than 90% of the total bitumen. A tentative explanation for these observations has been proposed by referring to microthermometric data obtained on aqueous fluids trapped in Autunian carbonates. These data show two types of fluids: meteoric waters and brines. Meteoric waters have brought the microorganisms responsible for the biodegradation of oils in some cases whereas saline brines, interacting with oils, may have led to genesis of chloroform insoluble bitumen without any biodegradation in other cases. (Authors' abstract)

LANG, J.R., 1986, A geochemical study of alteration and mineralization in the Wallapai mining district, Mohave County, Arizona: MS thesis, Univ. of Arizona.

The Wallapai Mining District hosts both porphyry mineralization and an extensive zone of base metal veins. The sequence of major vein stages, with their formation T, is 1) anhydrite-molybdenite (380-420°C), 2) quartz-molybdenite (380-400°C), 3) anhydrite-chalcopyrite (380-400°C), 4) quartz-sericite-pyrite (320-350°C), and 5) complex base metal (420-450°C). Molybdenite formed from boiling fluids, chalcopyrite from hypersaline fluids and the latter two vein stages from very low salinity solutions. The ranges of $\delta^{34}S$ (pyrite) value are 1.0 to 4.0‰ in the first three stages and 2.0 to 5.9‰ in the latter two stages. Sulfur isotope T from anhydrite-pyrite pairs indicate isotopic equilibrium was attained in the first and third stages.

The distinction between early and late veins suggests an evolution from magmatic(?) fluids to convecting meteoric fluids. Two separate convection cells are indicated by fluid inclusions. The first cell was small and formed the phyllic alteration. The second cell formed the complex veins and was much larger; it was driven by a large intrusion at depth. (Author's abstract)

LANG, J.R. and EASTOE, C.J., 1986, Sulfide-sulfate equilibrium and the sources of sulfur in the Mineral Park porphyry copper-molybdenum system, Arizona (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 666.

LARDEAUX, J.-M., CARON, J.-M., NISIO, Pascal, PEQUIGNOT, Guy and BOUDEULLE, Micheline, 1986, Microstructural criteria for reliable thermometry in low-temperature eclogites: Lithos, v. 19, p. 187-203.

LARSON, P.B., BAILEY, K.H. and TAYLOR, H.P., Jr., 1986, Oxygen isotope evidence for two distinct fluid sources in the Rico mining district, southwest Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 390. First author at Dept. Geol., Washington State Univ., Pullman, WA 99164.

The Rico mining district, western San Juan Mountains, Colorado, has produced more than 14 million ounces of Ag, substantial Pb and Zn, and minor Cu and Au from vein and replacement deposits in Paleozoic-Mesozoic sedimentary rocks. Recent drilling has delineated a deep porphyry Mo deposit underlying the east-central part of the district. Two series of Cretaceous-Tertiary intrusive rocks are present: 1) Laramide-age intermediate sills, stocks, and dikes, and 2) Pliocene quartz porphyry rhyolite and lamprophyre dikes and plugs. All mineralization is Pliocene in age. Quartz from quartz-Mo veinlets yield oxygen isotope values of +7.5 to +8.6 per mil, and contain two phase (liquid-vapor) P and S fluid inclusions that homogenize to a liquid or a vapor at ≤400°C. Calculated $\delta^{18}O$ values for water in equilibrium with this quartz are greater than 4 per mil and indicate a dominantly magmatic component in the porphyry-Mo mineralizing fluid. Vein quartz from Newman Hill and Silver Creek areas have low $\delta^{18}O$ values: -0.5 to +4.7 per mil and -6.1 to -0.9 per mil, respectively. Quartz from both areas contain P and numerous S liquid-vapor, low salinity, fluid inclusions that homogenize to a liquid between 220 and 285°C. These data yield calculated fluid $\delta^{18}O$ values lower than 0 per mil: these fluids are clearly dominantly meteoric in origin. Thus, two distinct fluid reservoirs were responsible for mineralization in the Rico district. Some of the quartz veins in the Silver Creek area (-4.4 to -0.9 per mil) lie several thousand feet directly above the porphyry Mo mineralization. This suggests that the porphyry Mo system was spatially restricted and that the two fluids did not interact over a large area, possibly because the Mo system was active early in the history of the district prior to establishment of large-scale meteoric-hydrothermal circulation. (Authors' abstract)

LARSON, P.B. and TAYLOR, H.P., Jr., 1986, An oxygen-isotope study of water-rock interaction in the granite of Cataract Gulch, western San Juan Mountains, Colorado: Geol. Soc. Am. Bull., v. 97, p. 505-515.

LATTANZI, P. and TANELLI, G., 1985, Le mineralizzazioni a pirite, ossidi di Fe e Pb-Zn (Ag) della zona di Niccioleta (Grosseto): Rendiconti Soc. Ital. Mineral. Petrol., v. 40, p. 385-408 (in Italian).

Contains a summary of available fluid inclusion data. (P. Lattanzi)

LEACH, D.L. and ROWAN, E.L., 1986, Genetic link between Ouachita foldbelt tectonism and the Mississippi Valley-type lead-zinc deposits of the Ozarks: Geology, v. 19, p. 931-935. Authors at U.S. Geol. Survey, P.O. Box 25046, Denver, CO 80225.

Fluids expelled from the Arkoma basin in response to Late Pennsylvanian-Early Permian orogenesis in the Ouachita foldbelt may have been ultimately responsible for formation of the Mississippi Valley-type lead-zinc deposits in the Ozark region of Missouri, Arkansas, Kansas, and Oklahoma. Fluid inclusions in both mineralized and barren rock record the passage of hot, saline fluids regionally throughout most of the Paleozoic section in the Ozarks. Dating studies in addition to structural and geologic observations provide further evidence for fluid migration and mineralization approximately coincident with the Ouachita orogeny.

Formation of foreland basins, such as the Arkoma, during convergent tectonism creates conditions exceptionally favorable to the migration of fluids from deep sedimentary basins. Proximity to a basin whose margin has undergone some form of tectonic deformation or uplift may be the unifying factor in the genesis of Mississippi Valley-type deposits in geologically diverse settings. (Authors' abstract)

LEBEDEV, I.P. and CHISTYAKOV, V.P., 1986, Nature of aegirine from ferruginous quartzites of the Kursk magnetic anomaly: Izv. Vyssh. Uchebn. Zaved., Geol. Razved., 1986, no. 8, p. 29-33 (in Russian).

Indexed under fluid inclusions. (E.R.)

LEDER, Frederic and PARK, W.C., 1986, Porosity reduction in sandstone by quartz overgrowth: Am. Assoc. Petrol. Geol. Bull., v. 70, no. 11, p. 1713-1728.

LEE, Y.I., ERGIN, Mustafa and FRIEDMAN, G.M., 1986, Burial history of Lockport Formation (Middle Silurian), New York, in light of studies of Ellenburger Group (Lower Ordovician), west Texas-southeastern New Mexico (abst.): Am. Assoc. Petrol. Geol. Bulletin, v. 70, no. 5, p. 610. First author at Brooklyn College of City Univ. of New York, Brooklyn, NY.

For studies of burial depth of the Lockport Formation (Middle Silurian) of the Appalachian basin, we used a control data from petrographic, stable isotope, and two-phase fluid-inclusion analyses of carbonate rocks cored from 5,000 to 23,000 ft (1.5 to 7 km) burial depth of the Ellenburger Group, west Texas and southeastern New Mexico. The coarse to very coarse crystalline nature of the host-rock dolomite, the vug-filling and fracture-filling saddle dolomite containing relatively light oxygen isotope compositions ranging from -6 to -12‰ (PDB), and the high mean Th for saddle dolomite formation from 100° to 260°C, all suggest diagenetic changes occurred under deep burial conditions.

Using Ellenburger carbonates as a control for burial depth diagenesis studies of saddle dolomite of the surface-exposed Lockport Formation, New York, other literature, and the regional conodont color alteration index (CAI) of 2-3, a former burial depth for the Lockport Formation strata of up to 5 km is indicated, much greater than the present estimation of less than 2 km of paleogeographic reconstruction. This depth was confirmed by $\delta^{18}O$ values ranging from -9 to -11‰, and two-phase fluid-inclusion Th ranging from 110° to 200°C with an average of 150°C. (Authors' abstract)

LEEDER, O., THOMAS, R., and BAUMANN, L., 1986, The importance of inclusion research for the investigation of mineral deposits: Freiberger Forschungshefte, v. C402, p. 7-30 (in German; English abstract).

The article contains a survey of the classification and the possibilities of examination of inclusions, especially of gaseous-fluid inclusions, in minerals of magmatic, late magmatic, and postmagmatic parageneses of deposits and sedimentary and metamorphic formations. (Authors' abstract)

LENNIKOV, A.M. and KONOVALOVA, N.P., 1986, Gas phase of plagioclases from the South-Aldan metaanorthosites: Dokl. Akad. Nauk SSSR, v. 288, no. 1, p. 210-213 (in Russian). Authors at Far-East Geol. Inst. of the Far-East Sci. Center of Acad. Sci. USSR, Vladivostok, USSR.

The samples of anorthosites metamorphosed under the granulite facies conditions from the massifs Verkhne-Undytkan and Kun-Man' of the Aldan Shield released on heating (up to 500 and 1000°C) gases, which were analyzed by gas chromatography. Plagioclases bear 1066-5653 cm^3 of gas per kg of sample (0.09-0.50 wt.%). Water is the main component (89-97 vol.% of total volatiles in the interval 20-500°C and 57-88 vol.% in the interval 500-1000°C, later the same units and T interval sequence); the second one is CO_2 (1.7-7.1 and 3.0-25); next gases come in various proportions: CO (0.2-1.0 and 0.8-5.7), CH_4 (0.1-2.0 and 0.1-1.3), H_2 (nil to 0.4 and nil to 12.8), N_2 (0.1-5.0 and 0.1-0.7). Regional differences and similarities are suggested, however, only on the basis of four samples from the Verkhne-Undytkan massif and three samples from the unspecified number of the Kun-Man' massifs. (Abstract by A.K.)

LEROY, J., FRITZ, B. and CATHELINEAU, M., 1986, Phyllitic alteration in granite-hosted uranium deposits: Analysis, modelling and distribution of the alterations (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 112 (in French). First author at CREGU, BP 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

Mineralogical and geochemical studies of U deposits in the NW Limousin (St Sylvestre, Marche, Millevaches) show two major stages of potassic alteration, one characterized by the formation of phengites and related to episyenitization of the granite before and during deposition of pitchblende, the other characterized by the formation of clays during the first hydrothermal alteration of pitchblende and its transformation into coffinite. The alteration zones formed during these two stages have much larger extents than the mineralized mica-bearing episyenites.

Geochemical modelling (by programs Dissol and Thermal) between 300 and 200°C for phengite and between 150 and 60°C for montmorillonite and kaolinite, based on data from fluid inclusions, results in mineral phases that are comparable to those observed in the field. The models indicate that fluids must have changed between the two alteration stages, which is confirmed by stable isotope date (O-H).

The observed montmorillonite-kaolinite zonation (coffinite stage) must have formed by percolation of fluids parallel to the draining system. This conclusion is supported by a study of the orientation of fluid inclusion trails which are considered to mark the passageways of fluids during alteration. (Authors' abstract, translated by R. Kreulen)

LESPINASSE, Marc, 1984, Structural setting for the uranium ore deposits of the Marche Occidentale: Fracturing, fluid circulation, propagation of episyenitization: Ph.D. dissertation, Inst. Natl. Polytech. de Lorraine, CREGU Memoire No. 8, 196 pp. (in French; English abstract).

The U ore deposits mined by the Compagnie Minière Dong Trieu (C.M.D.T.) are located in the Hercynian Marche Occidentale two-mica granite (Northwest French Massif Central). As in many U deposits of the French Massif Central, the mineralization occurs as disseminations in episyenitic rocks. The episyenite is a vuggy rock, which results from an alteration of the granite, with dissolution of quartz by hot hydrothermal aqueous solutions.

The principal episyenitic bodies are located in the N 120°E part of the Marche dislocation zone. They seem to be structurally controlled by N 20°E and, less clearly, by N 150°E faults. The percolation of the hydrothermal fluids occurred through a dense set of fractures at all scales. Part of the percolating fluids have been preserved in numerous healed microcracks, which now appear as thin trails of fluid inclusions. These trails are observed in the quartz which fills some of the mesoscopic fractures, but also form a dense set in all the preserved quartz crystals of the bulk granite around the episyenites. Trails of fluid inclusions are preferentially parallel to the main direction of stress (N 20°E) and to the episyenitic column section. They are more and more dense on approach of them[sic] and they should correspond to the drains of the hydrothermal fluids responsible for quartz dissolution.

Microthermometric studies in oriented thick sections show that Th and salinities decrease with the distance from the episyenites.

The Tm-Th pairs for the N 20°E trails are scattered over a large range of values. The N 20°E direction has been a preferred failure direction during most of the evolution of the hydrothermal system. The salinities are higher near the episyenitic rocks (6.1% eq. NaCl) in the N 20°E direction. The N 90°E and N 150°E trails have fossilized only very low salinity fluids (0.87% eq. NaCl). These trails were induced by the late N 00°E and N 150°E direction of compression. So we can now assume that the low salt content fluids correspond to the end of the evolution of the hydrothermal system.

In this work we show that there is a good relation between the distribution pattern of fluid inclusion trails and the regional large scale deformation. It is possible to analyze them statistically as any tension fracture (opening preferentially parallel to the shortening direction). With these structural data on fluid inclusions, it is then easier to distinguish between the different stages of percolation, particularly if the regional stress field rotated during the evolution of the hydrothermal system. (From the author's abstract)

LESPINASSE, Marc and PÊCHER, Arnaud, 1986, Microfracturing and regional stress field: A study of the preferred orientations of fluid-inclusion planes in a granite from the Massif Central, France: J. Structural Geol., v. 8, no. 2, p. 169-180. First author at Centre de Recherche sur la Géol. de l'Uranium, 3 Rue du Bois de la Champelle, 54500 Vandoeuvre les Nancy, France.

A study of the deformation of a granitic massif indicates a relationship between palaeostress fields and the geometry of microfractures as defined by fluid-inclusion trails, that is, healed microfractures. A statistical study of the distribution of the trails leads to the following conclusions: trails exhibit several distinct preferred orientations on the scale of a grain, which may be observed in many samples; the orientations of the trails are similar to those of micro- and mesoscale fractures in the granite; and the dominant trail direction is parallel to the main direction of regional shortening. Thus, fluid-inclusion trails are mode I cracks which can be used as excellent markers of palaeostress fields. (Authors' abstract)

LEUNG, I.S. and TREVES, S.B., 1986, Melt inclusions in olivine in a basalt flow from McMurdo, Antarctica (abst.): EOS, v. 67, p. 384. First author at Dept. Geol. & Geography, Herbert H. Lehman College, City Univ. of NY, Bronx, NY 10468.

Samples of a 44-meter thick basanite flow from a borehole near McMurdo Station contain abundant olivine xenocrysts derived from disintegration of olivine nodules. Melt (glass) inclusions exposed on polished sections were analyzed in an SEM equipped with an X-ray energy-dispersive spectrometer.

Results of this study shows direct correlation between increasing degree of crystallinity in the included melt globule and depletion of Si, concomitant with enrichment of Fe in the residual melt. From the globular magma trapped in the crystal, olivine grows on the walls of the cavity or as separate grains until silica is depleted[sic], thus, producing extremely Fe-rich patches of residual melts. From this metallic melt magnetite, chromite and spinel crystallized. Rhythmic concentric structures were observed in primary inclusions, which may be related to thermal regimes in the magma chamber. Further research will show if this type of structure is characteristic of primary melt inclusions in volcanic rocks.

An inclusion occurring in a halo formed by minute dust-like inclusions contains a daughter mineral of chromite and a smaller crystal of pyrrhotite. Other inclusions in the same halo contain, respectively, apatite, sanidine, ilmenite, and spinel. To understand if these phases are truly daughter minerals crystallized out of the trapped melt, or, if they are accidental solid inclusions,would contribute significantly to studies of liquid immiscibility in silicate melts. If all inclusions within this halo trapped an identical homogeneous liquid, similar daughter minerals should be present in all the globules. (Authors' abstract)

LEWIS, R.D. and SHIEH, Y.N., 1986, Stable isotopic, mineralogical and wall rock investigation of the Yellow Pine Au, W, Ag, Sb, Hg district, Valley County, Idaho (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 672.

LI, Binglun and SHI, Gang, 1986, Diagrams of physico-chemical parameters for gas compositions of inclusions in minerals: Geochimica, v. 2, p. 126-137 (in Chinese; English abstract). Authors at Inst. Geol., Acad. Sinica.

A great wealth of analytical data for fluid inclusions in minerals indicate that the major species of gases in fluid inclusions are H_2O, CO_2, CO, CH_4, H_2 and O_2. Three basic chemical reactions are supposed to prevail in rock-forming and ore-forming fluids:

$$H_2 + 1/2\ O_2 = H_2O,$$
$$CO + 1/2\ O_2 = CO_2,$$
$$CH_4 + 2O_2 = CO_2 + 2H_2O,$$

and equilibria were reached among them. Lg $f(O_2)$-T, Lg $f(CO_2)$-T and Eh-T diagrams for petrogenesis and minerogenesis in the supercritical state have been plotted under different P. On the basis of these diagrams $f(O_2)$, $f(CO_2)$, Eh, equilibrium T and equilibrium P can be readily calculated. In this paper some examples are presented to show the successful application in the study of the ore-forming environments of ore deposits. (Authors' abstract)

LI, Binglun, XIE, Yihan, ZHAO, Rui and LI, Ruomei, 1986, Magmatic process and geochemistry of Yangchuling calc-alkaline complex, Jiangxi Province: Geochem., v. 5, no. 1, p. 15-33 (in English). Authors at Inst. Geol., Acad. Sinica.

Oxygen and strontium isotope data indicate that the primary magma of the Yangchuling Complex resulted from the mixing of upper mantle materials with crustal materials. Under reducing environment with an oxygen fugacity of 10^{13} bar[sic, presumably 10^{-13} bar], the magma began to crystallize at a depth of 8 km between 1000°-1180°C, forming granodiorite and monzonitic granite porphyry. When the upper portion of the monzonitic granite porphyry became solidified, while its lower part remained to be liquid, explosion occurred due to P decrease, resulting in the formation of explosion breccia and autoclastic phenomenon, providing channels for the migration of hydrothermal solutions and favorite space for ore precipitation. The complex belongs to the calc-alkaline series. Various rock types were emplaced one after another during the process of constant differentiation from a common magma. As indicated by sulfur isotope data, the hydrothermal solutions were derived, for the most part, from the magma with only a small fraction coming from meteoric waters. Ore-forming components, including those leached out of the country rocks, carried by the solutions gave rise to W-Mo enrichment upon second boiling due to pressure drop. (Authors' abstract)

Includes Td data on many samples of quartz "from Yangchuling igneous rocks and ores," yielding numbers from ~100°C to 900°C; two analyses of gases evolved at <500 and >600°C (for H_2O, CO_2, CO, CH_4, and H_2); and Th data on aqueous inclusions from Mo-bearing quartz veins (110-160°C), W-bearing veins (196-253°C) and quartz from porphyries (380°C). Dm NaCl and liquid CO_2 observed also. (E.R.)

LI, P.J. and DU, Y., 1986, Estimation of apparent standard free energy of formation of ions in aqueous solutions, at high temperature conditions: Part 1: Geol. Rev., v. 33, no. 1, p. 31-41 (in Chinese; English abstract).

LI, Tiangang and HUANG, Zhizhang, 1986, Vein uranium deposits in granites of Xiazhuang ore field, in Vein type uranium deposits, IAEA - TECDOC-361, p. 359-376. Authors at Uranium Geol. Res. Inst., Beijing, PRC.

The Xiazhuang ore field is one of the important U districts of China from which substantial U resources are known. It lies within the Caledonian orogenic belt, where during the Yenshanian tectonic phase intensive tectono-magmatic activities took place. All U ore deposits of this district belong to the vein-type U deposits, being mainly characterized by a pitchblende-microquartz assemblage closely associated with an argillitization-pyritization alteration of the host rock. These deposits are located in a down-faulted block within the Guidong granite massif, which is characterized by a quite perfect granitic differentiation together with an intensive autometamorphism. The granite contains higher U and uraninite values. The age of the rock-forming period is 185 to 135 Ma, but the ore-forming period is 85 to 70 Ma. Thus the source of U must have been the consolidated granite itself. Fluid inclusion data and stable isotope information show that the ore formation took place mainly between 280 to 150°C under abruptly decreasing pressure conditions and significant escaping of gases. (Authors' abstract)(Continued)

Includes 6 analyses of fluid inclusions for K, Na, Ca, Mg, Fe, HCO_3, SO_4, F, Cl, H_2O, CO_2, CH_4, pH and Eh. (E.R.)

LI, Yuzu, 1986, On the genesis of the Huangshaping Pb-Zn deposit, Quiyang, Hunan in special reference to fluid inclusion studies of its minerals: Acta Mineralogica Sinica, v. 6, no. 1, p. 77-85 (in Chinese; English abstract). Author at Hunan Inst. Non-ferrous Metal Geol., Changsha.

The genesis of the Huangshaping Pb-Zn deposit has been studied based on its geological setting, mineral association and fluid inclusions. It is considered that the deposit shows distinct evolutionary characteristics of a magmatic mineralization series. From the endozone to the exozone, the mineral association, chemical elements, ore-forming T, salinity and density vary progressively. Thereby, the writer considers that ore-forming materials provided for magmatic fluids as the result of concentration and boiling of vapor phase and other volatile components, and thermodynamic conditions thus created are decisive factors controlling ore deposition. Although some material could be leached out of the sedimentary country rocks in the late stage, it would be of little importance. (Author's abstract)

LI, Zhaolin, 1986a The bearing of intergranular solution on mineralization: Acta Geol. Sinica, v. 60, no. 2, p. 189-201 (in Chinese; English abstract). Author at Dept. Geol., Nanjing Univ.

There are both melt and gas-liquid inclusions in the quartz in granite, and among the mother granite, altered rock and ore-bearing quartz vein there are many similarities in the characters of gas-liquid inclusions in quartz, such as Th, composition of ore-forming fluids and isotopic abundance ratio, etc. Hence the author believes that the fluids giving rise to the mineral deposits came mainly from intergranular solutions of the granite. (From the author's abstract)

LI, Zhaolin, 1986b Compositions of inclusions in chondrite minerals in China (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 155. Author at Dept. Geol., Nanjing Univ., Nanjing, PRC.

[Ed. note: The following abstract includes data from the published abstract, referenced above, and from an 8-page printed summary of the paper (in English), provided by the author.]

Solid, melt, and gas inclusions are found in olivine and pyroxene of these chondrites. The melt inclusions (most common) now contain glass, crystals and/or gas. Th [of gas bubble?] ranges from 1120 to >1250°C. Dms include a new species, green grains of chromic oxide, with Tm 1020°C. Microprobe analysis shows 89-97% Cr_2O_3, plus minor Fe, etc. Other dms include troilite (Tm 1240°C). CO_2 inclusions have Th = 35°C[sic]. Four electron microprobe analyses of glass inclusions show SiO_2 ranging from 65-72%. Mass spectrometric analyses of the gas phase shows major CO and H_2 (55 and 31%, respectively) plus lesser CO_2, N_2, CH_4, HC, and H_2O. (E.R.)

LIBERSBAKH, N.E., MATVIYENKO, A.D., KALYUZHNYI, V.A., PARKHOMCHUK, V.N., POTEBNYA, N.T., 1985, Characteristics of the mineralizing fluids and temperature conditions of formation of the Lugovsk granite massif (northwestern part of the Ukrainian shield) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 208-209 (In Russian; translation by Dorothy B. Vitaliano). Authors at IGGGI, Acad. Sci. Ukrainian SSR, L'vov, USSR.

The body (part of the Korosten pluton) consists of pink and grayish-pink albitized biotite granites. Compared to the other granites of this area (Korosten, Leznikov, Zhitomir), these rocks contain very high concentrations of alkalies (K_2O+Na_2O up to 9.5%) and F (0.14-0.25%). The latter forms the accessory minerals cryolite, prospite and yttrofluorite, the total content of which reaches 10 kg/t in isolated places (Marchenko et al., 1983).

Two genetic types of two-phase GLI were established by investigations of fluid microinclusions in the quartz of the Lugovsk granites: a) isolated groups of inclusions with no visible relationship to healed cracks (tentatively P); b) groups and chains of inclusions in healed cracks (S). The former have L = 60% and Th = 370°C, the latter L = 70-80% and Th = 290°C. Both types of inclusions homogenize to the liquid phase. The GLI from quartz veins have L = 85-90% and Th = 165-175°C.

Analysis of the mineralizing fluids by the aqueous extract method (analysts I. S. Got', I. M. Denega, Ye. N. Fedusiv) showed that the liquid phase of the inclusions from the Lugovsk granites has a HCO_3-F-alkali composition. The K:Na ratio is 1:4, the HCO_3:F ratio, 1:1. In the fluids which took part in the formation (alteration) of xenoliths of fine-grained granite, the ratio of cations and anoins changed, compared to the Lugovsk granites, toward an increase in content of K and F (K:Na = 1:3, HCO_3:F = 1:2.5). Analysis of aqueous extracts from the host migmatites of the Teterev series showed their essentially alkali-HCO_3 composition. Thus the fluids which took part in the formation and alteration of the granites of the Lugovsk massif were characterized by high alkali (especially Na) and F potentials.

T of formation of the Lugovsk granites were higher than the Th of the P inclusions in quartz (400°C); metasomatic reworking of the granites occurred at 300-400°C; and the last veins were formed at T close to 200°C. (From the authors' abstract).

LICHTNER, P.C., MURPHY, W.M. and HELGESON, H.C., 1986, Lagrangian formulation of fluid-rock interaction coupled to fluid flow (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 672.

LICHTNER, P.C., OELKERS, E.H. and HELGESON, H.C., 1986, Interdiffusion with multiple precipitation/dissolution reactions: Transient model and the steady-state limit: Geochimica Cosmo. Acta, v. 50, p. 1951-1966.

LIEBLER, G.S., 1986, Geology of gold mineralization at the Picacho mine, Imperial County, California: MS thesis, Univ. of Arizona.

Mineralization at the Picacho mine occurs in Mesozoic or older gneiss beneath a shallowly dipping detachment fault contact with overlying Tertiary volcanics. Brittle deformation during detachment faulting provided open spaces into which quartz, specular hematite, pyrite, calcite, and gold were deposited.

Native gold occurs in open-space quartz fillings in close association with pyrite and its oxidized derivatives. Fluid inclusions in veinlet quartz indicate precipitation from very dilute (<1 wt % NaCl) fluids at a minimum T of 201° to 226°C.

The hydrothermal system at Picacho was probably initiated and sustained by thermal energy related to mid-Tertiary igneous activity. T and salinity data from fluid inclusions suggest mineralization occurred in a meteoric water-dominated epithermal system. This mineralizing event occurred during and after detachment faulting, which provided open spaces for fluid circulation. (From the author's abstract)

LIN, Bin, 1985, Deduction and application of the thermodynamical equations for unitary two-phase fluid inclusions: Geochimica, 1985, no. 1, p. 90-97 (in Chinese; English abstract). Author at Xi'an Inst. Geol. & Mineral Resources, Chinese Acad. Geol. Sci.

Three thermodynamic equations for unitary two-phase fluid inclusions have been deduced.

(1) The thermodynamic equation for mutual transformation between gas and liquid phases in fluid inclusions. The transformation direction from one phase to the other can be known in terms of the density and filling degree of gas and liquid.

(2) The thermodynamic equation for pressure effect on temperature after homogenization of fluid inclusions. The coefficient of P-T variation is directly proportional to the filling degree of gas phase and inversely to the density of gas phase and liquid phase. Equations for homogenization, decrepitation and formation temperatures of fluid inclusions can be inferred from this equation.

(3) The thermodynamic equation for decrepitation temperatures of fluid inclusions. Many factors have effects on the decrepitation temperatures of fluid inclusions. Decrepitation temperature cannot be considered in any case as formation temperature. Thermal and vapor halos produced by decrepitation of minerals of the same kind and the same period from the same locality are worthy of consideration. (Author's abstract)

LIN, X.D., ZHANG, D.H. and CHANG, C.L., 1986, A discussion on the properties of ore-forming fluids of the wolframite quartz-vein in the Yaogangxian tungsten deposits, Yizhang county, Hunan province: Earth Sci. J. Wuhan College of Geol., v. 11, no. 2, p. 153-160 (in English; English abstract). Authors at Wuhan Colleg of Geol.

It has been consistently held that the mineralization fluid forming wolframite quartz-vein is high-middle hydrothermal solution. In this paper, according to a large number of geological facts it is believed that ore-forming fluid forming wolframite quartz-vein is likely a fluid which has transitional properties between hydrothermal solution and magma. It has great viscosity and density. It contains a great quantity of SiO_2. The facts are as follows: the transition from quartz-vein to aplite and to pegmatite, the changes of varieties and intensity of country rock alteration, vug characteristics in wolframite quartz-vein, the results of the study of mineral [i.e., fluid?] inclusions, the irregularity of local concentration of a large quantity of metallic minerals, the emerged features of wolframite in quartz veins, the granite breccias in quartz vein filling in hornfels, the variation of MnO/FeO ratio in wolframites and of the mineral assemblage and chemical composition in the ore vein, etc. The transitional fluid characteristically has its upper part akin to hydrothermal solution and lower part akin to magma after filling into the fissure which is almost vertical. (Authors' abstract)

LIND, T., SCHMETZER, K. and BANK, H., 1986, Blue and green beryls (aquamarines and emeralds) of gem quality from Nigeria: J. Gemm., v. 20, no. 1, p. 40-48. First author at Inst. Mineral. & Petrogr., Univ. Heidelberg, West Germany.

Two-phase fluid inclusions are described in these beryls. (E.R.)

LINDBLOM, Sten, 1986, Textural and fluid inclusion evidence for ore deposition in the Pb-Zn deposit at Laisvall, Sweden: Econ. Geol., v. 81, no. 1, p. 46-64. Author at Ore Res. Group, Geol. Inst., Stockholm Univ., S-106 91 Stockholm, Sweden.

Textures include growth zoning of sphalerite with systematic color changes traceable as a sphalerite stratigraphy over large areas of the deposit. Both sphalerite and calcite display several stages of mineral growth including dissolution breaks and etched surfaces. Fluid inclusion Th indicate that each stage was deposited in a distinct T interval during a generally overall T decrease. The environment of ore deposition was characterized by T of 120° to 180°C and a total salinity of 24 equiv. wt % NaCl. This resulted from mixing a hot, highly saline incoming solution with a cool local ground water. The principal minerals were deposited in the order calcite, barite, fluorite, sphalerite, and galena. This process was repeated several times and sulfide deposition was accompanied by calcite dissolution.

Deposition of the minerals was affected by different mechanisms during the mixing process: (1) heating of ground-water-deposited calcite, (2) cooling of brine-deposited barite, and (3) mixing which deposited sulfides and fluorite. The mixing occurred as a result of a double diffusion process where the equalization of densities resulted from salt diffusion along an extended interface between the hot brine and the cool ground water in the porous sandstone. (From the author's abstract)

LIU, Dongsheng and GENG, Wenhui, 1985, On the mineral association and mineralization conditions of the Carlin-type gold deposits in China: Geochimica, 1985, no. 3, p. 277-282 (in Chinese; English abstract). Authors at Res. Inst. Geol., Ministry of Metallurgical Industry, Guilin.

Fluid inclusion temperatures and salinities were also similar to Carlin-type deposits. (E.R.)

LIU, Guobin and LU, Huanzhang, 1986, Fluid inclusion study of gem tourmaline from Xinjiang, China: Geochemistry, v. 5, no. 3, p. 234-240 (in English). Authors at Inst. Geochem., Acad. Sinica.

This is an English version of an earlier paper published in Chinese. See same authors, Fluid Inclusion Research, v. 18, p. 247, 1985. (E.R.)

LIU, Relan, MU, Jilu and XU, Rong, 1985, A study of the fluid inclusions of Dalongshan tungsten-molybdenium deposits, Jiangxi province: J. Chengdu College of Geol., no. 2, p. 25-31 (in Chinese; English abstract).

The number of P fluid inclusions in quartz and their gas phase percentages increase from lower to upper part at the central section of the ore body. The mean Th measured in quartz and fluorite also increases from lower to upper part with a slope 0.42°C/m. Td of wolframite increases slightly as well.

From the data available it is concluded that the main ore-forming T is 340-240°C, which relates to hydrothermal mineralization of high-medium T range.

The salinity of fluid inclusions in quartz is about 6.33 wt%. No obvious variation has been found except a slight increase at the rich ore section.

The physico-chemical environment and the reverse zoning phenomenon of mineralization are discussed. (Authors' abstract)

LIU, Yingjun, LI, Zhaolin, WU, Qizhi, ZHAO, Meifang and JIANG, Haoshen, 1986, Studies of melt inclusions in some basalts from eastern China: Geochemistry, v. 5, no. 2, p. 108-122 (in English). Authors at Dept. Geol., Nanjing Univ.

Cenozoic basalts widespread in eastern China constitute an important sector of the circum-Pacific Cenozoic basalt belt. Basalt samples were collected from Wudalianchi (Heilongjiang Province), Nushan (Anhui Province), Fangshan (Jiangsu Province), Zhuji (Zhejiang Province), and Mingxi (Fujian Province). These basalts, for the most part, belong to the alkali basaltic series, and partly to tholeiites.

A variety of inclusions commonly occurs in the rock-forming minerals of these basalts. The physicochemical conditions of basalt formation in different areas have been reviewed in special reference to the inclusion data. Our studies have shown that there is a close relationship between the features of the inclusions and the physicochemical conditions of basalt formation, which can, therefore, be regarded as a guide to the mechanism of basaltic petrogenesis. The results of research in this aspect are presented in the present paper. (Authors' abstract)

LIU, Yushan and CHEN, Shuqing, 1986, An experimental study on cassiterite solubility and tin transport during mineralization: Acta Geol. Sinica, v. 60, no. 1, p. 78-88. Authors at Inst. Min. Deposits, Chinese Acad. Geol. Sci.

In order to examine the possible modes of tin transport and deposition during hydrothermal mineralization, cassiterite solubility was determined experimentally in pure water, NaCl and KF solutions, at room T and T up to 400°C at 600 x 10^5 Pa.

The experimental results are consistent with data obtained from fluid inclusion analysis for minerals of tin deposits in South China. Both show the important role of fluorine in the process of tin mineralization. (From the authors' abstract)

LLAVE, F.M., LUKS, K.D. and KOHN, J.P., 1986, Three-phase liquid-liquid-vapor equilibria in the methane + ethane + n-hexane and methane + ethane + n-heptane systems: J. Chem. Eng. Data, v. 31, p. 418-421.

LOFERSKI, P.J., 1986, Multiphase inclusions in plagioclase from the Stillwater anorthosites: Implications for REE geochemistry (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 158. Author at U.S. Geol. Survey, M.S. 954, Reston, VA 22092.

Mineralogical control on the anorthosite REE geochemistry is indicated by the presence of ubiquitous multiphase inclusions within cumulus plagioclase (Pl) grains. Individual multiphase inclusions consist of about 85% clinopyroxene (Cpx), 10% ilmenite (Ilm), and 5% Cl-apatite (Ap), a phase known to concentrate REE. The inclusions are commonly rounded, average from 10-50 µm, but locally vary up to several hundred µm across, and they generally occur closer to cores than rims of Pl grains, either singly, or in clusters. They are randomly distributed within and between samples. Microprobe analyses show that Cpx compositions range from Mg/Mg+Fe = 0.75 to 0.50 compared with 0.75 to 0.69 for the intercumulus Cpx. Furthermore, calcic Pl (An 90 to 95) forms 10 to 15 µm-wide rims around the inclusions, in contrast to Pl of An 75 to 85 throughout the rest of the grains.

Depsite its low modal abundance (<0.1%), the Ap inclusions may significantly affect the REE patterns of both whole rocks and mineral separates. The mutliphase nature and constant modal composition of the inclusions imply that they were trapped as liquid globules that were enriched in Ca, P, Ti, and Fe relative to the liquid crystallizing the bulk of the Pl. Liquid immiscibility has been documented experimentally between Fe-rich liquids, similar in composition to the multiphase inclusions, and Si+alkali-rich melts in the system K_2O-Al_2O_3-FeO-SiO_2. Furthermore, Pl crystallization drives liquids toward the miscibility gap, and the Fe-rich melt fraction is enriched in REE. This suggests that a miscibility gap was intersected during the anorthosite crystallization, and that the multiphase inclusions were trapped as small immiscible globules that formed, possibly by boundary layer effects, at the margins of crystallizing Pl grains. The calcic Pl rimming the inclusions probably also crystallized from this liquid, as suggested by abrupt compositional breaks. Boundary-layer liquid immiscibility implies that the crystallization of Pl in the Stillwater anorthosites was rapid enough, and/or diffusion rates were slow enough, for the Fe-rich globules to form. Interestingly, the inclusions are similar to nelsonites, Ilm + Ap-rich rocks, associated with massif-type anorthosites, and which are also attributed by some workers to liquid immiscibility. In both cases, the immiscibility is associated with the crystallization of abundant Pl.

Regardless of their origin, the fact remains that Ap-bearing inclusions occur within cumulus Pl grains in the anorthosites. They may occur in other areas of the Stillwater as well. Therefore, caution must be exercised when attempting to use REE abundances and ratios in order to model liquid fractionation trends, or when evaluating the possibility of multiple parental liquids in the Stillwater Complex. (From the author's abstract)

LOGACHEV, V.P., NOVIKOVA, N.V. and GILEV, A.V., 1986, Some typomorphic characteristics of cassiterites from tin ore occurrences of the Bazardarinsk deposit (southwestern Pamirs): Mineral. Tadzh., 1986, no. 7, p. 127-138 (in Russian).

The Sn ore deposit is localized at the exocontact and endocontact of granites with the Carboniferous-Triassic carbonate-terrigenous and terrigenous rocks. Three types of ore assemblages occur: quartz-cassiterite (Ct), Ct-sulfide, and Ct-chlorite. Crystal morphol., habit, twinning, color, and other physical properties of Ct are described from 3 associations. The Ta, Nb, Zr, Be, Sc, and Ag contents increase from the low-T to high-T genetic varieties of Ct. Ct samples from ore bodies located in granites have high contents of Mn, W, Nb, and Ta. Th and Td studies of the gas liquid inclusions indicate that the Ct crystallized at 300-395°. (C.A. 106: 70437d)

LONDON, David, 1986a Formation of tourmaline-rich gem pockets in miarolitic pegmatites: Am. Mineral., v. 71, p. 396-405. Author at Sch. Geol. & Geophys., Univ. Oklahoma, Norman, OK 73019.

Analysis of fluid inclusions in spodumene, beryl, tourmaline, and quartz from miarolitic pegmatites of Afghanistan, coupled with lithium aluminosilicate stability relations and with previous studies from gem pegmatites of San Diego County, California, indicate that pocket development in tourmaline-rich, miarolitic rare-element pegmatites occurs between approximately 475 and 425°C and between 2800 and 2400 bars. This range of P and T is comparable to the conditions of late-stage crystallization in geochemically similar massive (nonmiarolitic) pegmatites. Whether gem pockets form may be dependent largely on the timing of tourmaline crystallization. Formation of tourmaline removes an alkali borate component from residual pegmatitic melt, with the consequent deposition of other alkali aluminosilicate and oxide-forming minerals and exsolution of copius amounts of H_2O. If tourmaline crystallization is inhibited until the late stages of pegmatite consolidation, the large quantities of H_2O that are liberated may form pegmatitic pockets. (Author's abstract)

LONDON, David, 1986b Magmatic-hydrothermal transition in the Tanco rare-element pegmatites: Evidence from fluid inclusions and phase-equilibrium experiments: Am. Mineral., v. 71, p. 376-395. Author at Sch. Geol. & Geophys., Univ. Oklahoma, Norman, OK 73019.

Fluid inclusions in petalite, spodumene, eucryptite, and coexisting quartz from the Tanco mine, Manitoba, have been evaluated with respect to experimentally calibrated reaction relationships in the system $LiAlSiO_4$-SiO_2 to define the cooling path and fluid evolution within this pegmatite. At Tanco, the conversion of petalite to pseudomorphic intergrowths of spodumene + quartz occurred at approximately 500°C and 3000 bars in the presence of a dense hydrous alkali borosilicate fluid with a minor carbonate component. Between 470 and 420°C and between 2900 and 2600 bars, the borate component of this fluid was removed by the crystallization of tourmaline, resulting in the deposition of albite, micas, quartz, and ore minerals (e.g., microlite, beryl, and pollucite), and consequent evolution of a comparatively low-density, solute-poor, CO_2-bearing aqueous fluid (approximately 91 mol% H_2O, 5 mol% CO_2, 4 mol% NaCl equivalent). Reactions over this

P-T interval mark the transition from magmatic to subsolidus hydrothermal conditions. Ore-bearing albitic (aplite or cleavelandite) units probably were deposited directly from the borosilicate fluid and are not the result of subsolidus metasomatism. (Author's abstract)

LONDON, David, 1986c Petrogenesis of rare-element pegmatites: Evidence from fluid inclusions and phase equilibrium experiments (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 159. Author at Sch. of Geol. & Geophys., Univ. Oklahoma, Norman, OK 73019.

Pegmatites represent the ulitmate products of fractionation in plutonic silicic magma systems. Highly fractionated rare-element pegmatites are enriched in a number of incompatible lithophile elements (e.g., Li, Rb, Cs, Be, Ga, Sn, W, Nb, Ta) and volatile components (e.g., H_2O, B, F, P) by 10^4-10^6 above their average abundances in typical granitic plutons.

Preliminary phase equilibrium experiments with the rare-element-rich Macusani rhyolite as starting material corroborate many of the proposed processes of crystallization and fractionation within lithium-rich pegmatites. At 200 MPa(H_2O), the liquidus of the Macusani rhyolite occurs at about 650°C, and the solidus lies below 500°C. The naturally high contents of boron and fluorine increase melt depolymerization and crystal growth rates, and decrease nucleation densities. In H_2O-saturated runs of short duration, both quartz and (subsolvus) feldspars grown by supercooling of 100°C below liquidus saturation T form large (200 microns), sharply euhedral crystals. Muscovite saturation is driven in part by the speciation of Na with F and B(?), and the creation of peralkaline residual fluids. (From the author's abstract)

LONDON, David, WEAVER, B.L. and HERVIG, R.L., 1986, Liquidus relations of Macusani rhyolite, an analogue for rare-element granite-pegmatite systems (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 675.

LONG, K.R., KELLY, W.C., OHLE, E.L. and LOHMANN, K.C., 1986, Ground preparation and zinc mineralization in bedded and breccia ores of the Monte Cristo mine, north Arkansas: Econ. Geol., v. 81, p. 809-830. First author at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

Two distinct varieties of Mississippi Valley-type ore occur in the northern Arkansas zinc-lead district: (1) open-space fillings in solution collapse breccia, and (2) strata-bound replacement deposits generally conformable with their carbonate host rocks.

Fluid inclusion and stable isotope (C and O) data suggest a mixing of two brines during mineralization, both of probable deep burial origin. The mixtures were hot (90°-150°C) and highly saline (19-25 equiv. wt % NaCl) and were displaced by cool, dilute, presumably meteoric waters during deposition of late gangue quartz and calcite. It is noteworthy that, in the Monte Cristo mine, the bedded and breccia mineralizations are physically and mineralogically continuous and yield indistinguishable fluid inclusion, stable isotope, and rare earth element signatures. Hence, the bedded ores, which possess many characteristics of Mississippi Valley-type deposits attributed to a syngenetic or diagenetic origin elsewhere in the world, formed simultaneously with the discordant breccia ore and are, at least in northern Arkansas, epigenetic in origin. (From the authors' abstract)

LONG, P.E. and LUTH, W.C., 1986, Origin of K-feldspar megacrysts in granitic rocks: Implications of a partitioning model for barium: Am. Mineral., v. 71, p. 367-375. First author at Geosci. Group, Basalt Waste Isolation Project, Rockwell Hanford Operations, Richland, WA 99352.

Conflicting theories for the origin of K-feldspar megacrysts in granitic rocks are principally (1) the megacrysts crystallized from a melt or (2) they grew by replacement from a water-rich fluid phase under subsolidus conditions. Alkali feldspar megacrysts exhibiting reversed zoning are thus best explained by crystallization from a melt. (From the authors' abstract)

LOUCKS, R.R., 1986, Fluid dynamics associated with the boiling zone in epithermal fissure veins, Topia, Durango, Mexico (abst.): J. Geochem. Explor., v. 25, p. 231-232. Author at Dept. Geosci., Purdue Univ., West Lafayette, IN 4797, USA.

Extensive fluid inclusion studies indicate that very coarse-grained sphalerite, galena, pyrite, and intergrown freibergite were precipitated from non-boiling solutions, but intercalated quartz/chert crustification bands associated with sphalerite leaching episodes record fluid inclusion and textural evidence of repeated descent of the base of the boiling zone to depths within the main ore horizon in response to salinity decrease and possibly CO_2 increase or release of confining pressure, evidence of hydrofracturing of sealed veins at high levels in the system. The ratio of chert/comb quartz increases upward in the veins as sulfides diminish, substantiating evidence that a zone of persistent boiling probably occupied upper levels of the fractures most of the time during ore deposition at slightly greater depths.

The mineralized vertical interval in each fissure vein is dimensionally analogous to a 2-5 km Hele-Shaw cell some 200-500 m high, bounded above by gradation to reduced permeability in response to accelerated silica precipitation in a steep (boiling) temperature gradient, and bounded below by gradation to reduced permeability due to decreasing structural stability of open space with increasing lithostatic load. (From the author's abstract)

LOUCKS, R.R. and SOMMER, M.A., II, 1986, Solution of structural problems in the Topia Ag-Au-Pb-Zn district, Durango, Mexico, using laser decrepitation and capacitance manometer gas analysis for fluid inclusion geobarometry (abst.): J. Geochem. Explor., v. 25, p. 256-257. First author at Dept. Geosci., Purdue Univ., West Lafayette, IN 47907, USA.

$P(CO_2)$ and $P(H_2O)$ were determined from studies of fluid inclusions trapped during boiling in samples from four veins, spanning a strike length of two km in one vein and an elevation range of 545 m among the veins. $P(H_2O)$ was determined from heating and freezing tests on approximately 200 liquid-rich inclusions of 0.6-4 wt% NaCl equiv. salinity associated with vapor-rich inclusions, yielding sample mean values of $P(H_2O)$ in the range of 19-62 atm. for Th = 210-280°C, varying systematically over the 545 m depth range of the samples. $P(CO_2)$ was determined by a method developed by Sommer, involving selective decrepitation of individual liquid-rich fluid inclusions in vacuo by a Nd laser (blast area $\sim 50\ \mu$ diameter) and collection of the liberated volatiles in a liquid N_2 cold trap. Analysis of CO_2/H_2O was by fractional distillation into a capacitance manometer (detection limit $\simeq 7 \times 10^{-11}$ moles of gas, $\simeq 1$ fluid inclusion 15 μ diameter). Analytical precision of CO_2/H_2O determinations is better than ± 15% of the mean. Among the samples, mean mCO_2 varies from 0.32 to 0.57, yielding calculated $P(CO_2)$ at Th of 35-66 atm. A plot of relative sample elevations versus Th shows that the data are nearly coincident with the boiling-point-with-depth curve with a 2% NaCl, 0.4 m CO_2 solution, establishing that tilting of host rocks is premineralization, and that post-ore fault-block rotation resulted in relative post-ore displacements of veins that are on the order of tens, not hundreds, of meters. Therefore, the southwestward vein-to-vein trend of decreasing elevation of the ore horizon reflects a trend of increasing depth of ore formation and is a primary feature whose recognition may be of exploration significance in the district. (From the authors' abstract)

LOVELAND, R.P. and CENTIFANTO, Y.M., 1986, Mounting media for microscopy: The Microscope, v. 34, no. 3, p. 181-242.

LOZOVSKII, V.N., OVCHARENKO, A.N. and POPOV, V.P., 1986, Liquid-solid interface stability: Progr. Crystal Growth & Charact., v. 13, p. 145-162. Authors at Novocherkassk Polytech. Inst., Rostov, Region, USSR.

Of interest in the processes of formation of inclusions. (E.R.)

LU, H.-Z., 1986a The fluid inclusion geobarometry: Geol. of Guizhou, no. 3, 1986, p. 281-296 (in Chinese; English abstract). Author at Inst. Geochem., Acad. Sinica, Guiyang, Guizhou Province.

The use of fluid inclusions for geobarometry is a new development. The concept is based on the two systems: $NaCl-H_2O$ and CO_2-H_2O, which are major fluid compositions in fluid inclusions. Using Th, salinity, and density determined from the fluid inclusion studies, and the thermodynamic diagrams of these two systems, we can get the P of homogenization and formation for mineral deposits. In this paper the author suggests a term - the P of homogenization, defined as the minimum P of formation. Applying this method, many different P in various mineral deposits had been studied; the P are mostly <1 kbar. (Author's abstract)

LU, H.-Z., 1986b The origin of tungsten mineral deposits in South China: Wang, Zhenhuan, ed.: Chongqing, PRC, Chongqing Pub. House, 232 pp. (in Chinese; English abstract). Author at Inst. Geochem., Acad. Sinica, Guiyang, Guizhou Province, PRC.

Based on detailed geological studies, a new classification of W deposits is suggested: (1) granite, (2) porphyry, (3) volcanic rock, (4) porphyrite, (5) pegmatite, (6) greisen, (7) skarn, (8) hydrothermal veins, (9) strata-bound and stratiform, and (10) placer. The most important ones are hydrothermal veins, skarns, granite, and porphyry. Porphyry, W-Sb-Au strata-bound, and granite ore types have not been reported before.

The strata-bound W deposits occur in the oldest strata of the southern China. These strata may be one source of W in south China. Their fluid inclusions are almost all liquid-rich with Th 150 to 220°C, the lowest temperatures of all types of W deposits in south China. Based on isotopic evidence, the ore-forming fluid of that type may come from heated underground water, and the W from leaching of W-bearing strata. The results of fluid inclusions on the granite, porphyry, greisen, pegmatite, skarn and hydrothermal veins indicated the ore-forming fluids may relate to the Yanshanian age granites. Four types of fluid inclusions were found: liquid-rich, gas-rich, daughter-mineral-bearing, and CO_2-bearing. There are liquid-rich and CO_2-bearing fluid inclusions in the hydrothermal veins, with Th = 250 to 400°C and salinity = 1-10 wt.% NaCl equiv. in 16 hydrothermal W ore deposits. The fluid inclusion data in granite, greisen, and pegmatite are similar to those in the hydrothermal veins and show the ore-forming fluids may belong to the $NaCl-KCl-H_2O$ system.

In the skarn type, there are liquid-rich, daughter-mineral-bearing and gas-rich inclusions. The Th and salinities in this type of ore can be divided into two ranges: one has Th = 400 to 550°C and salinity of 30 to 40% NaCl equiv., and the other has lower salinity (1-15%) and Th (250-400°C). The ore-forming fluids in the skarn type may belong to the $NaCl-CaCl_2-KCl-H_2O$ system. Boiling occurred in the skarn and scheelite mineralization.

The fluid inclusion data of the porphyry type is similar to that in the skarn type, but the ore-forming fluid may belong to the $NaCl-KCl-H_2O$ system. The fluid inclusion isotopic data in skarns, porphyry, granite and hydrothermal veins show that δD and $\delta^{18}O(H_2O)$ of the ore-forming fluids ranged from -10 to -83 and +0.62 to +10.2%[sic; ‰ probably intended] respectively. That suggests the fluids are of magmatic origin, presumably from the Yanshanian age granites. (From the author's abstract)

LU, Huanzhang and CRAWFORD, M.L., 1986, Geological and fluid inclusion studies of the Dongpo tungsten skarn ore deposit, China: Geochemistry, v. 5, no. 2, p. 140-157 (in English). First author at Inst. Geochem., Acad. Sinica.

The Dongpo tungsten ore deposit, the largest scheelite skarn deposit in China, is located at the contact of a 172-m.y. biotite granite with a Devonian marble. The mineralization associated with the granite includes W, Bi-Mo, Cu-Sn and Pb-Zn ores. Several W mineralization stages are shown by the occurrence of ore in massive skarn deposits and in later cross-cutting veins. The high garnet/pyroxene ratio, the hedenbergite and diopside-rich pyroxene and the andradite-rich garnet show the deposit belongs to the oxidized skarn type. Detailed fluid inclusion studies of granite, greisen, skarn and vein samples reveal three types of fluid inclusion: (1) liquid-rich, (2) gas-rich and (3) inclusions with several dms. Type (3) is by far the most common in both skarn and vein samples. The dominant dm in fluid inclusions is rhombic, highly birefringent, and does not dissolve on heating even at 530°C. We assume that this mineral is calcite. The liquid phase in most of the fluid inclusions has low to moderate salinities: 0-15 wt. %; in a few has higher salinities (30-40 wt. % NaCl eq.). Th of inclusions in the skarn stage range from 350°C to 530°C, later tungsten mineralization-stage inclusions have Th between 200°C and 300°C, as do inclusions in veins. Fluid inclusions in granite and greisen resemble those of the late tungsten mineralization stage, with low salinity and Th of 200°-360°C. The tungsten-forming fluids are probably a mixture that came from biotite granite and the surrounding country rocks. (Authors' abstract)

LU, Jialan and YUAN, Ziqiang, 1986, Experimental studies of organic-Zn complexes and their stability: Geochimica, 1986, no. 1, p. 66-77 (in Chinese; English abstract). Authors at Inst. Geochem., Acad. Sinica.

Thermal decomposition T of four organic Zn complexes were evaluated experimentally by determining the change in sphalerite solubility with T in aqueous solutions containing organic compounds. The results show that decomposition takes place at 180 ± 5°C for lactic acid-Zn complex; 200 ± 5°C for EDTA-Zn; 240 ± 5°C for quian-Zn and 190 ± 5°C for fulvic acid-Zn. It also shows that at 190-200°C sphalerite solubility is 4 to 7 times higher in NaCl solution containing organic compounds than that in NaCl solution. Studies were also conducted on the contents of Pb and Zn complexed by fulvic acid and humic acid in aqueous solutions; infrared spectra of fulvic acid-Zn and humic acid-Zn complexes; the differential thermal analysis of fulvic acid, humic acid, quian and EDTA; and on the variation in fulvic acid solubility in the seawater with T. (Authors' abstract)

LUAN, F.C., PATERSON, M.S. and McLAREN, A.C., 1986, Synthetic quartz aggregates for deformation studies (abst.): EOS, v. 67, p. 1207.

LUCHITSKAYA, M.I. and NAUMOV, V.B., 1985, Physicochemical parameters for the formation of the Khingan tin-ore deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 134-135 (in Russian; translation by D.A. Brown). First author at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

The Khingan deposit (Soviet Far East) is an example of tin mineralization of the chlorite type in the cassiterite-silicate association; it occurs in an extrusive (volcanic), essentially rhyolitic complex, including relatively flat-lying rhyolite flows, transected by granite-porphyry intrusions. The ore bodies have been concentrated in breccia zones, which cut through the country rocks and consist of clasts of these rocks, cemented by fine-clastic material of the same composition and numerous ore veinlets.

The mineral composition of the ores is distingished by the widespread development of fluorite, which is a transcurrent mineral, and by the high iron-index of the minerals. From the morphology, color, and relations with other minerals, three generations of fluorite have been identified: I) pre-ore, II) contemporaneous with cassiterite, and III) post-ore. The sequence of mineral-formation has been : fluorite I-fluorite II, cassiterite, chlorite (thüringite), quartz I, wolframite-fluorite III, sulfides (pyrite, galena, sphalerite, etc.), quartz II, adularia, siderite.

The physicohemical parameters of formation of the deposit have been determined from fluid inclusions in fluorite and quartz from different ore bodies (~40 samples). The Th of P inclusions in fluorite of different generations and in late quartz are: fluorite I, 390-370°; II, 360-320°; and III 320-265°C; and quartz II, 310-265°C. Three-phase inclusions with liquid CO_2 were found in two specimens of fluorite I. From Th(partial), the density of CO_2 was estimated (0.77 g/cm^3) and P = 1.5 kbar at 350°C. The presence of syngenetic, essentially gaseous and essentially liquid inclusions in fluorite I and II indicates the heterogeneous state of the ore-forming fluid.

Cryometric studies of P inclusions in fluorite and quartz have separated three kinds of solutions, differing in Te and concentration (Table). (From the authors' abstract)

Mineral	Temperature, °C		
	Te	Tm	Th
Fluorite I	-34.0 to -36.0	-12.5 to -7.5	390 to 340
Fluorite II	-21.0 to -23.5	- 6.0 to -3.0	360 to 300
Fluorite III	- 6.0 to - 6.5	- 3.0 to -1.0	310 to 285
Quartz II	- 6.0 to - 6.5	- 2.0 to -1.0	310 to 265

LUCHITSKAYA, M.I., NAUMOV, V.B. and BARSUKOV, V.L., 1986, Change of composition and concentration of mineral-forming solutions during formation of the Khingan tin ore deposit: Dokl. AN SSSR, v. 288, no. 4, p. 970-972 (in Russian). Authors at Inst. Geochem. & Anal. Chem. of Acad. Sci., Moscow, USSR.

Khingan deposit belongs to the cassiterite-silicate formation; it occurs in a rhyolite complex, in a brecciated zone. Ores consist of cassiterite, wolframite, sphalerite, galena, pyrite, quartz, chlorite (thuringite), adularia, siderite and pre-, syn- and post-ore fluorite of various habit and color. The authors studied more than 150 fluid inclusions in 25 specimens of fluorite; Th of P inclusions in pre-ore fluorite ranged 390-360°C, in syn-ore fluorite associating with cassiterite 360-320°C, in post-ore fluorite 320-280°C, in late quartz 310-265°C; only few inclusions in post-ore fluorite homogenized in G phase, most homogenized in L phase. Te = -34 to -36°C (type I, chloride solutions with abundant Fe and Mg), concentration 17-5 wt.% equiv. NaCl; Te -20.5 to -23.5°C (type II, Cl-HCO_3-Na solutions), concentration 9.0-4.5 wt.% equiv. NaCl; solutions type I and II formed ores; Te -6.0 to -6.5°C (type III, HCO_3-K), concentration 3.0-1.5 wt.% equiv. NaCl, typical of post-ore minerals. (Abstract by A.K.)

LUPTON, J.E. and GARCIA, M.O., 1986, Helium isotopes in submarine basalts from the island of Hawaii (abst.): EOS, v. 67, no. 44, p. 1271.

LUTH, R.W. and BOETTCHER, A.L., 1986, Hydrogen and the melting of silicates: Am. Mineral., v. 71, p. 264-276.

LUTH, R.W., MYSEN, B.O. and VIRGO, David, 1986, The solubility mechanisms of H_2 in silicate liquids (abst.): EOS, v. 67, p. 415.

LYAKHOV, Yu.V., 1985, Thermobarogeochemical parts of the model of gold ore formation at various depths: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 2, p. 156-158 (in Russian).

Cited in Naumov, 1986 (this volume).

LYTKIN, V.A., 1985, Lateral zonation and temperature conditions of formation of the Zhayrem polymetallic ores (Central Kazakhstan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 104-106 (in Russian; translation by D.A. Brown). Author at Zhayrem Geol.-Explor. Exped., Zhayrem, USSR.

The stratified lodes at Zhayrem are an association of closely-spaced, unevenly-sized, layered and lensoid bodies of Zn and Pb-Zn sulfide, sulfide-barite polymetallic, and continuous barite and chert-barite ores, confined to a member of the Famennan marine flyschoid sediments.

There are a number of conflicting, and also compromising viewpoints about the origin of the ores, and also about the zonation. Currently, there is greatest support for the hypothesis concerning their hydrothermal-sedimentary and hydrothermal-metasomatic origin. According to N.M. Mitryayeva, Yu.S. Parilov, and V.A. Mikhayleva, the pyrite and pyrite-sphalerite 'rhythmites' with the Pb-Zn and Zn ores of the fourth and fifth zones, contain only liquid inclusions, and formed during the phase of sedimentation at ~40-70°C. Td of the inclusions in the pyrite 'rhythmites,' belonging to the third ore zone, did not exceed ~100-120°C.

In the case of the sulfide-barite association, which contains non-uniform inclusions (essentially liquid, solid, and often miltiphase solid-liquid) in the barites, Td of the bubbles[sic] was 150°C. The quartz-barite and chalcopyrite-barite ores of the central zone, along which lengthy vertical circulation of the ore-bearing hydrothermal solutions had taken place, have Tf = ~280-330°C.

These results conform well with the hypothesis concerning the polygenic hydrothermal-sedimentary origin of the deposits. (From the author's abstract)

MAASKANT, Pieter, 1986, Electron probe microanalysis of unopened fluid inclusions, a semiquantitative approach: N. Jb. Miner. Mh., v. 7, p. 297-304.

A method is described by which semiquantitative analyses of unopened fluid inclusions lying up to 7 micrometer under the surface can be made using an electron microprobe. Instrumental conditions include high accelerating voltages, analytical conditions include analysis of the host mineral, both above the fluid inclusion and in an inclusion-free surrounding.

Application of the method is restricted to asemblages in which different elements are present in host mineral and inclusions. The method is applied to solid chlorine-rich inclusions in an olivine host mineral. (Author's abstract)

The peridot crystals from Zebargad (Red Sea) were studied, and Na, K, Ca, and Cl of the inclusions determined. (E.R.)

McCURDY, Karr, RUSSELL, Norman and KESLER, S.E., 1986, Primary dispersion of trace elements, fluid inclusion zoning, and alteration zoning at the Pueblo Viejo Au-Ag deposit, Dominican Republic (abst.): J. Geochem.

Explor., v. 25, p. 259-260. First author at Rosario Dominicana, S.A., Apartado 944, Santo Domingo, Dominican Republic.

Fluid inclusions from 33 jasperoid samples taken from within and surrounding the Pueblo Viejo ore body have been analyzed for their H_2O, Ar, CH_4, CO, CO_2, H_2, N_2, and O_2 gas contents. Fluid inclusion gases from within the ore zone are H_2O rich and CO-CO_2 poor, while inclusions surrounding the ore body are CO-CO_2 rich. (From the authors' abstract)

MACDONALD, A.J., KRECZMER, M.J. and KESLER, S.E., 1986, Vein, manto, and chimney mineralization at the Fresnillo silver-lead-zinc mine, Mexico: Can. J. Earth Sci., v. 23, p. 1603-1614. First author at Mineral Deposits Sec., Ontario Geol. Survey, 77 Grenville St., Toronto, Ont., Canada M5S 1B3.

This is full paper for abstract by same authors in Fluid Inclusion Research, v. 17, p. 207-208, 1984. (E.R.)

McEWAN, C.J.A., 1986a Geological, stable isotope and fluid inclusion evidence for concealed epithermal precious metal mineralization, Rosita Hills, Colorado (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 16. Author at Dept. Geol. & Mineral., Univ. Aberdeen.

Light stable isotope determinations from vein minerals and silica cap show $\delta^{18}O$ enrichment (5.72-11.31‰) with increasing depth in the system and limited fluid inclusion data indicate that the hydrothermal fluid was of low salinity (<4 wt% NaCl equiv.), CO_2-rich and boiling in the upper part of the system.

It is concluded that resurgent felsic magmatism drove a hydrothermal system dominated by magmatic water at depth and by meteoric water nearer the surface. The system contains Au-Ag mineralization similar to that occurring in the active geothermal areas of the world today. (From the author's abstract)

McEWAN, C.J.A., 1986b Geological, stable isotope and fluid inclusion evidence for concealed epithermal precious metal mineralization, Rosita Hills, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 688. Author at Dept. Geol. & Mineral., Univ. Aberdeen, Marischal College, Aberdeen AB9 1AS.

The Rosita Hills volcanic center is an alkali-calcic mid-Tertiary complex overlying Precambrian ortho- and paragneissic basement on the eastern margin of the Wet Mountain graben. Vulcanism at the center is dominantly andesitic and occurred together with alteration and mineralization in 2 cycles separated by a period fo caldron subsidence and major erosion.

The 1st cycle ended with the emplacement of breccia pipes which carry most, if not all, of the recorded Au mineralization from the area, together with Ag (major), Cu, Pb, Zn, As, Sb and Te mineralization. The 2nd cycle terminated in a hot-spring system related to resurgent rhyolitic activity. Ag, Pb, Zn and notably Ba mineralization occurs with minor Au, Te, Sb, As and Mo in veins which acted as feeders to this system.

A feature of the hot-spring system are previously unrecognized hydrothermal eruption breccias occurring in areas of massive silicification and locally developed alunite alteration. These breccias are matrix supported and polylithic containing clasts of highly altered, locally derived volcanics. The breccias have anomalous Au (5-800 ppb) and Ag (4-19 ppm) concentrations.

Light stable isotope determinations from vein quartz and silica cap show $\delta^{18}O$ enrichment (5.72-10.07‰) with increasing depth in the system and limited fluid inclusion data indicate that the hydrothermal fluid was of low salinity (<1 wt% NaCl equiv.), CO_2-rich and boiling in the upper part of the system.

It is concluded that resurgent felsic magmatism drove a hydrothermal system dominated by magmatic water at depth and by meteoric water nearer the surface. The system contains Au-Ag mineralization similar to that occurring in the active geothermal areas of the world today. (Authors' abstract)

McGOWAN, K.I., 1986, Fluid characteristics and trace element mobility in a Tertiary epithermal precious metal system-Wind River Au prospect, Washington (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 2, p. 156. Author at Dept. Earth Sci., 253 Science Hall I, Iowa State Univ., Ames, IA 50011.

Mineralization at the Wind River Au prospect occurs in andesitic pyroclastic rocks. Main system alteration associated with major upflow zones is characterized by K-metasomatism and silicification of wallrocks due to high water/rock ratios. At increasing distance and decreasing water/rock ratios, H-metasomatism caused by reactions of CO_2 with Ca-Al silicates produced alteration assemblages containing calcite, clay minerals, and quartz.

Ore-forming fluids were <1 equiv. wt. % NaCl, rich in CO_2, and reducing in nature. Minimum depths of formation of 300-600 m and fluid Ts of 220°-259°C determined by fluid inclusion studies are too shallow and too low, respectively, to fit accepted models of porphyry Cu metallogenesis in Washington and Oregon. (From the author's abstract)

McKAY, G.A., 1986, Crystal/liquid partitioning of REE in basaltic systems: Extreme fractionation of REE in olivine: Geochimica Cosmo. Acta, v. 50, p. 69-79. Author at SN4, NASA Johnson Space Center, Houston, TX 77058.

Partition coefficients for Nd, Sm, Gd, and Yb between olivine and synthetic basaltic melts were determined using the percent level doping technique and special microprobe analytical techniques for REE in olivine. These techniques permit much more accurate background measurement and thus greater sensitivity than conventional techniques. Spurious results were obtained if REE contents were measured in olivine at locations closer than about 100 micrometers to crystal margins, because of detection of REE x-rays generated in surrounding glass.

These values for the light REE are much lower than those for previous experimental or phenocryst/matrix studies. The higher LREE values, and consequently flatter patterns obtained in earlier experimental studies probably resulted from measurement of spuriously high LREE contents in olivines, because of small crystal size. Flatter patterns from phenocryst/matrix studies probably result from small amounts of contamination in olivine mineral separates. The steep slope of the new olivine/liquid pattern is consistent with olivine/clinopyroxene patterns previously obtained from inclusion-free olivines separated from peridotite nodules. (From the author's abstract)

McKIBBEN, M.A., WILLIAMS, A.E., ELDERS, W.A. and ELDRIDGE, C.S., 1986, Metamorphosed Plio-Pleistocene evaporites and the origins of salinity and sulfur in the Salton Sea geothermal brines (abst.): EOS, v. 67, no. 44, p. 1258. First author at Dept. of Earth Sci. & Inst. Geophys. & Planet. Physics, Univ. California, Riverside, CA 92521.

The Salton Sea geothermal system (SSGS) is hosted by Plio-Pleistocene sediments deposited in the non-marine restricted-basin setting of the northern Salton Trough. Temperatures exceeding 350°C and Na-Ca-K-Cl brines with TDS exceeding 25 wt % are encountered at 2 km depth within this system. New commercial drill core from the central part of the system contains abundant recrystallized, bedded anhydrite at 900 m depth, ranging from fine-grained massive material to stratabound pseudomorphs after gypsum in shale. Shales below the bedded anhydrite are brecciated and cemented by remobilized anhydrite.

Fluid inclusions in the anhydrite range from simple liquid-vapor inclusions to multiphase inclusions with over 50 volume % halide and carbonate crystals. All of the inclusions homogenize near 290°C and have NaCl equivalent salinities averaging 23 wt %[sic]. The brine produced from the same depth has 211,813 TDS, 153 ppm sulfate and >15-25 ppm sulfide. Sulfur isotopic $\delta^{34}S$ values for the bedded anhydrite range from +7 to +12 per mil. Interbedded biogenic pyrite has $\delta^{34}S$ values ranging from -4 to -16 per mil. In contrast, $\delta^{34}S$ values for vein sulfides in the SSGS cluster uniformly around zero per mil.

All of these data imply that recrystallization and dissolution of halides in the non-marine evaporites contributes to the salinity of the SSGS brines. Brine sulfide does not originate by reduction of evaporitic sulfate or by leaching of biogenic sulfide, but rather is derived from intrusive magmatic rocks. (Authors' abstract)

MACKWELL, S.J., KOHLSTEDT, D.L. and PATERSON, M.S., 1985, The role of water in the deformation of olivine single crystals: J. Geophys. Research, v. 90, no. B13, p. 11,319-11,333. First author at Dept. Materials Sci. & Engrg., Cornell Univ., Ithaca, NY.

Hydrothermal treatment experiments have been performed on single crystals of San Carlos olivine at 1100° to 1300°C and 300- and 1500 MPa confining pressure, with the oxygen fugacity around the specimen constrained near the Fe/FeO buffer. The diffusion coefficients for the hydroxyl species giving rise to the sharp band and broadband features in the infrared spectrum of hydrothermally treated olivine have been determined to be greater than 10^{-10} m^2 s^{-1} under all pressure and temperature conditions tested; the solubility of the hydroxyl species seems to vary between crystals but to show little variability for specimens from the same crystal over the temperature range investigated at 300-MPa confining pressure. Crystals hydrothermally treated at 1300°C, 300-MPa confining pressure, and 10^{-5} s^{-1} strain rate are a factor of 1.5 to 2.5 weaker than those treated in an anhydrous environment. Microstructural investigations suggest that this reduction in strength is due to enhancement of the rate of climb of dislocations in the "wet" experiments. First-order calculations suggest a stress exponent of $n \sim 2.5$ and a water fugacity exponent of $m \sim 1/5$ for deformation under hydrous conditions, assuming that the deformation obeys a power law relation. (Authors' abstract)

McMILLAN, P.F. and REMMELE, R.L., Jr., 1986, Hydroxyl site in SiO_2 glass: A note on infrared and Raman spectra: Am. Mineral., v. 71, p. 772-778.

McNAUGHTON, K. and SMITH, T.E., 1986, A fluid inclusion study of sphalerite and dolomite from the Nanisivik lead-zinc deposit, Baffin Island, Northwest Territories, Canada: Econ. Geol., v. 81, p. 713-720. Authors at Dept. Geol., Univ. Windsor, Windsor, Ontario N9B 3P4, Canada.

Fluid inclusions trapped in the Nanisivik main ore body show that gradients in T [mostly 110-220°C] and salinity [25-35 wt.%] existed during the formation of this Mississippi Valley deposit. These T and salinity gradients can be most satisfactorily explained as resulting from the mixing of two brines, one cooler and of lower salinity and one hotter and of higher salinity. This mixing model is in agreement with the model derived by Olson (1977) from isotopic and trace element data. (From the authors' Conclusions)

MACQUEEN, R.W., 1986, Application of hydrocarbons and vapor phase geochemistry (abst.): J. Geochem. Explor., v. 25, p. 256.

MACQUEEN, R.W. and POWELL, T.G., 1986, Origin of the Pine Point lead-zinc deposits, N.W.T., Canada: Organic geochemical and isotopic evidence (abst.): Terra Cognita, v. 6, no. 2, p. 134.

MADANYAN, O.G., 1985, Conditions of formation of the copper-molybdenum deposits of Southern Armenia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 155-156 (in Russian; translation by Dorothy B. Vitaliano). Author at IGN (Inst. Geol. Sci.), Acad. Sci. Armenian SSR, Yerevan, Armenia.

The Zangezur ore district is the southern segment of the Pambak-Zangezur structural-formational and metallogenetic zone. In the Alpine stage of geotectonic evolution this region was characterized by powerful manifestation of Paleogene-Neogene effusive and, particularly, intrusive magmatism. As a result, the complex polyfacies Megri pluton, largest in the Lesser Caucasus, was formed; the large Cu-Mo deposits of the Lesser Caucasus (Kadzharan, Agarak, Dastakert, Aygedzor, and others) are spatially and genetically related to it. The ore process, which was multi-stage and prolonged, occurred after the formation of the complex of porphyritic granitoids and related dike rocks, of Lower Miocene age.

A combination of thermobarometric and geochemical investigations made it possible to establish the main parameters of the ore mineralization (P, T, X, and concentration of salts in the solutions) of those Cu-Mo deposits in Southern Armenia.

1. The Cu-Mo deposits were formed from pneumatolytic-hydrothermal, highly concentrated chloride solutions in a temperature range of 520° to 60°C (420-220°C for the ore stages) and pressure of 1600 to a few tens of bars.

2. The main components of the ore-forming solutions were NaCl, KCl and to a lesser extent $CaCl_2$, $MgCl_2$, and of the gaseous components, HCl and CO_2. The concentration of dissolved components reached 50-60% by weight (average 20-30% by wt.).

3. The variation in concentration of salts in solution occurred against a background of decreasing T and P, and was manifested in the formation of different paragenetic associations. This is consistent with ideas on the pulsed arrival of the original solutions.

4. In the formation of the ore-bearing associations, at the beginning of each stage of mineralization there was a sharp drop in pressure (200-250 bar) due to opening of fractures, which led to boiling of the solution. On the whole the deposition of each mineral association occurred under conditions of a relatively quiet tectonic setting. (Author's abstract)

MAESTARTI, R., LASNIER, B. and RZEPKA, E., 1986a, Raman spectral catalog of gems and their inclusions (abst.): Bull. Mineral., Supplement, v. 109, p. 64-65 (in French). First author at Gemmologue, Cannes.

150 high-quality gems were analyzed in the range 18-1800 cm^{-1} on carefully selected sections and orientations, resulting in a catalog of 1000 spectra that can be used as an initial set of possible standards. Essential data include: 1) Schematic reproductions of spectra; 2) List of observed rays, arranged by indices; 3) Relations of intensity of rays; 4) Schematic diagrams of the selected standards; 5) Reproductions of additional spectra; 6) Qualitative observations of specific, observed Raman effects; and 7) Supplementary characteristics (e.g., fluorescence). (Modified from the authors' abstract by M.J. Logsdon)

MAESTARTI, R., LASNIER, B. and RZEPKA, E., 1986b, Index of Raman spectra of minerals (abst.): Bull. Minéral., Supplement 1986, v. 109, p. 67-68 (in French). First author at Gemmologue, Cannes.

The authors have begun compiling a catalog of Raman spectra for minerals in a manner analogous to the ASTM/JCPDS catalog of x-ray diffraction spectra.

The objectives of the compilation include: 1) Compile Raman spectra for minerals of primary interest to the earth-science community, including natural and synthetic-equivalent minerals, but excluding artificial minerals, organic crystals, gases, liquids and glasses; 2) Provide the minimum set of data needed to characterize each mineral species; 3) Index the data in a manner that will allow the systematic identification of unknown minerals based on Raman data, particularly emphasizing the indexing of wave number for each characteristic peak of a mineral; and 4) Complete the compilation quickly (on the order of one year).

Most of the Raman spectrographic data concerning the earth sciences, chemistry and physics have been skimmed in order to collect the maximum number of published Raman spectra for minerals. The principal table of the catalog, containing approximately 500 spectra, was completed in the summer of 1986. The compilation of chemical, crystallographic and bibliographical data is in progress, and it is planned that the indexing and publication will be completed in 1987.

Because of the need to rationalize different sets of data and different scientific conventions (and to deal with limited and sometimes ambiguous results), the authors have devised a series of "rules" to standardize the data. Specialists requiring additional data can refer to the original sources, since this is a reediting of original data rather than being a catalog of Reference Standards. (Authors' abstract, translated by M.J. Logsdon)

MAINPRICE, David, BOUCHEZ, J.-L., BLUMENFELD, Philippe and TUBIÀ, J.M., 1986, Dominant c slip in naturally deformed quartz: Implications for dramatic plastic softening at high temperature: Geology, v. 14, p. 819-822. First author at Lab. de Tectonophys., 44072 Nantes, France.

A combined microstructural, X-ray texture goniometry and transmission electron microscopy study has been undertaken to document rare examples of c direction of slip in naturally deformed quartz. The presence of optically visible basal (0001) subgrain boundaries and strong concentrations of c axes parallel to the inferred shearing direction (close to the stretching lineation) are considered characteristic of c slip. Dominant c slip appears to be limited to high-temperature (>650°C) and possibly hydrous conditions. The possibility of plastic softening associated with the relatively easy glide on this system is discussed. (Authors' abstract)

MALAKHOV, V.V. and FATIANOV, I.I., 1985, The peculiarities of the development of a hydrothermal system during formation of one of the gold ore deposits of Lower PriAmurije (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 47-48 (in Russian; translation by I.V. Kulikov). Authors at DVGI DVNC AN SSSR, Vladivostok, USSR.

The deposit is situated on the northern flank of the Eastern-Sikhotei-Alinsky volcanic belt. The ore field is connected with an upper-Cretaceous volcanic structure, which is represented by asymmetric graben-like depression, filled with predominantly intermediate volcanic-pyroclastic formations. The ores are located in linear vein-metasomatic zones of irregular structure and composition, striking NE, which are represented by three mineral assemblages.

The first assemblage, which is the host for the ore-bearing zones, is predominantly composed of metasomatites formed under conditions of acidic leaching of the rocks up to their complete silicification. With the help of thermobarogeochemical methods the acidic nature of hydrothermal-metasomatic process was confirmed, and T interval established as 450-150°C. The work shows that in the places of high fluid pressure explosive brecciation of the metasomatites occurred; the separation of volatiles, increase in pH and deposition of productive associations of minerals with Au:Ag ratio up to 1:2 took place.

On the zones of acid leaching the second assemblage was superimposed. This appeared somewhat later, under the conditions of local appearance of Fe-Mn metasomatism at rather high initial T, >600°C. This is confirmed by the presence in that complex of skarn-like associations (wollastonite + bustamite + rhodonite + pyroxene + garnet + magnetite). The formation of minerals occurred in an alkaline medium at sufficiently high pH. Subsequent decrease in T, the change of the composition and the thermodynamic properties of the hydrothermal system conditioned the deposition of the major masses of sulfides and tellurides with Au:Ag ratio of up to 1:10 in productive associations of the complex.

The third mineral assemblage was discovered in N-W structures, which cut the ore-bearing NE zones. It is represented by quartz and sulfide-carbonate formations with the Tf 400-100°C. In the composition of productive associations the sulfides of base metals, silver sulfosalts and low grade gold prevail. The ratio of Au:Ag in these formations can reach the 1:15.

From the above data, the hydrothermal-metasomatic process during the formation of the deposit was composite, and took place under sharply changing conditions, connected with the close association both in time and space of hydrothermal and magmatic activities, and also with the evolution of ore-generating chamber. (Authors' abstract)

MALISA, Elias, KINNUNEN, Kari and KOLJONEN, Tapio, 1986, Notes on fluid inclusions of vanadiferous zoisite (tanzanite) and green grossular in Merelani area, northern Tanzania: Bull. Geol. Soc. Finland, no. 58, pt. 2, p. 53-58. First author at Univ. Helsinki, Dept. Geol., SF-00170, Helsinki, Finland.

Almost all inclusions are S. The few non-leaked P inclusions contain liquid, two transparent and 1 opaque dm (graphite?), and vapor. Some evidence of natural decrepitation. Th (L) at 37-51°C, suggesting the system CH_4-C_2H_{10}[sic]. One Th (V) at 242°C. Dms begin to dissolve at 350°C but some persist even for 12 h at 440°C. Associated green vanadian grossular have fluid inclusions (where not naturally decrepitated) of homogeneous liquid HC(?), with two anisotropic dms. (E.R.)

MALLEY, Patrick, JOURDAN, Alain and WEBER, Francis, 1986, Study of fluid inclusions in the silica overgrowths of the North-Sea reservoir sandstones: A possible new diagenetic history of the Brent of the Alwyn area: C.R. Acad. Sci. Paris, v. 302, Ser. II, no. 9, p. 653-658 (in French; English abstract).

The study of fluid inclusions found in silica overgrowths indicates that silicification is contemporaneous with the first migration stages of hydrocarbons in the reservoir sandstones. Temperature data do not fit with the depth of burial at this time. In contrast, they are likely to indicate an introduction in the reservoirs of hot fluids generated from source rocks situated in deeper parts of the basin. (Authors' abstract)

MALYUK, G.A. and VOZNYAK, D.K., 1986, Mass-spectrometric determination of gas composition of inclusions of mineral-forming fluids in quartz in the process of its heating in vacuum: Geokhimiya, 1986, no. 6, p. 819-824 (in Russian; English abstract).

Using mass-spectrometric technique the determination of contents of gases of inclusions (0.05 to 0.07 mm in size) in the honeycomb quartz from the cavity pegmatites of the Volyn' area was made. Based on the kinetic curves of degassing the optimum conditions of the experiment was chosen (size of fraction, temperature) under which the distortion of composition of the mineral-forming solutions' inclusions by a supply of gases having other nature has become minimal. (Authors' abstract)

MANGAS, J. and ARRIBAS, A., 1986, Hydrothermal fluid evolution of the Sn-W mineralization in La Parrilla deposit (western Spain) (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 15. First author at Dpto. de Geol., Fac. de Ciencias del Mar, Apdo. 550, Las Palmas, Spain.

The La Parrilla orebody, located in the southern border of the Caceres province, is a stockwork of quartz with scheelite and cassiterite. The Sn-W ore is filling fractures in the pre-Ordovician schist and greywacke complex, intruded in this area by Hercynian granites. Most of the veins strike N 30°E and dip 45°SE. The mineral association includes, apart from scheelite and cassiterite which are the most important economic minerals, arsenopyrite, wolframite, sphalerite, chalcopyrite, pyrite, Bi sulfosalts, pyrrhotite, quartz, muscovite and tourmaline.

The study of the fluid inclusions was made on quartz and scheelite belonging to three different veins. The physical-chemical characteristics of the inclusions indicate three stages of fluid circulation. The first stage is characterized by complex CO_2 aqueous inclusions (<6 wt% NaCl eq.) trapped between 350° an 270°C. The second stage is represented by low salinity aqueous inclusions (<6 wt% NaCl eq.) trapped at Th between 270° an 150°C. The third stage is characterized by mixed salt aqueous inclusions (<31 wt% NaCl eq.) trapped between 150° and 70°C. (Authors' abstract)

MANNING, D.A.C., 1986, Assessment of the role of organic matter in ore transport processes in low-temperature base-metal systems: Transactions of Inst. Mining & Metall. Sec. B - Applied Earth Sci., v. 95, p. B195-B200.

MANNING, D.A.C., 1985, Comparison of influence of magmatic water on form of granite-hosted Sn-W deposits and associated tourmalinization from Thailand and southwest England, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 203-212.

MANRIQUE, Jose, CAMPBELL, Andrew and NORMAN, David, 1986, Fluid inclusion study of a zinc-lead replacement skarn deposit, Waldo-Graphic mine, Socorro County, New Mexico (abst.): New Mexico Geol., v. 8, no. 3, p. 67-68. Authors at Geosci. Dept., New Mexico Inst. of Mining & Tech., Socorro, NM 87801.

Mineralization occurs as both open-space filling and limestone replacement. The igneous rock exhibits prophyllitic and argillic alteration and the limestone has been altered to chlorite and skarn minerals. The paragenesis encompasses: a skarn stage, formed above 320°C and includes the formation of hedenbergite,actinolite, quartz, and specularite-magnetite aggregate; a sulfide stage, formed in the temperature range of 310-170°C and with the formation of pyrite, dark-colored sphalerite, chalcopyrite, galena, and minor quartz; and a carbonate stage, formed below 200°C, which contains calite, barite, quartz, and minor light-colored sphalerite. Fluid inclusion measurements from quartz, sphalerite, and barite show that the fluids responsible for ore deposition had low salinity (0.2-7.4 eq. wt. % NaCl and Th range from 110°C to 367°C. The theoretical pH values, calculated from fluid inclusion salinity and T, of the dark sphalerite fluid inclusions are in the range of 5.0-5.9; of light-colored sphalerite, 5.8-6.3; of pre-ore quartz, 4.6-5.6; and of post-ore quartz, 5.9-7.3. Geochemical modeling of the fluids suggests an appropriate Zn depositional mechanism to be cooling, perhaps aided by a slight rise in pH resulting from water-rock reaction. (From the authors' abstract)

MARIKOS, M.A. and LAUDON, R.C., 1986, Relationship of bitumen to ore in the Magmont-West ore body, Viburnum Trend, Missouri (abst.): Symp. on the Bonneterre Formation (Cambrian), southeastern Missouri, May 1 and 2, 1986, Univ. of Missouri-Rolla, Rolla, MO [Abstracts], p. 16.

MARIKOS, M.A., LAUDON, R.C. and LEVENTHAL, J.S., 1986, Solid insoluble bitumen in the Magmont West orebody, southeast Missouri: Econ. Geol., v. 81, p. 1983-1988. First author at Missouri Dept. Natural Resources, P.O. Box 250, Rolla, MO 65401.

Solid bitumen (here used to refer to an altered, insoluble crude oil) occurs as black blebs and fracture fillings in the Magmont West orebody of the Viburnum Trend. Today, the bitumen is hard, brittle, and insoluble, but streamers show that in the past it was soft and viscous. In open cavities many of the blebs line up preferentially along organic-rich layers in the dolostone suggesting (though not proving) that the bitumen was "sweated" out of the organic-rich layers. This preferential alignment, plus the presence of sulfide chimneys, indicates that the bitumen is probably derived from an oil that was immobilized in the act of primary migration from the Cambrian Bonneterre Formation.

The bitumen that we observed was most commonly found on the surface of galena and sphalerite crystals. Some bitumen was encased in calcite and dickite which are both generally considered to have formed after lead-zinc mineralization. Thus, paragenetically the bitumen is late and may have even been generated after mineralization.

Elemental analyses show the blebs to be predominantly hydrocarbons with an H/C atomic ratio of around 1.4 and an NSO content of 2.6 percent. Pyrolysis gas chromatography of the blebs yields normal alkanes with up to 26 carbon atoms and no odd or even carbon preference. Trace element composition of the bitumen blebs shows enrichment in Zn, Pb, and Cu. The blebs were probably derived from a crude oil that was generated near the end of mineralization and later condensed into an insoluble macromolecular material. (Authors' abstract)

MARKOVA, O.M., YAKOVLEV, O.I., SEMENOV, G.A. and BELOV, A.N., 1986, Some general results of experiments on vaporization of natural melts in the Knudsen cell: Geokhimia, 1986, no. 11, p. 1559-1569 (in Russian; English abstract).

MARSHALL, W.L., 1986, Modified Raoult's law including the solvent structural constant and solute solvation; aqueous sodium chloride solutions, 25 to 300°C; other electrolytes and urea, 25°C: J. Solution Chem., v. 15, no. 5, p. 439-452. Author at Chem. Div., Oak Ridge National Lab., Oak Ridge, TN 37831.

The form of Raoult's law is modified to express the activity of water [$a(H_2O)$] for aqueous electrolyte solutions by the mole fraction of a free (nonsolvating) solvent structural unit raised to the reciprocal power of the solvent structural constant. Relatively close agreement with experiment is obtained for $a(H_2O)$ of aqueous sodium chloride solutions up to 300°C and nearly saturated concentrations, and of other aqueous electrolyte solutions at 25°C. In an example for aqueous-organic systems, $a(H_2O)$ for urea solutions at 25°C is described with an average deviation of 0.09% for molalities from 0 to 20 m (54.6 wt%) by using the necessary (universal) structural constant and a single solvation parameter. (Author's abstract)

MARTIN, D.J., 1986, Geochemistry of a suite of teschenitic intrusions from the Sydney-Gunnedah Basin - Evidence of crustal tension (abst.): Eighth Australian Geol. Conv., Geol. Soc. of Australia, "Earth Resources in Time and Space," Feb. 16-21, 1986, Flinders Univ., Adelaide, Abstracts, no. 15, p. 132-133. Author at Sch. Earth Sci., Macquarie Univ. Sydney.

CO_2 inclusions are mentioned, from mantle xenoliths. (E.R.)

MARTINI, M., CELLINI LEGITTIMO, P., PICCARDI, G. and GIANNINI, L., 1984, Composition of hydrothermal fluids during the brandyseismic crisis which commenced at Phlegraean Field in 1982: Bull. Volcanol. v. 47, no. 2, p. 267-273 (published 1986). First author at Dept. Earth Sci., Univ. Florence, Italy.

Acid gases will be preferably absorbed by the above mentioned aquifers, while other species like H_2, N_2, O_2, CH_4, will instead increase their relative concentrations. Because of this, water vapor concentrations and the ratios H_2S/CO_2 and H_2/CH_4 in surface thermal manifestations appear to reflect better the varying extent of the observed phenomenon. (From the authors' abstract)

MARTINI, M., CELLINI LEGITTIMO, P., PICCARDI, G. and GIANNINI, L., 1986, The fumaroles of Vulcano (Italy): Differences in chemical compositions produced by the surface environment: Geothermics, v. 15, no. 2, p. 205-209.

MARTIN-LAUZER, F.R., INGRIN, J. and POIRIER, J.P., 1986, Transmission electron microscopic study of the immiscibility in natural and synthetic rhyolitic glasses: Earth & Planet. Sci. Letters, v. 79, p. 168-178. Authors at Inst. de Phys. du Globe de Paris, 4 Place Jussieu, 75252 Paris Cedex 05, France.

Transmission electron microscopy of nuée ardente scoriae from the Soufrière, St. Vincent, 1979 eruption has revealed the existence of immiscibility at the scale of 300-900 A. Similar phase separation was reproduced in a synthetic glass with the same composition and the miscibility gap was approximately determined. From these results and the analysis of the natural phase-separated glass, the maximum temperature of the magma prior to the eruption was estimated.

A crude model of the immiscibility, based on Flory's model for polymer solutions, is proposed. It reproduces fairly well the experimentally observed miscibility gap. (Authors' abstract)

MARTY, B. and JAMBON, A., 1986, He/CO_2 ratios of fluid inclusions and volcanic gases: Constraints on CO_2 degassing of the earth (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 122 (in French). First author at IMRG BRGM, BP 6009, 45060 Orléans Cedex, France.

The solubility constant of CO_2 in basaltic liquids is very close to that for He. According to data on $^4He/^{40}Ar$ ratios, most of the gas found in vesicles is very little fractionated and as a result the He/CO_2 ratio in basaltic glasses is probably identical to the ratio in the initial magma: $CO_2/^3He = 10^9$.

$CO_2/^3He$ ratios for the "atmosphere" (atmosphere + sediments + oceans + continental crust) appear to be two or three orders of magnitude smaller. Degassing models based on rare gases, predicting very high early-stage degassing rates, do not seem to be valid for major volatile species, especially not for CO_2. (Authors' abstract, translated by R. Kreulen)

MARTY, Bernard and OZIMA, Minoru, 1986, Noble gas distribution in oceanic basalt glasses: Geochimica Cosmo. Acta, v. 50, p. 1093-1097. First author at IMRG/BRGM BP6009, 45060 Orleans Cedex, France.

The distribution of noble gases has been investigated in six MORB glass samples using stepwise heating, vacuum crushing and the analysis of grain size fractions. These experiments indicate a strong noble gas partitioning into CO_2-filled vesicles. An inhomogeneous distribution of argon isotopes within individual glasses is observed in several cases and is believed to result from the combined effects of the deep-seated component partitioning into vesicles and the contamination of the residual component dissolved in the glass by atmospheric noble gases. Using a mixing diagram, we are able to discriminate against atmospheric contamination and estimate the Ar partition coefficients. These coefficients are in qualitative agreement with the Henry's law constant for silicate melts. (Authors' abstract)

MASSARE, Dominique and CLOCCHIATTI, Robert, 1986, Glass inclusions in olivine pyroclasts from the Bellecombe crater (Piton de la Fournaise) (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 123 (in French). Authors at Lab. Pierre Sue, Groupe des Sci. de la Terre, C.E.N. Saclay, 91191 Gif-sur-Yvette Cedex, France.

The olivine (Fo83) crystals are characterized by their trapping of numerous spinel crystals, often associated with glass inclusions. Microthermometry under controlled atmosphere gave Th of ~1150 ± 10°C. Some of the crystals are characterized by planes of very flat inclusions where CO_2 gas can be observed in the shrinkage bubble. Freezing data indicate CO_2 densities of 0.06 to 0.07 g/cm^3 which corresponds to a $P(CO_2)$ of about 180 bars (18 MPa) at the measured Th. The same material has been used for crystallization experiments (Clocchiatti and Massare, 1985; Fluid Inclusion Research, v. 18, p. 83-84, 1985) the first results of which are presented and discussed. (Authors' abstract, translated by R. Kreulen)

MASUDA, Harue, SAKAI, Hitoshi, CHIBA, Hitoshi, MATSUHISA, Yukihiro and NAKAMURA, Takeshi, 1986, Stable isotopic and mineralogical studies of hydrothermal alteration at Arima Spa, southwest Japan: Geochimica Cosmo. Acta, v. 50, p. 19-28.

MATHEZ, E.A., BLACIC, J.D., BEERY, J., MAGGIORE, C. and HOLLANDER, M., 1986, Carbon in olivine by nuclear reaction analysis (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 273-275. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195, USA.

It is concluded that the solubility of C in olivine is negligible under all conditions found in the crust and upper mantle and that analytical problems likely plagued some of the earlier experiments [e.g., Freund and coworkers] to the extent that their reliability is questionable. (From the authors' abstract)

MATKOVSKIY, O.I., 1985, Thermobarogeochemistry of metamorphic and postmetamorphic mineralization in the crystalline basement of the Eastern Carpathians (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 190-192 (in Russian; translation by Dorothy B. Vitaliano). Author at L'vov State Univ., L'vov, USSR.

More highly metamorphosed (epidote-amphibolite facies) rocks of the Belopotok complex and less metamorphosed (greenschist facies) formations of the Delovetsk complex constitute the crystalline basement of the Eastern Carpathians.

The T of metamorphic mineralization, proper, obtained by various geothermometers, are not the same, the lowest values being characteristic of the formations of the Delovets complex (300-500°C) and higher values of the Belopotok complex (450-500°C). The T are determined by Th and Td of inclusions in quartz and garnet, from the garnet-biotite equilibrium and from the Lambert curve were most comparable to each other. Maximum values of T (600-665°C) for the staurolite- and garnet-bearing rocks of the Belopotok complex are in poor agreement with the upper limit of stability of staurolite and muscovite in paragenesis with quartz, according to the data of experimental investigations and theoretical calculations (Sobolev, Marakushev, Evans, Althus, Hoschek, Richardson). Minimum T (300-400°C) for the rocks of the Delovets complex are close to the upper limit of stability of sedimentary minerals (Winkler). These T values support the conclusion of many authors as to the low T boundary of the greenschist facies, at 350-400°C (Dobretsov et al.).

Post-metamorphic mineralization is distinctly hydrothermal, which is confirmed by the results of study of inclusions in the main vein mineral, quartz, by the Th and Td methods. It is accompanied by phenomena of recrystallization and mobilization of ore material. In the gangue quartz there are inclusions with Th in three T ranges: 1) 390-320°C; 2) 280-245°C; 3) 220-160°C. They are in fair agreement with the three intervals of decrepitation of the inclusions (results of decrepitation analysis), the T of which are slightly above Th. These data, together with mineragraphic investigations of the ore mineralization, make it possible to distinguish three stages of post-metamorphic mineralization: 1) gold-pyrite-quartz; 2) gold-telluride-sulfide-quartz; 3) gold-quartz-mica-carbonate. From the presence of inclusions with CO_2, the P of post-metamorphic mineralization is estimated as 70-110 MPa. (From the author's abstract)

MATSAPULIN, V.U., KUCHER, M.N. and GAZALIYEV, I.M., 1985, The oxidizing environment of paleohydrotherms (based on gas-liquid inclusions) in connection with the origin of the sulfide mineralization of Southern Dagestan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 112-113 (in Russian; translation by D.A. Brown). First author at Inst. Geol. Dagestan Br. Acad. Sci. USSR.

The gas phase in GLIs from the Southern Dagestan sulfide deposits and prospects has been determined by gas analyzer [chromatograph?]/mass-spectrometer. Along with the principal gas components, CO_2 and N_2, the inclusions always contain Ar, H_2S, H_2, and O_2. The amount of O_2 in the mineral-forming medium in the Kyzyl-Dere Cu-pyrrhotite deposit (44 analyses) ranges from a trace up to 0.17 mol/L, on average 0.067 mole/L. Analyses have been done on all the minerals involved in multi-staged mineral-formation. Oxygen has been recorded in all minerals and associations. Its concentration increases somewhat during the ore phases of sulfide-formation. The inclusions in the veined polymetallic ores of the Khal prospect contain 0.006-0.18 mole/L O_2, average 0.054 mole/L (21 analyses), and in the Borch-I prospect, 0.0027-0.092 mole/L, average 0.02 mole/L (21 analyses). In the vein minerals of the Kurush ore field prospects, the O_2 amounts are: North Sel'dy prospect, quartz, 0.01 mole/L (1 analysis), and Skalistoye prospect, quartz, 0.018 mole/L (2 analyses).

The calculated N/Ar rations for GLIs in the Kyzyl-Dere deposit are 100-888 (average 316.9); Khal prospect, 182-887.5 (527); and Borch-I, 304.6-833.3 (584.5). N_2 exceeds O_2 by 11-64 times (averaged data). These data suggest that the GLI gases have been formed in deep-seated processes. Molecular O_2 may appear in the hydrotherms as a result of dissociation of water at high T, radiation-chemical processes, and thermometamorphism of organic matter. Low O_2 contents in the hydrotherms have been correlated with the presence of magnetite and hematite amongst the rare ore minerals of the Cu-pyrrhotite and Cu-Co polymetallic prospects and in the quartz-pyrite and quartz-chalcopyrite veins (see Andreyev et al., 1973).

It is interesting to note the large amount of Fe hydroxides in the Kurush ore field prospects, displaying the features of stratiform hydrothermal-sedimentary formations. (...) The relations between the abundant iron hydroxides and the vein minerals and sulfides indicate their contemporaneous formation with the ores, and not as a result of processes of sulfide oxidation in the hypergene zone. (From the authors' abstract)

MATSUHISA, Y., 1986a Effect of mixing and boiling of thermal fluids on isotopic compositions of hydrothermal vein minerals (abst.): Mining Geol., v. 36, no. 1, p. 49 (in Japanese; translation courtesy K. Okano, via J. Hedenquist).

Decrease in T and changes in concentration are considered to be the result of mixing and boiling of thermal fluids, and to have a significant impact on the formation of shallow hydrothermal Au-Ag deposits. The origin, chemical features and temperature of thermal fluids are recorded in the isotopic composition of the minerals deposited from the thermal fluids. Present study examined how mixing and boiling influenced changes in isotope compositions of thermal fluids, and what isotopic compositions were observed in the minerals deposited from the thermal fluids. This was done in reference to the oxygen and carbon isotopic compositions of thermal fluids, quartz and calcite.

The effects of boiling on changes in the C and O_2 isotope composition of thermal fluids are discussed. (From the author's abstract)

MATSUHISA, Yukihiro, 1986b Effect of mixing and boiling of fluids on isotopic compositions of quartz and calcite from epithermal deposits: Mining Geol., v. 32, no. 6, p. 487-493. Author at Geol. Survey Japan, 1-1-3 Yatabe-Higashi, Ibaraki-ken, 305 Japan.

O and C isotope effects due to boiling and mixing of fluids were examined for epithermal vein systems. The magnitude of O isotope change of fluid which could be produced by boiling is not greater than 2‰ at T higher than 100°C. In case of C isotopes, boiling could produce an increase in $\delta^{13}C$ values of precipitating calcite (up to 2 to 3‰) due to increasing pH of the fluid. Mixing of a deep hydrothermal fluid with a low-T groundwater could provide a wide range of $\delta^{18}O$ values in a relatively small T interval, depending upon variable initial compositions of the deep hydrothermal fluid. The data for quartz and calcite from the Kushikino Au-bearing epithermal veins suggest either boiling or mixing with a low-T groundwater of a slightly ^{18}O-enriched (by 3 to 4‰) deep hydrothermal fluid. (Author's abstract)

MATSUSHIMA, S., 1986, The effects of frequency on the elastic wave velocity in rocks at high temperatures under pressure: Tectonophysics, v. 124, p. 239-259. Author at Inst. Earth Sci., Sch. Liberal Arts, Kyoto Univ., Japan.

P- and S-wave velocities in nepheline basalt (Hamada), as well as diabase (Maryland), were measured experimentally to 1000°C and 2.5 GPa. A remarkable frequency dependence of large velocity-decrease was observed for both P- and S-waves at temperatures above 500°C. Remarkable velocity-characteristics, which cannot be explained by the existing theories were:

(1) Velocities were decreased considerably at 1-3 MHz. Above 3 MHz, samples showed elastic behavior like that of a perfect solid, and below 1 MHz, velocity-decrease decayed gradually.

(2) Both P- and S-wave velocities decreased in the same way and almost to the same degree.

(3) The higher the temperature, the more remarkably velocities decreased at least up to the experimental temperature limit.

Elastic wave velocities in solids containing fluid inclusions are appreciably decreased compared to the velocity in the corresponding perfect solid. Such velocity-decrease depends not only on the geometry of the inclusion and the viscosity of the included fluid, but also on the frequency of the transmitting elastic waves.

A hypothesis of the relaxation of stress waves by the fluid-flow in the inclusions is proposed. Examples of geophysical applications are given for the attenuation and travel-time anomalies in the volcanic region and the P- and S-wave velocity-decrease in the upper mantle beneath continents. (Modified from the authors' abstract)

MATTEY, DP., EXLEY, R.A., PILLINGER, C.T., MENZIES, M.M., PORCELLI, D.R. and O'NIONS, R.K., 1986, Trapped CO_2-rich fluids in mantle peridotites: Carbon isotope compositions and implications for sediment recycling (abst.): Terra Cognita, v. 6, no. 2, p. 239.

MATVIYENKO, A.D., 1985, Effect of the conditions of formation of the Bobrinets granite massif (southern part of the Ukrainian shield) on the distribution of carbon dioxide and methane of the mineralizing fluids in the rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 235-236. (In Russian; translation by Dorothy B. Vitaliano). Author at IGGGI, Acad. Sci. Ukrainian SSR, L'vov, USSR.

The Bobrinets granite massif is situated in the southern part of the Ingul-Ingulets block (Shcherbak, 1982) and consists of rocks of the Kirovograd-Zhitomir complex. Two types of granites are observed here, a central pink porphyritic and a peripheral gray indistinctly porphyritic. The CO_2 and CH_4 contents were derived by a method described earlier (Kalyuzhnyi and Matviyenko, 1975). The results are given in the table.

No.	No. of samples	Sampling site (Sector) Rocks, minerals	Content, cm^3/kg		$\frac{CO_2}{CH_4}$
			CO_2	CH_4	
		Bobrinets sector			
1	1	Gneiss (xenoliths in granite)	0.7	8.0	0.09
2	3	Gray granite, indistinctly porphyritic	1.2	4.2	0.28
3	3	Pegmatite	25.6	8.7	2.94
		Sugokley sector			
4	6	Pink, gray-pink porphyritic granite	10.5	3.7	2.83
5	5	Pegmatite	51.0	5.8	8.79
6	2	Gray quartz from quartz veins	125.0	11.8	10.59

The following particulars of the distribution of the gases investigated were established:

1. The average CO_2 content in the central granite is almost an order of magnitude higher than in the marginal part, since the central part was more highly ultrametamorphosed.

2. An inverse relationship is observed in the distribution of CH_4 in these rocks, which is reflected in the CO_2/CH_4 ratio. This fact supports the genetic relationship of CH_4 to the sedimentary-metamorphic formations that form xenoliths in the Bobrinets sector.

3. Study of the distribution of CO_2 and CH_4 in the pegmatites of the region confirms the accumulation of CO_2 in the residual mineralizing fluids.

4. The highest concentrations of these gases are found in monomineralic quartz veins. Those were formed in the final stage of development of the Bobrinets granite massif. (From the author's abstract)

MAZUROV, M.P., 1985a Genetic models of skarn iron-ore formation: Novosibirsk, "Nauka," 184 pp. (in Russian).

Cited in Naumov, 1986 (this volume).

MAZUROV, M.P.,1985b Temperature of mineralization in the Precambrian skarn magnetite deposits of the Aldan shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 217-218 (in Russian; translation by Dorothy B. Vitaliano). Author at Inst. Geol. & Geophys., Siberian Br. Acad. Sci. USSR, Novosibirsk, USSR.

The accumulation of ore masses in the Precambrian skarn-magnetite deposits of the Aldan shield was governed by a complex combination of processes occurring before and at the time of regional metamorphism and accompanying metasomatism, and also accompanied by retrograding and the development of palingenetic granitoids. The ores formed in the progressive stage acquired a polygonal equilibrium structure in the later stages; in magnetite, the fine crystal structure became more perfect (the size of the blocks of coherent scatter increased, microdistortions became smaller), impurities were separated in the form of three-phase segregations or segregates in defective regions within grains and on intergrain boundaries; in the iron silicates hysterogenic magnetite and(or) ilmenite were deposited. All this introduced errors of indeterminate size into thermometric determinations obtained on the basis of phase-correspondence diagrams -- the most suitable geothermometer for these ores and the enclosing metamorphic rocks.

The Tf of spinel-forsterite-hypersthene-magnetite ores of the progressive stage (magmatic stage) is close to the maximum T of metamorphism and anatexis. According to the two-pyroxene, biotite-garnet, biotite-hypersthene, and magnetite-ilmenite geothermometers and determinations of the Th of melt inclusions in quartz, it was 710-830°C. The monoferrite solid solutions crystallizing under these conditions contained high amounts of Ti, Mg, Al, and Mn, represented at present by magnetite with an isomorphous mixture of Mg and numerous exsolution grains of ilmenite, spinel, hercynite, galaxite and pyrophanite.

In the silicates associated with magnetite from the ore of the regressive stage there are multiphase inclusions. The proportion of phases in the inclusions in different minerals and different parageneses are not the same. Most of the coincident Th of inclusions in scapolite and pyroxene fall in the 710-680°C range, and those in scapolite and amphiboles (pargasite and hastingsite), at 660-590°C. In post-ore coarse-grained veins, the Th of the GLIs in quartz are 525-425°C.

In most magnetites in diopside-forsterite, clinohumite-phlogopite, pyroxene-amphibole-scapolite ores of the regressive phase there also are products of decomposition of solid solution, therefore the solvus curves of the systems magnetite-ilmenite and magnetite-hercyite can serve as a lower estimate of the T of ore formation. These lines have not been determined experimentally for all the fields of composition, therefore a value of 580-660°C, corresponding to Th of P inclusions in amphiboles and scapolites of the latest ore veins, was taken as the lower estimate of the Tf of the metasomatic magnetite ores. In rare calcareous-skarn constituting less than 10% of hysterogenic serpentine-magnetite associations, the magnetite is homogeneous and crystallized at 400°C at least.

On the basis of examples of the Taiga, Pioneer and Komsomol' deposits, typical of the individual subformations, the evolution of the T of the ore-forming processes and specifics of the succession of parageneses of the metasomatites, and the change in composition and microstructure of the magnetite and other minerals has been demonstrated. (Author's abstract)

MAZZULLO, S.J., 1986a Mississippi Valley-type sulfide mineralization, Sheffield Channel, and implications for Delaware Basin evolution (abst.): Southwest Sec. of AAPG Transactions & Guidebook of 1986 Convention, Ruidoso, New Mexico, p. 153-154. Author at 401 E. Illinois, #301, Midland, TX 79701.

A zinc-lead deposit of Mississippi Valley-type character occurs in the subsurface (1,312 m) Sheffield Channel, in basal Leonardian (Permian) dolomites, along the southern Central Basin Platform, Pecos County. The host dolomites represent shelf-margin facies that pass landward into an inner-shelf carbonate evaporite province (lower Clear Fork), and abruptly seaward adjoining a prominent basement fault into equivalent basinal facies of the Bone Spring Formation. Zoned sphalerite and accessory gypsum and abundant pyrite are the major sulfide species present in the deposit. Sulfur-isotope and fluid-inclusion data, in conjunction with reconstructions of Delaware Basin geothermal history, suggest that sulfide mineralization occurred during, or subsequent to, burial-temperature maxima in the late Mesozoic to early Tertiary. Mineralizing fluids appear to have been derived from basinal rocks older than the Bone Spring (3,355 m depth) and to have migrated upward along the platform-bounding fault system. Sulfide precipitation at temperatures of 96°C ± 10° resulted from mixing of basinal brines and ambient host fluids that were charged with sulfur derived locally. Burial paragenesis sequentially involved a major period of pre-ore dolomitization, minor carbonate dissolution, complex sulfide-mineral emplacement, and post-ore dolomite and calcite cementation. Similar carbonate diagenetic sequences found elsewhere in the Delaware Basin may be evidence of a common regional hydrodynamic history of the basin. (Author's abstract)

MAZZULLO, S.J., 1986b Mississippi Valley-type sulfides in Lower Permian dolomites, Delaware Basin, Texas: Implications for basin evolution: The Am. Assoc. Pet. Geol. Bull., v. 70, no. 8, p. 943-952. Author at 2800 Sentinel Drive, Midland, TX 79701.

Sulfur isotopes and fluid inclusions, in conjunction with considerations of the burial history of the area, suggest that Pb-Zn precipitation occurred during the late Mesozoic to Tertiary, in contact with mineralizing fluids heated to 96°-122°C (205°-252°F). These fluids were likely discharged along the Central Basin platform from basin aquifers that are part of a regional, eastward, gravity-driven flow system that has been operative since at least the Tertiary. Sulfide precipitation appears to have resulted from mixing of basinal brines and ambient host fluids that were charged with sulfur derived from laterally contiguous shelf evaporites. (From the author's abstract)

MEDEIROS NETO, F.A., 1986, Gold mineralization in the Pojuca area: Extraction, transport, and deposition by saline hydrothermal fluids: XXXIV Brazilian Geol. Congress, Bull. No. 1 - Abstracts and short communications, p. 208-209, Goiania, Goias State (in Portuguese; English abstract). Author at DOCEGEO, Trav. Lomas Valentinas, 2717 - 66.000 - Belem, Para, Brazil.

Abstract same as Medeiros Neto, 1985, Fluid Inclusion Research, v. 18, p. 274-275, 1985. (E.R.)

MELKONYAN, R.L., AKOPYAN, M.S. and ROMANCHEV, B.P., 1985, Origin of trondhjemites of the Kokhb-Shnokh massif: Izvestiya Akad. Nauk. Arm. SSR-Nauki o Zemle, v. 38, no. 5, p. 32-38 (in Russian).

Cited in Naumov, 1986 (this volume).

MELSON, W.G., JEREZ, D. and WILLIAMS, S., 1986, Largely degassed magma of the 13 Nov. 85 plinian phase of Ruiz Volcano, Columbia (abst.): EOS, v. 67, p. 406. First author at Smithsonian Inst., Washington, DC 20560.

Electron probe analyses of melt inclusions in two pumice samples indicate <2% H_2O, <.1% F, .08 to .15% Cl, .02-.14 (Ave. .05) S as SO_3. (From the authors' abstract)

MENON, A.G. and ANANTHA IYER, G.V., 1986, Modelling of trace element behavior in hydrothermal brines: J. Geol. Soc. of India, v. 27, p. 121-129. First author at Instrumentation & Service Unit, Indian Inst. Sci., Bangalore 560012, India.

Details of a new method to model trace element distribution in hydrothermal ore deposits is outlined. The behavior of Pb^{2+} at 100°, 200° and 300°C has been highlighted as a function of solution parameters fS_2, fO_2 and pH. (Authors' abstract)

MERCHANT, R.J., 1986, Mineralization in the Thames district - Coromandel: Monograph Ser. on Mineral Deposits, v. 26, p. 147-163: Berlin-Stuttgart, Gebrüder Borntraeger.

Includes some inclusion data on base metal ± telluride veins in the halo of the Ohio Creek porphyry Cu-Mo-Au prospect, Coromandel Peninsula (New Zealand). Th = 350-450°C; salinity = 2-4 wt.% NaCl eq.; frequent evidence of boiling. Later telluride veins were nonboiling, dilute, and 250-320°C. (E.R.)

MERGELISHVILI, Zh. Sh., GROMOV, A.V., PAL'MOVA, L.G., ROYZENMAN, F.M., 1985, Some problems of the thermobarogeochemical particulars of formation of the Bektakari porcelain stone deposit in Georgia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 185 (In Russian; translation by Dorothy B. Vitaliano). First author at Caucasian Inst. of Mineral Raw Materials, Tbilisi, USSR.

1. The Baktarari porcelain-stone deposit was formed as a result of hydrothermal-metasomatic transformation of acid effusives. The original magmatic melt, according to the data of microprobe study of melt inclusions in relicts of magmatic quartz, was similar in composition to the rhyolites developed on the flanks of the deposit.

2. The uniform phase relationships in the P magmatic inclusions and the character of distribution of their Th in the 910-1020°C range indicates that the effusive rocks in the region of the deposit formed from a single magma chamber under similar physicochemical conditions.

3. The postmagmatic hydrothermal solutions which caused the reworking of the original volcanics to porcelain stone had T = 580 to 140°C (without correction for P).

4. In composition the hydrothermal solutions were slightly acid, according to the data of chemical analysis of aqueous extracts of fluid inclusions. On the basis of which alkali cations predominate in their composition, two types of solutions can be distinguished: essentially potassic and essentially sodic, occurring in spatially separate parts of the deposit.

5. Sectors of high-quality porcelain stone are outlined on the basis of intensity of "steaming" of the country rocks, determined by decrepitometric surveying in secondary quartzites. (Authors' abstract).

MICHAILOV, A.G. and GRACHEV, A.M., 1985, Use of thermobarogeochemical properties of minerals in exploration for rare metal granite pegmatites (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 26-27 (in Russian; translation by S. Jaireth). Authors at KazIIIMS. MINGEO, Kaz SSR, Alma-Ata, USSR.

Thermobarogeochemcial properties of GLI are important in characterizing zoning within rare metal pegmatites and differentiating them from barren pegmatites. Composition of leachate and gases obtained from fluid inclusions in blocky-zone quartz and microcline from hanging wall to footwall parts of rare metal and barren pegmatites have been studied. Data on quartz and microcline indicate distinct decrease in pH, and concentration of Fe^{+2}

in leachate. Decrease in the concentrations of SO_4, HCO_3 and increase in the K, Na, Cl is less distinct. Variation (less distinct) in the composition of gases from blocky quartz is represented by decrease in the H_2O/H_2 and CO_2/CO ratios from barren rare metal pegmatites by 5 and 10 times, respectively. In microcline, H_2O/CO_2 ratio decreases by 10 to 40 times. Reduction coefficient as determined from microcline and quartz increases from barren to rare metal pegmatites. Though Td are displaced mostly to higher T compared to the true T, relative characteristics of Td and Th of monomineral fractions can be used as indicators, in the evaluation of rare metal pegmatites.

Decrepitation of microcline indicates increase in the number of impulses in the direction: barren pegmatite, footwall, central and hanging wall parts of rare metal pegmatites. Microcline of intensively mineralized pegmatites shows highest number of impulses between 500 and 700°C. Most informative T intervals are 400-500°C and 500-700°C which correspond to supercritical and pneumatolytic pegmatoid geophases of A.Ye. Fersman. Abrupt increase in the frequency of peaks recorded in the high-T intervals (>700°C) in microcline, from barren to weakly and sufficiently mineralized pegmatites, indicates low concentration of volatiles in the initial pegmatite-forming melts and solutions. During subsequent stages concentration of volatiles increased. In blocky quartz, number of impulses (decrepitation) increases from barren to mineralized pegmatites. In coarse-blocky ceramic grade pegmatites the smallest number of impulses are recorded. (From the authors' abstract)

MICHARD, Annie and ALBAREDE, Francis, 1986, The REE content of some hydrothermal fluids: Chem. Geol. (Isotope Geosci. Sec.), v. 55, p. 51-60. Authors at Centre de Recherches Petrogr. et Géochim. & Ecole Nationale Supérieure de Géol., 54501 Vandoeuvre-lès-Nancy Cédex, France.

REE concentrations were determined in solutions from submarine hydrothermal vents on the East Pacific Rise and, for the first time, from continental geothermal fields in Tibet and Bulgaria. They indicate that, in hydrothermal systems, REE are immobile at temperatures below 350°C and for water/rock ratios of $<10^5$. ε_{Nd}-values of submarine solutions and anhydrites (+4.7 to +6.2) suggest recharge on the sediment-covered flanks of the ridge. Carbonate anions, as measured by alkalinity, appear to increase the solubility of heavy REE somewhat, but not to the extent that substantial amounts of REE could be driven out from rocks by hydrothermal activity. (Authors' abstract)

MILLER, W.R. and RYTUBA, J.J., 1986, An occurrence of an epithermal gold system, Republic of Palau, western Pacific (abst.), in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 106. First author at U.S. Geol. Survey, Box 25046, MS 912, DFC, Denver, CO 80225.

A geologic reconnaissance of the Island of Babelthuap, Republic of Palau, revealed a large epithermal gold system. Preliminary fluid inclusion studies of sphalerite indicate T of 240°C and low salinities typical for epithermal gold deposits. (From the authors' abstract)

MILLERO, F.J., 1986, The thermodynamics and kinetics of the hydrogen sulfide system in natural waters: Marine Chem., v. 18, p. 121-147.

MILLERO, F.J. and SOTOLONGO, Sara, 1986, PVT properties of concentrated aqueous electrolytes. 7. The volumes of mixing of the reciprocal salt pairs KCl, K_2SO_4, NaCl, and Na_2SO_4 at 25°C and I = 1.5 m: J. Chem. Eng. Data, v. 31, p. 470-472.

MIRONENKO, M.V., SAVEL'YEVA, N.I., 1985, Zoning of the composition of solutions in inclusions in quartz of wall-rock metasomatites of uranium deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 207-208 (In Russian; translation by Dorothy B. Vitaliano). Authors at GEOKhI of the USSR Acad. Sci., Moscow, USSR.

1. The composition (concentration of CO_2, Na, K, Cl) and total gas-"saturation" (amount of fluid in the inclusions per gram of sample) of inclusions in quartz of metasomatically altered granitoids was studied across the strike of the ore zone of a low-T (200-150°C) U deposit. The outer zone of the metasomatic column consisted of quartz-carbonate-hydromica altered rocks, the inner of albite-hematite rock.

2. The main components of the solutions in the inclusions are CO_2 and Na^+, and their content decreases systematically from the zone of hydromica alteration (CO_2 - 5.1, Na - 0.8) to albite (CO_2 - 1.5, Na - 0.25 mol/kg H_2O). K and Cl occur in sharply subordinate amounts. The total gas saturation, unlike the concentration of CO_2, increases as the ore-bearing structure is approached, which apparently reflects an increase in microfracturing of the rocks toward the axial parts of the ore-containing tectonic dislocations at the time of the hydrothermal process.

3. Results of computer calculations of the equilibrium state of multicomponent heterogeneous systems "granite - orebearing hydrothermal solution with different content of CO_2" makes it possible to explain the formation of the observed metasomatic zoning, ore deposition, and also the zoning of the Na content in the solutions of the inclusions, by a drop in partial pressure of CO_2 (degassing) in the hydrothermal solution. (Authors' abstract).

MIRONOVA, O.F., ROSTOTSKAYA, N.M. and NAUMOV, V.B., 1985, Pyrochromatography in determining fluid-inclusion hydrocarbons: Geokhimiya, no. 12, p. 1779-1785 (in Russian; translated in Geochem. Int'l., v., 23, no. 5, p. 144-150, 1986). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Abstract in Fluid Inclusion Research, v. 18, p. 278-279, 1985. (E.R.)

MIRONOVA, O.F., SAVEL'YEVA, N.I., IKORSKIY, S.V. and VASYNTA, Yu.V., 1985, Comparison of results of bulk analysis of fluid inclusions using various methods of extracting the gas phase: Geokhimiya, no. 1, 1985, p. 111-117 (translated in Geochem. Intl., v. 22, no. 6, p. 1-7, 1985).

Abstract in Fluid Inclusion Research, v. 18, p. 279, 1985.

MIRONYUK, A.F., SINYAKOV, Ye.Ya., SHAKHRAY, S.A., BOTRYAKOVA, O.O. and GAYDENKO, Yu.P., 1985, Composition of fluids in inclusions in the minerals of the Khingan tin-ore deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 131-132 (in Russian; translation by D.A. Brown). First author at Amur Interdiscip. Res. Inst. of Far Eastern Sci. Center of Acad. Sci. USSR, Blagoveshchensk, USSR.

The deposit is located in the Khingan-Olonoy Trough, filled with Cretaceous silicic volcanics. The ore bodies are mineralized sectors in near-vertical zones of breccias with veinlets and nests of ore minerals, 90-95% of which consist of quartz, fluorite, and cassiterite. Minor minerals are arsenopyrite, sphalerite, galena, chalcopyrite, and wolframite.

The following ore phases are recognized in the deposit: early fluorite, cassiterite-quartz, chlorite-sulfide, siderite-calcite, and pyrite. Cassiterite has been released during the second and third phases, but the bulk of it separated during the second phase. Fluorite is also a principal mineral of this phase, along with cassiterite and quartz.

Inclusions from cassiterite in the cassiterite-quartz phase, and also those from quartz in all phases, have been examined.

Samples consisted of monofractions of cassiterite and quartz, measuring 0.25-0.5 mm and about 10 g in weight, typical of different parts of the deposit over a vertical range of ~500 m. The gas composition of the fluids and the quantity of H_2O were determined by gas-chromatography during decrepitation. Their salt composition was determined from triple aqueous extracts with an ion-selective determination of the anions and the NH_4-ion and atomic-absorption-spectrometry for determining the cations.

From this, it appears that the cassiterites of the cassiterite-quartz phase were released from concentrated solutions, containing ≤30% salts. On all horizons, Na, K, and Ca predominate amongst the cations in the inclusion fluids, with NH_4 and Mg present in minor amount. The predominant anion is F, the relative amount of which is 45-70 equiv.%. Cl and Br are constantly present, and I sometimes. On the whole, halogens make ≤90 equiv.% of the cation composition. HCO_3, and less frequently NO_3, have been found in all cassiterites.

The gaseous component of the fluids is mainly CO_2 and CO. CH_4, H_2, and N_2 are present in minor amounts.

Hence, the composition of the cassiterite-producing fluid in the Khingan deposit was halide-Ca-K-Na, with a marked predominance of F amoungst the halides. This large quantity of F was responsible for the complex cassiterite-fluorite nature of the deposit. (From the authors' abstract)

MITCHELL, P.A., 1986, High-level hydrothermal alteration within the Iamalele geothermal field, D'Entrecasteaux Island, Papua New Guinea, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 67-72. Author at Dept. Geol., Univ. Canterbury, Christchurch, New Zealand.

Intensely altered rhyolite was sampled by a 200 m diamond drillhole in the Iamalele geothermal field. Hydrothermal alteration of the drill core may be classified as strong argillic (2 to 15 m), advanced argillic (15 to 65 m), intermediate argillic (65 to 82 m) and potassic (82 to 202 m) based on characteristic mineral assemblages. Cristobalite-alunite hydrothermal breccias characterize the upper 65 m, whereas quartz-adularia breccias dominate from 174 to 198 m. Fracture-controlled and disseminated pyrite occurs below 15 m, and dominantly fractured-controlled stibnite is present between 129 and 180 m. Trace elements characteristic of high-level, epithermal gold systems were detected in the core, including As, Bi, Hg, Se, Te, and Tl, although gold assays never exceeded 0.06 g/t. Hot hydrothermal fluid was encountered near the bottom of the drill hole, but downhole T were not taken. Fluid inclusion Th for core samples below 165 m average 227°C and indicate that the fluid was boiling. (Author's abstract)

MIURA, Y., 1986, Serpentine-group minerals with and without chlorine in terrestrial and extraterrestrial materials (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 172.

MODNIKOV, I.S., KANDINOV, M.N., NECHAYEV, A.N., CYCHEV, I.V. and ARMAN, O.P., 1985, Possibilities of finding and evaluating uranium-bearing structures in basement granitoids of volcanic depressions by integrated study of gas-saturated rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 158-160 (in Russian; translation by Dorothy B. Vitaliano). First author at Min. Geol. of USSR, Moscow, USSR.

Granitoid bodies of different age in the basement of volcanic depressions containing hydrothermal U mineralization are subjected to the action of fluid flows of different depth of formation, composition and age, which are stable in time. Long-lived tectonic structures in bodies of that type are distinguished by very great intensity of manifestation of both high-T pneumatolytic-hydrothermal (microclinization, albitization and greisenization) and medium- to low-temperature metasomatic processes (beresitization, eysitizatsiya[sic] argillization, etc.), which immediately precede mineralization.

These structures can be assigned, on the basis of a combination of geological and geochemical criteria, to the category of zones of heat and mass transfer that are stable in time. However, they usually are poorly expressed in the volcanogenic-sedimentary cover of the depression and hence they are difficult to distinguish by the usual methods of geologic mapping.

The effect of hydrothermal solutions on the main rock-forming minerals of the ore-enclosing granitoids is reflected in the intensity of development of inclusions of the mineral-forming medium in them, i.e., in their gas content. Using combined vacuum decrepitation and gas analysis, selective investigation of the gases from secondary inclusions, produced by the action of hydrothermal solutions of different composition and age on the minerals of the granitoids, is possible (Naumov et al., 1983).

To ascertain hidden ore-bearing structures in one area of the Soviet Union, we studied the gas content of the basement granites using gas-dynamic decrepitation and chromatography. Preliminary study of the mineralizing solutions showed their essentially HCO_3 composition and a very significant concentration of CO_2 in them. It was established that the gas content of quartz in the granitoids varies systematically both across the strike of a presumed ore-controlling structure and along its strike.

The overall gas liberation and the CO_2 content of samples of quartz collected in the structure in the temperature interval 100 to 450°C is 1.5-2 times greater than that from outside its boundaries (0.39-0.24 against 0.18-0.10 mg/g of sample, respectively).

Thus the data obtained make it possible not only to bring out U-bearing structures, but also to evaluate the prospects for possibly finding the mineralization. (Abbreviated by E.R. from the authors' abstract)

MOECHER, D.P., VALLEY, J.W. and ESSENE, E.J., 1986, Carbon isotopic composition of high grade scapolites: Constraints on possible fluid sources in granulites (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 697.

MOGAROVSKIY, V.V., ROMAN'KO, Ye.F. and ISHAN-SHO, G.A., 1985, TP conditions of formation of the Alpine polymetallic and celestite deposits of central Iran (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 118-120 (in Russian; translation by D.A. Brown). First author at Inst. Geol. Acad. Sci., Tadzhik SSR, Dushanbe, USSR.

Tt of minerals was determined from Td and Th, measured by standard methods, allowing for pressure correction. The latter was estimated from inclusions with CO_2, which occur in most minerals in the deposits.

The celestite and sulfide-celestite deposits were formed at ~315-90°C and P 80-20 MPa and lower [$8\text{-}2 \times 10^7$ Pa]. Mineral-formation commenced here with the crystallization of quartz at ~315-285°C and ~80 MPa. Precipitation of celestite, sphalerite, galena, and calcite occurred in the range ~280-130°C and 43-24 MPa. The process ended with marcasite formation at ~100-90°C.

The barite stratiform and vein deposits (Dorreh, Boteh-Baneh, etc.) were formed at ~140-120°C and 30 MPa. An early generation of barite (T = 240-220°C) was manifested only in the vicinity of Gol'-Chashme.

Formation of the galena deposits began with precipitation of quartz at ~200°C and 70-65 MPa, followed by galena (150-130°C and 30-28 MPa).

The Pb-Zn deposits (sometimes with chalcopyrite and celestite) were formed at ~280-90°C and 28 MPa. Mineralization also began here with precipitation of quartz. Galena, sphalerite, and celestite crystallized mainly at ~150-100°C and <32 MPa. However, they are distinguished in a number of deposits by higher T-P values: celestite (Nahlak) 240-220°C and 34-32 MPa, sphalerite (Goud and Gorgab Sh) and galena (Gorgab Sh) at 260-240°C and 42-38 MPa. Calcite, barite, and chalcopyrite corresponding to them have 240-130°C and 35-28 MPa.

Thus, reliable formation has been obtained for the first time on the T-P-conditions of formation of a number of typical Alpine deposits in the Middle East, which form the eastern part of the Mediterranean metallogenic belt. It has been shown that mineralization in the sulfide-celestite deposits commenced at relatively high T (300-380°C), but continued to lower T (250-150°C) (celestite, galena, and sphalerite). The galena prospects were formed at ~200-130°C, whereas the barite and polymetallic deposits were marked by relatively low T (150-100°C). Higher T (260-220°C) have shown up in individual deposits (Nahlak, Gol'-chashme, and Goud).

Throughout the entire region, mineralization took place at virtually constant pressure, close to 35-30 MPa. (From the authors' abstract)

MOINE, B., CHOPIN, C., FORTUNE, J.P., MOREAU, Ph. and VIGUIER, F., 1986, High-pressure hydrothermal alteration forming the talc-chlorite deposits of Rabenwald (Austria) (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 130 (in French). First author at Lab. Minéral., UA 67 du CNRS, 39 Allées Jules Guesde, 31400 Toulouse, France.

The talc-chlorite deposits of Rabenwald were formed by hydrothermal alteration of Hercynian gneisses and micaschists in a tectonic contact in the lower Austrian Alps (Moreau, 1981). In this contact we also find magnesite lenses from which the most talc-rich rocks were derived. The main ore consists of chlorite-talc and formed from gneiss and micashists. In the same area, the gneiss is locally altered into quartz-chlorite-kyanite rocks.

The deposit is characterized by the presence of the talc-phengite assemblage and the absence of chlorite-biotite. Variations in composition of the phengite related to the parageneses were observed. On the basis of these, it is estimated that PH_2O ≥8-9 kb at T = 500-550°C (Massonne, 1981) which is in agreement with the stability field of talc-phengite (Massonne and Schreyer, 1984). Chlorites are sheridanites (with quartz-kyanite), clinochlores (with talc and magnesite) and intermediate compositions (with talc ± quartz). These variations give information on the origin of the various parts of the deposit.

Microthermometric study shows that the fluid inclusions contain brines rich in $CaCl_2$ and $MgCl_2$ with variable proportions of NaCl (Viguier, thesis in prep.). The high density of the inclusions is in agreement with high-P hydrothermal conditions. (Authors' abstract, translated by R. Kreulen)

MOISEENKO, V.G. and SOROKIN, A.P., 1985, Mineral-forming fluids, magmatism and ore-forming zones at the boundary between Pacific Ocean and the continent (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 29-30 (in Russian; translation by S. Jaireth). Authors at Amur KNII, the Far-East Center of Acad. Sci. USSR, Blagoveshensk, USSR.

Three types of ore-forming fluid are associated with Pacific Ocean belt structures: gaseous (aqueous phase 22 to 40%), predominantly aqueous

(aqueous phase >90%) and high-salinity fluids. The fluids show specific changes laterally. Fluids of Sikhote-Alin block have high concentration of water in liquid phase, CO_2 in gaseous phase and fluoride amongst anions. Amongst cations Na>K. Block is characterized by predominantly Sn-W mineralization with B, polymetallic and Ag in subordinate amounts. Fluids and metallogenic specialization of Transbaikal blocks are not significantly different from Sikhte-Alin block. Primore block predominantly has S associated with Cu, Pb and Zn mineralization.

Mineral-forming systems of Amur block are characterized by reduced saline gaseous fluids with low concentration of water. Gaseous phase in native gold is enriched by H_2S and CO_2. Amongst anions halides (Cl, F, Br, I) predominate. Amongst cations K>Na. Block is characterized by Au, Cu, Pb and Mo mineralization, maximum intensity of which is observed at the intersection of Pacific Ocean structures with Mongol-Okhotsk structures.

Variations in fluid systems is also underlined by variations in the composition of volcano-plutonic structures in a direction away from ocean towards continent: from low potassium tholeiites, andesites and trachybasalts to effusives of andesite-dacite composition and polyphase intrusives of diorite-granodiorite composition (alkali-rich in Amur block).

Thus mineral zoning in the zone of transition from the Pacific Ocean to the continent is explained by variation of mineral-forming fluid in time and space, closely associated with magmatism. (From the authors' abstract)

MOISEENKO, V.G. and ZAYKIN, I.D., 1985, Types of mineral-forming fluids: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 1, p. 49-50 (in Russian).

Cited in Naumov, 1986 (this volume).

MONTEIRO, R.L.B.P., 1986, Tungsten mineralization in the middle Jequitinhonha Valley, Minas Gerais, Brazil: MS thesis, Univ. Brasilia, 245 pp. (in Portuguese; English abstract). Author at Dept. Geosci., Univ. Minas Gerais, CEP 31270, Belo Horizonte, MG, Brazil.

Psamo-pellites and calc-silicate rocks of the Salinas Group in the Rubelita-Coronel Murta region of the middle Jequitinhonha Valley support a sedimentary environment of the stable continental margin type, which was disturbed by episodic reactivations, marked by deposition of orthoconglomeratic and quartzitic beds. Two well characterized folding phases are found all over the Rubelita area. The folding axial trends of the F_n isoclinal and the F_{n+1} open assymetric folds and likewise those of the crenulations related to the assymetric folding show the same orientation to NE and NNE. Regional metamorphism of Barrowian type was overprinted by subordinate thermal effects in aureoles of intrusive granitoid plutons. Mineral paragenesis of amphibolite-facies, sillimanite-type, suggest P from 3.5 to 5 kb and T from 650°C. The intrusive plutons, with foliated margins, are essentially homogeneous, alkali-potash late- to post-tectonic two-mica granitoids of Brasilian age; they resemble those of northern and northeastern Coronel Murta, and are inferred to have been derived through anatexis of metasedimentary rocks. Metasomatism is widespread particularly at the margins and cupolas of plutons; at the cupolas, later pegmatoid granites do occur and pegmatitic veins indistinctly transect all country rocks.

Tungsten anomalies relate predominantly to the muscovitized facies of granitoid plutons with W concentrating in the neoformed muscovites generated from alkali-feldspar and biotite. Two types of W mineralization occur in the region: (1) scheelite associated with thin layers of calc-silicate rocks hosted by the schistose country rocks; (2) scheelite plus wolframite related to quartz veins in the Jenipapo-Itinga district. This study suggests an epigenetic origin for type 1 and 2 of W mineralization, but with the metal originally associated with volcanic-sedimentary sequences which underwent anatexis, with W becoming incorporated in the granitoid plutons, and concentrating near the cupolas due to magmatic fractionation, with enrichment in muscovite in the more metasomatized facies of the granitoid plutons.

Fluid inclusion data suggest that the mineralizing fluids were essentially aqueous fluids of low salinity. Other fluids were enriched in carbon species like CO_2 and CH_4. In the scheelite-wolframite quartz veins at Itinga pure CO_2 inclusions indicate T from 300°C to 450°C, at a P of 2 kb. Fall of T and pH increase through neutralization of slighly acid solutions via reactions with wall rocks and/or progressive loss of CO_2 by immiscibility of (metamorphic/meteoric?) aqueous fluids, led to W deposition. The metal was precipitated as scheelite when calcium was available and/or wolframite always when Fe concentration exceed the wolframite solubility product. Thus both scheelite and wolframite are related to the end phases of the granitic magmatism as suggested by the late genetic nature of scheelite with undeformed features and association with retrogressive paragenesis of calc-silicate rocks. (Authors' abstract)

MONTEL, J.-M, WEBER, Catherine, BARBEY, P. and PICHAVANT, Michel, 1986, Thermobarometry of the Velay anatectic domain (Massif Central, France) and conditions of generation of the late-migmatitic granites: C.R. Acad. Sci. Paris, v. 302, Ser. II, no. 9, p. 647-652 (in French; English abstract).

P-T determinations carried out on selected rocks from the southern part of the Velay anatectic domain constrain the metamorphic conditions for the migmatites (3 kb, 700°C), for the generation of the anatectic granites (5-6 kb, 800°C) and for the deep crust (8-10 kb, 700-800°C). A model of melting of the continental crust is proposed that accounts for the P-T conditions of generation of the anatectic granites. (Authors' abstract)

MOON, K.J., 1986, Study on the temperature and the origin of mineralization at the Samkwang Au deposits: J. Korean Inst. Mining Geol., v. 19, no. 1, p. 19-24 (in Korean; English abstract).

The Samkwang mine is one of the Au deposits distributed mainly in the southwestern province (Chungnam) of the Korean peninsula. Au occurs in quartz veins aged of 223 ± 4 MA according to K-Ar age dating from muscovite in a pegmatitic quartz vein. Quartz veins intrude Precambrian biotite-granite gneiss and mica schist of unknown age.

Fluid inclusions in the quartz show a range of Th from 159 to 274°C. A calculated T from the isotopes of the galena-sphalerite pair is 375°C. Two-phase fluid inclusions homogenizing in either liquid or vapor phase over 260°C are frequently observed in specimens, which may indicate boiling. P of formation of the quartz veins inferred by the Th of liquid-CO_2-bearing fluid is 1 kb. Based on these data, it is assumed that the T of the formation of the Samkwang mine may lie between 350-230°C.

$\delta^{34}S(\Sigma s)$ values of sulphide minerals show narrow range of +2.1 to +4.6, and show a trend of enrichments of ^{34}S in the fluid from deep to the surface. $\delta^{34}S(\Sigma s)$ in the fluid is estimated to be less than 3 permil, suggesting sulphur fluid originated from the magma. (Author's abstract)

MOORE, J.N. and ADAMS, M.C., 1986, Thermal and chemical evolution of the caprock in the Salton Sea geothermal field, California (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 699. Authors at Univ. Utah Res. Inst., 391A Chipeta Way, Salt Lake City, UT 84108.

The Salton Sea geothermal field is located in an active rift zone where greenschist facies metamorphism is currently taking place. The field is capped by low-permeability rocks that control the distribution of fluid and heat flow to a depth of several hundred meters. Chemical, petrographic, and fluid inclusion data from two high-temperature wells show that the composition of the brines, fluid flow patterns, and thermal characteristics of the caprock changed as the geothermal system evolved. The caprock in these wells consists of two layers. The upper 250 m is composed of impermeable lacustrine claystone and evaporite deposits. The lower layer consists of deltaic sandstones. During the initial development of the geothermal system, downward percolatng waters deposited anhydrite in the sandstones, reducing their permeabilities. Homogenization temperatures of fluid inclusions in anhydrite define a conductive gradient through the caprock. Temperatures reached 245°C near its base at a depth of 335 m. The salinities of the brines ranged from 7 to 24 equivalent weight percent NaCl.

Subsequent incursion of high-temperature brines into the sandstones resulted in potassic alteration, deposition of base metal sulfides, and dissolution of anhydrite and calcite. The final stage in the evolution of the caprock records the initiation of fracture permeability. During this stage, veins containing quartz, barite, and base metal sulfides formed at temperatures ranging from 180 to 240°C. (Authors' abstract)

MORA, C.I. and VALLEY, J.W., 1986, Chlorine-rich scapolite in Belt Series metasediments: Implications for fluid infiltration (abst.): EOS, v. 67, p. 398. Authors at Dept. Geol. & Geophysics, Univ. Wisconsin, Madison, WI 53706.

Chlorine-rich scapolite is abundant in the biotite zone of the regionally metamorphosed Wallace Formation of the Belt Series northwest of the Idaho Batholith, near Clarkia, Idaho.

Using the results of Ellis (1978), NaCl/(NaCl + H_2O) in the coexisting fluid was in the range of 0.5-0.75. The high salinity of fluids in equilibrium with scapolite places an upper limit to the amount of aqueous fluid which has been added to the rock by metamorphic infiltration. For example, to form an average scapolite with a composition of EqAn 33, Cl/(Cl + CO_3) = 0.66 and a modal abundance of 25% requires a minimum of 1.5% NaCl in the sediment, if there has been no infiltration. Salt casts and other evidence for thin evaporite layers could account for sufficient NaCl to stabilize scapolite (~5%) and are reported in unmetamorphosed equivalents of the Wallace Formation. Strict stratigraphic control of the occurrence of scapolite suggests that large-scale infiltration by a brine is unlikely to have been the dominant source of NaCl. Infiltration by large fluid/rock ratios (≥0.6) of pure H_2O would remove NaCl in solution and thus require initial sediments with ≥30% halite, for which there is no evidence in unmetamorphosed equivalents. Hence, scapolite compositions may restrict models of large-scale aqueous fluid movement proposed to account for oxygen isotopic compositions in Belt Series metapelites or metasomatism of the Boehls Butte anorthosite. (From the authors' abstract)

MORALEV, G.V., 1985, On the temperature zoning of a deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 57-58 (in Russian; translation by I.V. Kulikov). Author at MGU, Moscow, USSR.

Thermobarometric investigations were conducted at a deposit [unnamed] located at the eastern limits of a large granodioritic massif, and represented by a series of steep quartz-carbonate veins. According to the classification of N.V. Petrovskaya the deposit belongs to the group of low-sulfide deposits.

On the data of V.M. Turlichkin two stages of mineralization are distinguished, which were divided by intrusion of diabase dikes in Triassic time: early quartz - gold ore stage and late silver-polymetallic stage. Gangue minerals (mainly white sugary ore-bearing quartz; 50 samples) of the early stage were studied, by decrepitation on the device "D-1" from three veins at different levels.

For discovering of changes in relative T of quartz deposition in space the T of the beginning of mass explosions of inclusions were used. Usually they vary in the limits of 290-320°C at lower levels, and in the limits of 260-300°C at upper levels. The vertical T gradient at vein No. 1 - "Steep" was 23°/100 m, at vein No. 2 - 7°/100 , and at vein No. 2 "North" - 7°/100 m.

The analyses of T changes of the beginning of mass decrepitation establishes that paleo-T gradient increased toward the surface. The data obtained confirm the investigations of Y.V. Lyakhov, and they verify the suggestion of near-surface conditions of formation.

The changes in relative T in a horizontal direction were also noted. For vein No. 2 - "North" the lateral gradient turned out to be 30°/100 m, and T of the beginning of mass decrepitation in quartz increases toward crosscutting faults. This suggests an ore-conductng role for these faults.

These results could help to determine the depth of erosion and the direction of movement of hydrothermal solutions. (Abbreviated by E.R. from the author's abstract)

MORGAN, P., HARDER, V. and GIORDANO, T.H., 1986, Heat and fluid flow in the Rio Grande rift: A possible modern thermal analogue of a Mississippi Valley-type ore-forming system, in Nesbitt, R.W. and Nichol, Ian, eds., Geology in the real world - the Kingsley Dunham volume: Inst. Mining & Metallurgy, p. 295-305. First author at Dept. Geosci., Purdue Univ., West Lafayette, IN, USA.

The thermal structures of modern Rio Grande rift basin geothermal anomalies and Mississippi Valley-type (MVT) ore-forming systems appear to be somewhat analogous. Through a study of observational data and a simple theoretical model for the Rio Grande systems, we show that the most plausible mechanism for these modern geothermal anomalies is gravity-driven forced convection. We suggest that the mechanisms responsible for MVT ore fluid heating and transport may be similar. The high salinities of typical MVT ore fluids may require forced convection in confined aquifer systems. Study of the modern geothermal systems may provide valuable information for the investigation of MVT deposit genesis. (From the authors' synopsis)

MORIMOTO, Nobuo, SAKANAKA, Kenzi and KITAMURA, Masao, 1986, Diffusion coefficient of silica in supercritical water (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 177.

MORISHITA, Y., 1986, Temperature and pressure estimation for tungsten-bearing hypothermal quartz veins: Oxygen and carbon isotope studies of the Ohtani and Kaneuchi ore deposits, Kyoto, Japan (abst.): Terra Cognita, v. 6, no. 2, p. 225. Author at Geol. Survey of Japan.

Oxygen and carbon isotope compositions were determined for quartz, muscovite, calcite and whole-rock samples. The Th of fluid inclusions from the same deposits have been reported as being 90 to 155°C lower than the isotope equilibrium T. This T difference is ascribed to apparently low Th as a result of P effect. Making appropriate corrections for salinity and CO_2 concentration, the ore-forming P at the Ohtani and Kaneuchi ore deposits are calculated to be 1.5 and 1.4 kb, respectively. (From the author's abstract)

MOROZOV, S.A. and GRIGORIEVA, E.P., 1985, The peculiarities of genesis of gold-bearing mineral associations of Tadzhikistan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 44-45 (in Russian; translation by I.V. Kulikov). Authors at IG AN Tadzh. SSR, Dushanbe, USSR.

Gold mineralization, located in three geologically different regions (Karamazar, Central Tadzhikistan and Pamirs), are related to two formations: gold-quartz and gold-sulfide. Gold-bearing mineral associations in Tadzhikistan are represented by gold-arsenopyrite, gold-quartz, gold-pyrite-chalcopyrite, and gold-tetrahedrite. Gold is present also in a number of other associations, but these are insignificant in quantity. Gold ores in the North and Central Tadzhikistan are related to Hercynian tectono-magmatic cycle. Its age is late Carboniferous-late Permian (300-250 my). Gold mineralization formed at medium (1.5-2 km) and shallow depths (800 m).

Gold mineralization formed during a hydrothermal polystaged cycle at 500°-100°C and 1 to 0.2 kbar during changes of T, P and the chemical properties of hydrothermal solutions. Gold-bearing associations themselves were formed in two intervals: 450-300°C and 1-0.3 kbar; and 250-150°C and 0.3-0.2 kbar from HCO_3-Cl-K-Na solutions (for gold-quartz formation) and from HCO_3-S-Mg-Ca solutions (for gold-sulfide formation).

The studied gold mineralization appeared as a result of complex processes of interactions of primary hydrothermal solutions with surrounding geological media under changing T, P, pH, Eh, etc. The main regulating factor of mineral deposition was fluctuation of T, which resulted in changes in both the concentrations of components and the oxidation-reduction potential of the solution; it also resulted in a change of behavior of the gold itself. The change in T occurred not only as a result of pulsating (polystaged) input of fluids from a deeper source, but also as a result of complex chemical reactions during mineral deposition, which occurred with exothermal effect (sericitization, silicification, etc.).

Analysis of the data obtained suggests that the transportation of gold at the studied gold mineralizations was made in the form of chloride, sulfur-arsenic, sulfide and oxygen complexes. The composition of primary solutions and the form of transportation of gold influenced the character of the gold-bearing associations: the presence of chloride complexes and acidic solutions conditioned the deposition of gold in quartz-carbonate associations, but sulfide and sulfur-arsenic complexes with alkaline solutions conditioned the relation of gold with arsenopyrite, pyrite and chalcopyrite in sulfide associations. (Authors' abstract)

MORRISON, Jean, BROWN, P.E., VRY, J.K. and VALLEY, J.W., 1986, Cordierite CO_2 as a record of metamorphic $\delta^{13}C$: Results from the Pikwitonei domain, central Manitoba, Canada (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 700. Authors at Dept. Geol, Univ. Wisconsin, Madison, WI 53706.

Controversy surrounds the interpretation of high XCO_2 observed in the channels of granulite facies cordierites (Cd). Is there an equilibrium relationship between the Cd channel constituents and the peak metamorphic fluid? If so, are the fluid compositions preserved or does XCO_2 in Cd change upon cooling and uplift? Co-existing Cd and graphite (Gr) occur in the Archean Pikwitonei granulite domain, at the NW margin of the Superior Province, central Manitoba. The terrane consists of supracrustal rocks, meta-igneous rocks and related migmatitic gneisses. Discontinuous metapelite layers are widespread and often contain Cd and Gr. Some Cds in the terrane are optically (+) and IR spectroscopy confirms the presence of CO_2 and H_2O in the Cd channels. Channel CO_2 was collected for carbon isotopic analysis by heating at 950°C in a vacuum combustion line. Yields are 0.2-

0.4 μmoles CO_2/mg of pure Cd (~1-2 wt %). CO_2 in Cd channels (Cd/CO_2) ranges in $\delta^{13}C$ from -31.8 to -34.8 (n = 4, σ =1.1). Values of $\delta^{13}C$ for coexisting coarsely crystalline Gr (up to 2 mm flakes) = -36.1 to -41.8 (σ = 2.1). These 4 Cd/CO_2-Gr pairs yield Δ's (Cd/CO_2-Gr) of 4.3, 6.6, 7.0 and 7.7. Despite uncertainties in the fractionation effects during entrapment of CO_2 in Cd, the consistency of these results suggests that Cd may faithfully preserve the peak metamorphic fluid $\delta^{13}C$, and hence the XCO_2.

Other Grs from the granulite terrane range from -31.4 to -45.2‰. Possible explanations for these light ratios include 1) deposition of unusually light organic carbon in the metasediments, 2) Rayleigh distillation during volatilization of CO_2 from normal organic carbon ($\delta^{13}C$ = -25 to -30) in the metasediments, and 3) quantitative oxidation of influxing methane. We regard the second possibility as the most likely because nearly all published values of $\delta^{13}C$ for organic carbon range between -25 to -30, and there is no evidence to support CH_4 infiltration. Rayleigh distillation under reducing conditions would enrich the residual Gr in ^{13}C as CH_4 preferentially fractionates ^{12}C. Thus, likely peak metamorphic fO_2 conditions were fairly oxidizing and near the maximum stability of graphite, ~QFM at the P-T of peak metamorphism. (Authors' abstract)

MORRISON, Jean and VALLEY, J.W., 1986, Post-metamorphic hydrothermal alteration of anorthosite in the Adirondack Mountains, N.Y. (abst.): EOS, v. 67, p. 399. Authors at Dept. Geol. & Geophys., Univ. Wisconsin, Madison, WI 53706.

Fluid inclusion thermometry is being conducted to determine the alteration temperature which will enable a more rigorous evaluation of the source of the mineralizing fluids and the timing of the mineralization. (From the authors' abstract)

MORRISON, Jean, VALLEY, J.W., BROWN, P.E. and LAMB, W.M., 1986, Retrograde fluid infiltration and high density CO_2-rich fluid inclusions, Adirondack Mts., NY (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 700. Authors at Dept. Geol, Univ. Wisconsin, Madison, WI 53706.

High density CO_2-rich fluid inclusions (FI's) in granulite facies rocks are often cited as evidence for CO_2-flooding at the peak of metamorphism. In the Adks, high density CO_2-rich FI's occur in samples for which phase equilibria results yield low peak metamorphic $f(CO_2)$. This suggests that the CO_2-rich FI's were not trapped at the peak of metamorphism and are post-metamorphic. This conclusion is supported by examination of retrograde alteration (rtgrd alt) asemblages of chlorite (chlt) ± calcite (cc) ± sericite ± quartz (qt) ± pyrrhotite (po) ± scapolite ± epidote, that clearly postdate the peak of metamorphism and occur throughout the Marcy Anorthosite Massif. Variable %'s of rtgrd alt occur in ~90% of the 150 samples examined; the alt generally occurs as cross-cutting veins of chlt and cc (.05 to 5 mm wide) or as intergrowths of py cubes with cc, qt, po. Values of $\delta^{18}O$ (29 rtgrd cc's) = 11.2 to 14.9, and $\delta^{13}C$ = -4.0 to 0.2. $\delta^{34}S$ (25 sulfides) = 2.9 to 8.3. C-O-H fluid mixing models show that the isotopic composition of the rtgrd cc can be explained by mixing of postmetamorphic, deep-seated CO_2-H_2O fluid with igneous or mantle affinities, and Adk supracrustal lithologies (Morrison and Valley, 1986). A correlation exists between the isotopic composition of the rtgd cc and regional lithology. Rtgrd cc in the NE lobe of the massif shows greater scatter in $\delta^{18}O$ and $\delta^{13}C$, reflecting variability of the country rock, which includes marbles, calc-silicates and charnockites. NW lobe samples are relatively homogeneous, consistent with the dominantly granitic country rock.

CO_2-rich FI's of variable density occur in the rtgrd qt. The CO_2-rich FI's range from 3 to 7 μm in diameter, Th (L-V) CO_2 ranges from 28.3 to

-4.2°C; densities range from 0.65 to 0.95. An orthopyroxene in one altered sample shows CO_2-rich FI's with densities from 0.87 to 1.03. Texturally these inclusions appear primary, however, cathodoluminescence shows that even mineralogically unaltered grains are crosscut by rtgd cc veins. We interpret these FI's to be trapped during infiltration of rtgrd fluids. These results show that apparently primary metamorphic FI's in opx were actually trapped after the peak of metamorphism at the time of rtgrd cc precipitation. The genetic link between late carbonic fluids and tectonically controlled, Paleozoic "crackle-zones" is being investigated. (Authors' abstract)

MORRISON, S.J. and PARRY, W.T., 1986, Formation of carbonate-sulfate veins associated with copper ore deposits from saline basin brines, Lisbon Valley, Utah: Fluid inclusion and isotopic evidence: Econ. Geol., v. 81, p. 1853-1866. Authors at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

Copper (± silver) ores occur along faults related to salt anticlines in red-bed sediments of the Paradox basin and in coal-bearing horizons of the Dakota Sandstone in southeastern Utah and southwestern Colorado. Deposits of this type occur at Salt Valley, Sinbad Valley, and Paradox Valley; the largest deposits are at Lisbon Valley. These deposits are related by geologic setting and ore and gangue mineralogy. Fluid inclusions, mineral chemistry, and C-O stable isotopes in calcite gangue associated with copper ores at Lisbon Valley suggest that mixing of two solutions caused precipitation of the ore. Fluid T ranged from 72° to 103°C and salinities were 5 to 20 equiv wt % NaCl during calcite deposition. Copper-bearing, saline, basinal fluids migrated upward along fault zones and deposited ore and gangue minerals upon mixing with shallower, reduced, Ba-rich ground water. Mineral precipitation was induced by a combination of dilution and reduction. (Authors' abstract)

MORROW, D.W., CUMMING, G.L. and KOEPNICK, R.B., 1986, Manetoe facies - A gas-bearing, megacrystalline, Devonian dolomite, Yukon and Northwest Territories, Canada: Am. Assoc. Petrol. Geol. Bull., v. 70, p. 702-720. First author at Inst. Sed. & Petrol. Geol., Geol. Survey of Canada, 3303 33rd St. NW, Calgary, Alberta T2L 2A7, Canada.

The Manetoe facies is a broadly stratiform and regionally developed (38,000 km^2 or 15,000 mi^2) body of white sparry dolomite hosted in Lower and Middle Devonian strata, and is the northwestward continuation of the similar, but better known, Presqu'ile facies dolomite. Several large gas fields have been discovered within anomalously thick developments of the Manetoe dolomite close to the northwest limit of the Devonian Elk Point basin of Alberta.

The external geometry of the Manetoe facies indicates that it may have been a cavern of karst system excavated in the late Middle Devonian by a large, vertically confined coastal aquifer. The local regions of anomalously thick Manetoe facies may have developed where the aquifer "stoped" upward into strata above the confining aquiclude of the Headless Formation shale.

Dolomite cementation may have occurred during any of three possible episodes of large-scale fluid movement. Fluid-inclusion and strontium isotope data favor the hypothesis that Manetoe dolomites precipitated from heated (150°-210°C or 300°-410°F) hypersaline evaporitic brines that have interacted with the underlying Precambrian crust, probably in the late Devonian. Lead-isotope data support the general concept of pre-Mesozoic dolomite cementation, and largely preclude a late Early Tertiary deep burial setting. Spectacular zones of detrital dolomite cement within the

Manetoe are most readily accommodated by a near-surface, very early Middle Devonian aquifer mixing-model origin, but the presence of these zones does not preclude the other possible origins. Carbon and oxygen isotope data from the Manetoe facies support the concept that the Presqu'ile and Manetoe facies are physically continuous and had a common origin. (Authors' abstract)

MUEHLENBACHS, K., MUROWCHICK, J.B. and NESBITT, B.E., 1986, Pristine and highly evolved meteoric waters as ore fluids in accreted terranes (abst.): Terra Cognita, v. 6, no. 2, p. 132. Authors at Dept. Geol., Univ. Alberta, Edmonton, Alberta, Canada T6G 2E3.

A wide variety of lode Au deposits have been examined in the Canadian Cordillera to determine the origin of the ore fluids. In all the Cretaceous and younger examples D/H studies show the fluids to be of local meteoric origin (-100 to -160‰, SMOW). However, the $\delta^{18}O$ values of these fall into two contrasting groups, -5 to -10 vs. +6 to +10‰. Fluid inclusion Tt and isotopic partitionings yield T of mineralization of 250 to 350°C for all these deposits. Mineralogical, geochemical, and field relations prove they can be divided into two classes recognized elsewhere: epithermal and mesothermal. The epithermal deposits are comparable with the better known U.S. analogues, having formed from low CO_2, low salinity, low $\delta^{18}O$, and low δD waters. These deposits may be found in any of the Cordilleran terranes and the ore fluids are clearly unevolved meteoric water. In stark contrast, contemporaneous mesothermal deposits, including related Sb and Hg mineralization, formed from high CO_2, low salinity, high $\delta^{18}O$ but low δD waters. These mesothermal deposits are found in minor fault systems splaying off major transcurrent fault zones between accreted autochthonous terrances. We suggest that following the assembly but during transcurrent rearrangement of the terranes, local meteoric water penetrated 5 to 7 km deep within the crustal slivers to the brittle ductile transition zone where extensive oxygen exchange occurred. The exiting evolved fluids were focused in the off-axis, subsidiary fault systems where the Au, Sb, Hg and gangue minerals were deposited. We suggest that similar mesothermal deposits, e.g., California Mother Lode, and Archean Au deposits of the Canadian Shield, were formed by the same mechanism involving highly evolved, ^{18}O-enriched meteoric water. (Authors' abstract)

MUNHA, J., BARRIGA, F.J.A.S. and KERRICH, R., L986, High ^{18}O ore-forming fluids in volcanic-hosted base metal massive sulfide deposits: Geologic, $^{18}O/^{16}O$, and D/H evidence from the Iberian pyrite belt; Crandon, Wisconsin; and Blue Hill, Maine: Econ. Geol., v. 81, p. 530-552. First author at Dept. Geol., Fac. de Ciencias, 1294 Lisboa CODEX, Portugal.

The origin and evolution of hydrothermal reservoirs implicated in polymetallic massive sulfide deposits are evaluated in terms of the variability in $\delta^{18}O$ and δD and the temperature of their ore-forming systems. [Ts from isotopic fractionation are given for the Iberian belt and Crandon.] Fluid inclusion filling T in stringer quartz range from 220° to 310°C.

For all these deposits the ore-forming fluids are regarded as dominated by marine water that had undergone variable positive ^{18}O shifts up to 6.1 per mil, according to the extent of isotopic exchange with volcanic rocks under high T and low water/rock conditions. At Blue Hill a significant proportion of magmatic fluid is present. No covariance is observed between the size of deposits and the fluid $\delta^{18}O$ values. (From the authors' abstract)

MUNOZ, M., DONG, K.Y., VERRAES, G. and TOLLON, F., 1986, Hydrothermal alteration paragenesis associated with the zinc vein deposit of Noailhac-Saint Salvy (Tarn, France): Conditions of mineralization deposition (abst.):

Terra Cognita, v. 6, no. 3, p. 505. First author at Lab. de Minéral., 39 allées Jules Guesde, 31400 Toulous, France.

Noailhac-Saint Salvy is a vein deposit with total Zn and Ag contents of 350,000 and 260 tons, respectively, and it is the first producer in the world of Ge.

Six successive mineralizing stages in the development of the ore body can be distinguished. The mean homogenization temperature of fluid inclusions within albite correlated with stage 1 is 160°C. The presence of montmorillonite formed during stages 2, 3 and 4 indicates a crystallization T of around 100°C. The mean Th of fluid inclusions within stage 3 quartz is approximately 115°C. The stage 5 mineral assemblage occurred during a thermal peak (150-200°C) as indicated by the crystallization of illite and mixed-layer illite-smectite. Finally, low T conditions (<100°C) are suggested for stage 6 deposition by the presence of wurtzite and kaolinite. (From the authors' abstract)

MUNOZ, Marguerite, KIM, Y.-D, VERRAES, Gérard and TOLLON, Francis, 1986b, Hydrothermal alterations and zinciferous vein mineralizations of the Noailhac-Saint-Salvy deposit (Tarn, France); their successions and crystallization conditions: C.R. Acad. Sci. Paris, v. 302, Ser. II, no. 8, p. 575-577 (in French; English abstract).

See previous item. (E.R.)

MUNTEAN, J.L. and LOUCKS, R.R., 1986, Gold mineralization in Proterozoic ductile shear zones, Keystone district, Medicine Bow Mountains, Wyoming (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 398. Authors at Dept. Geosci., Purdue Univ., West Lafayette, IN 47907.

In the metamorphic-igneous complex of the Medicine Bow Mountains, Wyoming, numerous Au-Ag-Cu veins occupy faults active during and after peak metamorphism

Investigations of six Au-mineralized vein systems along sheared mafic dikes indicate a reasonably consistent vein paragenetic sequence of (1) early electrum (39-86 at.% Au) + cpy + py + qtz + sericite + tourmaline; (2) elect + cpy + bn + py + Mag + K-spar + qtz; (3) ankerite/siderite + qtz ± cpy ± py ± mag ± chlorite; (4) hematite + calcite + quartz; (5) coarse goethite + calcite + quartz. $\delta^{18}O$ data and fluid inclusion geothermobarometry reveal a T decrease >300°C and P decrease of several kilobars during uplift and erosional unloading during protracted mineralization. Fluid inclusions trapped CO_2-rich (10-15 mol% CO_2) chloride brines as a homogeneous fluid during Au-Cu mineralization accompanying greenschist facies metamorphism and ductile deformation along shear zones. Immiscible brine and CO_2-rich fluids were trapped heterogeneously during subsequent, lower P deposition of hematite + carbonate assemblages. Brittle deformation accompanied precipitation of lower T hydrothermal goethite + quartz + calcite as vuggy veins. (From the authors' abstract)

MUROWCHICK, J.B., MUEHLENBACHS, K. and NESBITT, B.E., 1986, Isotopic gradients around gold mineralization, Coquihalla Gold Belt, southern B.C. (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 701. Authors at Dept. Geol, Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

The Coquihalla Gold Belt (located approximately 20 km NE of Hope, B.C.) hosts 23 Au producers and occurrences along the eastern edge of the fault bounded Coquihalla Serpentine Belt. The Carolin mine, a mesothermal lode Au deposit typical of that type in the Canadian Cordillera, last operated from 1981-84, and was the largest of 5 producers in the Belt.

Stable isotope (^{18}O, D, and ^{13}C) studies at Carolin mine and vicinity indicate that the ore fluids were highly evolved meteoric waters that ascended adjacent to the East Hozameen Fault zone (EHFZ) after deep circulation through local metasediments and volcanics. Mapping of $\delta^{18}O$ SMOW values of quartz veins (15 to 19%) and whole rock samples (12 to 19%) in the mine area reveals anomalies (lower $\delta^{18}O$) coinciding with Au mineralization. These lows are superimposed on a more uniform gradient of 6.3% /km (quartz veins) to 7.0% /km (whole rock) in the mine area, increasing NE to 0.5 km from the EHFZ. 3 to 5 km SE of the Carolin mine, the $\delta^{18}O$ gradient in meta-argilites is only 1.8% /km to 2.5 km from the EHFZ.

Fluid inclusion data do not reveal temperature gradients that could account for the $\delta^{18}O$ gradients, thus we interpret the δ^{18} gradients as reflecting decreasing water/rock (W/R) ratios as the ascending fluids dispersed laterally into the country rocks. Mineralization thus formed in zones of abundant fluid flow (i.e., high W/R).

Isotopic similarities among lode Au, Sb, and Hg deposits associated with transcurrent faults in the Cordillera suggest that $\delta^{18}O$ patterns may be used to delineate mineralized zones elsewhere. (Authors' abstract)

MURPHY, G.C., BAILEY, Andrew and PARRINGTON, P.J., 1986, The Blendevale carbonate-hosted zinc-lead deposit, Pillara, Kimberley region, Western Australia: Proc. Commonwealth Mining & Metal. Congr., Australia, 13th, Perth, Australia 1986, v. 2, p. 153-161.

Indexed under fluid inclusions. (E.R.)

MYSEN, B.O. and VIRGO, David, 1986a, Volatiles in silicate melts at high pressure and temperature. 1. Interaction between OH groups and Si^{4+}, Al^{3+}, Ca^{2+}, Na^{+} and H^{+}: Chem. Geol., v. 57, p. 303-331.

MYSEN, B.O. and VIRGO, David, 1986b, Volatiles in silicate melts at high pressure and temperature. 2. Water in melts along the join $NaAlO_2$-SiO_2 and a comparison of solubility mechanisms of water and fluorine: Chem. Geol., v. 57, p. 333-358.

MYSNIK, A.M., 1985, Mineralogical-geochemical model of formation of the gold-bearing pyrite-polymetal formations: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 2, p. 159-161 (in Russian).

Cited in Naumov, 1986 (this volume).

NABELEK, P.I., 1986, Trace-element modeling of the petrogenesis of granophyres and aplites in the Notch Peak granitic stock, Utah: Am. Mineral., v. 71, p. 460-471. Author at Dept. Geol., Univ. Missouri-Columbia, Columbia, MO 65211.

The petrogeneses of a granophyre and an aplite in the Notch Peak stock, Utah, were modeled using published experimental data for mineral/melt, mineral/fluid, and melt/fluid partitioning of alkali, alkaline-earth and rare-earth elements. Calculations suggest that the granophyre formed by 2-13% crystallization from an aqueous fluid that exsolved from the magma during emplacement and was trapped beneath the limestones. (From the author's abstract)

NADEAU, Serge and FRANCIS, Don, 1986, Fluid inclusions in upper mantle xenoliths from Nunivak Island, Alaska, relicts of mantle metasomatism (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 106. Authors at Geol. Sci., McGill Univ., Montreal, Quebec, H3A 2A7, Canada.

Upper mantle xenoliths found in Tertiary and Recent alkaline basalts from Nunivak Island, Alaska, contain numerous fluid inclusions. The abundance of fluid inclusions in xenoliths which do not contain hydrous minerals increases from dunite through harzburgite, spinel lherzolite, websterite, to pyroxenite. The abundance of fluid inclusions in minerals within any given xenolith increases from spinel through olivine, orthopyroxene, to clinopyroxene. Xenoliths containing hydrous minerals have the highest abundances of fluid inclusions. Within such xenoliths, anhydrous minerals adjacent to interstitial and/or veinlets of phlogopite and pargasite are enriched in fluid inclusions which decrease in abundance away from the hydrous minerals. The fluid phase in the inclusions of the Nunivak xenoliths is almost pure CO_2 as shown by melting T between -56.6 and -57.4 (±0.2°C). The highest fluid densitites are observed in P inclusions within amphibole-garnet pyroxenite ($d = 1.17$ g.cm^3, $P = 11$-12 Kb) and amphibole-spinel pyroxenite xenoliths ($d = 1.14$ g.cm^3, $P = 10$ Kb). Lower fluid densities obtained for inclusions in the other xenolith types are thought to reflect decrepitation of P inclusions during xenolith transport to the surface. The spatial association of the fluid inclusions with silicate glass and sulfide inclusions within healed fractures in xenoliths containing hydrous minerals suggests that these are all components of a late stage, metasomatic process which produced the incompatible trace element enrichment in these upper mantle rocks. Analyses of phlogopite and pargasite indicate that the fluid involved in this metasomatism had a D/H(SMOW) of -60 to -80‰ while analyses of the fluid inclusions indicate a light $\delta^{13}C$(PDB) of -24 to -26‰. (Authors' abstract)

NAGARAJAN, N. and ROBINSON, R.L., Jr., 1986, Equilibrium phase compositions, phase densities, and interfacial tensions for CO_2 + hydrocarbon systems. 2. CO_2 + n-decane: J. Chem. Eng. Data, v. 31, p. 168-171.

NAGY, K.L. and MORSE, J.W., 1986, The solubility of calcite in sodium-calcium-chloride brines to 90 degrees C and evaluation of the interaction between calcium and carbonate ions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 701. First author at Geol. Dept., Texas A&M Univ., College Station, TX 77843.

The results suggest that aqueous NaCl may not always be a good analogue to subsurface brines. Other major inorganic components can strongly affect the amount of calcite that can be dissolved, and hence, the amount of porosity created. (From the authors' abstract)

NÄHLE, R., NEUHAUS, D., SIEKMANN, J., SRULIJES, J. and WOZNIAK, G., 1986, Separation of fluid phases and bubble dynamics in a temperature gradient: Naturwissenschaften, v. 73, p. 387-389. First author at DFVLR-Inst. für Raumsimulation, D-5000 Köln.

Experimental studies of bubble motion in a temperature gradient, part of a series of papers on Marangoni effects in this journal issue. (E.R.)

NARSEEV, A.V., 1986, Fluid regime study in the prospecting and appraisal of rare-metal ore deposits: Razved. Okhr. Nedr., 1986, no. 6, p. 2-8 (in Russian).

Indexed under fluid inclusions. (E.R.)

NAUMKO, I.M. and KALYUZHNYI, V.A., 1985, Genetic importance of one type of primary inclusion in amythyst from zanorsh type granite pegmatites from Ukraine (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 6-8 (in Russian; translation by S. Jaireth). Authors at IGGGI, Inst. Geol. & Geochem. of Fuels, L'vov, USSR.

Amythyst from a "zanorsh" zone of a pegmatite body contains primary inclusions very different from those described in earlier studies (Kalyuzhnyi, Voznyak, 1967; Voznyak, 1971; Kalyuzhnyi et al., 1971). Predominantly gaseous inclusions (degree of filling 3 to 5%) have typically negative crystal shapes and size of 1 to 4 μm. On freezing gas meniscus becomes sharper, particularly after solidification of the aqueous phase.

In addition to water, the gas phase contains CO_2 and CH_4 (freezing studies). Concentrations of CO_2 and CH_4 in the inclusions based on mass spectrometric analysis (analysts I.M. Svoren and B.E. Sakhno) is 56.5 to 72.8 and 43.5 to 27.2 vol.% respectively.

Heating of inclusions above 220°C followed by fast cooling generates in them fine aggregates of a material uniformly dispersed over the surface of inclusion cavity. During subsequent 3 to 18 months from the day of experiment, in addition to fine aggregates, new coarse, drop-like aggregates also appear. Scanning of inclusions under ultraviolet radiation reveals that the aggregates are concentrated predominantly along edges of negative crystals, very different from finer aggregates that are dispersed uniformly all over the cavity surface. The latter show fluorescence in ultraviolet radiation, which is characteristic of carbonaceous material. In coarser aggregates fluorescence was not observed. After keeping the samples for 5 years at room temperature, rims around coarser drop-like aggregates also started showing fluorescence probably because the carbonaceous material had undergone redistribution.

During emplacement of "zanorsh" pegmatites at the contact of two different types of granites γ_1 and γ_2, cooling was very slow. Carbonaceous material present in the mineral forming fluids of pegmatites underwent uniform precipitation all over the walls of inclusion cavities due to which cavity surfaces of unheated inclusions showed fluorescence. On fast cooling, uniform redistribution of carbonaceous material failed to occur. Instead, separation took place; the originally largely homogeneous fluid formed two different phases - organic (rich in carbonaceous material) and inorganic (composed of aqueous saline solution with some dissolved silica). (Authors' abstract)

NAUMKO, I.M., MAMCHUR, G.P., KOVALISHIN, Z.I., 1985, Isotopic composition of CO_2 carbon in fluid inclusions in topaz from pegmatites of zanorysh type in the Ukraine (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 240-241. (In Russian; translation by Dorothy B. Vitaliano). Authors at IGGGI, Acad. Sci. Ukrainian SSSR L'vov, SSSR

Results are given of the first determinations made of the isotopic composition of CO_2 carbon of fluid inclusions in topaz, from zanorysh pegmatites genetically and spatially related to the rapakivi granites of the Korosten pluton (Volhynia).

The gas components were extracted during volumetric chemical analysis by mechanical break-up of the inclusions in a vacuum (the bulk sample of topaz weighed 250 g). CO_2 gas was absorbed by a saturated solution of $Ba(OH)_2$. The carbon isotopic composition was determined on an MI-1201 mass spectrometer. The results of the measurements are given in comparison with PDB standards.

The isotopic composition of CO_2 carbon of the fluid inclusions differs slightly for three samples of topaz ($\delta^{13}C$ equal to -19.3, -18.7 and -19.4‰ respectively from different mineral parageneses of the pegmatites. On the basis of analysis of these data, several conclusions can be drawn.

CO_2 carbon of the inclusions in topaz is relatively enriched in the light isotope. No correlation was found between its isotopic composition and the CO_2 gas content. Mixing of CO_2 from deep sources and from the volatiles of the granitic melt in the formation of the topaz mineralization in the late inversion stage of the pegmatite process is presumed. The established similarity in isotopic composition of CO_2 carbon of the mineralizing fluids at the time of crystallization of the quartz (Mamchur et al., 1968; Kovalishin et al., 1980) and topaz indicates the space-time unity of the processes of mineralization in the zanorysh pegmatites of the Ukraine. (From the authors' abstract)

NAUMOV, G.B., MIRONENKO, M.V., SAVEL'YEVA, N.I. and SALAZKIN, A.N., 1985, Fluid inclusion compositions in conjugate hydromicaite and albitite zones around ores: Geokhimiya, no. 12, p. 1706-1712 (in Russian; translated in Geochem. Int'l., v., 23, no. 5, p. 75-81, 1986). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Zoning occurs in the compositions of fluid inclusions in quartz from metasomatically altered granites enclosing U mineralization. The CO_2 and Na^+ concentrations decrease from the outer hydromicaization zones to the inner albitite bodies and on to the ore bodies, while there are no definite changes in Th. The metasomatic zoning is considered as having been formed by CO_2 loss from the hydrothermal solutions. (Authors' abstract)

NAUMOV, G.B., MIRONOVA, O.F., SAVEL'YEVA, N.I. and DANILOVA, T.V., 1984, Uranium concentration in hydrothermal solutions, as shown by the study of fluid inclusions: Dokl. Akad. Nauk SSSR, v. 279, no. 6, p. 1486-1488 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., v. 279, p. 224-226, 1986). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., USSR Acad. Sci., Moscow, USSR.

Abstract in Fluid Inclusion Research, v. 17, p. 237, 1984. (E.R.)

NAUMOV, G.B. and NAUMOV, V.B., 1985, Evolution of fluid regime in the gradient-characterized thermobaric fields of lithosphere: Underground waters and evolution of lithosphere: Materials of the All-Union Conference, Moscow, "Nauka," v. 1, p. 130-138 (in Russian).

Cited in Naumov, 1986 (this volume).

NAUMOV, G.B., SALAZKIN, A.N., MIRONOVA, O.F., SAVEL'YEVA, N.I., 1985, Methods of studying fluid aureoles in prospecting for hydrothermal ores (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 243-244. (In Russian; translation by Dorothy B. Vitaliano). Authors at Vernadsky Inst. Geochem. & Analyt. Chem., Acad. Sci. USSR, Moscow.

The use of geochemical methods of prospecting for mineral deposits involving fluid inclusion aureoles has at present become an important component part of geological exploration. (Abbreviated by ER from the authors' abstract.)

NAUMOV, G.B., SOKOLOVA, N.T., MATYUSHIN, L.V. and MALYSHEV, B.I., 1986, Role of contact metamorphism in the uranium ore formation: Geokhimiya, 1986, no. 8, p. 1113-1128 (in Russian; English abstract).

Based on quantitative petrochemical, radiochemical and thermobaric data mechanisms of migration of material in the contact metamorphism zones and the main characteristics of formation of uranium deposits in these conditions have been considered. A geochemical model of these processes is suggested. The main point of the model is a generation of aureole of high-dense H_2O-CO_2 fluid during the progressive stage of the metamorphism (compression) and its discharge in the local spots of fracture-formation during the regressive stage (decompression). Migration of U occurs due to formation of its mobile forms in the ore-preparation processes and concentration on the geochemical barriers. (Authors' abstract)

Apparently only previously published data are given. (H.E.R.)

NAUMOV, V.B., ed., 1985, Inclusions in minerals. Bibliography of the Soviet (1984) and foreign (1983) literature: Publ. Sci. Council on Ore Formation of the Acad. Sci. USSR, Section on Ore-Forming Solutions in Inclusions, Moscow (in Russian). Editor at Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

NAUMOV, V.B., 1986, Inclusions in minerals. Bibliography of the Soviet (1985) and foreign (1984) literature, 93 pp., issued by Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow (in Russian). Editor at Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

Citations from this bibliography that were not abstracted earlier are included, verbatim, in the present volume even though many of these have no evidence, from the title, that fluid inclusion studies were involved. Unfortunately, some of these citations, as given in the original, are incomplete. (E.R.)

NAUMOV, V.B., AKHMANOVA, M.V., SOBOLEV, A.V. and DHAMELINCOURT, P., 1986, Use of laser Raman microprobe for studying the gas phase of inclusions in minerals: Geokhimiya, no. 7, p. 1027-1034 (in Russian). See Translations.

NAUMOV, V.B. and KOVALENKO, V.I., 1985, Volatile components of magmatic and metamorphic processes from data obtained during the study of inclusions in minerals: Doklady Akad. Nauk SSSR, v. 284, no. 6, p. 1461-1463 (in Russian). First author at Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

The authors summarize data from about100 published papers on studies of volatiles in inclusions from about 300 rock specimens from deep zones of the Earth. Maximum fluid P [i.e., Pfl] [was] 13 kbar, T 1500°C (Fig. 1); acid melts may crystallize in very wide T ranges: 1250°C (or even more) to 550°C (ongonite melts). Basic and ultrabasic melts have higher T: 1500-1000°C. Maximum Pfl are typical of CO_2 and N_2 (11-13 kbar); for water maximum Pfl is 5.5-6 kbar. For basic melts CO_2 is most common volatile, for acid - H_2O. Basalt magmas are essentially water-free, only low water concentrations were found in inclusions in minerals of rocks of island arcs magmas of calc-alkaline type. In acid rocks water may comprise 13.9 wt. %, but also as low contents as <0.1 wt. % were found. For the area T 500-1000°C, P 6-13 kbar, deep fluids consist of CO_2, CH_4 and N_2, and water was not found. These conditions are not typical of magmatic conditions, but only of the metamorphic ones. Main mantle volatile component is CO_2 plus up to 8-12 mole % of CO (Raman spectroscopy data) and/or low content of sulfur-bearing gases. (Abstract by A.K.)

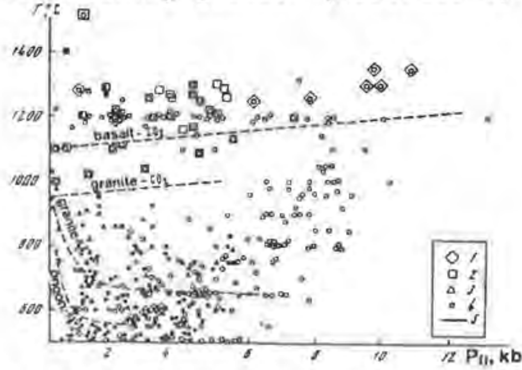


Fig. 1. Temperatures and fluid pressure [Pfl] in magmatic and metamorphic processes, obtained during fluid inclusion studies in minerals. 1 - deep-seated nodules in alkaline basalts, 2 - melts of basic and ultrabasic composition, 3 - acid melts, 4 - fluids (metamorphic? - A.K.), 5 - lines of solidus, heavy lines = H_2O, light lines = CO_2, CH_4, N_2; ongon. = ongonite.

See also Fluid Inclusion Research, v. 18, p. 290-291. (E.R.)

NAUMOV, V.B. and KOVALENKO, V.I., 1986, Characteristics of the main volatile components of natural magmas and metamorphic fluid based on the data of study of inclusions in minerals: Geokhimiya, no 5, 1986, p. 590-600 (in Russian; English abstract).

See previous (1985) paper by same authors. (E.R.)

NAUMOV, V.B., KOVALENKO, V.I., SOBOLEV, A.V., TIKHONENKOV, P.I. and SAMOYLOV, V.S., 1986, Immiscibility of silicate and salt melts according to inclusion study data in high-temperature fluorite: Dokl. Akad. Nauk SSSR, v. 288, no. 2, p. 453-456 (in Russian). See Translations.

NATIVEL, P., CLOCCHIATTI, R. and BACHELERY, P., 1986, Origin and conditions of formation of quartz phenocrysts from the Plaine des Sables (Piton de la Fournaise, Reunion Island) (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 135 (in French). First author at Lab. Pétrogr., Univ. Paris-Sud, Centre d'Orsay, Bat. 504, 91405 Orsay Cedex, France.

Scoria and ejecta from the Plaine des Sables are known for their abundant olivine crystals. At the "Plateau des Basaltes," automorphic quartz crystals are known since 1959 (Bussiere); the only quartz occurrence studied up to the present (Clocchiatti and Nativel, 1984) is that of the quartz-bearing syenite of Chapelle de Cilaos (Massif du Piton des Neiges).

In the scoria of la Fournaise, quartz crystals are rare. They have recently been found in a piece of lava containing plagioclase An60-40, salite and titanium-rich magnetite. This rock underwent hydrothermal alteration which formed sphene, chlorite, albite, K-feldspar, quartz and gibbsite(?). Fluid inclusion studies indicate that the quartz formed from nearly pure aqueous fluids under boiling conditions, between 270 and 255°C (75% of the studied inclusions) and PH_2O of about 50 bars. (Authors' abstract, translated by R. Kreulen)

NEAL, W.S. and LARSON, P.B., 1986, Mineral and fluid geochemistry of the Hoosier vein, Chloride mining district, New Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 703. Authors at Dept. Geol., Washington State Univ., Pullman, WA 99164-2812.

Veins of the Chloride mining district, SW New Mexico, host an unusual calc-silicate and Cu-rich, Fe-poor sulfide assemblage. The Hoosier vein is a N75W zone of left-stepping echelon quartz veins cutting Tertiary andesite and Pennsylvanian limestone. The veins are complex with multiple veining and brecciation episodes. Samples across the surface of the vein every 100 feet and vein intercepts from 19 drill holes were assayed for Au, Ag, Cu, Pb, and Zn. Metal ratios show a vertical zoning from Cu at depth to Pb-Zn and Ag-Au at the surface. Bornite, chalcocite, chalcopyrite, galena, sphalerite, with traces of pyrite, hematite, and native gold occur in the veins. Silver occurs in chalcocite (up to 32 wt %) and in bornite (up to 0.7 wt %). Calc-silicate vein minerals include pyroxene (Jo18-91 Di8-73 Hd0-18), garnet (Ad20-74), epidote (Ps3040), prehnite, and sub-calcic amphibole. Sulfide minerals are intimately intergrown with amphiboles and calc-silicate minerals in the veins. Limestone wall rocks are recrystallized to marble, altered to wollastonite, and locally silicified along thin vein selvages. Andesite wall rocks are flooded with K-spar near the veins and regionally propylitized to epidote-chlorite-pyrite. Average fluid inclusion homogenization temperatures in vein quartz range from 280°C at depth to 250°C near the surface with salinities of 10.3 and 5.0 equiv wt % NaCl, respectively. Fluid inclusions have rare CO_2 bubbles and uncommon unidentified daughter minerals. Banded veins and crustiform textures suggest that boiling may have occurred. Early stages of fluid flow resulted in brecciation, alteration of the wall rocks and deposition of calc-silicate and sulfide minerals. Later fluids produced banded quartz veins with few accessory minerals. The log activity of sulfur based on Fe in sphalerite ranges from -9.4 to -10.9. Mineral stabilities indicate that at 250°C the pH was >5.2 and the log activity of oxygen ranged from -34.2 to -32.8. (Authors' abstract)

NEGGA, H.S., SHEPPARD, S.M.F., ROSENBAUM, J.M. and CUNEY, M., 1986a, Late Hercynian uranium-bearing veinlets of La Lauziere (western Alps): Evidence for fluid mixing, based on isotope data (C, O, H) and fluid inclusions (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 135 (in French). First author at CREGU, B.P. 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

U mineralizations in the Lauziere intrusion (Belledonne massif) are often associated with carbonate veinlets and carbonate-cemented breccias. The first carbonate phase is dolomite or ankerite, the second is calcite formed at the same time as pitchblende. The fluids associated with these carbonate phases have been trapped at different P and T (dolomite or ankerite >1.5 kb, 350-400°C; calcite <1.5 kb, 300-350°C). The chemical composition of the fluids was also different: salinity and δD decrease from the dolomite/ankerite stage (20 to 15 wt% eq. NaCl; -34 to -49‰) to the calcite stage (17 to 8 wt% eq. NaCl; -50 to -65‰). The physico-chemical conditions leading to precipitation of the carbonates show a continuous evolution. Low $\delta^{13}C$ values of the carbonates (-10 to -14‰) indicate an organic origin of the carbon. H and O isotopes suggest that two types of fluid were involved in the formation of the veinlets. Saline formation (or metamorphic) water, rich in deuterium (-35‰) and with a low $f(O_2)$, was generated by the underlying sediments. This was mixed with water of meteoric origin which was more oxidized, less saline and contained U. The presence of deep formation (or metamorphic) water implies overthrusting of sediments by basement rocks(?) during the late Hercynian. (Authors' abstract, translated b R. Kreulen)

NEGGA, H.S., SHEPPARD, S.M.F., ROSENBAUM, J.M. and CUNEY, M., 1986b, Late Hercynian U-vein mineralization in the Alps: Fluid inclusion and C, O, H isotopic evidence for mixing between two externally derived fluids: Contrib. Mineral. Petrol., v. 93, p. 179-186. First author at CREGU, BP 23, F-54501 Vandoeuvre-les-Nancy Cedex, France.

See previous item. (E.R.)

NEKVASIL, Hanna, 1986, The calculated effects of pressure and water content on the position of the 4-phase curve in the granite system (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 704.

NERAD, B.A. andf SHLICHTA, P.J., 1986, Ground-based experiments on the minimization of convection during the growth of crystals from solution: J. Crys. Growth, v. 75, p. 591-608. First author at Dept. Chem. Engrg., Univ. Colorado, Boulder, CO 80309, USA.

Crystals were grown from solution in the Earth's gravitational field with the substantial absence of convection by (a) downward unidirectional growth in an isothermally cooled solution and (b) upward unidirectional growth in a positive vertical thermal gradient. Growth rates were 1.3 to 1.8 times the predictions for convectionless growth and an order of magnitude less than for growth with vigorous convection. Crystals grown in the isothermal configuration were of comparable or superior quality to those grown with substantial convection. The imposition of 0.5 to 0.8°C/mm gradient stabilized the growth interface so that flat (001) surfaces could be grown on KDP. Crystals grown in a thermal gradient, however, were filled with far more fluid inclusions than crystals grown isothermally. (Authors' abstract)

NESBITT, B.E., MUROWCHICK, J.B. and MUEHLENBACHS, Karlis, 1986, Dual origins of lode gold deposits in the Canadian Cordillera: Geology, v. 14, p. 506-509. authors at Dept. Geol., Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

From Late Jurassic to late Tertiary time, two geologically, geochemically, and genetically distinct gold mineralization processes were active in the Canadian Cordillera. One group of deposits can be characterized as epithermal because of its association with intermediate to felsic volcanics, regional caldera structures, low pH alteration zones, low Au/Ag values, and quartz-chalcedony-barite-fluorite gangue. The second group of deposits is mesothermal in character and has strong similarities to the Mother Lode deposits of California, being associated with transcurrent faults, intermediate pH alteration zones, and quartz ± carbonate, albite, mariposite, pyrite, arsenopyrite, scheelite gangue. Compared to epithermal deposits, mesothermal deposits have higher As, W, and Au/Ag values, higher CO_2 content in fluid inclusions, and $\delta^{18}O$ values of ore-forming fluids of +3‰ to +10‰ vs. -14‰ to -7‰ for epithermal deposits.

Like the gold deposits in Nevada and Colorado, epithermal mineralization in the Canadian Cordillera formed from the shallow circulation of meteoric water in subaerial, intermediate to felsic volcanic complexes. In contrast, mesothermal gold deposits throughout the North American Cordillera are shown to be the product of deep circulation and evolution of meteoric water in structures associated with major, transcurrent fault zones. Similarities between Archean lode gold deposits and mesothermal deposits of the Cordillera suggest that Archean lode deposits may have been produced by processes similar to those involved in the formation of Cordilleran mesothermal deposits. (Authors' abstract)

NEUHAUS, D., 1986, Bubble motions induced by a temperature gradient: Naturwissenschaften, v. 73, p. 348-349. Author at Inst. für Raumsimulation, DFVLR, D-5000 Köln.

Experimental studies involving air bubbles in oils, with holographic documentation. Part of a series of papers on Marangoni effects in this journal issue. (E.R.)

NEUMANN, W. and TISCHENDORF, G., 1986, Genesis of sulfide mineralization in pyroclasites of the Hartmannsdorf granulite massif: Int'l. Conf. on the Metallogeny of the Precambrian (IGCP Project 91), Geol. Survey (UUG), Prague 1986, p. 81-84 (in English). Authors at the Central Inst. Physics of the Earth Acad. Sci. of GDR, 1199 Berlin-Adlershof, Rudower Chaussee 5, GDR.

In addition to the geological, petrographic, and mineralogical description, and lead isotope age determinations, some results of the investigations on fluid inclusions in quartz (with jamesonite) are presented. Th were mostly in the range of 407-367°C in quartz. Therefore, oxides and sulfides are katathermal formations. The salinity of inclusions with Th 374 ± 8°C is very high (20 wt.% NaCl + 27 wt.% KCl). (Note: In addition to the inclusions with high salinity there are also inclusions showing critical boiling with about the same Th range.) On the basis of the salinity and the density of the fluids the hydrostatic depth of formation is assumed to be only 1.7 km. This implies a relatively high position of the granulite massif at the time of formation of the quartz-sulfide mineralization. (Abstract courtesy R. Thomas.)

NEWMAN, Sally, STOLPER, E.M. and EPSTEIN, Samuel, 1986, Measurement of water in rhyolitic glasses: Calibration of an infrared spectroscopic technique: Am. Mineral., v. 71, p. 1527-1541. Authors at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125, USA.

A series of natural rhyolitic obsidians were analyzed for their total water contents by a vacuum extraction technique. The grain size of the crushed sample can significantly affect these analyses. Coarse powders must be used in order to avoid surface-correlated water. These analyses were used to calibrate infrared spectroscopic measurements of water in glass using several infrared and near-infrared absorption bands. We demonstrate that infrared spectroscopy can yield precise determinations of not only total dissolved water contents, but also the concentrations of individual H-bearing species in natural and synthetic rhyolitic glasses on spots as small as a few tens of micrometers in diameter. (Authors' abstract)

NEWTON, R.C., 1986a Late-Archean/early Proterozoic CO_2 streaming through the lower crust and geochemical segregation (abst.): EOS, v. 67, p. 387. Author at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL 60637.

Extensive flushing by low-P(H_2O) vapors has been proposed as a principal mechanism of granulite-facies metamorphism in the deep-crustal terrains of Scourie (Scotland), S. India, Bamble (S. Norway) and Buksefjorden (S.W. Greenland). In all of these terrains great crustal thickening preceded metamorphism and, in the latter three, transcurrent shearing followed overthrusting and may have provided avenues for ascent of vapors.

Carbon dioxide is implicated as the major constituent of granulite-facies metamorphic fluids by 1) high-density CO_2 inclusions in minerals, 2) mineral-vapor calculations of C-O-H fluids in equilibrium with graphite in paragneisses and 3) default, there being no other likely dilutent for H_2O to stabilize orthopyroxene. Abundant field evidence of deformation-induced access of low-H_2O vapors to produce pyroxene gneisses exists throughout southern India.

Important effects of vapor steaming in the lower crust are 1) removal of H_2O by destruction of biotite and amphibole, 2) depletion of the LIL elements K, Rb and the heat producers U and Th, 3) lowering of $\delta^{18}O$ in paragneisses over large terrains, and 4) granitization of mid-crustal levels by H_2O and K brought up the deep curst.

Sources of voluminous CO_2 may have been 1) decarbonating upper mantle "hot-spots," 2) exsolution from crystallizing basaltic "underplates," 3) carbonate strata deeply buried in overthrusting, or 4) marine carbonates deeply subducted under continental interiors. The latter mechanism may have been needed to replenish CO_2 in the subcontinental mantle after earlier crust-making magmatic episodes.

Removal of LIL elements and H_2O from the lower continental crust in the late Archean and early Proterozoic by CO_2-transport may have been an important agent of continental stabilization which enabled long-term survival of sialic masses. (Author's abstract)

NEWTON, R.C., 1986b Fluids of granulite facies metamorphism, in J.V. Walther and B.J. Wood, eds., Fluid-Rock Interactions during Metamorphism, New York, Springer-Verlag, p. 36-59.

A detailed examination of the nature and origin of dense CO_2 inclusions (and other volatiles) in granulite rocks. (E.R.)

NIVIN, V.A., 1985, Distribution of microinclusions of gases in the ore horizons of the Lovozero massif (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 236-237. (In Russian; translation by Dorothy B. Vitaliano). Author at Geochim. Inst., Kola Affiliate, USSR Acad. Sci., Apatity, USSR.

A noteworthy feature of the alkaline rocks of the massif is the presence in them of a gas phase of essentially CO_2 composition. Zoning in the distribution of microinclusions of gases relative to the mineralization, which forms stratiform disseminated occurrences, has been established. The maximum content of the main gas components is observed in the foot and(or) hanging walls of the deposit, and the maximum concentration of He corresponds to the maximum of ore mineralization. Gas content ranges from fractions to 100 mm^3 of gas per gram of rock or mineral; foyaite and urtite are the most gas-rich compared to malignite and lujavrite. The main minerals holding microincluded gases are nepheline, K-Na feldspar and sodalite. Microscope observations, and also the relationships brought out between the gas contents of the rocks and the development of late and secondary mineralization, indicate a relationship between the formation of gas microinclusions and the post-magmatic stage of development of the ore complex. Sufficiently stable epigenetic zoning of the distribution of microincluded gases can be used in geological exploration as a typical criterion of mineralization and along with other data, as indirect evidence of the participation of post-magmatic processes in the formation of ores. (From the author's abstract)

NOBEL, F.A., 1986, Sr isotopes from Spanish lamproites, possible evidence for magma-evaporite interaction (abst.): Terra Cognita, v. 6, no. 1, p. Author at Geol. Inst., Univ. Amsterdam, Amsterdam, The Netherlands.

^{87}Sr/^{86}Sr ratios of Neogene lamproitic volcanics, cogenetic and thought to be of mantle origin, from four different localities in SE Spain have been determined. The observed isotopic ratios show a considerable range (0.715-0.721) and are inversely related to Sr-contents (1660 ppm - 560 ppm).

To explain these characteristics a model is proposed involving contamination of lamproitic magma, highly enriched in radiogenic Sr(^{87}Sr/^{86}Sr $\geq$ 0.721) by Triassic gypsum. Supporting evidence for such a model is provided by trace element chemistry and fluid inclusions. (Author's abstract)

NOLLER, J.S., 1986a, Solid and fluid inclusions in mantle xenoliths: An analytical dilemma?: Geology, v. 14, p. 437-440. Author at U.S. Geol. Survey, Menlo Park, CA 94025.

Two Cr-diopside lherzolite xenoliths with kaersutite selvages, from Dish Hill, California, contain four types of solid and fluid inclusions that can be used to discriminate between actual mantle processes and processes acting upon a fragment of mantle as it is entrained and carried to the earth surface. On the basis of distribution, early formed inclusions are assigned to a process associated with emplacement of dikes in the mantle. The other types of inclusions were generated during ascent in the host basalt magma.

Solid and fluid inclusions are important sites of incompatible element concentrations in mantle xenoliths. Scientists assigning specific chemical signatures to mantle processes are confronted with an analytical dilemma: leaching of xenolith samples before analysis may destroy inclusions that are carrying intrinsic mantle components, whereas failure to leach the samples probably leaves a host-rock contaminant. Thin-section maps of these xenoliths show that the distribution and abundance of two types of solid inclusions are systematic. Through the use of these maps it is demonstrated that zones in xenoliths with the least amount of postentrainment contamination can be pinpointed, and the problems resulting from random leaching can be minimized. (Author's abstract)

NOLLER, J.S., 1986b, Solid and fluid inclusions in mantle xenoliths from Dish Hill, California: An analytical dilemma (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 2, p. 164. Author at U.S. Geol. Survey, Menlo Park, CA 94025. See previous item.

NORDSTROM, D.K., 1986, A possible mechanism for fluid-inclusion leakage into the deep granitic groundwaters at the Stripa research site, Sweden (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 708. Author at U.S. Geol. Survey, MS-421, 345 Middlefield Rd., Menlo Park, CA 94025.

The internationally sponsored research program at the Stripa mine to develop techniques for characterizing subsurface conditions in granitic bedrock for the radioactive waste management community has accumulated 9 years of chemical and isotopic data on the groundwaters, gases and mineral assemblages of a small Proterozoic granite in central Sweden. Elevated chloride concentrations in deep groundwaters, up to 700 mg/L, are irregularly distributed with depth (down to 1200 m) and reflect the lack of direct connections between fracture zones and/or the lack of a single external source for the saline components. Br/Cl and I/Cl ratios from the groundwater analyses most closely match rock leachate ratios, indicating fluid inclusions as a source of the saline components. This hypothesis is substantiated by measurements of the size, the abundance and the average salinity of fluid inclusions in both the rock matrix and the fracture-fillings. Although calcite supersaturation is clearly maintained by the deep groundwaters, careful examination of calcite vein minerals shows no clear evidence for recently (<100,000 yrs) precipitated calcite. Present evidence suggests that stress changes caused by blasting, excavating, drilling and dewatering the mine over the last 80 years has resulted in leakage of fluid inclusions, prompting an additional input of calcium into the deep groundwaters, causing calcite supersaturation and an irregular distribution of anomalous Na-Ca-Cl concentrations among different fracture zones. This hypothesis would indicate the type of hydrogeochemical changes that might be expected during the excavation and dewatering of a radioactive waste repository in crystalline bedrock. (Author's abstract)

NORMAN, D.I., BOADI, I., SOBA, D. and SEGELSTAD, T.V., 1986, Gold deposits associated with granites (abst.): Terra Cognita, v. 6, no. 3, p. 540. First author at Mineralogisk-Geologisk Museum, Sars gate 1, Oslo 5, Norway.

Fluid inclusion studies indicate mineralizing solutions were CO_2 rich, with less than 12 eq. wt.% NaCl, and unmixing of CO_2 accompanied deposition which occurred at T of about 300°C and at a P of 1.5 to 2 kb. In New Mexico, alteration associated with gold mineralization is iron-carbonate and sericite in volcanic rocks, and sodic alteration plus elevated gold values in the granites; in Cameroon, alteration is propylitic.

The spatial relationships between gold mineralization and intrusions, and the isotopic evidence, indicate that gold mineralization resulted from CO_2-rich fluids derived from felsic magmas during intrusion of cooling. Modeling indicates that the intrusions must have had at least 0.4 wt% CO_2; our data suggest that such intrusions were derived by fractional crystallization of basaltic magmas generated concurrently with regional metamorphism. The indicated unmixing of the gaseous components during gold mineralization suggest that unmixing was a principal cause of deposition. The deposits studied are remarkably similar in occurrence and conditions of formation to gold deposits in Precambrian shield areas, suggesting they are Mid and Late Proterozoic analogs of shield-area Au deposits. (From the authors' abstract)

NORMAN, D.I. and MEARNS, E.W., 1986, Sm-Nd isotopic analyses of fluid inclusion waters (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 708. First author at Dept. Geosci., New Mexico Inst. of Mining & Tech., Socorro, NM 87801.

Sm-Nd isotopic analyses were attempted on 3 samples of well studied miarolytic quartz from the Drammen granite, Norway, which is associated with Mo mineralization. Rb-Sr isotopes in the inclusion fluids and Sm-Nd and Rb-Sr isotopes in the granite were measured.

Inclusions have 0.3 to 2.1 ppm Sm and 0.8 to 5 ppm Nd. Duplicate analyses of inclusion fluids yielded ^{147}sm/^{144}Nd values of 0.0735 and 0.0749 and ^{143}Nd/^{144}Nd values of 0.51253. ε_{Nd} (274 Ma) for inclusion brines trapped at 650 to 800°C are +1.8 to 2.7, whole rock $\varepsilon_{Nd} = -0.4$ to +1.3, and ε_{Nd} for CO_2-rich inclusions trapped at 400 to 600°C is -1.0.

These data indicate that inclusion waters comprise both magmatic and crustal waters. The magmatic waters had an origin in depleted mantle whereas the Nd and Sr isotopic composition of CO_2-rich inclusions are consistent with an origin in Proterozoic gneisses or Paleozoic sediments which the granite intrudes. Sr isotopic systematics suggest crustal fluids fluxed through the granite some 10 to 15 Ma after crystallization of the granite (which would coincide with major caldera formation in the Oslo rift) and led to modification of the granites Sm-Nd and Rb-Sr composition.

We conclude that Sm-Nd isotopic analyses of fluid inclusion waters can be readily done. The analyses can unequivocally indicate magmatic waters and are potentially a most useful tool as a geologic tracer in hydrothermal systems. It appears the isotope systematics of the unaltered Drammen granite are only preserved in fluid inclusions. (Authors' abstract)

NORTON, Denis, 1986a Fluid pressure variations in the near-field region of magmas (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 708.

NORTON, Denis, 1986b Transport processes in hydrothermal systems (abst.): EOS, v. 67, p. 242.

NOSIK, L.P. and SEROVA, L.S., 1985, Isotopes in geochemical investigations (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 237-238. (In Russian; translation by Dorothy B. Vitaliano). Authors at IGEM, Acad. Sci. USSR, Moscow, USSR.

At the present time the isotopic composition of He, Ar, O, H, C, N and S in mineral inclusions has been studied; physical factors (diffusion, sorption and mixing) affects their fractionation, and also the chemistry of the mineralizing medium (pH, Eh, T, level of equilibrium reached in the system, etc.) affects H, O, C, S and N.

Physical factors may lead to directional fractionation of the isotopic composition of elements, as repeated processes of diffusion (Taylor, 1945; Nosik, 1980) and sorption (Nosik, 1980) of gases can cause essential changes in the isotopic composition of the diffusing and sorbed gases.

The chemistry of the mineralizing medium leads both to impoverishment (nonequilibrium oxidation) and to enrichment (nonequilibrium reduction and isotope exchange reactions) of more oxidized compounds in the light isotopes of S, C, O, N and H and for this reason it, unlike the physical factors, cannot lead to essential change in the isotopic composition.[sic] The isotopic effects arising in this case between the chemical elements of paragenetic minerals can be used to calculate the isotopic composition of the source of the material, level of equilibrium reached, T of formation of the minerals, pH and Eh of the medium, redox conditions of mineralizing medium, and extent of variation of the physiochemical parameters of the medium, during crystallization of the minerals.

The level of equilibrium reached in the system can be calculated... [Equation given in original]

The T of formation of paragenetic minerals is calculated from the measured isotopic effect at 100% equilibrium and constancy of the physicochemical parameters of the mineralizing medium, which is established from the isotopic composition of CO_2 carbon in the vacuoles.

Nonequilibrium formation of compounds with different state of oxidation (C, CO, CO_3^{2-}) makes it possible to judge the redox properties of the medium: $\Delta\delta^{13}C = \delta^{13}C(CO_2)-\delta^{13}C_c < 0$ characterizes an oxidizing environment, and $\Delta\delta^{13}C = \delta^{13}C(CO_2)-\delta^{13}C_c > 0$, reducing environment.

On the basis of the variation in isotopic composition of carbon of C, CO_2, CO_3^{2-} and their compounds in successive paragenetic minerals formed under nonequilibrium conditions, the extent of change in the redox properties of the mineralizing medium can be estimated.

The pH and Eh of the medium are calculated from the equilibrium of formation of paragenetic minerals according to the pH-Eh diagram with contours, isotopic composition, T and concentration of the chemical element (S, C) in the system. (From the authors' abstract)

NOSYREV, I.V. and ROBUL, V.M., 1985, Inclusions in accessory apatite (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 162 (in Russian; translation by Dorothy B. Vitaliano). Authors at Odessa State Univ., Odessa, USSR.

Melt inclusions, according to our own and published data, most frequently are observed in apatite and zircon, less often in monazite, orthite and some ore minerals. Apatite and zircon with melt inclusions have been established in intrusive, dike and effusive formations of different composition, and also in ultrametamorphic granitoids and other rocks. Tm of glass exceeds 1000°C. The SiO_2 content in the glass of the inclusions from various morphological types of apatite varies markedly. Melt inclusions in zircon are of similar character, although they are less often encountered. Gas-liquid and liquid inclusions are often encountered in apatite. Th in ultrametamorphic rocks ranges from 350°C to 200°C.

Available data on inclusions in apatite and other accessory minerals makes it possible to draw conclusions as to the role of the melt in the course of formation of ultrametamorphic granites, and as to the evolution of the composition of the magmatic melt during its crystallization. (From the authors' abstract)

NOVOGORODOVA, M.I. and BOYARSKAYA, R.V., 1985, Composition and structure of solid phases from gaseous inclusions in native metals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 38-39 (in Russian; translation by S. Jaireth). Authors at IGEM Acad. Sci. USSR, Moscow, USSR.

Electron microscopy in combination with microdiffraction and local energy dispersive analysis has been used to study solid phases of gaseous inclusions in native Au and Zn and in natural silicide of iron-zuccite [suessite, $(Fe, Ni)_3Si$?]. Mass-spectrometry showed that within gaseous phase in Au, CO_2 predominates (with small admixture of CH_4, N_2 and H_2); in native Zn, CO and N_2 (with traces of CO) predominate and in suessite, N_2 and CH_4 (with traces of CH_4, CO_2, CO, SO_2, Ar) predominate.

Structures of internal surfaces of inclusion cavities were also studied. These are dendritic in Au and suessite and corroded in Zn. Nature of surfaces indicates that gaseous phase is chemically reactive towards the host matrix. Solid phases, the products of such reactions, are represented in Au by dendrites and spheres of amalgam with a composition of Au_3Hg (average composition from 3 determinations in wt.%: Au 78.2 and Hg 21.22), in suessite of Fe_3Si composition solids are dendrities, spheres and rounded crystals of iron disilicide ($FeSi_2$) and native iron. In Zn they are crystals of zincite and spheres of secondary Zn.

In addition to these solids, cavity walls of the inclusions are covered by finely dispersed, powdery mineral mixtures of silicates and alumino-silicates with a sharp predominance of Si and traces of Al and Fe (native Au); and K, Fe, Al; K, Fe, Mg, Ca, Al[sic] in suessite. These mineral phases are characterized by weak binding with crystal surface of host matrix and are easily liberated from the inclusions on opening them. In an earlier classification of solid phases in G/L and gaseous inclusions proposed by us, finely dispersed silicates and alumino-silicates were named as protogenetic inclusions entrapped in solid state by gas bubbles. (From the authors' abstract)

NOVGORODOVA, M.I., NOSIK, L.P., KOVALENKER, V.A. and SHILIN, N.L., 1985, The role of gas-liquid inclusions during the study of gold deposition conditions in minerals, ores and rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 41-42 (in Russian; translation by I.V. Kulikov). Authors at IGEM AN SSSR, Moscow, USSR.

Study of inclusions in quartz and sulfide specimens from the ores of many shallow gold ore prospects in central Tien Shan, and in magmatic rocks of Kamchatka permit the following conclusions:

1. The tendency of increasing of CO_2 concentration from early to late generations of quartz, and the maximum concentration of CO_2, characteristic of fluid inclusions in gold-bearing quartz, testify that the ore stage mineral associations were formed under conditions of increasing CO_2 concentration. Since ore stage, and post-ore quartzes, containing carbonic acid, do not bear above normal contents of gold, one may believe that high concentrations of carbonic acid promoted the deposition of gold only in highly heterogeneous solutions during strong fluctuations in pressure, boiling and degassing.

The enrichment of carbonic acid with heavy carbon isotopes in gold-bearing quartz, from its early to late generation, and increasing content of the light isotope in quartz of the latest gold-free generation prove the degassing of the solution or reduction of carbonic acid. Still, increasing concentrations of carbonic acid in solutions by the end of the ore-forming process could be provided only with increasing income of carbonic acid.

2. Gold-bearing sulfides were formed against a background of increasing concentrations of carbonic acid in solutions during the mixing of oxidizing and reducing solutions: a direct correlation can be established between the gold content in sulfides and the extreme value of isotopic composition of CO_2 carbon from GLI in minerals.

3. Increasing content of gold in the rocks of Kamchatka is observed in biotite granites from gabbro-plagiogranite magmatic formations, in leucocratic granites from gabbro-granodioritic formations, in biotite-amphibole granodiorite porphyries from grandioritic porphyritic magmatic formations during decreasing state of oxidation of the melt against a background of decreasing carbonic acid in GLI in these rocks and of enrichment of that carbonic acid in light carbon isotopes. With it all the content of gold in rocks, which were formed during decreasing oxidation of the melt, exceeds its clark content several times; in minerals and ores from shallow gold deposits, which were formed during the change from oxidizing to reducing conditions, the gold concentrations increased three orders of magnitude. (From the authors' abstract)

NOVOTNÁ, M., 1985, Fluid inclusion study of minerals on Březové Hory deposit (Příbram ore district, Czechoslovakia): Senior thesis archives, Charles Univ., Prague, 70 pp. (in Czech).

Fluid inclusion study of vein minerals - sphalerite (II stage), siderite (I stage), quartz (I stage), dolomite, ankerite, and calcite - in the Březové Hory deposit of the Příbram ore district brought the first data on these well known Pb-Zn-Ag ore deposits. The minimum crystallization T of sphalerite determined by Th of P fluid inclusions are in interval 205-225°C, those of siderite from 200 to 255°C. The Th of S inclusions go down to a minimum of 110°C. The crystallization of vein minerals took place in medium saline brines (9.5-25 wt. % NaCl equiv.), mainly consisting of chlorides of sodium and calcium. (Author's abstract, translated by J. Ďurišová)

NOWAK, E.J., 1986, Preliminary results of brine migration studies in the Waste Isolation Pilot Plant (WIPP): U.S. Dept. Energy, SAND86-0720, 64 pp.

NUELLE, L.M. and SHELTON, K.L., 1986, Geologic and geochemical evidence of possible bedded barite deposits in Devonian rocks of the Valley and Ridge province, Appalachian Mountains: Econ. Geol., v. 81, p. 1408-1430. First author at Missouri Dept. Natural Resources, Div. Geol. & Land Survey, P.O. Box 250, Rolla, MO 65401.

The $\delta^{34}S$ values (28.0-47.4‰) and $\delta^{18}O$ values (19.3-30.4‰) show that barite nodules are considerably enriched in these constituents relative to coeval seawater. Systematic decreases of $\delta^{34}S$ values updip from zones of abundant nodules combined with a slight decrease of ^{34}S content downdip suggest two styles of deposition: deposition of smaller nodules updip because of increasing distances for the critical redox boundary or by remobilization during diagenesis, and deposition from a warm Ba-rich spring system subject to biogenic alteration.

Sulfur isotope values of vein- and vug-filling barite from shrinkage cracks in barite nodules are generally heavier than those of the host nodule. This fact coupled with elevated temperature (72°-142°C) fluid inclusions, some of which are organic-bearing, suggest that barite enriched in ^{34}S was remobilized during diagenesis.

We speculate that these sediment-hosted barite occurrences represent the margins of larger, yet undiscovered, bedded barite deposits. We feel that barium-bearing fluids were derived from submarine springs developed during the initial stages of the Acadian orogeny and deposited barite in minor submarine euxinic basins. (From the authors' abstract)

OBUT, S.T., ERTEKIN, T. and GEISBRECHT, R.A., 1986, A versatile phase equilibrium package for compositional simulation: Soc. Petrol. Engineers, Golden Gate Sec., Proc. 56h Ann. California Regional Meeting, v. 1, p. 399-416, paper SPE 15083.

OELKERS, E.H. and HELGESON, H.C., 1986, Are hydrothermal solutions really associated at supercritical pressures and temperatures? (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 709.

O'HARA, P.F. and HIGGINS, R.E., 1986, Geochemical evaluation of fossil hydrothermal systems in submarine volcanic terrain and the origin of mineralization (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 400.

OHMOTO, H., 1985, Applications of sulphur isotopes to genetic studies and exploration of massive sulphide deposits: Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 11-16. Author at Dept. Geosci., The Pennsylvnia State Univ., University Park, PA 16802, USA.

A review. (E.R.)

OLIVER, Jack, 1986, Fluid expelled tectonically from orogenic belts: Their role in hydrocarbon migration and other geologic phenomena: Geology, v. 14, p. 99-102. Author at Inst. for the Study of the Continents & Dept. Geol. Sci., Cornell Univ., Ithaca, NY 14853.

This paper presents and supports a speculative hypothesis, the essence of which follows. When continental margins in zones of convergence are buried beneath thrust sheets, fluids expelled from the margin sediments travel into the foreland basin and the continental interior. These tectonic fluids have key roles in phenomena such as faulting, magma generation, migration of hydrocarbons, transport of minerals, metamorphism, and paleomagnetism. The thrust sheet, crudely speaking, acts like a great squeegee, driving fluids ahead of it and producing widespread geologic consequences. (Author's abstract)

OLIVER, N.H.S., WALL, V.J. and PEARSON, P.J., 1986, The Mary Kathleen uranium-REE deposit: A product of regional metamorphism (abst.): Proc. Eighth Australian Geol. Conv., Geol. Soc. Australia, Earth Resources in Time and Space, Feb. 1986, Abstracts, v. 15, p. 149-150. First author at Dept. Earth Sci., Monash Univ., Melbourne,

The Mary Kathleen uranium and rare-earth ore body is hosted by calcic exoskarn in the Mary Kathleen Syncline. The original ore body held about 10,000 tonnes of U_3O_8 at a grade of 1.2 kg/tonne, as well as several percent REE, up to 7.6%. Debate in the literature has centered on timing of the ore with respect to granite intrusion and skarn formation. [We] favor a model of syn- to late-metamorphic ore deposition, some 200 m.y. after granite intrusion, in contrast to syn- to post-tectonic granite intrusion, skarn formation and related U mineralization. In this paper, we discuss skarn formation and later modifications, including U mineralization.

The age relations, mineral assemblages and structural association of the Mary Kathleen ore body are consistent with its development during early retrograde regional metamorphism. Fluid inclusion Th of 400-500°C in pyroxene, amphibole, apatite and garnet gangue minerals are, as noted in 1984 by Abeysinghe and others, concordant with this model. However, the latter authors concluded that mineralization formed during the retrograde stage of primary skarn formation. The inclusion densities reported are more compatible with fluid trapping under high P (3-4 kb, similar to those operating during the regional metamorphism), although some relatively low density inclusions were also recorded. Moreover it seems unlikely that fluid inclusions formed during primary skarn formation, at shallow depth, would survive the regional metamorphism. We would thus suggest that fluids trapped in inclusions were of regional metamorphic origin. Our studies have demonstrated that highly saline fluids, derived from evaporite dissolution, were widespread in the Mary Kathleen area during regional metamorphism, and indeed very high salinities are evident in fluid inclusions in regional metamorphic rocks throughout the belt. The hypersaline metamorphic fluids involved in the Mary Kathleen system could have owed their inferred high ratio of $SO_2^{2-} + SO_3/H_2S$ to evaporite dissolution and/or interaction with sulphate-bearing scapolite. Uraninite and sulphide precipitation resulted from partial reduction by Fe-bearing skarn minerals and probably increases in pH due to fluid-skarn interaction. (From the authors' abstract)

O'NEIL, J.R., JOHNSON, C.M., WHITE, L.D. and ROEDDER, Edwin, 1986, The origin of fluids in the salt beds of the Delaware Basin, New Mexico and Texas: Applied Geochem., v. 1, p. 265-271. First author at U.S. Geol. Survey (MS 937), Menlo Park, CA 94025, USA.

Oxygen and hydrogen isotope analyses have been made of (1) brines from several wells in the salt deposits of the Delaware Basin, (2) inclusion fluids in halite crystals from the ERDA No. 9 site, and (3) local ground waters of meteoric origin. The isotopic compositions indicate that the brines are genetically related and that they probably originated from the evaporation of paleo-ocean waters. Although highly variable in solute contents, the brines have rather uniform isotopic compositions. The stable isotope compositions of brine from the ERDA No. 6 site (826.3 m depth) and fluid inclusions from the ERDA No. 9 site are variable but remarkably regular and show that (1) mixing with old or modern meteoric waters has occurred, the extent of mixing apparently decreasing with depth, and (2) water in the ERDA No. 6 brine may have originated from the dehydration of gypsum. Alternatively, the data may reflect simple evaporation of meteoric water on a previously dry marine flat. Stable isotope compositions of all the waters analyzed indicate that there has been fairly extensive mixing with ground water throughout the area, but that no significant circulation has occurred. These conclusions bear importantly on the suitability of these salt beds and others as repositories for nuclear waste. (Authors' abstract)

O'REILLY, S.Y. and GRIFFIN, W.L., 1985, The nature and role of fluids in the upper mantle: Evidence in xenoliths from Victoria, Australia (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 58-59. First author at Sch. Earth Sci., Macquarie Univ., North Ryde, N.S.W., 2113, Australia.

The presence or absence of a free fluid phase in the upper mantle has important implications for the mechanisms and effects of mantle metasomatism and anatexis, both in the mantle and in the lower crust. The nature of this fluid also has fundamental implications for the large-scale structure and dynamics of the Earth's mantle, its convection style, the consequences of mantle degassing, and whether or not there is a deep, primitive reservoir. Recent isotopic studies of rare gases in basalts and xenoliths provide important constraints on mantle evolution and convection models. Petrographic and geochemical data on xenoliths suggest that these gases are dominantly contained in fluid inclusions. These fluid inclusions are currently the only source of direct samples of the free fluid phases in the mantle.

In mantle-derived xenoliths from southwestern Victoria, Australia, the trapped high-pressure fluids comprise up to 3 vol. % of the rock. The fluid-filled cavities range in size from 1 µm to 1.5 cm across. Microthermometry and Raman laser microprobe analyses show that the fluids are dominantly CO_2. Mass-spectrometric analyses of gases released by crushing show the presence of He, N_2, Ar, H_2S, CO_2 and SO_2 in small quantities. Isotopic analyses of fused samples show a He^3/He^4 ratio, relative to atmospheric, that is comparable with that for MORB, but less than that for hot-spot activity such as occurs in Iceland and the Hawaiian Islands. The moderately high He^3/He^4 ratio suggests that degassing of a deep, primitive reservoir (the lower mantle?) is continually taking place. This also implies convective isolation of this deep reservoir from the upper mantle during the evolution of the upper mantle through partial melting events.

Petrographic, SEM and microprobe studies indicate that the original trapped fluids have reacted with the cavity walls (in clinopyroxene grains) to form secondary amphiboles and carbonates. The trapped CO_2 therefore does not represent the composition of the original fluid, but only the residual portion after (a) metasomatic alteration of the mantle wall-rock to form amphibole (± mica ± apatite ± carbonate) and, (b) reaction with fluid cavity walls. The inferred original fluid was a CO_2-H_2O mixture, with significant content of Cl and S species.

In addition, spherical and cylindrical inclusions of sulphides (pyrrhotite, chalcopyrite and pyrite) are common in clinopyroxenes in xenoliths which represent frozen basaltic liquids and cumulates crystallized within the mantle. The association of these sulphides with CO_2-rich fluid inclusions suggests that three immiscible fluids (sulphide, CO_2/H_2O and silicate magma) may coexist within the upper mantle. (Authors' abstract)

ORKAN, N.I., VOIGHT, Barry and YOUNG, K.D., 1986, Regional joint evolution and paleotemperature estimates from fluid inclusion study in the Valley and Ridge province of Pennsylvania in relation to the Alleghany orogeny (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 712. Authors at Dept. Geosci., Pennsylvania State Univ., University Park, PA 16802.

Systematic transverse (cross-stike) joint sets in the Pennsylvania Valley and Ridge display distinct incremental changes in orientations. Some of these joint sets have undergone rotation with respect to north as a consequence of progressive deformation. Consideration of predeformation orientations using palinspastic base reconstructions enhanced the interpretation of joint trajectories. The palinspastic perspective, essential to classification and to interpretation of fractures in the Valley and Ridge Province, requires independent reconstructions for the stiff Cambro-Ordovician sequence, and the overlying, LPS strained, cover layer. Incremental propagation of the transverse joints may be related to incremental imbrication of the stiff-layer duplex. A "working classification" is proposed for the interpretation of local and regional transverse joint sets in the Valley and Ridge and adjacent plateau. This classification recognizes that at any locality, joints of a particular orientation may include fractures produced in several stages by progressive deformation, whereas at different spatial locations, elements of different structural stages may be contemporaneous.

Paleotemperature and fluid pressure estimates from CH_4-rich and H_2O-rich inclusion pairs in individual samples suggest average geothermal gradients <35°C. Regional paleotemperature and overburden estimates were determined, and at some locations suggest thick (>5 km) tectonically replaced overburden, e.g., the Anthracite nappe west of the Susquehanna River. High temperatures in veins in Pennsylvanian rocks may reflect flow of hot fluids from the base of superjacent thrust sheets. (Authors' abstract)

ORKUSTOFNUN, NATIONAL ENERGY AUTHORITY, ICELAND, 1986, Extended Abstracts, 5th Int'l. Symp. on Water-Rock Interaction, Reykjavik, Iceland, Aug. 8-17, 1986.

Contains many papers of interest to fluid inclusion research; only the most pertinent are abstracted in this volume. (E.R.)

OSICHKINA, R.G. and TILLYAKHODZHAYEV, Kh.N., 1986, Experimental determination of intra-phase distribution of copper, manganese and iron (II) in aqueous salt systems of chlorides of sodium, potassium, magnesium: Geokhimiya, 1986, no. 4, p. 522-528 (in Russian; English abstract).

OSTAPENKO, N.S., 1985, The changing of fluids with time during formation of mineral associations at a gold-ore deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 56-57 (in Russian; translation by I.V. Kulikov). Author at Amur KNII DVNC AN SSSR, USSR.

The studied gold-ore deposit [locality not given] is of the arsenopyrite, low-sulfide, gold-quartz type. The minerals formed in the sequence fine-grained arsenopyrite, quartz and carbonates - pyrite (pyrrhotite), sphalerite, galenite, native gold - coarse-gained quartz - ankerite, pyrite (marcasite).

Analyses of the ore-forming fluids [methods not stated] showed that they contained Na, K, Ca, Mg, NH_4, F, Cl, Br, I, HCO_3, SO_4 and NO_3. Gases included CO_2, H_2S, CH_4, CO, N_2. H_2 and Li were not found. Significant changes in composition were found, especially at the stage of late ankerite deposition, during a sharp drop in T. The changes in mineralogy, and of composition and concentrations of the fluids, suggests changes in pH and Eh of the solutions. After completing of sulfides and gold deposition the contents of S and I decreased sharply, or they are not present at all. The concentration of Cl increases in time. During ankerite deposition the solutions become sharply oxidized. (Abbreviated by E.R. from the author's abstract)

OSTERMANN, R.D., PARANJPE, S.G., GODBOLE, S.P. and KAMATH, V.A., 1986, The effect of dissolved gas on geothermal brine viscosity: Soc. Petrol. Engineers, Golden Gate Sec., Proc. 56th Ann. California Regional Meeting, v. 1, p. 381-390, paper SPE 15081.

OTTAWAY, T.L., WICKS, F.J., BRYNDZIA, L.T. and SPOONER, E.T.C., 1986, Characteristics and origin of the Muzo emerald deposit, Colombia (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 193. First author at Dept. Mineral. & Geol., Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S 2C6, Canada.

Emeralds occur in a stockwork of albite + calcite-dolomite ± barite veins cross-cutting Cretaceous shales and limestones. Fluorite and parisite occur in association with emerald mineralization and pyrite and quartz are locally abundant. There is no direct evidence of igneous activity either at Muzo or at other localities in the emerald belt of the Cordillera Oriental, and thermal metamorphism has not been seen in the region of the vein systems. Fluid inclusions in Muzo emeralds contain -40 wt % NaCl, ±KCl, and homogenize by NaCl dissolution at 324 ± 10°C (1σ; $n = 154$). Emeralds and intergrowths of albite/emerald or shale/emerald both known as trapiche are found in the vicinity of bleached zones locally called the Cenicero. The Cenicero is an irregular, extensively brecciated formation containing native sulphur. It is interpreted to be the remains of an evaporite which conducted hydrothermal fluids into the Muzo deposit through the development of solution porosity, and may have been the source, or partial source, of the hypersaline fluids found in the fluid inclusions in emeralds, quartz and parisite. It is suggested that evaporite dissolution either regionally and/or locally mobilized other elements such as Be^{2+}, Mg^{2+}, Ca^{2+}, Ba^{2+}, F^- and LREE. Evaporitic sulphates were reduced to sulphur. Hydrothermal fluids exceeding 300°C were not restricted to fractures but permeated the deposit, carbonizing palynomorphs and "cracking" the organic matter, to produce a well-ordered pyrobitumen, impsonite. The resultant N_2 and CH_4 are detected in the fluid inclusions in the emerald, and N_2 is detected in the fluid inclusions in the parisite. Pyrobitumen reflectance measurements indicate diagenetic/metamorphic T levels in the range of metagenesis to middle greenschist facies. A range in density of CO_2 in emerald fluid inclusions suggests a significant pressure interval over which crystallization occurred. This was produced by cycles of increased P up to lithostatic values followed by partial release through fracture propagation. (From the authors' abstract)

OUSTRIÈRE, P., HUBERT, P. and TOURAY, J.C., 1986, Composition and evolution of fluids associated with gold mineralization at the Cros-Gallet deposit (Haute-Vienne, France) (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 141 (in French). First author at BRGM-DAM/GMX, BP 6009, 45060 Orléans Cedex, France.

The Au deposit of Cros-Gallet belongs to the St Yrieix Au district (Haute-Vienne). The mineralized zone, situated on a NE-SW structure, consists of a brecciated quartzitic lens which was formed by silification of a mylonized gneiss. Mineralization with arsenopyrite, pyrite, sphalerite, Ag-bearing Au, Pb-sulfosalts, Ag and galena took place after brecciation of the quartzitic lens. Mineralization occurs in micro-geodes with clear quartz crystals, within the brecciated or deformed milky quartz. Two types of fluid inclusions were studied by microthermometry and Raman-spectrometry: type A, early inclusions of $H_2O + CO_2 + (CH_4)$; type B, late aqueous inclusions. Type A inclusions are characterized by high and rather constant Th (300-350°C) and by a large range in compositions. A model for the evolution of fluids is proposed, predicting that the Au-bearing paragenesis was deposited during a P drop which followed the mixing at high T and P (<2kb) of a slightly saline (~6% NaCl) aqueous fluid and a CO_2-rich fluid. In a subsequent stage, dilution produced low-T fluids (<200°C) of low salinity (<2% NaCl). (Authors' abstract, translated by R. Kreulen)

OVSIENKO, D.E., FEDOROV, O.P., KIRIYEVSKY, B.A., GERSHTEIN, G.I. and CHEMERINSKY, G.P., 1986, The effect of solid and liquid inclusions on morphology of crystallization front: Cryst. Res. Technol., v. 21, p. 721-727. First author at Inst. Metal Physics, Ukrainian Acad. Sci., Kiev, USSR.

The interaction between crystallization front and solid particles was studied for substances characterized by the normal growth mechanism (continuous growth). It has been measured the critical velocity below which the particle of radius R is repulsed by moving interface and above it is captured. It has been shown that critical velocity is proportional to $R^{-(1.4-1.8)}$ that satisfactorily agrees with Chernov-Temkin's theory. Data have been received about change of interface morphology at capture of solid particles for growth from pure and impurity-containing melt. The dendrites have been found to split at interaction with particles and concentration inhomogeneities. Taking for example Al-Cu alloy, possibility has been shown to disperse the dendritic structure by formation concentration inhomogeneities in the melt. (Authors' abstract)

OZIMA, M. and ZASHU, S., 1986, Solar type He and Ne in diamonds (abst.): Lunar & Planetary Sci. XVIII, p. 752-753.

PAGEL, M., DUBESSY, J. and HICKEL, B., 1986, Fluid inclusions containing molecular hydrogen from the Oklo natural reactor (Gabon): Evidence for radiolysis of water in the presence of organic matter (abst.): Program, 11th Ann. Meeting, Earth Sciences, Clermont-Ferrand, 25-27 March, 1986, p. 143 (in French). First author at CREGU et GS-CNRS-CREGU, BP 23, 54501 Vandoeuvre Cedex, France.

Analysis by Raman spectrometry of fluid inclusions in zones 7-8-9 of the Oklo natural reactor (Gabon) shows evidence for trapping of heterogeneous H_2O-H_2-CH_4 fluids. The composition of the gas phase of the inclusions at room T is 99.5 mole% H_2 and 0.5 mole% CH_4. Molecular H_2 has also been found in fluid inclusions in a quartz vein several tens of meters away from the zone where nuclear reactions took place.

Thermal maturation of organic matter produces gases with CH_4/H_2 ratios well above 1. Molecular H_2 is a minor species in normal geological fluids. The association of H_2O-H_2-CH_4 inclusions with zones where fission reactions took place (high radiation fluxes), suggests that H formed by radiolysis of water in the presence of organic matter. According to the available experimental data, oxidation of the organic matter is compatible with such processes.

A numerical model was developed by which the amount of molecular H_2 can be calculated as a function of time and energy produced by the fission reactions. The calculations show that only a few tens of years are needed to introduce 1 mole% H_2 into the pore fluids of a closed system. Also, it is shown that the remaining water becomes appreciably enriched in deuterium.

(Authors' abstract, translated by R. Kreulen)

PAGEL, Maurice and PIRONON, Jacques, 1986, A genetic model for uranium deposits in continental black shales: Sci. Géol., Bull., v. 39, pt. 3, p. 277-292 (in French; English abstract). First author at Centre de Recherches sur la Géol. de l'Uranium, PB 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

A model is proposed for the genesis of U deposits located in continental black shales below an oxidized cover on the base of geochemical and mineralogical data. Elements such as Cu, V, Se, Ag, Co, Ni, Mo and Zr were [particularly] considered. In the St Hippolyte (Haut-Rhin, France) and Müllenbach (Bade-Wurttemberg, Germany) U deposits mineralogical and geochemical vertical zonations are evidenced. These zonations are interpreted as oxido-reduction profile at pH close to neutrality (St Hippolyte) or more basic (Müllenbach). Clay minerals, illite crystallinity, chemical data on organic matter and fluid inclusions are in agreement for T >100°C. The proposed model implies circulation of oxidized diagenetic solutions issued from the overlying sediments into black shale. At Müllenbach, pitchblende was deposited during the Late Permian, with leaching of volcanic rocks which induces zirconium mobility. The origin of other elements enriched in the mineralized areas are discussed and several hypotheses are still considered. (Authors' abstract)

PAGEL, M., WALGENWITZ, F. and DUBESSY, J., 1986, Fluid inclusions in oil and gas-bearing sedimentary formations, in Thermal modeling in sedimentary basins, J. Burrus, ed.: Editions Technip., p. 565-583. First author at Centre de Recherche sur la Geol. de l'Uranium & Groupement Sci., Centre Nat'l. de la Recherche Sci.-CREGU, Vandoeuvre-les-Nancy, France.

A review of the pertinent chemical systems and the applications of fluid inclusions in petroleum geology. (E.R.)

PAKHOMOVA, V.A. and TISHKIN, B.M., 1985, Thermobarometric aspects of ore formation from colloidal solutions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 32-33 (in Russian; translation by S. Jaireth). Authors at DVGI, Far-East Geol. Inst., Far-East Sci. Center, Acad. Sci. USSR, Vladivostok, USSR.

Study of mineral composition of ores reveals presence of following mineral associations: tourmaline-magnetite, predominantly quartz, bismuthinite-stibnite, pyrite-arsenopyrite, polysulphide and quartz-stibnite (Gurov., 1969). Quartz and sulphides are often recrystallized, indicated by widespread development of crystalloblastic structures. Study of fluid inclusions in quartz reveals presence of four types of inclusions:

GLI (G = 25 to 50%) are the dominant type of inclusions, observed in quartz of all associations. Th L-V(L) = 231-358°C, Th L-V(L) for some inclusions in recrystallized quartz varies between 400 and 414°C.

GLI are accompanied by CO_2-bearing bi- and polyphase inclusions of varying degree of filling. Based on aqueous and CO_2 inclusions (result of homogeneous entrapment), P during formation of quartz of bismuthinite-chalcopyrite association is estimated to lie between 45 and 50 MPa.

The third type of inclusions are observed in quartz of quartz-sulphide, bismuthinite-chalcopyrite and predominantly quartz associations. These metacolloidal inclusions are in general oval to spherical in shape with sharp relief, curved cavity boundaries and a gas bubble. Often colloidal inclusions are accompanied by fine globular inclusions of predominantly aqueous composition.

Quartz of polysulphide and predominantly quartz association are marked by primary GLI (Fourth type) with halite. Halite starts melting at 98°C, bubble disappears at 196°C and final Th is 287°C; salinity based on data of Keevil (1942) varies between 37 and 38 wt.%, P of entrapment <5 MPa.

Widespread development of metacolloidal inclusions in quartz of different associations unequivocally points toward participation of colloidal solutions in the ore formation process. Significant inversions in Th of inclusions in quartz of same mineral association is related to the processes of recrystallization of ores. Presence of CO_2-bearing inclusions in quartz of different associations indicates high CO_2 concentration in the ore-forming fluids. (From the authors' abstract)

PALACIOS, C.M., HEIN, U.F. and DULSKI, P., 1986, Behavior of rare earth elements during hydrothermal alteration at the Buena Esperanza copper-silver deposit, northern Chile: Earth & Planet. Sci. Letters, v. 80, p. 208-216.

PALAIS, J.M., SIGURDSSON, Haraldur and BROWNING, David, 1986, Volatile emissions from major historic and prehistoric volcanic eruptions: A petrologic estimate (abst.): EOS, v. 67, p. 397. Authors at Graduate Sch. of Oceanography, Univ. Rhode Island, Kingston, RI 02881.

We report results of an ongoing study to estimate the minimum masses of sulfur and chlorine released to the atmosphere from major historic and prehistoric volcanic eruptions.

We have analyzed the major and trace element (S, Cl, F) composition of glass inclusions in mafic and felsic phenocrysts and matrix glass adhering to the crystals, in order to estimate the content of volatiles degassed during eruption. Our preliminary results for these samples confirm the relationships discussed by Devine et al. (1984) regarding the variations of S and Cl with silica and iron content of the magma. Glass inclusions in mafic phenocrysts (e.g., pyroxene) tend to have a higher concentration of sulfur than the corresponding felsic phenocrysts (e.g., plagioclase) from the same samples. (From the authors' abstract)

PAL'MOVA, L.G., 1985, Physical-chemical characteristic of the two levels of precious metal concentration in an ore province (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 53-54 (in Russian; translation by I.V. Kulikov). Author at MGRI, Moscow, USSR.

In an ore province in the area of black-schist development systems of various types of quartz veins were widely formed.

Above background but subeconomic, and partly poor, ores of Au and Ag were formed during the process of metamorphism; the first level of their concentration is characterized by the parameters of that metamorphic process: 100-380°C and 90-160 MPa. During the reworking of the primary inclusions in the quartz assemblages significant parting of fluid components (H_2O, CO_2) occurred, which contributed to redistribution and to concentration of ore substance.

Economic concentrations of Au and Ag are connected with the deposition from hydrothermal solutions. Gold-bearing solutions in the beginning of productive process were of low density, mainly CO_2; at the final stages they were high density alkaline-chloride. Ore deposition occurred during sharp drops in P (60-180 MPa) and relatively small changes in T (200-350°C).

Ag-bearing solutions were of a different nature. They were significantly aqueous with low concentrations of CO_2 and of salts, but with relatively high content of CH_4. Economic Ag ores were formed at lower T (200-300°C) and smaller drops in pressure (40-80 MPa).

Although concentrations in the first stage of noble metals assemblage were connected with the quantity of ore substances in primary rocks and with the grade of metamorphism, the concentrations of the second level are structurally controlled. For the studied province the superpositioning of the two processes is characteristic of the deposits, but the significance of each one in the balance of the economic ores could be different. (From the author's abstract)

PALMOVA, L.G., BITSOEV, K.B. and PRUSAKOV, A.M., 1985, Use of thermobarogeochemical data for evaluating ore-bearing capacity of vein-quartz systems (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 33-34 (in Russian; translation by S. Jaireth). Authors at MGRI, Moscow Inst. Geol. & Explor., Moscow, USSR.

Area is noted for polystadial gold-quartz and silver-polymetallic deposits. Ore bodies are represented by quartz veins, lenses and stockworks. Apart from mineralized quartz veins of various stages, there are large members of monomineralic quartz veins. Thermobarogeochemical methods (optical microscopy, homogenization, decrepitation, composition of gaseous and aqueous phases and concentration of ionic gold in the solutions) have been used to distinguish the two sets of quartz veins.

As compared to the gold-bearing veins, vein-quartz systems of segment one have been formed in a relatively stable tectonic set up. Layered veins have been weakly affected by gold-bearing solutions. They have higher carbonate concentration in solutions, thereby ruling out possibility of higher gold concentration. Parts of the vein system have been reworked by low T, CO_2-poor solutions characteristic of silver-forming stages.

Vein quartz systems of segment two show effects of high T, predominantly gaseous (CO_2) fluids. Similar solutions within ore deposits have as yet not been recorded. Though gold deposition in this segment is indicated by higher concentration of ionic gold in solutions of inclusions in the mineralized veins, gold mineralization can be expected only in areas with different physico-chemical parameters. Silver mineralization in this segment is absent.

Ore-bearing capacity of vein-quartz systems can be evaluated by using CO_2/H_2O ratio in solutions. For quartz of productive gold and silver veins, ratio averages to 14 and 3 respectively. Hence, vein-quartz systems of segment 1 (CO_2/H_2O = 5) have low potential while segment 2 veins (CO_2/H_2O = 68) hold no potential for Au mineralization. (From the authors' abstract)

PANINA, L.I. and MOTORINA, I.V., 1985, On the connection of the alkaline and acid magmatism (examples of intrusions of the Northern Pribaykal'ye): Geologiya i Geofizika, no. 10, p. 40-45 (in Russian).

Cited in Naumov, 1986 (this volume).

PANOPOULOS, D.K., KANEKO, Hiroyuki and SPIRO, Michael, 1986, Transference numbers of sodium chloride in concentrated aqueous solutions and chloride conductances in several concentrated electrolyte solutions: J. Solution Chem., v. 15, no. 3, p. 243-252.

PANOV, B.S. and ZATSIKHA, B.V., 1986, Formation conditions of fluorite in the southern part of the Donets Basin: Izvestiya Vyssh. Uchebn. Zavedeniy-Geolgiya i Razvedka, no. 5, p. 66-72 (in Russian). First author at Donetsk Polytech. Inst., Ukrainian SSR.

Among the more than 50 occurrences of fluorite mineralization in the S. part of the Donets Basin in the junction of the folded area with the Priazov'ye crystalline massif, the largest is the deposit Pokrovo-Kireevskoe, the quarry Dal'niy. It occurs in the Tournaisian limestones and Devonian arkosic sandstones, and belongs to the stratiform type. Fluorite is associated with calcite and quartz in veins and veinlets and it occurs as fluorite-quartz metasomatite replacing limestones with CaF_2 content up to 26 wt.%. Sometimes carbonate-fluorite metasomatites (up to 38 wt.% CaF_2) also occur.

External zone of the metasomatite bears gray fluorite with Th of fluid inclusions 170-150°C. Inner zones of metasomatite with colorless and violet fluorite yielded Th 145-141°C, with the composition of gas phase of inclusions (by mass spectrometry) as follows (in %): CO_2 81.09, N_2 9.32, C_2H_6 1.47, H_2 2.19, CH_4 5.91. Innermost zone of the cubic fluorite crystals typically has Th 130-120°C. The parent solutions were almost neutral (pH 6.6-8.2) with low total salt concentration (5.2-4.3 wt.%); pressure of the mineral-forming process was (400 to 136) x 10^5 Pa. In sequence of formation of minerals, water leachates yielded the following salt compositions (in wt.% of the total cations and anions contents): early fluorite (Th 170°C) - Na 13.6, K 73.9, Ca 9.1, Mg 3.4, Cl 22.7, SO_4 67.3, HCO_3 nil, BO_3 4.5, F 5.5; main fluorite (Th 170-150 and 145-141°C): Na 45.5, K 54.5, Mg and Ca nil, Cl 100.0; calcite (Th 120-100°C): Na 67.3, K 10.6, Ca 22.1, Mg nil, Cl 30.7, SO_4 15.3, HCO_3 52.1, F 1.0; quartz (Th 130°C): Na 83.0, K 5.9, Ca 11.1, Mg nil, Cl 67.3, SO_4 5.3, HCO_3 21.3, BO_3 0.8, F 5.3. Thus, early solutions were of the SO_4>Cl, K>>Na type and composition systematically changed to the type Cl>HCO_3, Na>>K. The $\delta^{18}O$ of water from the fluid inclusion solutions ranged from -4.8 to +10.0%. indicating the mixing of water of the various sources. (Abstract by A.K.)

PARRISH, J.T., SU, Zhongrui, ZHANG, Yirong and HU, Wenhai, 1986, Source rock potential of Nanpanjiang basin, south China - Preliminary report (abst.): AAPG Bull., v. 70, p. 629. First author at U.S. Geol. Survey, Denver, CO.

The Nanpanjiang basin of south China occupies 100,000 km^2 in southern Guizhou and eastern Yunnan Provinces and northwestern Guangxi autonomous region. The basin contains primarily Paleozoic and Triassic rocks. As yet, no producible hydrocarbons have been found in Nanpanjiang basin, although oil seeps exist in margins of the basin and producing wells are present in adjacent basins. We analyzed Ordovician through Permian carbonate rocks and Cambrian through Triassic clastic rocks from within the margins of the Nanpanjiang basin for total organic carbon (TOC), vitrinite reflectance, and extractable hydrocarbon (HC) content and composition. TOC values ranged from 0.02 to 3.91%, total HC (S_1 and S_2) ranged from 0.004 to 0.11 mg/g (S_1:0.003-0.048; S_2:<0.003-0.07), and vitrinite reflectance values were mostly above 1.0%. Permian carbonates throughout the basin contain solid bitumen in cavities and fractures; the one available sample of this solid bitumen contained no chloroform-soluble bitumen.

Previous studies by several groups of scientists in this region have found very low TOC values and evidence of overmaturity. Our studies found higher TOC values, but otherwise confirm the findings of previous workers. Our preliminary conclusion is that hydrocarbons have been generated but not preserved because the basin is now thermally overmature. This conclusion is supported by fluid inclusion studies and by the conodont alteration index, which ranges from 3 to 5, both of which indicate high temperatures. Generated liquid hydrocarbons may be represented by the solid bitumen in the Permian carbonates; the presence of gas is not ruled out by the geochemical evidence. (Authors' abstract)

PARRY, W.T., 1986, Estimation of $X(CO_2)$, P, and fluid inclusion volume from fluid inclusion temperature measurements in the system $NaCl-CO_2-H_2O$: Econ. Geol., v. 81, p. 1009-1013. Author at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

A procedure is outlined for estimating $X(CO_2)$ of fluid inclusions in the system H_2O-CO_2-NaCl using thermometric data rather than physical volume measurements; it is said to be more accurate. (E.R.)

PARRY, W.T. and BRUHN, R.L., 1986, Pore fluid and seismogenic characteristics of fault rock at depth on the Wasatch fault, Utah: J. Geophys. Res., v. 91, no. B1, p. 730-744. Authors at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT.

Fluid inclusions and structural fabric in fault rock in the exhumed footwall of the Wasatch fault allow measurement of fluid pressure, temperature, and composition and estimation of rheological characteristics of fault behavior. Hydrothermally altered and deformed Oligocene quartz monzonite of the Little Cottonwood stock forms a partially preserved footwall carapace at the southern end of the Salt Lake segment of the Wasatch normal fault zone. Cataclasite and phyllonite contain two syndeformational alteration mineral assemblages that formed during progressive faulting and displacement of the footwall. An early epidote-chlorite-sericite-magnetite alteration assemblage developed in phyllonite and cataclasite, and a later laumontite-prehnite-hematite alteration assemblage developed during cataclasis. Fluid inclusions associated with the formation of alteration minerals are preserved in healed fractures in quartz grains. Fluid inclusions that record the transition temperature from quasi-plastic flow to frictional deformation are associated with hydrothermal alteration to chlorite, epidote, and sericite and were trapped at minimum temperatures of 223°C-353°C and minimum fluid pressures of 1150-2800 bars. The fluids average 13 mol% CO_2 and 8.2 wt % NaCl. A radiometric age of hydrothermal sericite suggests that the age of the alteration is 17.6 ± 0.7 m.y. If maximum fluid pressure is near lithostatic, the minimum depth of formation of the alteration was 11 km at 337°C consistent with a thermal gradient of 30°C/km. The ratio of pore fluid pressure to lithostatic pressure varied from 0.52 to nearly 1.0 and indicates that effective normal stress on the fault at these depths may have approached zero. Structural fabrics and fluid inclusion characteristics are used to estimate seismogenic characteristics of the fault. Cleavage lineation and S-C bands in the phyllonite indicate that deformation at temperatures above 350°C and depths greater than 11 km was dominated by a seismic creep. Unstable fracture propagation in cataclasite developed during seismic slip at shallower levels. The downdip, seismogenic length of the Salt Lake segment is estimated at 16 km using a fault zone dip of 45° and a minimum depth of 11 km for the quasi-plastic/frictional transition. The segment strike length is 35 km, and the seismogenic area is about 600 km^2, compatible with generation of $M = 7.0$ earthquakes. (Authors' abstract)

PARSONS, Ian and BECKER, S.M., 1986, High-temperature fluid-rock interactions in a layered syenite pluton: Nature, v. 321, p. 764-766. First author at Dept. Geol. & Mineral., Univ. Aberdeen, Aberdeen AB9 1AS, UK.

Variation in mineral composition with stratigraphic height in layered igneous intrusions is generally taken to indicate progressive fractional crystallization, and, following pioneering work on the Skaergaard complex, petrologists have used this variation in modelling the evolution of magma bodies. In cooling plutons, however, major chemical changes may occur in circulating deuteric fluids. In the Klokken (South Greenland) layered syenite we have discovered that mineral compositions vary both along and normal to the strike of individual layers, and we argue that major chemical changes have occurred in a circulating aqueous fluid constrained to move along relatively permeable high-temperature aquifers in the layered series. (Authors' abstract)

PASTERIS, J.D., KUEHN, C.A. and BODNAR, R.J., 1986, Applications of the laser Raman microprobe RAMANOR U-1000 to hydrothermal ore deposits: Carlin as an example: Econ. Geol., v. 81, p. 915-930. First author at Dept. Earth & Planet. Sci. & McDonnell Center for Space Sci., Washington Univ., Box 1169, St. Louis, MO 63130.

The laser Raman microprobe has been used effectively in the identification of polyatomic gases, complex ions, and daughter crystals in fluid inclusions in a variety of host rocks (e.g., Dhamelincourt et al., 1979a; Rosasco and Roedder, 1979). This is a generally nondestructive, in situ, semiquantitative analytical technique in which a monochromatic laser beam is focused into a sample. The spectrum resulting from the inelastically scattered radiation indicates the chemical speciations of the irradiated sample. Although laser Raman microprobe analysis is not very effective for brines composed of simple salts, the nonelectrolyte components of hydrothermal fluid inclusions can be readily analyzed. Raman spectroscopy also provides important information, on a microscale, for solid phases in the assemblage. Fluid inclusions in quartz and calcite from several types of samples from the disseminated gold deposit at Carlin, Nevada, were studied petrographically and analyzed by microthermometry and Raman spectroscopy. The laser Raman microprobe was used to scan for CO_2, CO, N_2, H_2S and $CH_4 \pm H_2O$. The semiquantitative microprobe analyses confirmed the presence of three-phase inclusions containing water and different amounts of CO_2, one-phase inclusions of high-density CH_4-dominated fluid, and very weak aqueous brines. Very minor H_2S was detected in a CO_2-H_2O inclusion and small amounts of CO_2 were detected in some of the CH_4-dominated inclusions. These gases may have affected ore deposition. In any event, their identification is necessary for correct estimations of pressure to be derived from homogenization temperatures of the fluid inclusions. The laser Raman microprobe provides more than compositional data. For instance, the exact spectral position and shape of the CH_4 peak indicate the internal pressure, even in inclusions too small (<3 µm) to be analyzed by microthermometry. The laser Raman microprobe was also used to help characterize the structure of the carbonaceous material in the jasperiod host rock at Carlin (disordered graphite, in part) and to distinguish between the TiO_2 molymorphs anatase and brookite (both present) in hydrothermal quartz deposits at Magnet Cove, Arkansas. The ability of the laser Raman microprobe to provide pinpoint analyses has many advantages over bulk extraction methods, which mix the volatiles from separate generations of fluids and may also produce chemical artifacts. (Authors' abstract)

PATERSON, C.J. and NORBY, J.W., 1986, A gold deposit associated with amphibolite and graphitic metasediments, Tinton, Black Hills: Comparison with Owl Creek and Hoyle Pond deposits, Ontario (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 715. First author at Dept. Geol. & Geol. Engrg., South Dakota Sch. Mines & Tech., Rapid City, SD 57701.

A 6 km wide window of Precambrian rocks at Tinton in the northern Black Hills is dominated by metagraywacke, with minor amphibolite and quartz-graphite schist. Based on geologic and geochemical distinctions, there are 2 types of amphibolite. The Rusty Mine amphibolite (20-170 meters thick) extends for 3 km, is conformable with the underlying quartz-graphite schist, and is interpreted to represent a tholeiitic basalt flow. Small amphibolites occurring as thin lenticular bodies within the graywacke are less differentiated than the Rusty Mine amphibolite, and are interpreted as intrusive features.

Gold occurs as inclusions in arsenopyrite in and adjacent to quartz veins occupying the axial plane follation in a tight fold in the Rusty Mine amphibolite. Fluid inclusions in quartz directly associated with auriferous arsenopyrite contain CO_2, cubic daughter crystals, and give homogenization temperatures of 208-230°C. Alteration of the amphibolite is manifested in replacement of hornblende by chlorite and biotite, and plagioclase by kaolinite. From mass balance considerations, it is unlikely that sufficient gold could be secreted from the graphitic schist or amphibolite. Deposition of gold was probably due to a decrease in fO_2 as the auriferous hydrothermal fluid passed up the hinge zone of the fold and encountered the graphitic schist. There are similar associations of gold mineralization with graphite, tholeiitic basalt, and graywacke in the Owl Creek and Hoyle Pond gold deposits. (Authors' abstract)

PATERSON, M.S., 1986, The thermodynamics of water in quartz: Phys. Chem. Minerals, v. 13, p. 245-255. Author at Research Sch. of Earth Sci., Australian Nat'l. Univ., Canberra, 2601, Australia.

The thermodynamic model of Doukhan and Trepied (1985) for water solubility in quartz, based on the $(4H)_{Si}$ substitution, has been developed to take into account the variation in oxygen fugacity under different buffering conditions, as well as the solubility of the quartz in the water. An evaluation of the thermodynamic parameters has then been made using analogous data on grossular and hydrogrossular. This evaluation, although approximate, leads to predicted solubilities that are lower than some published experimental values but are consistent with other observations indicating that the solubility is relatively low, less than 100 $H/10^6$ Si at most, even at the highest temperatures and pressures. The predictions give a monotonically increasing solubility with increasing temperature at given pressure, and an increase in solubility with increasing pressure at given temperature up to a maximum, beyond which the solubility decreases with further increase in pressure. The variation of solubility with oxygen fugacity at fixed pressure and temperature broadly mirrors the observations of Ord and Hobbs (1986) although not predicting the finer details. An interstitial H_2O model is also considered and shown to be probably less important as a mechanism for water solubility than the $(4H)_{Si}$ mechanism. Hydrogen/alkali exchange depends on hydrogen fugacity rather than water fugacity and is predicted to be more important at lower oxygen fugacities. (Author's abstract)

PAVLUN', N.N., 1985a Genetic model and thermobarogeochemical zoning of the molybdenum-tungsten greisen-type deposits in Central Kazakhstan: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 3, p. 28-30 (in Russian).

Cited in Naumov, 1986 (this volume).

PAVLUN', N.N., 1985b Investigation of the physicochemical evolution of the ore-magmatic system of the Akchatau tungsten deposit in central Kazakhstan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 145-147 (in Russian; translation by Dorothy B. Vitaliano). Author at L'vov State Univ., L'vov, USSR.

Investigation of the P-T-X parameters showed that the Mo-W mineralization was preceded by powerful high-temperature pneumatolytic processes of greisen formation around the veins (570-415°C). Complex rare-metal and W ores were formed under high to medium temperature (>480-300°C) pneumatolytic-hydrothermal conditions against a background of fluctuations of pressure, from 160-120 to 100-55 MPa. The mineralizing solutions had a complex F-Cl-K-Na composition and usually high salt concentration (>65% NaCl-equivalent): the inclusions syngenetic with the mineralization constantly contain numerous crystals of alkali-metal chlorides, which often occupy >50% of the volume of the vacuole; in the gas component, CO_2 predominated -- up to 88%.

According to theoretical and experimental data of G.N. Shcherba, in the residual silicate melt of the fluid-generating apical parts of the plumasitic intrusions the concentration of water was 4-5%, [and] for the Akchatau alaskites, 8-9%, with a fluorine content in the melt of 3-4%.

That high content of water and fluorine determines the fluid regime of formation of the Akchatau ore-associated granite massif, lowers the temperature of crystallization and determines the very possibility of magmatic distillation, the existence of which is also well supported for the pluton in question by the finding of primary inclusions of both melt and fluid in the rock-forming quartz of the granites and relict magmatogenic quartz of the granoblastic quartz-topaz greisens.

Fluctuations in pressure are the main reason for the decomposition of the migrating complexes of Mo and W. Their main complexing agents -- F, Cl, and CO_2 as "working medium" carrying the complexes (possibly fluorohydroxides for W) of metal compounds -- were trapped in inclusions during the growth of the gangue and ore minerals, forming soluble phases, daughter minerals, and CO_2.

The regularities described probably appear more widely, as the deposit in question is a typical rare metal-Mo-W formation of the greisen group. (From the author's abstract)

PAVLUN', N.N., KOSTENKO, A.I. and KOSTIN, V.A., 1986, Factors affecting the results of bulk mass-spectroscopic analysis of the gas phase of fluid inclusions in minerals: Dokl. Akad. Nauk SSSR, v. 289, no. 5, p. 1230-1234 (in Russian). Authors at the L'vov State Univ., L'vov, Ukraine, USSR.

Samples of minerals, in which fluid inclusions were studied in detail, were analyzed for content of CH_4, N_2 and CO_2 with use of the mass spectrometer MI-1201 (H_2 was not determined). Three grain classes of every sample were used (in mm): 3-1, 1-0.5 and 0.5-0.05, the inclusions were opened by crushing under vacuum in an electromechanical mortar made from stainless steel. The results are listed in the Table 1 (in %).

Characteristics of samples: 1 - barite from polymetal-quartz assoc., P incl. 2-0.5 mm, S incl. 1-0.05 mm; 2 - barite from carbonate-sulfate-quartz assoc., P and PS incl. 0.5-0.05 mm; 3 - morion P and PS G and L<G incl. 2.5-0.5 mm; 4 - quartz, GLI with dms, 1-0.5 mm; 5 - chalcedony and opaline silica, incl. L (75-85%) + G; 6 - quartz from molybdenite-quartz assoc., P and PS G and L<G incl. 0.5-0.05 mm; 7 - quartz from rare metal-molybdenite-wolframite-quartz assoc., P and PS G and L<G incl., subordinate with LCO_2, 0.5-0.05 mm; 8 - quartz from galena-sphalerite-quartz assoc., P

No. of sample	Component	[Sample size range before crushing], mm			No. of sample	Component	[Sample size range before crushing], mm		
		3-1	1-0.5	0.5-0.05			3-1	1-0.5	0.5-0.05
1	CH_4	1.3	1.4	1.4	9	CH_4	1.1	0.4	0.6
	N_2	54.8	85.4	85.2		N_2	33.4	40.0	40.7
	CO_2	43.9	13.2	13.4		CO_2	65.5	59.6	58.7
2	CH_4	1.4	1.2	1.4	10	CH_4	1.9	4.8	5.6
	N_2	85.3	85.5	85.4		N_2	10.6	20.1	20.7
	CO_2	13.3	13.3	13.2		CO_2	87.5	75.1	73.7
3	CH_4	0.5	1.6	1.9	11	CH_4	0.3	0.4	0.4
	N_2	6.9	8.7	7.0		N_2	12.8	13.1	13.0
	CO_2	92.6	89.7	91.1		CO_2	86.9	86.5	86.6
4	CH_4	2.7	3.0	7.9	12	CH_4	7.5	18.8	22.0
	N_2	14.4	11.7	63.8		N_2	27.0	29.3	20.4
	CO_2	82.9	85.3	28.3		CO_2	65.5	51.9	57.6
5	CH_4	6.3	7.0	6.4	12a	CH_4	16.2	14.9	10.2
	N_2	77.7	79.1	78.2		N_2	23.1	28.4	25.3
	CO_2	16.0	13.9	15.4		CO_2	60.7	56.7	64.5
6	CH_4	12.0	12.3	12.1	13	CH_4	5.4	7.9	10.1
	N_2	7.8	6.9	7.1		N_2	38.0	20.2	17.3
	CO_2	77.3	80.8	80.8		CO_2	56.6	71.2	72.6
7	CH_4	3.5	0.3	2.3	14	CH_4	1.8	1.4	2.0
	N_2	8.3	26.8	7.1		N_2	48.9	55.6	47.3
	CO_2	88.2	72.9	90.6		CO_2	39.3	44.0	50.7
8	CH_4	1.1	0.4	0.6					
	N_2	33.4	40.0	40.7					
	CO_2	65.5	59.6	58.7					

and PS incl. with LCO_2 + LH_2O + G ~0.05 mm; 9 - quartz from calcite-fluorite-quartz assoc., rare PS incl., size not given; 10 - quartz from pyrite-wolframite-quartz assoc., PS GLI with halite, 1.5-0.05 mm; 11 wolframite from pyrite-wolframite-quartz assoc., PS incl. G + LH_2O + halite and other halite dms, <0.5 mm; 12 - quartz from gold-bismuthinite-calaverite-quartz assoc., S GL incl. of various size, sometimes with LCO_2; 12a - the same sample, analysis made 6 months later; 13 - quartz from pyrite-chalcopyrite-quartz assoc., PS and S incl. G + LH_2O, size not given; 14 - quartz from barite-ankerite-quartz assoc. PS incl. G + LH_2O, 1-0.5 mm.

The conclusions are as follows: either 1) quantitative composition of gases practically does not change with the degree of crushing, or 2) the degree of crushing determines the quantitative variation of chemical composition of G phase of inclusions. Case 1) occurs when late generations of minerals with one type of inclusion are analyzed, the minerals crystallized under quiet conditions from homogeneous fluid, and the host mineral has very low sorption activity, e.g., quartz. Case 2) occurs when specimens bear several generations of inclusions of various size. Thus, correct interpretation of the gas analyses is possible only after a thorough microscope, etc., study of fluid inclusions in the analyzed sample. (Abstract by A.K.)

PAVLUN', N.N., PIZNYUR, A.V. and KOSTENKO, A.I., 1985, Conditions of mineral-formation at a gold-ore deposit in the Eastern Uzbekistan (thermobarogeochemical data): Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 2, p. 166-168 (in Russian).

Cited in Naumov, 1986 (this volume).

PAYETTE, Christine and MARTIN, R.F., 1986a, The Harvey volcanic suite, New Brunswick. I. Inclusions of magma in quartz phenocrysts: Can. Mineralogist, v. 24, p. 557-570. Authors at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec H3A 2A7, Canada.

The quartz phenocrysts of the quartz-feldspar porphyry member of the Cherry Hill unit, Harvey volcanic suite, New Brunswick, contain melt inclusions preserved as glass since the emplacement of this early Carboniferous ignimbritic sequence. Most of the small- and medium-sized inclusions were spared of any alteration or devitrification and yield a composition representative of the parent fluorine-rich (up to 2%), potassic, peraluminous rhyolitic magma. Two types of minerals are found in the inclusions: trapped minerals (liquidus phases) and daughter minerals formed by incipient devitrification in some inclusions. Britholite, which is a fluorine- and rare-earth-rich silicate-phosphate apatite-group mineral, magnetite and a Na-, Fe-rich fassaitic pyroxene are the common liquidus phases. High concentrations of Al, F, Rb and Th and low concentrations of B and Sr in the melt emphasize the similarity of the Harvey rocks with topaz (F-rich) rhyolites and ongonites. (Authors' abstract)

PAYETTE, Christine and MARTIN, R.F., 1986b, The Harvey volcanic suite, New Brunswick. II. Postmagmatic adjustments in the mineralogy and bulk composition of high-fluorine rhyolite: Can. Mineralogist, v. 24, p. 557-570. Authors at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec H3A 2A7, Canada.

The composition of the glass trapped in the quartz phenocrysts indicates a fluorine-rich (up to 2% F) potassic peraluminous rhyolitic magma (71% SiO_2, 6.5% K_2O, 14.9% Al_2O_3). Comparison of the glass and bulk-rock compositions shows a net dilution of all elements by SiO_2 added after devitrification. (From the authors' abstract)

PEACH, C.L. and MATHEZ, E.A., 1986, Au and Ir in immiscible sulfides from submarine basalt glasses (abst.): EOS, v. 67, p. 410.

PEARMAN, G.I., ETHERIDGE, D., de SILVA, F. and FRASER, P.J., 1986, Evidence of changing concentrations of atmospheric CO_2, N_2O and CH_4 from air bubbles in Antarctic ice: Nature, v. 320, p. 248-250.

PENG, Guozong, 1986, A preliminary discussion on the origin of stratabound lead-zinc ore deposits in the Yutan region, Huayuan County, Hunan Province: Scientia Geol. Sinica, 1986, no. 2, p. 179-186 (in Chinese; English abstract). Author at Team 405 of Bureau Geol. & Mineral Resources, Hunan Province.

The stratabound Pb-Zn ore deposits in the study region occur mainly in upper Cambrian algal limestone. They are controlled by the statigraphy, lithology and structures. No evidence of magmatic activity has been found, and no evidence of synsedimentary or diagenetic ores, so it is clear that the ore deposits are epigenetic. The S-isotopic determinations show that the source of S is chiefly juvenile water, oil field brine and vadose brine. The great changes in Pb-isotopes indicate Pb comes directly from strata. Barite and anthraxolite are common and salt can be seen. T of fluid inclusions in sphalerite ranges from 60 to 280°C. The ore deposits formed by deep circulating hot brine. (From the author's abstract)

PERCHUK, L.L., 1985, Evolution of metamorphism in the light of thermobarometry of minerals and fluid-mineral equilibria (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 186-187 (In Russian; translation by Dorothy B. Vitaliano). Author at Inst. Exper. Min. USSR Acad. Sci., Chernogolovka, USSR.

For comparison of the methods, data on the cryometry of CO_2 inclusions in minerals from the metamorphic rocks of the Aldan shield, Khankay massif in Primor'ye and the Sharyzhaltay complex (Southwestern Pri-Baikalia) were obtained. In these same samples, the P-T parameters of the evolution of metamorphism were estimated on the basis of the method of phase ratio. It was assumed that the densest CO_2 inclusions correspond to the highest P-T parameters of metamorphism in the granulites. Accordingly, the highest T established by mineral geothermometry for the central parts of grains of garnet, biotite, cordierite and orthopyroxene were attributed to these inclusions. To inclusions with the lowest density of CO_2, the lowest values of mineral equilibrium T were assigned.

As a rule the peak of mineral equilibrium T corresponds to the peak Th on the histograms. On the basis of the values of T thus estimated, the maximum, minimum and intermediate values of P in one and the same rock samples were established. These estimates coincide practically exactly with independent determinations of P by the mineralogical barometer.

Thus for the first time it has been possible to compare not just unequivocally two methods of determining the P-T parameters, determined in rocks by the solid and liquid phases, but also to ascertain the regularities of the evolution of metamorphism on the basis of them. (From the author's abstract).

PERKINS, C., 1986, The Red Rock deposit, Drake volcanics, New South Wales, Australia - An example of a submarine epithermal system, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 79-80. Author at Dept. Geol. & Geophysics, Univ. New England, Armidale, N.S.W. 2351, Australia.

The epithermal Red Rock deposit is hosted in the predominantly andesitic, terrestrial to marine Late Permian Drake Volcanics, New England, N.S.W. Epiclastic pumice breccias host mineralization, and are interbedded with marine mudstones. The hydrothermal system is capped by impermeable marine mudstones and sandstones, and was active in a sub-seafloor setting.

The Red Rock deposit has a Ag/Au ratio of 70/1 with significant base metals, and the alteration assemblage is indicative of a near neutral pH hydrothermal fluid. Tt of 222°-295°C and salinity of 0.5-7 equiv. wt % NaCl is given from fluid inclusions.

The submarine Red Rock deposit has similar characteristics to subaerial epithermal and geothermal systems. Modern analogs of the paleogeography in New England in the Late Permian, and of the Red Rock system may exist in the Taupo Zone, New Zealand, and southern Kyushu, Japan. (Author's abstract)

Inclusions contain much CO_2 and vary widely in density, suggesting boiling at 295°C; nonboiling fluids were cooler. The data suggest an upper hydrostatic depth limit of ~800 m. (E.R.)

PERKINS, E.H., BROWN, T.H. and BERMAN, R.G., 1986, PT-system, TX-system, PX-system: Three programs which calculate pressure-temperature-composition phase diagrams: Computers & Geosci., v. 12, no. 6, p. 749-755.

PERSIKOV, E.S., EPEL'BAUM, M.B. and BUKHTIYAROV, P.G., 1986, The viscosity of a granite magma interacting with an aqueous chloride fluid: Geokhimiya, no. 1, p. 25-34 (in Russian; translated in Geochem. Int'l., v., 23, no. 6, p. 21-30, 1986).

PETER, J.M., SCOTT, S.D. and SHANKS, W.C., III, 1986, Genesis of hydrothermal vent deposits in the Southern Trough of Guaymas basin, Gulf of California (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 114. First author at Dept. Geol., Univ. Toronto, Ontario, M5S 1A1, Canada.

Fluid inclusion and stable isotope studies aid in elucidating the genesis of hydrothermal vent deposits in the Southern Trough of Guaymas Basin. Heating measurements on P, two-phase fluid inclusions in calcite from individual chimneys sample give mean trapping T of 213° to 277°C and are in good agreement with T of venting hydrothermal fluid measured with Alvin's thermocouple probe. Freezing measurements give salinities of 4.1 to 5.8 eq.wt.% NaCl (enhanced over typical seawater of 3.5 eq.wt.% NaCl) which cannot be reconciled with salinities measured from the presently venting fluids. This suggests temporal variations in vent chemistry do occur. Carbon and oxygen isotopic values of calcites give a range of $\delta^{13}C(PDB) = -9.6$ to 14‰ and $\delta^{18}O(SMOW) = +7.3$ to +10.8‰, respectively. Carbon isotope values indicate vent fluid CO_2 derivation in approximately equal quantities from dissolution of marine carbonate minerals and oxidation of organic matter, both due to hydrothermal fluid migration through the underlying sediment. Combined fluid inclusion Tt and oxygen isotope values of calcites yield calculated oxygen isotope values for the vent fluids of $\delta^{18}O = -2.2$ to +2.6‰ (assuming equilibrium isotopic fractionation). Sulfur isotopic values for chemically extracted pyrrhotite-marcasite and chalcopyrite-isocubanite range from $\delta^{34}S(CDT) = -3.7$ to +4.5‰ whereas barite and anhydrite range from +20.7 to 26.4 (seawater sulfate = 21‰) and indicate sulfate reduction in the vent fluid source area. As well, sulfur isotope values of sulfide reflect an apparent regional increase from southwest to northeast in the Southern Trough. Sulfur isotopes indicate sulfur contribution from three sources: 1) basaltic sulfide, 2) sulfide from hydrothermally reduced seawater sulfate, and 3) bacteriogenic sulfide from underlying sediments. (Authors' abstract)

PETERS, Tjerk, 1986, Structurally incorporated and water extractable chlorine in the Boettstein granite (N. Switzerland): Contrib. Mineral. Petrol., v. 94, p. 272-273. Author at Mineral.-Petrograph. Inst., Baltzerstrasse 1, CH-3012 Bern, Switzerland.

Samples from fresh to strongly hydrothermally altered granite have been analyzed for water-, HNO_3-extractable and total chlorine. From the total of 115 ppm Cl, 60 ppm are contained in fluid inclusions, 1-2 ppm in apatite and 50 ppm in biotite. It is obvious that the high salinity (1,330 mg/l) of the deep ground water in this granite can be obtained by extraction from a fraction of chlorine originating from broken inclusions in tectonic breccias in fault zones. (Author's abstract)

PETERSEN, J.S. and LOFGREN, G.E., 1986, Lamellar and patchy intergrowths in feldspars: Experimental crystallization of eutectic silicates: Am. Mineralogist, v. 71, p. 343-355.

PETROV, P.P., 1984, Classification and genetic peculiarities of fluid inclusions in ore-bearing quartz in the Madan and Madzharovo ore fields: Summary of the Ph.D. dissertation, 26 pp., Sofia Univ., Kliment Okhridski', Geosci. Center, Geol.-Geogr. Faculty, Dept. Raw Mineral Materials & Geochem. (in Russian).

The author briefly discusses previous works performed in the studied areas, present day state of fluid inclusion studies, genetic classification of fluid inclusions in quartz from the Madan and Madzharovo ore fields (fourteen types), Th up to 310°C. He presents also the probable mechanisms of formation of various types of fluid inclusions. See also in Fluid Inclusion Research Kol'kovski et al., 1974, v. 7, p. 106; Kol'kovski and Petrov, 1974, v. 7, p. 106; Kol'kovski et al., 1976, v. 9, p. 69; Kol'kovski and Petrov, 1977, v. 11, p. 107-108; Kol'kovski et al., 1978, v. 12, p. 92; Petrov, 1982a and b, v. 15, p. 190-191. (A.K.)

PETROV, P. and VLAKHOV, A., 1986, Typogenic fluid inclusions of quartz and amethyst from the polymetallic ore deposits of Ruen: Dokl. Bolg. Akad. Nauk, v. 39, no. 8, p. 73-75 (in English). Authors at Res. Inst. Miner. Resources., Sofia, Bulgaria.

Inclusions in quartz are genetically related to ore fluids but have a spatial character of PS origin and show areal alignment. The gas-liquid inclusions have variable phase ratios. Th = 360-140°. The larger the inclusions are, the less perfect their void crystallography. The fluid inclusions in amethyst have mainly irregular shapes, with some isometric shapes. The large amount of CO_2 in these fluid inclusions indicate PS origin. The CO_2-rich inclusions are of fluids which were not ore-forming; the amethyst and ore sulfides are not paragenetically related. (C.A. 105: 230080s)

PHUTELA, R.C. and PITZER, K.S., L986, Thermodynamics of electrolyte mixtures. Enthalpy and the effect of temperature on the activity coefficient: J. Solution Chem., v. 15, no. 8, p. 649-662.

PICHAVANT, M. and MANNING, D.A.C., 1986, F, B, and H_2O: Effects on phase equilibria in granitic systems (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 199.

PICKERING, L.A. and INDELICATO, G.J., 1985, Abnormal formation pressure: A review: The Mountain Geologist, v. 22, no. 2, p. 78-89. First author at Magic Circle Energy Corp., 4141 NW Expressway, Oklahoma City, OK 73116.

Abnormal formation P is defined as any P that deviates from the normal hydrostatic gradient. In order for the P to form and be preserved, a near-seal is required. The seal is not necessarily impermeable but may be a low permeability formation, such as shale, or a fault-related barrier.

The possible causes of abnormal formation P are: 1) compaction of sediments, 2) tectonic activities, 3) T changes, 4) osmosis, 5) diagenesis, 6) methane generation, and 7) buoyancy. T changes due to decay, diagenesis, and changes in burial depth of the formation are one of the two most important causes of abnormal formation P. The other important cause is compaction P related to the weight of overburden with increased depth of burial. If the pore fluids cannot escape, they will support a greater proportion of the total overburden stress and become abnormally highly pressured.

Tectonic activities such as faulting as well as removal of overburden by erosion also play an important role in either raising or lowering pore fluid P. Osmosis, diagensis, methane generation, and buoyancy are all additive to the overall effects of P and T. (Authors' abstract)

PIERRE, Catherine and ROUCHY, J.-M., 1986, Oxygen and sulfur isotopes in anhydrites from Givetian and Visean evaporites of northern France and Belgium: Chem. Geol. (Isotope Geosci. Sec.), v. 58, p. 245-252.

PINEAU, F. and JAVOY, M., 1986, The volatile record of a 'popping' rock from the Mid-Atlantic Ridge at 15°N: Concentrations and isotopic compositions (abst.): Terra Cognita, v. 6, no. 2, p. 191. Authors at Lab. Géochimie des Isotopes Stables, UER des Sci. Physiques de la Terre and I.P.G.P., Univ. Paris VII, 2 Place Jussieu, 75251 Paris Cedex 05, France.

A popping rock dredged at 15°N on the Mid-Atlantic Ridge contains the highest content of gas so far reported in MORB = 1.41 cc $STPg^{-1}$. These gases consist mainly of CO_2 (78%) and H_2O (21.9%). Incondensible gases (0.11%) consist of N_2 (94.5%) He (2.86%) Ar (1.76%) and very small amounts of CO, H_2 and CH_4. The main component ratios are: $CO_2/N_2 = 732$; $CO_2/He = 24\ 190$; $N_2/Ar = 53.7$. From the argon isotopic composition the combined atmospheric and sea water contamination is estimated to less than 5% of the nitrogen.

The sample contains additionally 191 ppm of dissolved carbon and 0.512% of dissolved H_2O. $\delta^{13}C$ is -3.64‰ in the gas and -6.78 in the glass. ($\delta^{13}C_T = -4.45$.) δD is -25‰ in the gas and -69‰ in the glass. ($\delta D_T = 68$.)[sic, presumably -68] $\delta^{15}N$ is -2.6/ATM.

The hydrogen isotopic composition is very similar to those reported before. The carbon isotopic composition is significantly heavier than those of other Mid-Atlantic MORB. The nitrogen is markedly depleted in ^{15}N relative to the atmosphere.

Most of the chemical and isotopic characteristics can be assigned to the high gas content. Chemical ratios such as CO_2/N_2 and CO_2/He are very similar to those found in other MORB vesicles. (Authors' abstract)

See also Pineau et al., 1976, Fluid Inclusion Research, p. 105. (E.R.)

PINGITORE, N.E., Jr. and EASTMAN, M.P., 1986, The coprecipitation of Sr^{2}_{+} with calcite at 25°C and 1 atm: Geochimica Cosmo. Acta, v. 50, p. 2195-2203.

PISKUNOV, Yu.G., MALAKHOV, V.V. and IGNATIEV, A.V., 1985, Physical-chemical conditions of forming of the deposits of the lower part of the Amur river (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 46-47 (in Russian; translation by I.V. Kulikov). Authors at DVPI MV, AN SSSR, Vladivostok, USSR.

On the basis of thermobarogeochemical study of the ore features the change in space and time of paleohydrothermal systems of one of gold deposits of Amur river basin is considered. The deposit belongs to the complex type, in which two cycles of mineral formation are revealed: an ore cycle (hydrothermal-metasomatic) and a post-ore cycle (skarn-hydrothermal).

It is established that from the stage of quartz-sericite metasomatites to gold-quartz stage and further to the gold-carbonate stage, among the components of the inclusions the content of Ca and NH_4 increased significantly, Cl increased slightly, and Na decreased. The solutions forming the sericite-quartz metasomatites were HCO_3-Na; for the gold-quartz stage, NH_4-alkaline earths-HCO_3. Salinity decreased from 26.4% (quartz-sericite-metasomatites) down to 11.65% (gold-quartz), and again increased to 27.52% (gold-carbonate). The change in the composition of solutions in time was accompanied by an increase in acidity from pH 76 to pH 4.9, and by an increase in oxidation-reduction potential from -1.18 to -0.56.

The space evolution of paleohydrothermal systems was reconstructed by the models of gold-quartz stage. In the direction of paleosurface the fraction of HCO_3 increased, and Cl and N_2 decreased, as well as T. The ore interval is characterized by maximum Na and K, by maximum total sulfur, and by maximum CO_2 and CH_4 among the gases; Mg, H_2 and CO were minimal.

In various ore zones a directional change of composition of paleohydrothermal systems was observed. Thus, from S-E to N-W the amounts of most components in inclusions of quartz decrease. The same tendency was discovered during the analysis of inclusions in the native gold. This is the most conspicuous by the sums of cations, anions, and gases, and by the salinities. The acidity and oxidation-reduction potential of solutions also increased in this direction.

The deposition of ores occurred under conditions of low oxidation-reduction potential out of Cl-Na-alkaline-earths-HCO_3 solutions with Na>K, of near neutral pH. (From the authors' abstract)

PITZER, K.S., 1986, Theoretical considerations of solubility with emphasis on mixed aqueous electrolytes: Pure & App. Chem., v. 58, no. 12, p. 1599-1610.

PITZER, K.S. and PABALAN, R.T., 1986, Thermodynamics of NaCl in steam: Geochimica Cosmo. Acta, v. 50, p. 1445-1454. Authors at Dept. Chem. & Lawrence Berkeley Lab., Univ. California, Berkeley, CA 94720, USA.

On the basis of the statistical mechanics of a two-component imperfect gas, a successive hydration model is developed for the NaCl ion-pair molecule in steam which fits satisfactorily and extensive array of experimental solubility data including the measurements of Bischoff et al. (1986) at the three-phase P from 300° to 503°C and other concordant measurements extending to 600°C at 290 bars. Some published experimental results depart substantially from the concordant set here selected. The theoretical basis of this model should make it useful for estimates at higher T provided the mean hydration number and the total fluid density remain within the range corresponding to the fitted data. The measurements of Bodnar et al. (1985) at 500 bars and 800° and 825°C provide a test and the agreement with model predictions is good. (Authors' abstract)

PIZNYUR, A.V., 1985, On some problems of applied thermobarogeochemistry (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 241-243. (In Russian; translation by Dorothy B. Vitaliano). Author at L'vov State Univ., L'vov, USSR.

The author assumes that destruction of ore-element complexes in solution occurs due to T & P decrease, so T & P (from inclusion measurements) provide criteria for exploration. (Abstract by ER from the author's abstract).

PIZNYUR, A.V., PAVLUN', N.N., KOSTENKO, A.I. and PIZNYUR, O.N., 1985, New data on the physical-chemical conditions of formation of some near-surface deposits of Uzbekistan, of the north-east of the USSR and of the Kuril Islands (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 54-55 (in Russian; translation by I.V. Kulikov). Authors at LGU, L'vov, USSR.

Results of investigations of fluid inclusions in quartz of productive gold-bearing occurrences showed that physical-chemical conditions of formation of near-surface deposits bear both similarities and differences.

Their similarity consists of the fact that all were formed by hydrothermal, high-salinity solutions. But, while the quartz of Uzbekistan and of the Kuril Islands has no dms, the quartz of the North-Eastern deposits, which have long been thought to represent typical near-surface Au-Ag formations, contains inclusions with two to seven solid phases which are halite, sylvite and other readily soluble minerals. This fact suggests a deeper deposit. Water extractions from the quartz of Uzbekistan and of Kuril Islands (although saline inclusions were not discovered in them) also showed elevated contents of salts in solution. Thus, in all the above listed cases the Au-Ag ores formed from solutions which contained significant amounts of sodium chloride, which evidently had played a certain role in transportation and deposition of Au.

Inclusions with dms in quartzes of North-Eastern deposits of the USSR became an important prospecting and evaluation criterion for distinguishing between ore and barren veins. As a rule, ore-bearing quartz contains inclusions with dms. Such Au-bearing veins are spatially connected with stocks and dikes of granite-porphyries and diorite porphyries. The genetic relations of these veins with nearby granitoids were suggested by Goncharov et al. (1984).

Tf of Au-bearing quartz are of the same order in all the three regions, and fall in the limits of 280-190°C. Paleotemperature conditions of productive stages were characterized by a wider interval - 325-770°C. For the deposits of North-East region the data of Goncharov et al. (1972) were confirmed. They include the first generation electrum formation in the final period of quartz III crystallization (240°C). In the crystal termination of this quartz there are some clearly defined S inclusions, which were earlier described by Goucharov et al. (1972). We obtained the same Th of these inclusions - 320-300°C. According to Goucharov et al. (1972), the formation of the second generation electrum was connected with these solutions during their cooling to 250-230°C. These data demonstrated the value and the high accuracy of the results on inclusions. For the deposits of the North-East of the USSR we obtained a few data on pressure of mineral formation. It was defined with the help of inclusions containing dms, and inclusions with CO_2. The values of pressure are in the range 1100-800 bars.

Paleotemperature conditions of productive stages of Au deposits of Pritashkeut region of Uzbekistan were in the range 325-185°C. Typomorphic features of ore-bearing solutions include liquid CO_2. Here Au crystallized at 270-205°C. The composition of Au-bearing solutions was characterized by a prevalence of Cl and Na (54 and 60% equiv. respectively[sic]). Among other ions in solutions silicic ion was present (up to 40% equiv.). Gas component of productive solutions was represented by CO_2 (84-72 vol.%), CH_4 (28-38 vol.%) and by an insignificant quantity of nitrogen (19-13 vol.%). Small amounts of the latter, as well as high contents of CH_4 and CO_2 indicate probably relatively deep mineral-forming solutions. A few data on the pressure of productive mineral-forming solutions which exceeded 400 bar, also are not typical of near-surface ore formation. Thus, the totality of all thermobarogeochemical data obtained on the studied Uzbekistan deposits revealed some positive physical-chemical conditions of Au-ore mineralization development, and suggested its transition character, from subvolcanic type proper to intermediate-depth type. (Authors' abstract)

PLIMER, I.R. and KLEEMAN, J.D., 1985, Mineralization associated with the Mole Granite, Australia, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 563-569. First author at Dept. Geol., Univ. Newcastle, New South Wales, Australia.

Reviews inclusion data of Eadington, 1983b (Fluid Inclusion Research,

v. 16, 1983, p. 65) and Eadington and Nashar, 1978 (Fluid Inclusion Research, v. 11, 1978, p. 55). (E.R.)

PLUMLEE, G.S. and RYE, R.O., 1986, Extreme sulfur isotope, As, Sb and Ag variations in late-stage botryoidal pyrite from Creede, Colorado: Vestiges of a waning hydrothermal system (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 719.

POLIAKOV, A.I., TURKOV, V.A. and IGNATENKO, K.I., 1986, Composition of initial melts of trachyte-basalt series of the Udokan Ridge (Baikal Rift) from the data obtained in study of microinclusions: Dokl. Akad. Nauk SSSR, v. 283, no. 3, p. 691-695 (in Russian).

POLLARD, P.J. and TAYLOR, R.G., 1986, Progressive evolution of alteration and tin mineralization: Controls by interstitial permeability and fracture-related tapping of magmatic fluid reservoirs in tin granites: Econ. Geol., v. 81, p. 1795-1800. Authors at Dept. Geol., James Cook Univ. of North Queensland, Townsville, Queensland 4811, Australia.

Th of highly saline P inclusions from the Zaaiplaats Sn mine, South Africa, ranged from 300-600°C. Literature data on the inclusions at the Herberton Sn field, Australia, are also discussed. (E.R.)

POLLARD, P.J., WITT, W.K., MILBURN, D., GOLDING, S.D. and TAYLOR, R.G., 1985, Reconnaissance oxygen isotope study of granites and related alteration/mineralization in the Irvinebank-Emuford area of the Herberton tin field, north-east Queensland, Australia (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 60-68. First author at Dept. Geol., James Cook Univ. of North Queensland, Townsville, Qld., 4810, Australia.

The Upper Palaeozoic tin-bearing granites of the Herberton tin field intrude penecontemporaneous acid volcanics, and Lower Palaeozoic metasediments of the Hodgkinson Province. Mineralization occurs as a number of discrete centers which are spatially related to late-stage members of a strongly fractionated fluorine-rich granite suite. The granites exhibit widespread background alteration which is unrelated to macroscopic fractures. A reconnaissance isotope investigation of granites and their associated alteration/mineralization zones has been undertaken and the results are presented.

The Emuford region consists of several fine-grained biotite granite plutons which intrude a large body of coarse-grained biotite granite. Cassiterite mineralization occurs within fracture controlled, albitized zones and/or greisenized zones in granite, and within quartz-tourmaline and quartz-chlorite veins in the adjacent metasediments. Whole rock $\delta^{18}O$ values for granites range from +7.8 to +9.8 per mil. Despite the alteration, these values are within the range commonly observed for 'normal' granites. Quartzes from the various mineralization types have $\delta^{18}O$ values between +12.6 and +4.5 per mil. Fluid compositions in equilibrium with quartz have been calculated using P fluid inclusion Th [130-600°C] and range between +6.3 and -12.5 per mil.

This range in calculated fluid composition is consistent with progressive dilution of an original, dominantly magmatic fluid by cooler meteoric fluids. This is supported by the fluid inclusion data, where low-salinity and low-temperature fluid inclusions are associated with the calculated large negative $\delta^{18}O$ values in the fluid.

The mineralization in the Mowbray Creek center is associated with fracture-controlled greisenization and feldspathic alteration in medium-grained (Go Sam) and fine-grained (Percy) granites. The Go Sam granite displays more intense background alteration than the Emuford granites. The fracture-controlled alteration-mineralization comprises a temporal sequence; early K-feldspar, albite, greisen, late K-feldspar.

Measured whole rock $\delta^{18}O$ values for the granites are within the normal range for igneous rocks although the strongly altered Go Sam granite is at the lower end of the spectrum. Feldspathic rocks, resulting from the alteration of the Go Sam granite, display variable $\delta^{18}O$ character including some comparatively low values. Equilibration temperatures for $\delta^{18}O$ are not constrained by fluid inclusion data which indicate the presence of hydrothermal fluids (salinity 70-2 wt% NaCl equivalent) over a wide temperature range (>600°C-100°C), with dilute fluids entering the system at around 400°C. Tetrahedral closure temperatures for K-feldspar in Go Sam granite and K-feldspathic altered rocks are in the range 460-530°C implying $\delta^{18}O$ equilibration temperatures of ≤500°C. Calculated $\delta^{18}O$ for fluids, assuming temperatures of 500°C and 300°C, indicate a meteoric or connate component in addition to a magmatic component.

The Mt. Misery mineralization consists of a linear zone of feldspathic alteration and late greisen-bordered veining. The host granites are textural variants of the Go Sam Granite with characteristic extensive background alteration (see above). The sequence of alteration/mineralization includes early molybdenite-bearing aplite/pegmatite in the apical portion of a microgranite sheet, pipe-like bodies of K-feldspar alteration, extensive overprinting by fracture-controlled linear albitic alteration, greisen-bordered veins and minor late K-feldspar. All phases except the early aplite/pegmatite contain cassiterite.

Whole rock $\delta^{18}O$ values for the granite are uniformly low (+4.1 to +1.0 per mil), whereas whole rock values for the mineralization vary considerably within the range +4.9 to -0.3 per mil. However, individual alteration types are generally consistent. Fluid inclusion data and tetrahedral closure temperature for feldspars are not available. Calculated $\delta^{18}O$ of fluids for a range of temperatures indicate a substantial meteoric component. The granite and alteration/mineralization at Mt. Misery are identical to, and form part of, the general Mowbray Creek system. The lower $\delta^{18}O$ fluid compositions indicate a more substantial meteoric input at the Mt. Misery prospect.

Despite the differences in alteration-mineralization styles, the general features of fluid evolution are similar in both the Emuford and Mowbray Creek regions. This pattern of early magmatic fluid evolution with a later meteoric/connate input has also been recorded within other tin fields, e.g., Cornwall, Bolivia, and New England. [References to tables and literature citations deleted by E.R.] (Authors' abstract)

POLLASTRO, R.M. and BARKER, C.E., 1986, Application of clay-mineral, vitrinite reflectance, and fluid inclusion studies to the thermal and burial history of the Pinedale anticline, Green River basin, Wyoming, in Gautier, D.L., ed., Roles of organic matter in sediment diagenesis: Soc. Econ. Paleontologists & Mineralogists, Spec. Publ. 38, p. 73-83. Authors at U.S. Geol. Survey, Box 25046, MS 960 Denver Fed. Center, Denver, CO 80225.

Clay-mineralogy, mean random vitrinite reflectance (Rm), and fluid inclusion Th from host-rock and vein samples in cored intervals from 5000-18,000 ft (1500-5500 m) indicate that paleotemperature was higher than the T currently measured in siliciclastic rocks of the Pinedale anticline, Green River basin, Wyoming. The cored intervals are from lower Tertiary and Upper Cretaceous rocks in the El Paso Natural Gas Wagon Wheel no. 1 well.

Compositional analyses of mixed-layer clay show a progressive increase in ordering and the number of illite layers with depth (and T). T imply that the rocks of Wagon Wheel reached about 200°C at 18,000 ft (5500 m). Uncorrected log T at this depth is about 135°C-150°C. The thermal gradient calculated at maximum burial T (25°C/km), however, is similar to the thermal gradient established by present-day borehole T (24°C/km). These data suggest that maximum T was 30°-50°C higher than present-day uncorrected borehole T. The apparent T decrease can be explained by erosion of about 5600 ft (1700 m) of section. Major uplift of the Pinedale anticline occurred after apparent maximum burial and T were established in the Neogene.

Th of 130°-150°C from aqueous fluid inclusions in quartz within calcite and quartz veins at 17,000 ft (5200 m), however, conform to the present T regime. Fractures probably formed during uplift of the Pinedale anticline and were later mineralized in a T regime much like that of the present.

P, hydrocarbon-bearing fluid inclusions in veins from 8000-17,000 ft (2400-5200 m) are evidence for petroleum migration occurring during the filling of these late fractures. S oil fluid inclusions, trapped in healed microfractures that crosscut authigenic quartz in these veins at a depth of 17,000 ft (5200 m), indicate that petroleum migration continued sometime after these deep fractures were mineralized. (From the authors' abstract)

POLLOCK, J.M., THOMPSON, G.D., MESTROVICH, M.K., CUMMINGS, M.L. and HOWARD, D.G., 1986, Geologic processes in the subvolcanic portion of a porphyry copper deposit, North Santiam mining area, western Cascades, OR (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 720. First author at Geol. Dept., Portland State Univ., P.O. Box 751, Portland, OR 97206.

Geologic processes in the subvolcanic environment of a porphyry copper system in the North Santiam Mining Area of the Western Cascades of Oregon include a depositional volcanic environment, multistage alteration and brecciation, and possible surficial geothermal expression. Regional Pliocene uplift has exposed nearly 1000 m of the stratigraphy overlying the porphyry style mineralization. Mapping suggests that mineralization was contemporaneous with a developing volcanic center located south of the study area at about 11-10 m.y.B.P. Alteration is most intense in older rocks but extends into the deposits from this center which are preserved in the ridge tops.

Exposures of potassic alteration are localized around tourmaline-bearing breccias near the central portion of the mining area. High temperature, magmatically dominated fluids were restricted to the breccias themselves. Outside of the breccias, fluids contain less than 3 equiv. wt. % NaCl; homogenization temperatures <325°C. Mossbauer spectroscopy on tourmaline separates from cement within one breccia pipe display a ferric iron component while disseminated tourmalines outside the pipe contain predominately ferrous iron.

Base metal vein deposits with phyllic alteration halos are localized on faults and margins of intrusions. Hydrothermal propylitic alteration decreases with increasing elevation, in zones of low primary permeability, and with distance from the pipes. Quartz-chalcedony veins on the margins represent zones of mixing of geothermal fluids with regional ground water.

Later argillic alteration with gypsum along veins near the margins of the mining area suggests boiling of fluids as a result of a declining water table or erosional unroofing. (Authors' abstract)

POLVE, M. and KURZ, M., 1986, Helium systematics in ultramafic nodules (abst.): Terra Cognita, v. 6, no. 2, p. 104. Authors at Woods Hole Oceanographic Inst., Dept. Geol. & Geophys., Woods Hole, MA 02543, USA.

We studied the He concentrations and $^3He/^4He$ ratios in lherzolitic nodules brought up by recent volcanism in various continental areas and in Hawaii. This has been done by crushing and melting minerals.

He concentrations range from 10^{-6} to 10^{-9} ccSTP/g and are controlled by the mineral type (pyroxenes contain more He than olivines and spinels) and by the degree of recrystallization in each mineral, 60 to 80% of the total He is released by crushing. These facts are in agreement with He being principally located in fluid inclusions. Pyroxenes have more fluid inclusions than olivines. The expulsion of fluid inclusions at grain boundaries during recrystallization processes promotes further He loss. (From the authors' abstract)

POLYA, D.A., 1986, Calculation of ore component solubilities in the main stage ore-forming fluids from the Panasqueira W-Cu-Sn deposit, Portugal (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 19. Author at Dept. Geol., Univ. Manchester.

Panasqueira is a large vein-type W-Cu-Sn deposit in northeastern Portugal. It is associated with a post-orogenic S-type granite. The host rocks are largely pelitic schists, which are regionally metamorphosed to greenschist facies (300-400°C/P(fluid)<2 kbar) assemblages prior to mineralization. The 3-D lacework of predominantly sub-horizontal veins also cuts the upper greisened margins of the immediately underlying granite. The veins are dominated by quartz and muscovite with the most abundant "ore" minerals being Fe-rich wolframite, arsenopyrite and chalcopyrite. Fluid inclusion (quartz) trapping temperatures are typically 250-350°C.

Chemical compositions of the ore-forming fluids have been determined from the microthermometric analysis of individual fluid inclusions; from the chemical analysis of bulk fluid inclusion leachates; and indirectly from the compositions of ore and gangue mineral phases presumed to be in equilibrium with the ore-forming fluids. Cationic compositions have been determined in this study; extensive data on T and P of formation, salinities and CO_2 contents have been taken from Kelly and Rye (1979); whilst gas analyses (N_2:CH_4:CO_2) are known from the work of Bussink et al. (1984). Electron probe microanalyses of arsenopyrite, loellingite, wolframite, sphalerite, pyrrhotite, muscovite, stannite and pyrite were carried out as part of this study.

The calculated solubilities of ore components, in particular tungsten, indicate that the volume of fluid required for ore formation is too large to be provided by single pass magmatic or metamorphic fluid systems. A model of main stage ore formation from meteoric fluids is therefore proposed. (Author's abstract)

POLYAKOV, A.I., TURKOV, V.A. and IGNATENKO, K.I., 1986, Composition of the primary melts of the trachyte-basalt series of the Udokan Ridge, (Baykal rift) from data of fluid inclusion studies: Dokl. Akad. Nauk SSSR, v. 286, no. 3, p. 691-695 (in Russian). See Translations.

POLYVYANNYI, E.Ya., FREYMAN, G.G. and ZAIRI, N.M., 1985, Model of conditions of ore formation at a gold-ore deposit in the Eastern Kazakhstan: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 2, p. 170-171 (in Russian).

Cited in Naumov, 1986 (this volume).

POPIVNIAK, I.V., LEVITSKIY, V.V., DIOMIN, B.G. and KHRENOV, P.M., 1985, The periodity of element involvement in crystallogenesis with an example of one of the gold-ore-forming paleosystems (North Buriatia) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 51-52 (in Russian; translation by I.V. Kulikov). Authors at LGU, L'vov; VOSTSIBNIIGGiM, Irkutsk, USSR.

The process of ore formation in the region is divided into the following stages of mineral formation: 1 - quartz stage (460-350°C); 2 - tourmaline-quartz (500-350°C, 100-110 MPa); 3 - pyrite-quartz (460-310°C, 60-70 MPa); 4 - gold-sphalerite-galenite stage (330-170°C, 195-82 MPa); 5 - quartz-carbonate (160-100°C).

During the five stages of ore formation five uniform mineral complexes were formed (after N.V. Petzovskaya). Each stage of mineral formation began with prevailing deposition of corresponding quartz generation; then it was succeeded by (or it was changed by) sulfide complex, which in turn was changed by carbonate (I, II, III). The latter corresponds to the completion of the mineral formation in a given stage (excluding first and second stage).

The discovery of the cyclic nature of mineral formation suggests that to a first approximation, an increase in the basic properties of the solutions at the end of each stage, which is justified by the calculated data of V.A. Zharikov on the acid-basic properties of minerals, which relfects their ability to ionization[sic]. (From the authors' abstract)

POPIVNIAK, I.V., NIKOLENKO, A.E., GONCHARUK, S.G., ZHUK, B.T., ZHOVTULIA, B.D., LEVITSKIY, V.V., CHEREPANOV, V.K. and SHAMES, P.I., 1985, Physical-chemical conditions of mineral formation in Uriakh ore zone (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 49-50 (in Russian; translation by I.V. Kulikov). Authors at LGU, L'vov; VOSTSIBNIIGGiM, Irkutsk, USSR.

On the basis of structural-textural principles nine stable paragenetic associations of minerals were established: 1) tourmaline-quartz, 2) quartz-epidote-chlorite; 3) scheelite-pyrite-sphalerite-galenite; 6) galenite-tetrahedrite(tennantite); 7) chalcopyrite-tetrahedrite(tennantite); 8) quartz-carbonate (late); 9) quartz-fluorite-carbonate. These associations form four mineral complexes, in the formation of which four hydrothermal solutions took part. These portions differed significantly in chemical composition, and they functioned at different T and P.

I. Pre-ore stage: 1) tourmaline-quartz (250-200°C; 95-90 MPa), and 2) pyrite-quartz substage (430-330°C). II. Ore stage: 3) quartz-polysulfide substage with gold (350-130°C, 85-80 MPa). III. Post-ore stage: 4) quartz-carbonate substage (150-80°C).

By the results of thermobarogeochemical research it can be stated that the formation of the ore zone occurred exclusively in hydrothermal conditions. Notwithstanding the relatively wide T interval of mineral formation (430-80°C) no traces of gaseous solutions were discovered. This fact constitutes a significant difference of the studied zone in comparison with a number of other gold-ore deposits of the East and West Transbajkalia, Eastern Sajans, etc.

The precipitation of the ore components in the ore zone was limited to 350-130°C. Optimal conditions of crystallization of the major part of the ore were limited to an even more narrow T interval of 210-150°C.

It should be specifically mentioned that unlike the deposits of Eastern Sajans, and West and East Transbajkalia, the deposition of ore components in the studied zone occurred in agreement to the only mechanism (during the disruptions of PT-conditions in the system of mineral formation and active heterogenization of solutions)[sic].

For example, at the deposits of West Transbajkalia in the studied ore zone multiple stages of heterogenization of ore solutions was discovered. Besides, the number of the acts of intensive heterogenization corresponds to the number of mineral associations being deposited. Such a coincidence is not accidental. The appearance of mineral complexes and paragenetic associations of minerals was preceded by intensive tectonic movements, which increased the "working" volume of the system and caused a sharp drop of pressure. That caused "boiling" or "stratification" of mineral-forming solutions. With such sharp disruption of quasi-stable state of the system the deposition of mineral complexes of paragenetic associations of minerals was connected, including the ores. (From the authors' abstract)

POPIVNYAK, I.V., BAKALETS, P.M., KONDRAKHIN, S.I., KRYUCHKOV, A.K., LELYUKH, M.I., 1985, Prospecting value of low-temperature (20-130°C) degassing of limestones containing kimberlite bodies (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 257- 259 (In Russian; translation by Dorothy B. Vitaliano). First author at L'vov State Univ., L'vov, USSR.

For several years the decrepitation activity of rocks containing kimberlite bodies (Western Yakutia) has been studied. In particular, the Lower Paleozoic subhorizontal organoclastic limestones which, together with the kimberlites intruding them, are overlain by younger clastic deposits and traps, have been studied. The effect of the composition, structure and texture of the lithologic rock varieties enclosing the kimberlite bodies on their decrepitation activity has been established. Decrepitometric mapping was carried out on lithologically uniform rocks. More than a thousand samples (volume of sample 0.5 cm, 1.0-0.5 mm fraction) were analyzed on a VD-3 vacuum decrepitograph at Rostov State Univ.

Depending on the sampling site, when limestones were heated from 20 to 800°C 3 or 4 maxima of active gas liberation, not of the same nature, were recorded on the vacuum decrepitograms. We note that the first (20-130°C) and fourth (350-500°C) maxima of gas liberation are typical of every sample investigated. The intensity of gas liberation in the 20-130°C range in the aureoles of high decrepitation activity in the rocks near kimberlite bodies is much lower than in places characterized by background values of decrepitation activity. This regularity, along with others, is used as a supplementary criterion in prospecting practice. (From the authors' abstract)

PORCELLI, D.R., O'NIONS, R.K. and O'REILLY, S.Y., 1986, Helium and strontium isotopes in ultramafic xenoliths: Chem. Geol., v. 54, p. 237-249.

PORCELLI, D.R., STONE, J.O.H. and O'NIONS, R.K., 1986, Rare gas reservoirs and earth degassing: Lunar Plan. Sci. XVII, p. 674-675.

POREDA, R.J., JENDEN, P.D., KAPLAN, I.R. and CRAIG, H., 1986, Mantle helium in Sacramento basin natural gas wells: Geochimica Cosmo. Acta, v. 50, p. 2847-2853. First author at Isotope Lab., Scripps Inst. Oceanography, Univ. California, San Diego, La Jolla, CA 92093, USA.

Helium isotope ratios in Sacramento basin natural gas wells show a strong mantle signal. The $^3He/^4He$ ratios range from 0.11 times the atmospheric ratio (0.11 R_A) in the Rio Vista field to 2.75 R_A in the Moon Bend field, indicating that 1% to 34% of the helium is mantle-derived. $^3He/^4He$ versus $CH_4/^4He$ ratios provide evidence of two-component mixing between crustal and magmatic end-members. Extrapolation of the linear regression line to $CH_4/^4He = 0$ gives a hypothetical magmatic end-member $^3He/^4He$ ratio of 3.84 R_A, half the typical mantle ratio. This indicates that the magmatic end-member may actually represent a mixture of mantle and crustal helium. Gases which deviate from the simple two-component mixture can be explained by addition of pure methane, radiogenic ^4He, or a high N_2-He component with $^3He/^4He = 0.6\ R_A$ to 1.0 R_A. The $CH_4/^3He$ ratio of the magmatic end-member remains poorly constrained (0 to 3×10^9) and one cannot rule out the possibility that a significant proportion of the methane in some fields may be of deep-earth origin. However, fields with the highest $^3He/^4He$ ratios are associated with buried Plio-Pleistocene intrusives which have up-arched sediments to form hydrocarbon traps. The methane in these fields may have been produced by rapid thermal alteration of the intruded sediment. Elsewhere, the methane appears either to have migrated from deeply-buried sediments in the western basin or to have been produced by local microbial activity. (Authors' abstract)

POREDA, R., SCHILLING, J.-G. and CRAIG, H., 1986, Helium and hydrogen isotopes in ocean-ridge basalts north and south of Iceland: Earth & Planet. Sci. Letters, v. 78, p. 1-17. First author at Isotope Lab., Scripps Inst. Oceanography, Univ. California, San Diego, La Jolla, CA 92093, USA.

The concentration and isotopic composition of helium and hydrogen have been measured in submarine basalt glasses from the Mid-Atlantic Ridge between 52° and 73°N and in recent volcanic rocks from Iceland. Observations of "plume-type" $^3He/^4He$ ratios (R greater than the mean MORB value of 8 R_A) show that the effect of the Icelandic mantle plume on helium isotope ratios is observable along the entire length of the Reykjane Ridge (R = 11-16.1 R_A) and to 70°N on the Kolbeinsey Ridge (R = 10.3-12 R_A). These two ridges are unique among all mid-ocean ridge segments so far studied in possessing high $^3He/^4He$ ratios along their entire length. North of 70°N, basalts associated with the Jan Mayen province (based on major element chemistry) have $^3He/^4He$ ratios somewhat lower than the MORB average (R = 6.8-8.0 R_A) and similar to other alkali-enriched provinces such as the Azores Platform. In detail, however, the $^3He/^4He$ distribution does not correspond to trace element variations. A maximum ratio of 16.1 R_A is present near 60°N on the Reykjanes Ridge; north of this point, toward Iceland, the ratio decreases to a minimum of 12.7 R_A at 63°N. The $^3He/^4He$ ratios increase again on Iceland, reaching a maximum in south-central Iceland. In the area between 60° and 63°N, the $^3He/^4He$ ratios tend to be inversely correlated with La/Sm and $^{87}Sr/^{86}Sr$, which suggests that the isotopic heterogeneities beneath Iceland and the Reykjanes Ridge are long lived (>10^8 years).

The concentration and hydrogen isotopic composition of the water in this suite of basalts display a good positive correlation with trace element data (e.g., La/Sm). Between 61°N and 63°N on the Reykjanes Ridge, the water concentration in the basalt is high (0.22-0.41 wt. %) and its isotopic composition is enriched in deuterium (δD = -61 to -74‰; with one extreme value to -50‰), relative to MORB levels (0.2 wt.% and -77‰). South of 61°N, both the concentration and isotopic composition of water are normal MORB values (0.11-0.25 wt.% and δD = -71 to -91‰). The Mohns Ridge basalts have elevated water concentrations (0.37-1.23 wt.%) and an isotopic composition (-44 to -60‰) which is unique among all MOR basalts so far studied. It remains to be seen if these high δD values represent a "primary" mantle water, distinct from the MORB source, or "secondary" water, the result of recycling during subduction. (Authors' abstract)

PORITSKAYA, L.G., KRIVOVICHEV, V.G., 1985, T-P-X parameters of formation of rare alkali-metal metasomatites, according to the data of study of inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 211-212 (In Russian; translation by Dorothy B. Vitaliano). Authors at Leningrad State Univ., Leningrad, USSR.

During the formation of pegmatites, the rocks containing them are subjected to intensive metasomatic reworking.

In the minerals of the rare alkali-metal metasomatites, inclusions of three types have been identified: gas-liquid, gas liquid with a solid phase, and inclusions with CO_2. P inclusions were taken to determine the physicochemical parameters of the mineralizing medium. From inclusions of gas + liquid + halite, the T of formation of the quartz (about 300°C) and P (about 1 kbar) were estimated (Piznyur, 1973). The calculated density of CO_2 in CO_2-bearing inclusions from quartz made it possible to estimate the P as 3 kbar (Tomilenko, Chupin and Dolgov, 1976). For the first time, P GLIs (30% gas phase) were found in holmquisite from a metasomatically reworked xenolith of the country rock in a pegmatite vein. Th (L) of these inclusions was 520-570°C (without correction for P).

The salt composition of the mineralizing solutions was determined by the methods of cryometry of P inclusions and aqueous extracts from quartz from the trailing zone of the metasomatic column. Te of the inclusions (-55°C) indicates a eutectoid composition of the solution within the system $NaCl-CaCl_2-H_2O$. The relationship of the Te (from -24.4 to -23.2°C) and Tm (-4.5°C) of the contents of the inclusions suggests that the concentration of NaCl in the inclusions was about 6%. The following concentrations of the main components in the mineralizing solutions were obtained by the method of aqueous extracts, taking into account the water content in the inclusions: Na 0.75, K 0.27, Li 0.16, Pb 0.002, Ca 0.05, Mg 0.13 g/ion-liter [sic]. No sulfur was found in the extracts.

On the whole the T range of formation of the rare alkali-metal metasomatites is 650-300°C, with a drop in P from 3 to 1 kbar.

These data were used to calculate the activity of the components in solution, needed for constructing a quantitative physicochemical model of the formation of rare alkali-metal metasomatites. (From the authors' abstract).

PORTER, E.W. and JAMES, W.C., 1986, Influence of pressure, salinity, temperature and grain size on silica diagenesis in quartzose sandstones: Chem. Geol., v. 57, p. 359-369.

POTY, B., 1986, Fluid inclusion studies as a tool in uranium metallogeny (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 19. Author at CREGU, BP 23, 54501 Vandoeuvre les Nancy Cedex, France.

Despite the fact that uranium ores are usually not a good material for fluid inclusion studies, a rather large number of works have been performed on this subject during the last 20 years.

Nearly all types of deposits have been examined, except the surficial ones. They range from Archaean (Witwatersrand) to lower Proterozoic (Oklo), middle Proterozoic (Saskatchewan and Pine Creek), later Hercynian (western Europe), Mesozoic or Cenozoic (shales and sandstones in many countries), among others.

Used techniques have been largely microthermometry, crushing and leaching for ion analyses, gas chromatography and Raman spectrometry. Unfortunately trace analyses of metals have not been performed very often.

The frequent absence of gangue minerals in uranium deposits does not generally permit pinpointing of the transporting and depositing fluids, but rather fluids which are spatially associated to ore. Th of these fluids are varied, from very low, close to normal, to more than 400°C. Chemical compositions are also very diverse: dilute to concentrated solutions, gas-rich to gas-poor. No precise mechanism of deposition has been demonstrated yet. The data obtained from fluid inclusion studies do not give any exploration guide but are nevertheless essential for improving our understanding of the geological framework in which uranium ore deposits are fitted. They are, in this respect an important tool in uranium metallogeny and thus help uranium exploration. (Author's abstract)

POTY, B., LEROY, J., CATHELINEAU, M., CUNEY, M., FRIEDRICH, M., LESPINASSE, M. and TURPIN, L., 1986, Uranium deposits spatially related to granites in the French part of the Hercynian orogen, in Vein type uranium deposits, IAEA - TECDOC-361, p. 215-246. First author at CREGU, Vandoeuvre-les-Nancy, France.

During the last ten years, a number of research projects have been conducted on the French part of the Hercynian orogen especially on the vein-type U deposits. This paper is a review of the new concepts worked out on this type of U occurrences.

Sources for U mobilization and metallogenic stages appear to be more diversified and complex than suggested in previous models. In particular, an intermediate stage of U concentration, structurally controlled, occurring at a late magmatic stage and related to U enriched fine grained intrusions has been discovered in the Saint-Sylvestre and Bois Noirs granites. U metallogenesis for vein-type deposits appears now to occur during four main periods: Middle Palaeozoic, Early Permian, Jurassic, and Alpine to the present day. The physicochemical conditions of 'episyenites' formation and U deposition have been largely revised by additional mineralogical and fluid inclusion studies, and by the development of stable and radiogenic isotope measurements. Origin of the fluids related to 'episyenitization' and U mineralizations has been outlined. All these studies have considerably reinforced the hydrothermal genetic model for the Hercynian vein-type U mineralizations. (Authors' abstract)

PRADHANANGA, IKEDA, Y. and MATSUO, S., 1986, Fractionation of hydrogen and oxygen isotopes in some crystal-aqueous solution systems (abst.): Terra Cognita, v. 6, no. 2, p. 262.

PRASOLOV, E.M., SEMENOV, V.S. and TRAVNIKOVA, L.G., 1985, Occurrence of hydrocarbon gases in parametamorphic rocks of Antarctica: Doklady Akad. Nauk SSSR, v. 283, no. 3, p. 687-690 (in Russian).

Cited in Naumov, 1986 (this volume).

PRATT, L.M., BURRUSS, R.C. and OLSEN, P.E., 1986, Petroleum generation and migration in Lower Jurassic sequences, Hartford basin, Connecticut and Massachusetts (abst.): AAPG Bull., v. 70, p. 635. First author at U.S. Geol. Survey, Denver, CO.

The Hartford basin is one of a series of elongate fault-bounded basins in eastern North America containing Triassic and Jurassic sedimentary rocks. The Lower Jurassic Shuttle Meadow and East Berlin Formations contain 8 to 10 deep-water lacustrine cycles (1-1.5 m thick) composed of gray silty mudstone and black laminated shale.

Temperatures of maximum pyrolytic yield (Tmax) and hydrogen indices (HI) of 66 samples of shale and siltstone (TOC = 0.9-3.8 wt. %) from the Shuttle Meadow and East Berlin Formations indicate sharply decreasing thermal maturity from north to south. In Massachusetts and northern Connecticut, these units have T(max) >460°C and HI <50 mg/g, indicating potential for gas but overly mature for oil. In central and southern Connecticut, T(max) is 445°-425°C and HI is 150 to 440 mg/g, indicating moderate to good oil potential. The less mature shales have solvent extract yields of 1,500-3,100 ppm. N-alkanes are smoothly distributed with a maximum between n-C_{17} and n-C_{19}, typical of good petroleum source rocks.

Bitumen-coated calcite spar in jointed Holyoke Basalt, and silica and carbonate cements in a concretion from the East Berlin Formation contain aqueous liquid and vapor inclusions and abundant petroleum inclusions. The petroleum inclusions variously contain fluorescent hydrocarbon liquid, nonfluorescent brown solids (bitumen), vapor, and rarely, aqueous liquid. Preliminary measurements of homogenization temperatures are 75°-115°C. The regional setting, presence of bitumen-coated fractures, and occurrence of petroleum liquids in fluid inclusions with temperatures in the range of the oil window demonstrate generation and migration of oil during maturation in the Hartford basin. (Authors' abstract)

PRATT, L.M., VULETICH, A.K. and BURRUSS, R.C., 1986, Petroleum generation and migration in lower Jurassic lacustrine sequences, Hartford basin, Connecticut and Massachusetts (abst.): USGS Circular 974, p. 57-58.

Extraction yields are 1,800 to 3,100 ppm for the black lacustrine shales. The n-alkanes have a smooth distribution with a maximum between n-C_{17} and n-C_{19}. Pristane/phytane ratios are about 1.6. The distribution of n-alkanes and biomarkers in the extractable portion of the "solid" bitumen from the Holyoke Basalt is indistinguishable from that of the shale extracts. The extractable portion of the "sticky" bitumen contains n-alkane with slight even-carbon predominance from n-C_{18} to n-C_{24}, but the distribution of biomarkers is similar to that of the shale extracts. Two-phase, liquid and vapor fluid inclusions in cements adjacent to both types of bitumen contain brightly fluoresent hydrocarbons. ...

The presence of hydrocarbon liquids in fluid inclusions demonstrates at least local generation and migration of petroleum in the Hartford basin. (From the authors' abstract)

PREECE, R.K., III, 1986, Intrusive-hosted alteration and mineralization within the Morenci porphyry copper deposit, Arizona (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 722. Author at Geol. Dept., Phelps Dodge Morenci Inc., Morenci, AZ 85540.

Hydrothermal alteration and mineralization at Morenci is associated with a 59-58 m.y. intrusive complex composed of biotite monzonite porphyry and later granite porphyry. Adjacent to both intrusions, Cu-Zn skarns occur in Paleozoic sediments while Precambrian granite and granodiorite host dikes and attendant Cu-Mo stockwork mineralization. Crosscutting relationships indicate that temporal variations of vein-controlled mineral assemblages are essentially identical in the various Laramide and Precambrian intrusive rocks. Early, sulfide-deficient potassic alteration is characterized by quartz + k-feldspar that is preceded by biotite in more mafic lithologies. Pyrite + chalcopyrite ± bornite mineralization is associated with quartz ± sericite and, along with pyritc quartz + sericite, overprint potassic and paragenetically intermediate molybdenite veins.

Potassic and molybdenite veins exhibit shallow dips and multiple, weakly-defined preferred strike orientations, while later quartz + sericite + pyrite veins show strongly-preferred NNE to NE strikes with steep NW dips. Vein densities at current mining levels average 0.2-0.5 cm^{-1} for phyllic veins and, where present, 0.05-0.15 cm^{-1} for potassic veins, and 0.004-0.02 cm^{-1} for molybdenite veins.

Fluid inclusion studies indicate that low to moderate salinity fluids (2-15 wt. %) were associated with sulfide deposition, while hypersaline brines (30-45 wt. %) were present in early potassic veins. Homogenization temperatures generally decrease with younger paragenetic position: 330-450°C in potassic veins, 310-360°C in molybdenite veins, and 290-330°C in pyritic phyllic veins. Homogenization temperatures from quartz + sericite + chalcopyrite veins are 340-370°C. Coexisting vapor-rich and liquid-rich inclusions indicate that boiling occurred at 375-410°C and at pressures of 200-300 bars. (Author's abstract)

PREZBINDOWSKI, D.R., 1986, Cementation and burial temperatures by oxygen stable isotopic and fluid inclusion analyses - A comparison (abst.): Terra Cognita, v. 6, no. 2, p. 111. Author at 3228 E. 15th Street, Tulsa, OK 74104.

The oxygen isotopic composition of carbonate cements can be used to determine T ranges of cementation. The precision of these T determinations is dependent on the availability of supporting geological information (i.e., depositional environment, paleolatitude, structural history, age of the sediment package and the oxygen stable isotopic composition of current formation water).

Fluid inclusions in calcite cements can be used to determine cementation and maximum burial T. Hydrothermal experiments have shown that fluid inclusions contained in naturally occurring calcite crystals will undergo reequilibration when subjected to T and P greater than entrapment conditions. This reequilibration occurs as a result of "stretching" of the fluid inclusions. Fluid inclusions formed in calcite during burial will record T which approach the maximum burial T of the rock. The degree of reequilibration is dependent on the size, shape and orientation of the fluid inclusions. The smaller fluid inclusions in a calcite crystal tend to undergo less reequilibration. Short term retrograde reequilibration of fluid inclusions is shown not to occur. (From the author's abstract)

PROKOF'YEV, V.Yu., NAUMOV, V.B., MIRONOVA, O.F. and ROSTOTSKAYA, N.M., 1985, The gas regime of polymetallic ore-formation in the Zyryanka area (Rudnyy Altay) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 99-101 (in Russian; translation by D.A. Brown). First author at Vernadskiy Inst. Geochem. & Anal. Chem. (GEOKhI AN SSSR), Moscow, USSR.

A study of the composition of the gases in mineral-forming solutions is essential for a better understanding of the origin of the polymetallic deposits of the Rudnyy (Ore) Altay. With this in mind, we have carried out an investigation of the P and PS inclusions in the minerals from ore parageneses in a number of deposits in the Zyryanka area: Maleyevsk, Zyryanka, Promezhutochnoye, and Platovsk.

The polymetallic ores were formed at T = 300-130°C from chloride solutions, containing Na, K, Mg, and Ca (Te = -38 - -28°C). According to cryometric data, the salt concentration was 18-7 wt % NaCl equiv. The pressure during the interval of ore-formation varied from 1.7 to 1.2 kbar. Later, quartz, quartz-carbonate, and quartz-barite veins and small copper deposits of the vein type were formed (Promezhytochnoye and Aleksandrovka) at T = 160-80°C from NaCl and KCl solutions (Te = -26 - -23°C). Their concentration varied from 15 to 6 wt % NaCl equiv. The pressure during this interval was 1.2-0.6 kbar.

The gas phase of the inclusions during the first stage has been studied by the cryometric method. From the melting temperature of CO_2 in inclusions in the minerals of the polymetallic phase (sphalerite and calcite), being -67.7 - -56.8°C, we concluded that significant quantities of substances with melting temperatures lower than in CO_2 were present in the gas phase. The appearance of gas-hydrates, existing above +10°C (up to +18.6°C) suggested the presence of CH_4 (not recorded in these materials up till now). On the basis of inclusions of regular shape, we estimated the concentration of CO_2 reached 6.2, and for CH_4 1.6 mol/kg of solution. From the reaction between CO_2 and CH_4, we calculated $f(O_2)$, which changed from -37 [presumably 10^{-37} atm.] for inclusions with Th 300°C to -45 with Th 200°C. As Th fell, so also did the Tm of the gas-hydrates (from +18.6 to -8.8°C), which points to the ongoing of the ore-process against a background of degassing of the solution. This is indicated by the presence of significantly gaseous inclusions in some samples. During the post-ore vein phase, the solutions contained virtually no gases (gas-hydrates dissolved at -2.8 - -11.0°C or are not observed at all).

Mineral samples with large gas content have been analyzed on a "Tsvet-1000" gas-chromatograph with a P-75 pyrolite attachment. These analyses showed the presence of CH_4, enabled us to determine the gas concentration (CO_2 and CH_4), and demonstrated the presence of inclusions of more complex hydrocarbons in substantial amounts in the solution. The overall gas content of the mineral-forming solution, obtained from the analyses, agrees well with the cryometric data.

The high concentrations of CO_2, CH_4, and more complex hydrocarbons in the solutions suggest the significant role of bicarbonate complexes during transfer of the ore metals and the involvement of metalloorganic compounds in this process. (From the authors' abstract)

PROKOF'YEV, V.Yu., NAUMOV, V.B., MIRONOVA, O.F. and ROSTOTSKAYA, N.M., 1986, Participation of hydrocarbons in the polymetallic ore formation of the Zyryanovsk region (Rudnyi Altai): Dokl. Akad. Nauk SSSR, v. 290, no. 6, p. 1490-1492 (in Russian). Author at Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

Ores of the deposits: Maleevskoe and Zyryanovskoe consist of sphalerite, galena, chalcopyrite, pyrite plus minor tetrahedrite, arsenopyrite and others; gangue minerals are calcite, quartz, tremolite, chlorite, sericite. The deposits belong to the polymetallic formation and are of hydrothermal-metasomatic origin. The data which were yielded by fluid inclusions are as follows (°C): *Maleevskoe deposit*, Ore Body No. 1, calcite (21 incl.) Th 235-190, Te -32.6 to -29.1, Tm ice -8.2 to -2.4, Tm CO_2 -57.3 to -56.6, Tm clathrate 7.2-5.6, Th CO_2 24.0-19.4; sphalerite (56 incl.) Th 180-130, Te -35.2 to -28.0, Tm ice -5.0 to -6.2, Tm CO_2 -59.6 to -57.4, Tm clathrate 11.5-11.2, Th CO_2 +9.0 to -3.6; *Zyryanovskoe deposit*, ore bodies: Aleksandrovskaya, Zavodskaya, Yugo-Vostochnaya, calcite (71 incl.) Th 300-145, Te -36.1 to -28.8, Tm ice -11.6 to -5.6, Tm CO_2 -67.8 to -57.5, Tm clathrate +18.4 to -8.8, Th CO_2 20.3 to 2.8; *same*, ore body Yugo-Vostochnaya, sphalerite (8 incl.) Th 172-142, Te -33.6 to -29.2, Tm ice -9.8 to -9.6, Tm clathrate -3.2, pressure about 1.2 to 1.7 kbar, salt concentration in inclusion fluids 7-17 wt. equiv. NaCl. Essentially CO_2-filled inclusions from heterogeneous trapping yield Th CO_2 in L from -20.8 to +10°C; the above P values were obtained from these data. From the volumetric calculations and phase changes on the basis of the Henry's law the amount of CO_2 and CH_4 dissolved in water solution was calculated, thus the concentrations of CO_2 and CH_4 in the ore-forming fluid were 5.4 and 1.6 mole/kg, respectively. From the CO_2/CH_4 ratio the fO_2 values were estimated for 10^{-35} at 300°C to 10^{-43} at 200°C. By gas chromatography (chromatograph Tsvet-1000 with the pyrolytic section) besides CO_2 and CH_4, significant amounts of C_2H_6 and heavier hydrocarbons (up to C_4) were found. The parent solutions contained also H_2, N_2 and ions of sulfur, HCO_3, Na and Ca. (Abstract by A.K.)

PROL-LEDESMA, R.M., 1986, Hydrothermal alteration patterns and fluid inclusions in Rotokawa geothermal field (drill hole RK-6), New Zealand (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 448-451. Author at Inst. de Geof., UNAM, Cd. Univ., 04510 Mexico, D.F., Mexico.

Homogenization temperatures were measured for inclusions in crystals of calcite and quartz. In samples from 261, 1364 and 2280 m Th show only one group of inclusions with a mean temperature about 10°C higher than the down hole temperature measured after 6 weeks shut-in. On the other hand, fluid inclusions from depths 1175 and 1612 m yielded two groups with different mean values for their Th. The largest difference between the two groups was for 1175 m of depth - where the main feeding zones are located according to data from the first discharge ejecta.

Tm ice show low values of %eq NaCl, those from the deepest sample being the highest (-0.6°C, i.e., 1.05 %eq NaCl). The lowest salinity 0.35 %eq NaCl (-0.2°C) was measured for inculsions from 1364 m depth. When analyzing the data from 1175 and 1612 m samples, where two groups of inclusions can be identified, it was observed that in both cases the group with lower temperature has a higher mean value of %eq NaCl (0.7% NaCl, i.e., (-.4°C), while higher temperature inclusions have a lower mean value of %eq NaCl (0.5% eq NaCl, i.e., -0.3°C). (From the author's text)

PRUSHINSKAYA, E.Ya. and MANUCHARYANTS, B.O., 1985, Essential geologic-genetic models of gold-antimony deposits of the Eastern USSR: Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 3, p. 123-124 (in Russian). Cited in Naumov, 1986 (this volume).

PUKHNAREVICH, M.M., NAUMOV, V.B., BANNIKOVA, L.A. and DEVIRTS, A.L., 1985, Genesis of mineral-forming fluids and sources of ore substance at the Korshunovo iron-ore deposit (South of the Siberian Platform): Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 1, p. 141-143 (in Russian). Cited in Naumov, 1986 (this volume).

QIAN, Kai, 1986, Fluid inclusions in authigenic minerals in Tertiary sedimentary rocks and oil and gas prospecting in red beds in Qaidam Basin: Oil & Gas Geol., v. 7, p. 1-11 (in Chinese; English abstract). Author at Res. Inst. Geol., Shengli Oil Field, PRC.

Usually there are three kinds of fluid inclusions in Tertiary sedimentary rocks in Qaidam Basin: P, S and hereditary. Among them the most important information for oil and gas exploration are provided by P fluid inclusions formed in diagenetic stage. The pressure measurement of the inclusions indicates that there is an abnormal high pressure body in the lower Ganchaigou Formation in the south part of the western Qaidam Basin. Oil pools of the red beds just preserved in this body. The reservoir voids are mainly residual primary pores and non-fractured secondary pores in sandstone. So many pores could be preserved because the abnormal high pressure of pore fluids keep quartz and felspar from pressure-solution and the impermeable beds block the outside siliceous solution source. So the quartz and feldspar cannot overgrow. Oil composition show that source rocks are mainly lateral lacustrine synchronous deposits of the red beds, while oil from overlying and underlying source rocks cannot enter the trap in large quantity. According to the temperature determination of fluid inclusions, the oil generated and entered the trap when paleotemperature was 78°C. It is 26°C lower than the threshold temperature calculated formerly. If other conditions remained constant, the quantity of oil generated in western Qaidam Basin should be much more than that calculated. The time of generation, migration and accumulation of oil and gas might start approximately from the Late Miocene and continued to the Late Pliocene. (From the author's abstract)

QUIRK, D.G., 1986, Genesis of the South Pennine ore field (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 20. Author at Geol. Dept., Univ. Leicester, Leicester, LE1 7RH, UK.

The South Pennine ore field consists of vein, replacement and cavity-fill ore bodies occupying the eastern half of an inlier of Lower Carboniferous limestone in North Derbyshire. The deposits contain fluorite, barite, calcite, galena, sphalerite, and minor iron sulphides formed at temperatures of about 80-100°C. The northern part of the ore field is traversed by long sinuous veins that occupy wrench faults formed during WNW-ESE compression and uplift in mid-Carboniferous times. Basin development during the Upper Carboniferous led to formation of a strong joint pattern throughout the ore field. At about 2 km depth the fractured limestone began to dilate and overpressured, late diagenetic fluids from the Namurian shales directly above the limestone began to circulate within the open fissures. Mineral formation was due to simple reactions between wall rock and ore fluid. Further south the corrosive nature of the ore fluids is well illustrated by stratiform ore bodies that were built up by a process of overhead dissolution, metasomatism and crustiform growth. (Author's abstract)

RAFAL'SKIY, R.P., 1985, Solubilities of heavy-metal sulfides and their deposition from hydrothermal solutions: Geokhimiya, no. 7, p. 988-1002 (in Russian; translated in Geochem. Int'l., v., 23, no. 1, p. 68-82, 1986).

RAFAL'SKY, R.P. and ALEXEYEV, V.A., 1986, Kinetics of interaction of silicates with aqueous solutions: Geokhimiya, 1986, no. 10, p. 1452-1463 (in Russian; English abstract).

RAFAL'SKY, R.P., PRISYAGINA, N.I., ALEXEYEV, V.A., KRIGMAN, L.V., FEDOROV, P.L., MEDVEDEVA, L.S., BRYZGALIN, O.V. and YUDIN, E.I., 1986, Experimental study of interaction of amphibolite with aqueous solutions at 250°C: Geokhimia, 1986, no. 11, p. 1570-1587 (in Russian; English abstract).

Dependences of pH and concentrations of K, Ca, Mg and Si in solutions, interacting with amphibolite at 250°C, on pH and composition of the initial solution (NaCl, NaCl+HCl, HCl), value of water-rock interface and duration of experiments were under study. The interaction process is controlled by complex of chemical reactions the relative role of which varies depending on the experiment conditions. Under action of neutral and weakly acid solutions of NaCl on amphibolite the system reaches soon the partial equilibrium in relation to silica which content is lower than the corresponding solubility of quartz. If the interface value is rather large in some cases partial equilibrium in relation to hydrogen ions is reached. Concentrations of K and Ca passing into NaCl solutions as a result of exchange reactions are not at equilibrium; their passing into the solution is limited by formation of the protective layer of the reaction products on the hornblend surface. (Authors' abstract)

RAFAL'SKY, R.P., PRISYAGINA, N.I. and KRIGMAN, L.V., 1986, Experimental study of interaction of gneiss with aqueous solutions at 250°C: Geokhimiya, 1986, no. 12, p. 1743-1754 (in Russian; English abstract).

RAJ, Rishi, 1986, Unstable spreading of a fluid inclusion in a grain boundary under normal stress: J. Am. Ceram. Soc., v. 69, p. 708-712. Author at Dept. Materials Sci. & Engrg., Bard Hall, Cornell Univ., Itahca, NY 14853.

A fluid inclusion trapped in a stress-free grain boundary will assume an equilibrium lenslike shape. The dihedral angle at apex will be determined by the ratio of the (isotropic) solid-solid and solid-liquid interface energies. The radius of curvature of the lens surface will depend on the volume of the inclusion. If a normal stress is now applied across the interface, then the mechanical energy (equal to the sum of the external work and the strain energy) and the interface energy will together determine the shape of the inclusion. In this paper it is shown that the inclusion can spread catastrophically if the applied stress is greater than a critical value. The magnitude of the critical stress depends on the equilibrium dihedral angle and the volume of the inclusion. A smaller angle and a larger volume lead to a smaller value of the critical stress. As an example a fluid inclusion which is ≈ 1 μm in size and forms a dihedral angle of 15° is unstable under an applied stress of 100 MPa. The results have significance in the phenomenon of liquid-phase-enhanced sintering and diffusional creep. (Author's abstract)

RAJLICH, P., BENEŠOVÁ, Z., ČADEK, J., LENK, J. and ŠMEJKAL, V., 1986, Fluorite metasomatic deposit Chulut Cagan Del, Central Mongolia: Sbor. Geol. Věd, Ložisk. Geol., Mineral., v. 27, p. 233-292 (in Russian; English abstract).

The study contains metallogenic interpretation of the geological, geochemical and isotopic data along with results of fluid inclusion study of precretaceous metasomatic fluorite deposit Chulut Cagan Del. The deposit is situated in the Central Mongolia about 30 km of Ulan Bator and belongs to a great central Asiatic fluorite province. Th of fluid inclusions were determined in the pegmatite fluorite (225-245°C). The highest Th in the metasomatic bodies were found in the early black fluorite (160-215°C). The later stages yielded T from 97 to 177°C, the pale violet fluorite from 73 to 105°C. The approximate salinity determined of fluids from the pegmatites is 8 wt. % NaCl eq. and from metasomatic bodies is very low (<1 wt. % NaCl eq.). The source of fluorine is considered to be in granite enriched during pneumatolytic activity and greisenization process. During the tectonomagmatic activity in Cretaceous F was leached by the activity of alkaline vadose water and deposited as metasomatic bodies of fluorite in Proterozoic limestones. (From the authors' abstract, by J. Ďurišová)

RAKHMANOV, A.M., 1985a Physicochemical conditions of scheelite formation in the rare-metal skarn deposits of Central Tadzhikistan, (on the basis of inclusions of the mineralizing solutions) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 147-148 (in Russian; translation by Dorothy B. Vitaliano). Author at TGU [Tadzhik State Univ. or Tadzhik Geol. Admin.].

In Central Tadzhikistan, scheelite-bearing skarns are extensively developed and are high-temperature post-magmatic formations, genetically related to Hercynian intrusions.

The temperature range of scheelite mineralization was established as a result of detailed investigations of gas-liquid inclusions of the mineralizing solutions. In the scheelite of several deposits in the Gissar and Zeravshan ranges the following inclusions were found, on the basis of aggregate composition and origin: primary and pseudoprimary [pseudosecondary?] essentially gaseous (gas 60-70%), three-phase CO_2 (gas 10-30%, CO_2 60-90%), three-phase gas-liquid with a solid phase (halite, sylvite) and two-phase (gas 30-40%), and also secondary gas-liquid inclusions (gas 10-20%).

Homogenization of the two-phase primary inclusions of type ($L_W < G$) to the gas phase occurs at 450-480°C. Solution of easily soluble solid phases, consisting of halite and sylvite, occurs at 180-140°C. Difficultly-soluble phases of the inclusions (sulfides, oxides) undergo no essential change even at temperatures of 450-520°C. Secondary inclusions have Th = 240-160°C. The pressure in the mineralizing environment was calculated by the Nacken-Kalyuzhnyi method from inclusions with CO_2. The pressures calculated from these inclusions are 750-850 atm. The chemical composition of the solutions in the inclusions was investigated by the method of triple aqueous extraction.

Na, K, Mg and Ca were established in order of increasing[sic] concentration. The anions were CO_3^{2-}, SO_4^{2-}, Cl^-, F^-, and HCO_3^-, in the same order. Evidently the solutions were characterized by a slightly alkaline (pH = 8.3) essentially F and F-Cl-HCO_3 composition. In increasing order, Ti, Mg, Fe, Na, Ca[sic], Al, and Si were established by spectrographic analysis of dry residues from evaporation of the aqueous extract.

Investigation of the gases in the inclusions in the scheelite-skarn mineral parageneses of the rare-metal deposits of this region made it possible to bring out several general space-time regularities in the composition of the volatile components of the ore-forming fluids and their metallogenetic specialization. In the quartz-scheelite and skarn-scheelite stages of ore formation, the content of CO_2 increases appreciably, reaching

95-99%, and that of N_2, CH_4 and H_2 appreciably decreases. A direct relationship between the concentration of CO_2 in the ore-forming solutions and scale of scheelite mineralization was established. Thus the volatile components which saturated the mineralizing fluids to different extents can affect the geochemical activity of the ore-bearing solutions and contribute to their metallogenetic specialization, under certain geologic-structural and physicochemical conditions of variation of the P-T-X parameters of the environment. (Author's abstract)

RAKHMONOV, I.U., 1985, Temperature conditions of formation of the metasomatites of the southern Gissars (central Tadzhikistan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 210 (In Russian; translation by Dorothy B. Vitaliano). Author at Tadzhik State Univ., Dushanbe, USSR

To determine the T conditions of formation of these metasomatites, GLIs in garnet, quartz, calcite, fluorite, barite, etc. were studied. Analysis of thermometric data on these minerals shows that the neogenic minerals in the regional metasomatites crystallized in a broad T range, from 600°C to 220°C. The wall-rock metasomatites (according to the data of A. R. Fayziyev) were formed in the T range of 450-50°C (orthoclasites at 450-300°C, propylites at 400-200°C, albitites at 400-150°C, and argillizites at 150-50°C).

Thus the metasomatic processes in the region began at high T, on the order of 600°C and possibly more, and ended at low T. The highest-T processes of metasomatism accompanied shows of rare metals, and the lowest T deposits of fluorite, Hg and Sb. (From the author's abstract).

RAMAN, S.V., 1986, Liquid phase separation and interface repulsion in the system diopside-albite (abst.): EOS, v. 67, p. 415.

RAN, Chongying, 1986, Environmental significance of algal stromatolites and their relation to copper ore in the Luoxue formation of the Kunyang group in Dongchuan, Yunnan (abst.): Canadian Miner., v. 24, pt. 1, p. 201. Author at Dept. Geol., Kunming Inst. Tech., Kunming, China.

It has been proven that the stratiform copper deposits formed essentially during diagenesis. Recently, through the study of fluid inclusions in minerals from the Luoxue stratiform copper deposits, we have discovered that there was a hot brine with T of 170-220°C and a salinity of 16.5% in this region. This brine permeated the host rock during diagenesis and played an important part in the lixiviation, resolution and removal of copper, i.e., in the genesis of cupriferous beds formed by sedimentary-diagenetic processes. (From the author's abstract)

RANAWAT, P.S. and DASHORA, R.S., 1986, Paragenesis and fluid inclusion study of fluorspar associated with volcanic rocks of Karara, India, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 81-86. First author at Dept. Geol., Univ. Rajasthan, Udaipur, India.

Fluorspar mineralization occurs in pyroclastic and to lesser extent in flow rocks of volcanic vent near Karara, Rajasthan, northwestern India. The volcanic rocks of western Rajasthan belong to Malani suite, 505-735 m.y., and represents the largest silicic volcanic activity in India. The pyroclastic rocks near Karara are volcanic breccia, lapilli tuff, and welded tuff including ignimbrite. Flows of mafic to silicic rocks are present. Three distinct stages of fluorspar mineralization are present as cavity filling. Two-phase primary fluid inclusions having high degree of fill are present. Th: Stage-I: 110°-240°C, Th: Stage-II: 50°-130°C. Mineralizing fluids had low salinity, 2.25 ± 1.99 equiv. wt % NaCl. Phenocrysts in the saturated volcanic rocks contain melt inclusions (glass +

vapor bubble), Th: 1050 ± 50°C. (Authors' abstract)

RANAWAT, P.S. and NAUMOV, V.B., 1986, Microthermometry of fluid inclusions in octahedral fluorite from Chokri, India (abst.): Terra Cognita, v. 6, no. 3, p. 510-511. First author at Dept. Geol., Univ. Rajasthan, 51 Saraswati Marg, Udaipur-313001, India.

Aggregates of color-zoned octahedral crystals of fluorite occur in post-Dehli tonalite (1010 m.y.), quartz reefs (quartz-I), and hornblendite located between the villages of Chowkri and Salwari (27°40'00"N/75°37'00"E), India. The order of mineral deposition is: quartz-I, fluorite, calcite quartz-II. Primary fluid inclusions (FIs) in fluorite contain an aqueous phase + vapor bubble ± halite. In green fluorite, the FIs are of regular shapes, mostly tetrahedral (hemihedral form of octahedron) while, in purple fluorite or purple zones in green fluorite, they are of irregular outline. The FIs are low in abundance but fairly large (100 μm). A characteristic feature of these FIs is hydrohalite instability and precipitation of halite from the frozen matrix. Based on cryoscopic observations and phases present at room temperature, the fluid inclusions can be grouped into the following three types:

Type of FI	Phases at RT	Te(°C)	Tm_{ice}(°C)	Tm_{NaCl}(°C)	Th_{l-v}(°C)	Remarks
Type I	l+v	-52 to -45	-28 to -22	-10 to +21	120 to 190	Freeze to dark brown phase. In rare cases, NaCl persists up to RT.
Type II	l+v+h	-52 to -45	-28 to -22	80 to 170	130 to 230	Freeze to dark brown phase, more than two NaCl crystals after melting.
Type III	l+v	Uncertain, but less than that of Types I and II, -45 to -23	-26 to -2	-	110 to 190	Freeze to light brown to colorless phase with reduction in size of vapor bubbles.

Quartz-I contains multiphase inclusions while quartz-II contains FIs with a variable degree of fill and a variable proportion of an acicular, entrapped phase which also occurs as solid inclusions in quartz. Calcite contains two-phase inclusions having low salinity.

This fluid inclusion study shows that the bulk of fluorite mineralization was brought about by solutions nearly saturated in NaCl and having a high $CaCl_2/NaCl$ ratio. A drop in salinity of mineralizing fluids is noted from quartz-I (>60% TDS) to calcite (~3 equiv. wt.% NaCl). The range of salinity for fluorite mineralization is 31 to 5 equiv. wt.% NaCl. Basal sections of larger crystals (up to 10 cm across) show a drop in salinity from core to margin. Significant variation of Th is, however, not observed. Fluorine-bearing solutions, genetically related to granitic activity, leached calcium from the granitic host rock resulting in depletion of its calcium content. The host rock shows a tonalitic composition with Fe_2O_3 >FeO. (Authors' abstract)

RANAWAT, P.S. and SHEKHAWAT, M.S., 1986, Fluid inclusion study of apatite associated with talc in an ultramafic belt west of Udaipur, India (abst.): Terra Cognita, v. 6, no. 3, p. 511. Authors at Dept. Geol., Univ. Rajasthan, 51 Saraswati Marg, Udaipur-313001, India.

Two talc deposits containing cogenetic apatite were selected for fluid inclusion study to ascertain the P-T-X conditions of steatitization in the area.

The talc lenses have a thin enveloping zone of chlorite followed by a zone of phlogopite. An outermost zone of talc-tremolite is present in some of the bodies. A talc lens near the village of Khakar, at the southern end of the belt, contains disseminated crystals of green apatite up to 15 cm in length. Apatite crystals also occur in chlorite and phlogopite zones but they are absent outside these zones. Veins of apatite have not been observed. Based on mode of occurrence, distribution of apatite and petrographic features, it is concluded that apatite is cogenetic with talc. These apatite crystals contain H_2O-CO_2-bearing, small (<20 µm), P fluid inclusions of perfect hexagonal outline. About 15 km north of this deposit, in a second talc lens near the village of Undithal, yellow crystals of apatite have been observed. They contain fluid inclusions of irregular to semiregular shapes. Fluid inclusion data on apatite samples from both these lenses are tabulated below:

Sample	Phases	Average density CO_2 (g/cc)	Average Tm(CO_2)(°C)	Salinity (Eq.wt.% NaCl)	Average Th(l+v)
Undithal Yellow apatite, talc zone	H_2O+v	–	–	3.8	210
Khakar Green apatite, talc zone	$H_2O+CO_2(l)+CO_2(v)$	0.759	-57.6	-	232
Green apatite, chlorite zone	$H_2O+CO_2(l)+CO_2(v)$	0.897	-59.3	-	245
Green apatite, phlogopite zone	$H_2O+CO_2(l)+CO_2(v)$	0.871	-64.8	-	233

XRD data show that the yellow apatite is fluor-apatite whereas the green apatite is hydroxyl-apatite.

Talc in the area formed due to metamorphism of ultramafic rock, and the metamorphic fluids supplied calcium and aluminium as indicated by the presence of tremolite, apatite and chlorite. On the northern side of the belt the fluids were devoid of CO_2 and had low salinity, whereas on the southern side the presence of CO_2 (5-15 mole %) is confirmed. CH_4 content decreases from the phlogopite zone to the talc zone. The fluid inclusion data and the relevant mineral assemblages show that the steatitization of impure ultramafic rock was brought about under varying x(CO_2) conditions in the range 550-600°C and at P about 3 kb. (Authors' abstract)

RANGANATHAN, Vishnu, 1986, Diffusion of dissolved NaCl from evaporites in sedimentary basins (abst.): EOS, v. 67, p. 274.

RANKIN, A.H. and ALDERTON, D.H.M., 1985, Fluids in granites from southwest England, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 287-299. First author at Dept. Geol., Imperial College of Sci. & Tech., London, England.

Fluid inclusions in quartz from the granites of S.W. England show a remarkable range of Th and salinities (from <70°C to >550°C and from 0 to >50 wt % NaCl eq.). Distinctive Th vs. salinity plots typify different granite samples. These form three broad linear trends. The first is a progression from high salinity fluids to fluids with lower salinity but higher Th. This trend typifies most of the unmineralized granites in the region. The second trend is a simple progression from high T and moderate salinities to lower T and salinities, and is characteristic of samples of intensely mineralized granite. The third trend, often superimposed on the other two, is a low T progression from high to low salinity (and vice versa). These thermometric data are discussed in conjunction with new data on the chemical composition of the inclusion fluids and models are presented for the evolution of the hydrothermal phase associated with granites througout the region. An important distinction can be made not only between mineralized and unmineralized granites, but also between different granite plutons. (Authors' abstract)

RANKIN, A.H., MILLER, M.F. and CARTER, J.S., 1986, The release of trace elements and volatiles from crystalline limestones during thermal decrepitation (abst.): Geol. Soc. Newsletter, v. 15, no. 2, p. 55-56. First author at Imperial College, London, England.

A suite of coarsely crystalline samples of Carboniferous Limestone adjacent to a PbS-CaF_2-$CaCO_3$ vein in the N Pennine ore field (Greenhow Rake) were analyzed by three independent methods (Inductively Coupled Plasma emission spectroscopy (ICP), Mass Spectroscopy (MS) and Gas Chromatography (GC)), in order to determine the nature and origin of trace elements and volatiles released on heating and thermal decrepitation, to establish whether fluid inclusions from the host limestone differed in composition from those within the vein, and to assess the value of the results obtained for mineral exploration. The ICP method gave reproducible results for Na and K, and significant values for Pb, Zn and Cu. Na and K correlate with H_2O and CO_2 levels determined by MS/volumetric analysis, suggesting their coexistence within fluid inclusions. No such correlation was found for Pb and Zn, suggesting that these elements were derived by volatilization from traces of galena and sphalerite. GC analysis revealed a range of hydrocarbons (up to and beyond C5 alkanes), again with no correlation with H_2O and a source other than fluid inclusions is thought probable.

The vein calcite showed much lower K/Na ratios (0.05 cf 0.1-0.2), higher CH_4 contents and lower H_2O contents than the limestones, and none of these parameters showed progressive changes away from the vein. The limestone-host fluids are believed to represent premineralization diagenetic fluids, unrelated to those associated with mineralization. It is concluded that ICP and MS techniques may be of considerable value for investigating samples where fluid inclusions may be too small for microthermometric and optical analysis. (Authors' abstract)

RASMUSSEN, J.D., CUNNINGHAM, C.G. and GAUTIER, A.M., 1986, Primary fluid inclusions in sphalerite from the Hack 1 and 2 mines, Mohave County, Arizona (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 404. First author at Energy Fuels Nuclear, Inc., Box 1320, Kanab, UT 84741.

Collapse breccia pipes penetrating Permian clastic and carbonate sedimentary rocks contain uraninite, often associated with chalcopyrite, pyrite, galena, tennantite, sphalerite, bravoite, gersdorffite, millerite, siegenite, and jordisite. Primary fluid inclusions in sphalerite related to crystal-growth features marked by color banding provide direct evidence of the P-T-X conditions at the time of deposition, the source of constituents, and the cause of deposition. Th of inclusions range from 93 to 115°C and salinity from 9.9 to 16.4 wt. % eq. NaCl and show no systematic variation with position in the deposit. Te which are between -24.0 and -21.7°C, suggest that the fluids are simple NaCl brines that could be derived from bedded halite rather than complex Ca-Cl or Mg-Cl residual bitterns. Fluid inclusions show no evidence of boiling, CO_2, or daughter minerals. Organic material (soft, black, bitumen) in P fluid inclusions, along growth planes, and in secondary fractures indicate that it was present in the hydrothermal fluids during and after the deposition of the sphalerite and may have been instrumental in the deposition of the ore. The T of the fluid was similar to that of Mississippi Valley deposit fluids, but the composition was not as saline. The fluids probably result from deep circulation along faults, solution of halite, and deposition by cooling, reaction with organic material, or mixing with less concentrated waters. (From the authors' abstract)

RAVENHURST, C., REYNOLDS, P., ZENTILLI, M. and AKANDE, S., 1986, Isotopic constraints on the genesis of the Gays River Pb-Zn deposit (abst.): Maritime Sediments & Atlantic Geol., v. 22, no. 2, p. 202. First author at Dept. Geol., Dalhousie Univ., Halifax, Nova Scotia B3H 3J5.

The Gays River deposit is the largest carbonate-hosted lead-zinc deposit known in the Mississippian Windsor Group of Atlantic Canada.

Ore-stage calcites are characterized by very uniform $\delta^{18}O$ and $\delta^{13}C$ values. The $\delta^{18}O_{smow}$ of water in equilibrium with these calcites at 170°C (the fluid inclusion Th) was +3.3‰. The δD of the fluid inclusion fluids is -39‰. The fluid isotopic composition indicates a basinal brine very close to the field representing typical Mississippi Valley-type deposits.

The ore fluid was probably completely reduced at the depositional site by organic compounds present. The isotopic composition of carbon in ore-stage calcites suggests that the carbon budget was dominated by this organic material. As expected in a reducing environment, ore-stage sphalerite and galena have $\delta^{34}S$ values which mimic the nearby (assumed source) sulfate rocks (= +14‰).

Our data so far suggest that the deposit formed epigenetically due to the influx of a hot sulfate-bearing, Pb-Zn-rich fluid from a clastic source, that was subject to reducing conditions of diminishing or fluctuating strength at the depositional site. (From the authors' abstract)

RAWSON, S.A., ALLEN, C.C., LANE, D.L. and HORTON, D.G., 1986, Effect of temperature and water-rock ratio on hydrothermal alteration of Columbia River basalts (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 2, p. 174.

READ, J.F., 1986, Cementation and dolomitization association with aquifers and burial fluids, Paleozoic carbonates, United States Appalachians (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 254. Author at Dept. Geol. Sci., Virginia Tech., Blacksburg, VA 24061, USA.

Sparry calcite cements associated with paleoaquifer systems in Paleozoic Appalachian carbonates have low Fe and Mn contents (few hundred ppm commonly), light oxygen isotope values, non-luminescent character, and stain pink. Aquifer systems were recharged at different times from the regional unconformities and from tectonic highlands. Aquifers were associated with widespread leaching of metastable carbonate grains in updip regions, and locally host sediments were dolomitized in the mixing zone. Non-luminescent calcite cements typify proximal and shallower parts of aquifers, whereas more Fe and Mn rich calcites formed deeper and more downdip, from reducing aquifer waters. These cements are precompaction, probably forming at depths of a few hundred meters.

As sediments became more deeply buried, influence of shallow aquifer fluids decreased, and cementation became increasingly dominated by basinal brines expelled during compaction, clay diagenesis and deformation. These later burial calcites commonly are Fe rich cements (generally 2000 ppm or more), commonly stain purple to blue, have depleted stable isotope values (reflecting precipitation at elevated temperatures from dissolved bicarbonate from pressure solution of meteoric and marine calcites, with some contribution from organic carbon). Burial history plots and fluid inclusion data suggest deposition of these cements at T from 50 to over 150 degrees C, from Na-Ca-Cl brines with salinities of 3 to 30 wt % salts. These cements locally coprecipitated with burial dolomite and locally are associated with MVT mineralization. Understanding the cementation history of this thick carbonate package has needed an integrated program of regional geologic analysis, petrography, and trace element and stable isotope geochemistry, coupled with a detailed knowledge of the basin evolution. (Author's abstract)

READ, J.J. and MEINERT, L.D., 1986, Gold-bearing quartz vein mineralization at the Big Hurrah mine, Seward Peninsula, Alaska: Econ. Geol., v. 81, p. 1760-1774. First author at Gold Fields Mining Corp., 1958 W. Parkway Blvd., Salt Lake City, UT 84119.

The Big Hurrah mine, located near Nome, Alaska, is an example of gold-bearing quartz vein mineralization in an uplifted metamorphic terrain. Five types of veins can be distinguished at the mine based upon structural style, mineralogy, and fluid inclusion populations. From oldest to youngest they are: type I, early quartz lenses; type II, tabular veins; type III, ribbon gold-bearing quartz veins; type IV, quartz-albite ± arsenopyrite veins; and type V, late carbonate-quartz veins.

Fluid inclusion studies indicate the presence of multiple generations of fluids which have evolved from early CO_2-CH_4-bearing fluids to later aqueous fluids with salinities of 2.1 to 6.6 equiv wt % NaCl. Fluid inclusion Th range from 390° to 90°C, decrease from early veins to late veins, and decrease with time in a single vein type. P and T estimates from S fluid inclusions in type I veins indicate that CO_2-CH_4-H_2O immiscibility may have occurred at 250°C and 0.8 kb. Au precipitation in type III veins may have been triggered by a change in pH associated with CO_2-CH_4-H_2O immiscibility, by a drop in T, or by reduction of the ore fluids by wall-rock C. The Big Hurrah deposit is broadly similar to other gold-bearing quartz vein deposits which occur in deformed metamorphic rocks and which are generally considered to have formed as a result of regional metamorphism. (From the authors' abstract)

REEVES, C.C., Jr. and TEMPLE, J.M., 1986, Permian salt dissolution, alkaline lake basins, and nuclear-waste storage, Southern High Plains, Texas and New Mexico: Geology, v. 14, p. 939-942.

REIF - See also REYF

REIF, F.G. and BAZHEEV, E.D., 1985, Determination of principles of ore-bearing molybdenum, tungsten, tin granites and their thermobarogeochemical features: Geol. Zb.--Geol. Carpathica, v. 36, no. 3, p. 375-384 (in English). Authors at Geol. Inst., Uhlan-Ude, USSR.

Analyses for Mn, Fe, Mo, and W, and temperatures of homogenization are given for fluid inclusions in quartz and fluorite from several deposits. The data offer useful guides to prospecting for deposits of Mo, W, and Sn of greisen type. (C.A. 104: 189966z)

REIMOLD, W.U., FLETCHER, P., SNOWDEN, P.A. and WILSON, J.D., 1986, Pseudotachylite - A general Witwatersrand Basin phenomenon! (abst.): Lunar & Planet. Sci. XVII, p. 701-702, Lunar & Planet. Inst., Houston. First author at BPI Geophys., Univ. Witwatersrand, Johannesburg, South Africa.

Includes photomicrographs of "fluid-inclusion decorated planar microfractures" in both Vredefort and Witwatersrand quartz clasts in pseudotachylite. See also next item. (E.R.)

REIMOLD, W.U. and HORZ, F., 1986, Textures of experimentally shocked (5.1-35.5 GPa) Witwatersrand quartzite (abst.): Lunar & Planet. Sci. XVII, p. 703-704, Lunar & Planet. Inst., Houston. First author at Bernard Price Inst. Geophys. Res., Univ. Witwatersrand, 1 Jan Smuts Ave., Johannesburg, 2001, South Africa.

Shows behavior of fluid inclusions in quartz of Witwatersrand quartzite after various degrees of experimental shock metamorphism. See also previous item. (E.R.)

REINTHAL, W.A., 1986, Geochemical evolution of precious metal mineralization in the Cracker Creek district of the Blue Mountains, northeastern Oregon: PhD dissertation, Univ. Wisconsin, 165 pp.

Precious metal occurrence in the North Pole-Columbia vein system is typified by coexisting pyrite and arsenopyrite with quartz or ankeritic carbonate, depending on the relative elevation of the ore horizon. Fluid inclusion study (Tt: ~300-350°C; $X(CO_2)$: ~0.3; salinity: ~3 wt.% NaCl eq.), combined with stable isotope analysis and field relations, has revealed a level of fluid unmixing where a CO$_2$-rich fluid separated from a water-rich fluid. Ores associated with this "boiling" horizon tend to be quartz-dominated sulfide ores. Ores at lower levels in the vein are carbonate and sulfide-banded. Phase equilibrium calculations between ankeritic carbonates and pyrite suggest that the lower level banded ore type can be explained by P release-induced dilution and cooling of the ore fluid. Maximum P estimates of 400 bars from sphalerite barometry (57 analyses: mean X(FeS) = .202) in Cable Cove have been corroborated by calculation of C-O and C-O-H-NaCl isochores from fluid inclusion data. This scenario is consistent with the system plugging and pressurizing at levels of massive mineralization associated with fluid unmixing, only to depressurize with consequent dilution/cooling through meteoric water influx from the wall rocks. Paragenetic traverses utilizing C-O-S systematics suggest an early, pre-ore, mineralization episode that was dominantly meteoric in character (δ^{18}O(fluid) ~-6) which matured into an ore-stage magmatic pulse (δ^{23}C(fluid) ~-6; δ^{18}O(fluid) ~+9; δ^{34}S(fluid) ~0), only to wane again into a progressively lighter, meteoric signature with time (δ^{18}O(fluid) ~0). H/D ratios indicate 3 probable fluid sources: 1) magmatic (δD(fluid) ~-70); 2) light meteoric (δD(fluid) ~-130), and; 3) heavy meteoric or exchanged seawater (δD(fluid): ~-40). These ratios suggest that mineralization occurred on the seaward flank of an arc-related volcanic edifice. (Author's abstract)

REN, Yingchen, CHENG, Minqing and WANG, Cunchang, 1986, Characteristics and vertical zoning of tungsten-bismuth minerals in the Pangushan quartz-vein type tungsten deposit of Jiangxi Province: Mineral Deposits, v. 5, no. 2(16), p. 63-74 (in Chinese; English abstract). Authors at Tianjin Geol. Acad., Ministry of Metallurgical Industry.

The Pangushan quartz-vein type W deposit has a great vertical extent and complicated ore mineral constituents characterized by obvious vertical zoning. Th values for quartz decrease from top to bottom. (E.R.)

RENDERS, Peter and ANDERSON, G.M., 1986, Solubility of beryl and kaolinite to 300°C (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 118.

REYF - See also REIF

REYF, F.G., 1985a Role of granitoids in ore formation and prognostication on a thermobarogeochemical basis (tungsten, molybdenum): Summary of the doctoral dissertation, Moscow Univ., 39 pp. (in Russian).

Cited in Naumov, 1986 (this volume).

REYF, F.G., 1985b Thermobarogeochemical criteria of connection of the hydrothermal deposits with granite intrusions: Criteria for distinguishing metamorphic vs. magmatic hydrothermal deposits: Scientific session, Ulan-Ude, Aug. 30-Sept. 1, 1983, Novosibirsk, p. 83-88 (in Russian).

Cited in Naumov, 1986 (this volume).

REYF, F.G., BAZHEYEV, D., ISHKOV, Yu.M., FIRSOVA, G.N., BONDOKHONOVA, T.A., 1985, Theory and practice of predicting W-Mo mineralization on a thermobarogeochemical basis (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 251- 252 (In Russian; translation by Dorothy B. Vitaliano). Authors at Geochem. Inst., Buryat Affil. Siberian Branch, Acad. Sci. USSR, Ulan-Ude, USSR.

The following regularities, established as a result of special investigations, are the basis of the thermobarogeochemical method of local prediction of W-Mo mineralization:

1. W, Sn-W, W-Mo, and Mo deposits and prospects in Transbaikalia and Central Kazakhstan are related to those granite intrusions in whose

development intensive fluid separation (magmatic distillation, after V. A. Nikolayev) began in the early stages of crystallization and involved large volumes of melt. This is established on the basis of accompanying fluid inclusions in early magmatic quartz of the granites (phenocrysts, central parts of quartz grains).

2. The magmatic distillate is the main hydrothermal system formed, which is proved by the distinct inheritance of its salt composition by the metalliferous hydrotherms. In addition, laser-spectral analysis established high concentrations of ore-forming elements in individual inclusions of the distillate (W up to 45 g/l, Re up to 98, Mn up to 145, Sn up to 1) comparable to their content in the hydrotherms in the ore-deposition stage.

3. The parts of the intrusions involved in intensive and prolonged distillation have considerable vertical extent and, according to data of thermobarogeochemical mapping, have clear-cut lateral boundaries. It is in these places that individual ore bodies and deposits as a whole are localized.

4. In the cases where the ore-bearing intrusions do not crop out at the surface, dike-like apophyses, which bear thermobarogeochemical signs of intensive fluid separation, usually are accessible for direct observation. In this case the mineralization is often localized in the supra-intrusive zone and partly or completely disposed in magma-permeable structures.

On the basis of these criteria, a working method was developed which has been industrially tested for 4 years by "Buryatgeologiya" during geological surveying and prospecting on a scale of 1:50,000. Checking was done by means of successive estimation of the areas, first by the discussed methods and then by traditional prospecting methods.

Both positive and negative predictions based on the thermobarogeochemical criteria were confirmed. In particular, the promising Talakhta Mo prospect, with complex mineralization, on which assessment work is being done, was predicted and found in a granite massif considered to be barren. Several places which had been assessed negatively by the proposed method were acknowledged to be barren after they were prospected.

Experience showed not only the efficiency of the proposed thermobarogeochemical method, but also its great economy and efficiency. The field of most effective use of the method is local prediction in order to select the most promising places under detailed prospecting in known Mo and W ore regions. (Authors' abstract)

REYNOLDS, P.H., RAVENHURST, C.E., AKANDE, S.O. and ZENTILLI, Marcos, 1986, Isotopic constraints on the genesis of the Pb-Zn mineralization at Gays River, Nova Scotia (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 118. First author at Dalhousie Univ., Halifax, Canada, B3H 3J5.

The Gays River deposit is the largest carbonate-hosted lead-zinc deposit known in the Mississippian Windsor Group of Atlantic Canada. The most probable age of mineralization was ~300 Ma.

Ore-stage calcites are characterized by very uniform $\delta^{18}O$, and $\delta^{13}C$ values. The $\delta^{18}O$(SMOW) of water in equilibrium with these calcites at 170°C (the fluid inclusion Th) was ≈3.3‰. The δD of the fluid inclusion fluids is -39‰. These values plot on a $\delta^{18}O$-δD diagram as basinal brines very close to the field representing typical Mississippi Valley type deposits.

The ore fluid was most probably completely reduced at the depositional site by organic compounds present. The isotopic composition of carbon in ore-stage calcites suggests that the carbon budget was dominated by this organic source. An apparent influx of oxidized meteoric water of lower (post-ore) T raised the oxidation state of the fluid and gave rise to the deposition of increasingly negative $\delta^{13}C$ calcite. As expected in a reducing environment, ore-stage sphalerite and galena have $\delta^{34}S$ values which mimic the nearby sulfate rocks (= +14‰), assumed source for the sulphur.

$^{87}Sr/^{86}Sr$ ratios of ore-stage calcites are ≈0.712. Post-ore calcite, fluorite and barite have ratios (~0.708-0.710), values which are closer to the ~0.7085 ratio characteristic of the host carbonates. Lead of extremely uniform isotopic composition characterizes both vein and stratiform galenas. Cambro-Ordovician Meguma Group metasediments possibly mixed with granitic rocks from the Devonian South Mountain batholith (or derivatives of these, the Devono-Carboniferous Horton Group clastics) appear the likely source rocks(s) on the basis of the strontium and lead data. (Authors' abstract)

RICHARDS, J.P. and SPOONER, E.T.C., 1986, Evidence for a magmatic fluid association in Keweenawan Cu-sulphide fissure-vein deposits at Mamainse Point, Ontario, with evaluation of possible relationships to stratabound basalt hosted native copper (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 118. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario, Canada M5S 1A1.

Fluid inclusion studies of Qz gangue in chalcocite rich fissure-veins containing the paragenetic sequence Py-Cp-Bn-Cc-Cu-Cu_2O at the Coppercorp mine, Ontario, give clear evidence for mixing between high T (350-450°C), high salinity (15 to 20 eq wt % $CaCl_2$), boiling fluid, and a cooler (50-350°C), more dilute hybrid liquid (zero to 15 eq wt % $CaCl_2$). $\delta^{13}C$(PDB) values of ten calcite samples from the fissure-veins average -4.0‰ (s = 0.7). Comparison with data from a small coeval Qz-Fsp, Cu-Mo mineralized porphyry stock (Jogran), 10.5 Km E of Coppercorp, strongly suggests a genetic link since four calcite samples give $\delta^{13}C$ = -4.0‰ (s = 0.8). This correlation, coupled with similarities in fluid composition and T, suggest that the high T fluids in the Coppercorp fissure-veins are of magmatic origin, and were derived from felsic intrusive activity deep within the lava pile. Fluid inclusions from Cu-bearing veinlets and amygdales in the hydrothermally altered basalts away from the main ore bodies similarly contain evidence for the intermittent invasion of high T saline fluids. The $\delta^{13}C$ ratios of five calcite samples from these veins range between the Coppercorp values and atmospheric (-2.7 to +0.7‰). Hence it is suggested that the brine influxes represent residual, oxidized cupriferous fluids from the major fissure system, which have been discharged into the stratiform and fracture-controlled aquifers of the lava pile. A logical extension of this theory would be to suggest that greater concentrations of native Cu would be expected where the influx of such cupriferous brine was greater as, possibly, in the deposits of the Keweenaw peninsula. (From the authors' abstract)

RICHARDS, J.P. and SPOONER, E.T.C., 1986, Native copper deposition by mixing of high temperature, high salinity fluids of possible magmatic association, with cool dilute groundwaters, Keweenaw Peninsula, Michigan (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 730. Authors at Dept. Geol., Univ. Toronto, Ontario, Canada M5S 1A1.

A study of 550 carefully selected fluid inclusions in Qz from samples of native copper-bearing Keweenawan basalt amygdaloid and flow-top breccia from the Pewabic and Kearsarge flows of the Michigan Copper District, shows well defined fluid mixing trends in Th/salinity space. Low temperature (to below 100°), low salinity (to 1.0 eq. wt. % NaCl) liquids represent one end of a range of data extending through and beyond fluids homogenizing around 415°C, and 10 eq. wt. % NaCl. Homogenization temperatures up to 600°C and salinities over 21 eq. wt. % $CaCl_2$ were recorded from many vapor-rich inclusions, which appear to represent supercritical fluids; these form the other end-member of the mixing trend.

Very similar fluid behavior has been recorded by the same authors (GSA Abs. + Progs., 1985, v. 17, p. 699) from Keweenawan fissure-vein copper sulphide mineralization at Mamainse Point, Ontario, where a combination of fluid inclusion, carbon and oxygen isotope data indicated a relationship to Keweenawan Qz-feldspar porphyry (QFP) Cu-Mo mineralization in the area. Fissure vein mineralization at the Coppercorp Mine, Mamainse Point, appears to represent a high level zone of interaction between ascending magmatic-associated, and descending meteoric fluids; residual fluids from this system may have deposited Cu° at higher levels in the basalt amygdaloids. $\delta^{13}C_{PDB}$ values of 12 Ct samples from Qz-sulphide-(Ct) veins at the Coppercorp Mine, average -3.9 ± 9.9‰; 4 samples of Ct from the Jogran Cu-Mo QFP (same area) average -4.0 ± 0.8‰; 118 samples of Ct from the Keweenaw Peninsula average -3.2 ± 1.7‰ (Livnat, A., 1983, PhD thesis, U. of Michigan). These values are consistent with a magmatic source of carbon, and the similarities of both fluid and carbon isotopic behavior in the three areas suggest a common process of mineralization - namely, ore deposition from magmatic-associated fluids by cooling and dilution on mixing with meteoric groundwaters. (Authors' abstract)

RICHET, Pascal, ROUX, Jacques and PINEAU, Francoise, 1986, Hydrogen isotope fractionation in the system H_2O-liquid $NaAlSi_3O_8$: New data and comments on D/H fractionation in hydrothermal experiments: Earth & Planet. Sci. Letters, v. 78, p. 115-120. First author at Lab. Isotopes Stables, Dépt. Sci. de la Terre et LA CNRS 196, Univ. Paris VII, Tour 54, 75251 Paris Cedex 85, France.

Measurements in the system H_2O-$NaAlSi_3O_8$ at $P = 2$ kbar and $T = 870$ and 1250°C indicate that the vapor is enriched in D relative to the silicate melt by 8 to 25‰. The large error margins of the data are due to the important changes in the isotopic compositions of the charges that are caused by the kinetic fractionations associated with hydrogen diffusion through platinum capsules in high-temperature, high-pressure experiments. A new interpretation of these effects is presented, and it is concluded that the equilibrium hydrogen fractionation should be at least 25‰ between 870 and 1250°C at 2-kbar pressure. (Authors' abstract)

RIKHVANOV, L.P., YAZIKOV, Ye.G. and SARNAEV, S.I., 1986, Uranium and thorium in carbonate minerals. Part I: Izv. Vysch. Uchebn. Zavedemiy-Geologiya, Razvedka, no. 7, p. 37-42 (in Russian). Authors at Polytech. Inst., Tomsk, USSR.

Carbonates from veins in an unnamed folded area yielded Td generally in the ranges of 200-370°C, with the average values for calcite 260°C, for ankerite 240°C and for dolomite 260°C. Water leachates indicated a SO_4-Cl-HCO_3 and Na>K composition of the parent fluids of carbonates and gas chromatographic analysis of fluid inclusions in calcite showed that volatiles consist mainly of H_2O and CO_2, and more rarely an admixture of CO, CH_4 and H_2 was found. (A.K.)

RINGROSE, C.R., HARMON, R.S., JACKSON, S.E. and RICE, C.M., 1986, Stable isotope geochemistry of a porphyry-style hydrothermal system, West Silverton District, San Juan Mountains, Colorado, USA: Applied Geochem., v. 1, p. 357-373. First author at Geol. Survey of Western Australia, 66 Adelaide Terrace, Perth, Western Australia 6000, Australia.

A porphyritic monzonite (25.1 Ma) intrudes Tertiary volcanic rocks of pre- and post-San Juan Caldera age along the western margin of the Silverton

Caldera and the northern side of the Sultan Mountain monzonite stock (25.9 Ma), within an area of strong sericitic to argillic alteration (25.0 Ma). These alteration facies, which are genetically related to the monzonite, are characterized by quartz-MoS_2 mineralization (Type 1), are surrounded by pyritic and propylitic facies alteration within which quartz/base-metal sulfide (Type 2), quartz pyrite (Type 3), and barren quartz (Type 4) veining occurs. Whole-rock H- and O-isotope compositions are variable throughout the district (δD = -148 to -72‰; $\delta^{18}O$ = -3.5 to +9.3‰). The propylitized country rocks are strongly depleted in ^{18}O and D but more highly altered samples have "normal" δD and $\delta^{18}O$ values. Coarse-grained sericites are D-enriched (-90 to -60‰) with respect to biotite and clay-sized sericites that also exhibit a very large range of δD values (-137 to -98‰ and -139 to -84‰, respectively). Type 1 veins have a very restricted range of $^{18}O/^{16}O$ ratios (+7.6 to 9.3‰), whereas veins of Type 2 and Types 3 and 4 have very large, overlapping, $\delta^{18}O$ ranges of -2.7 to +12.0‰ and -2.8 to +9.0‰, respectively. Type 1 veinlets are characterized by halite-bearing and vapor-rich types, whereas liquid-rich types (excluding halite-bearing types) are dominant in quartz and sphalerite of vein Types 2, 3, and 4. Homogenization and salinity data indicate higher temperatures and much higher salinities of quartz fluids in the central alteration zones (~350°C, ~40 ≡ wt% NaCl) compared with those of the peripheral pyritic and propylitic (~260°C, ≤5 ≡ wt% NaCl). The δD values for quartz fluid inclusion waters are quite variable: Type 1 (-125 to -79‰); Type 2 (-130 to -67‰); and Types 3 and 4 (-128 to -98‰). A "magmatic" fluid component is indicated by the calculated composition of sericitic fluids. Of the quartz fluids, those associated with MoS_2-mineralization lie closest to the field of "Primary Magmatic Water;" those associated with the other vein types lie within a large field which ranges from the composition of nearly unexchanged, local meteoric water to compositions reflecting extensive hydrothermal exchange and mixing. (Authors' abstract)

ROBB, L.J. and SCHOCH, A.E., 1985, Deuteric alteration and uranium mineralization processes in leucogranite intrusions from the Namaqualand metamorphic complex, South Africa, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 301-314. First author at Econ. Geol. Res. Unit, Univ. Witwatersrand, Johannesburg, South Africa.

Fluid inclusion data indicate distinct populations of brine, pure water and CO_2. Unmixing of the brine -CO_2 probably occurred at T corresponding to the onset of deuteric alteration, and may have been responsible for the precipitation of U from the fluid phase. Fluid entrapment conditions of 0.6-1.2 Kb and 170-340°C indicate a prolonged circulation of fluids, during the latter stages of which secondary redistribution of U occurred.

U mineralization in the leucogranites is considered to be a function of a closed-system alteration process and the retention of U in situ, rather than the outgassing of the fluid phase and the precipitation of U in extraneous vein, breccia or pegmatite systems. (From the authors' abstract)

ROBERT, François and BROWN, A.C., 1986, Archean gold-bearing quartz veins at the Sigma mine, Abitibi greenstone belt, Quebec: Part II. Vein paragenesis and hydrothermal alteration: Econ. Geol., v. 81, p. 593-616. First author at Geol Survey Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada.

The Sigma deposit consists of an Archean gold-bearing vein system in deformed volcanic rocks intruded by two generations of porphyries. The veins cut all rock types, and wall-rock alteration is superposed on greenschist facies metamorphic assemblages. There are two related vein sets: subvertical veins in ductile shears and subhorizontal veins in extensional fractures between shear zones. This paper reports on the paragenesis of extensional veins and related hydrothermal alteration.

Tension veins are composed chiefly of quartz and tourmaline, and subordinate amounts of carbonates, chlorite, pyrite, pyrrhotite, scheelite, and free gold. The veins formed by one or more episodes of open-space filling. The paragenetic sequence consists essentially of successive deposition of carbonate-scheelite, tourmaline, pyrite, pyrrhotite-carbonate-chlorite, and quartz. Most of the gold and tellurides was introduced into fractures and along grain boundaries of recrystallized vein minerals during a postfilling episode of deformation.

Veins are surrounded by zoned alteration envelopes. Mass balance calculations show that Ca, Na, Si, CO_2, S, and B in vein minerals were contributed from the hydrothermal fluid, whereas Fe, Mg, and Al were derived from the walls.

The development of alteration envelopes began with the infiltration of hydrothermal fluids into open extensional fractures and it ceased before compelte filling of the veins when continuous mineral coatings formed along vein walls. Deposition of carbonate accompanied development of cryptic alteration, including initial CO_2 additions to the wall rocks. Later bulk quartz deposition, which filled the vein openings, generally took place after complete development of the alteration envelopes. Except for this late quartz, deposition of vein minerals is attributed to chemical changes in the fluid resulting from progressive wall-rock alteration. Bulk quartz deposition is attributed to progressive cooling of the hydrothermal fluid. (From the authors' abstract)

ROBERTS, D.E., 1986, The Olympic Dam copper-uranium-gold deposit (abst.): Eighth Australian Geol. Conv., Geol. Soc. of Australia, "Earth Resources in Time and Space," Feb. 16-21, 1986, Flinders Univ., Adelaide, Abstracts, no. 15, p. 165-166. Author at Roxby Management Svcs. Pty. Ltd., Adelaide.

Limited fluid inclusion data indicate stratabound and transgressive mineralization were deposited from fluids with similar commpositions (about 7% NaCl eq.) but at different T (average 165°C for stratabound, 240°C for transgressive with some overlap in ranges). Sulphur isotope analyses indicate a common source of sulphur with similar [δ]^{34}S values (-5 to -8‰) for all sulphides. The source of metals within the deposit is unknown. (From the author's abstract)

ROBINSON, N., EGLINTON, G. and BRASSEL, S.C., 1986, Hydrocarbon compositions of bitumens associated with igneous intrusions and hydrothermal deposits in Britain (abst.): Terra Cognita, v. 6, no. 1, p. 23. Authors at Organic Geochem. Unit, Sch. of Chem., Univ. Bristol, Bristol BS8 1TS, UK.

Naturally occurring bitumens associated with igneous intrusions or hydrothermal mineralization have been found in many parts of Britain, notably in Cornwall, the Welsh Borderlands and several localities in Scotland. In many cases there are no obvious source rocks for such hydrocarbon deposits, which has led to speculation that they might be of deep source or even abiogenic origins. To evaluate the possible modes of formation and thermal history of these bitumens, the aliphatic hydrocarbon compositions of samples from a number of localities have been determined by GC and GC-MS procedures. Typically, the hydrocarbon distributions as seen in the stereochemical configurations and low abundance of steranes, hopanes and demethylated hopanes, resemble those characteristic of mature, weathered or biodegraded crude oils. Such results are compatible with the ultimate biological origins of these bitumens, and their subsequent thermal experience during intrusion and emplacement. (Authors' abstract)

ROCHOLL, A., MAINZ, K.T., OEHM, J. and RICHTER, H., 1986, Systematics of rare gases in Hawaiian mantle xenoliths (abst.): Fortschritte der Min., v. 64, no. 1, p. 154.

Concentrations and isotopic ratios of He, Ne, Ar, Kr and Xe were determined in mantle xenoliths of the Salt Lake Crater, Oahu, Hawaii. The data show:

1. ^{129}Xe/^{132}Xe values lie at 1.007 ± 0.010 (higher than all known MORB-data) and the value for the atmosphere. ^{3}He/^{4}He ratios lie between typical MORB-values ($\sim 1.2 \cdot 10^{-5}$) and a relatively "primitive" value of $4.15 \cdot 10^{-5}$. ^{40}Ar/^{36}Ar values lie between atmospheric and medium MORB-values (<5000). High ^{3}He values correlate with atmospheric Ar and Xe, and high ^{40}Ar values with MORB-like He and high ^{129}Xe values. By means of He-Ar-Xe-isotopy-diagrams and mixing-hyperbolas, these values can be interpreted as a mixture of three distinct end members, that differ concerning their isotopics and relative frequency: (i) atmosphere: $^{3}\mathrm{He}/^{4}\mathrm{He} = 0.1384 \cdot 10^{-5}$, $^{40}\mathrm{Ar}/^{36}\mathrm{Ar} = 295.5$, $^{129}\mathrm{Xe}/^{132}\mathrm{Xe} = 0.9832$; (ii) a degassed mantle reservoir with a high radiogenic component: $^{3}\mathrm{He}/^{4}\mathrm{He} \sim 1.2 \cdot 10^{-5}$, ^{40}Ar/^{36}-Ar >20000, ^{129}-Xe/^{132}-Xe >1.08; (iii) a non-degassed or slightly degassed mantle reservoir with a "primitive" rare gas composition: $^{3}\mathrm{He}/^{4}\mathrm{He} > 5 \cdot 10^{-5}$, ^{40}Ar/^{36}-Ar and ^{129}Xe/^{132}Xe about atmospheric.

Because of the short half-life (17 Ma) of ^{129}I, the mother isotope of ^{129}Xe, the anomalies of ^{129}Xe - and also the above mentioned reservoir - must have developed in the first 100 Ma of earth's history. The fact, that these heterogeneities still exist, means that they must have been isolated over a period of 4.4 Ga.

2. There exists no correlation between the petrological type of xenolith and its rare gas-systematics. This can be interpreted as an indication of the metasomatic supply of - at least a part of - the rare gases into the oceanic lithosphere.

3. Our data are compatible with a geochemical earth-model by Allègre et al. (1983): by degassing of the outer earth-mantle >4.4 Ga ago, the following developed simultaneously: (i) the atmosphere, (ii) a largely degassed upper earth-mantle from which was extracted later the continental and oceanic crust, and (iii) - convectively uncoupled with that - a not degassed, "primitive" lower mantle. A possible altenative to this model could be a storage of primitive rare gases in the earth-core and their slow evolution to form mantle-diapirs in the border area of core/mantle.

In the context of both models our xenoliths would represent parts of the oceanic lithosphere with MORB-isotopics, that have been at first seized by the magmas of the rising Hawaiian mantle-diapirs, were then overprinted by its "primitive" rare gases, and have subsequently been contaminated atmospherically on the surface of the earth. (Abstract translated by H.A. Stalder)

ROCKHOLD, J.R., NABELEK, P.I. and GLASCOCK, M.D., 1986, Origin of rhythmic layering in the Calamity Peak satellite pluton of the Harney Peak granite, Black Hills, South Dakota: The role of boron in petrogenesis (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 213.

RODDY, M.S., 1986, K-metasomatism and detachment-related mineralization, Harcuvar Mountains, Arizona: MS thesis, Univ. Arizona.

The Bullard detachment fault, a regional low-angle normal fault exposed in the Harcuvar Mountains of west-cental Arizona, separates lower-plate mylonitic rocks and chloritic breccia from K-metasomatized, upper-plate volcanic and sedimentary rocks. The volcanic rocks, originally rhyolitic ash-flow tuffs and basaltic andesite, have been altered to the mineral assemblage of K-feldspar + hematite + quartz. The secondary K-feldspar is very pure (Or 95-99.5), monoclinic, and structurally similar to orthoclase, and has a $\phi^{18}O$ of about 14‰. Metasomatized volcanic rocks contain 8 to 12% K_2O and less than 0.4% Na_2O. The $\phi^{18}O$ whole rock values vary from 10 to 14 for the tuffs and 5.6 to 8.6‰ for basaltic andesite. The K-metasomatism and ^{18}O enrichment are interpreted to have occurred as a result of the reaction of low-T, neutral to alkaline, oxidizing and saline solutions with permeable volcanic and sedimentary rocks in a detachment-created basin.

Cu-Au-Ag mineralization is concentrated along faults and fissures in metasomatized andesite. Fluid-inclusion studies show that mineralizing fluids had T of at least 325°C along the Bullard detachment fault, 232-290°C at the nearby Bullard Mine, and 95-125°C, in calcite-Mn-oxide veins farther from the detachment fault. The dominant mineralizing fluids near the detachment fault and at the Bullard Mine were saline brines with from 12.5 to 17.0 eq. wt % NaCl. More dilute brines with 6-12 eq. wt % NaCl are indicated for the calcite-Mn-barite veins. The oxygen isotopic composition of the mineralizing fluid varied from +3‰ for high-T quartz-sulfide veins to -5‰ for lower-T calcite-Mn-oxide mineralization.

Paragenetic relations and geochemical and isotopic data indicate that mineralization is superimposed on previously metasomatized rocks. Mineralization, although occurring later than K-metasomatism, probably involved the same basinal brines that previously caused the K-metasomatism. Geochemical data suggest that K-metasomatism liberated elements, such as Cu, Pb, Zn, and Mn, that were later incorporated into the mineralizing fluids. The mineralizing fluids apparently evolved from early deep-level, reduced, basinal brines to a later stage marked by the influx of higher-level, oxidizing basin brines; relatively minor amounts of meteoric water entered the system during the very late stages of mineralization. (Author's abstract)

RODIONOV, A.Ya. and SOLNTSEV, V.P., 1986, Gem varieties of beryl, chrysoberyl and phenakite grown by chemical vapor transport (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 213.

ROEDDER, Edwin, 1986a Fluid inclusions in salt, Palo Duro Basin, Texas: U.S.G.S. Water-Resources Invest. Rept. 87-4009, p. 30-34.

A review of three year's work done on inclusions in Palo Duro salt, with 19 references. (E.R.)

ROEDDER, E., 1986b Fluid inclusions, Part I: Changsha, South Central Univ. of Technology Pub. House (in Chinese).

This is a translation into Chinese, by Lu Huan-Zhang and Wang Qingduo, of the first half of a 1984 book (Roedder, 1984c, Fluid Inclusion Research, v. 17, p. 282-283, 1984). Part II was also planned for publication in 1986. (E.R.)

ROEDDER, Edwin and HOWARD, K.W., 1986a, Fluid inclusion study of the Taolin Zn-Pb-fluorite deposit, China (abst.): Abstracts of Posters, VII IAGOD Meeting, Lulea, Sweden, 18-22 Aug., 1986 (unpaginated). Authors at U.S. Geological Survey, Reston, VA 22092, USA.

The Taolin Zn-Pb-fluorite deposit, near Linxiang in NE Hunan Prov., China, has been known for 28 years. Its genetic affiliation, however, remains uncertain: Is it Mississippi Valley-type (MVT), or epithermal hydrothermal?

Following early, barren, preore quartz + minor py near the footwall (termed "Stage 0"), three stages of ore deposition are recognized at the mine: I) high-Fe dark sp (≤4% Fe) + amethystine quartz, closest to the footwall, II) dark sp, fluorite (fl) + minor gn and ba, and III) ba, yellow sp (≤0.1 Fe) + "gel" quartz. With increasing depth, the ore still has Cu

+ fl, but (Zn + Pb) decreases, and py increases.

Ding and Rees (1984, Geochim. Cosmo. Acta), on the basis of $\delta^{34}S$ studies, proposed a closed-system model operating at 325-250°C for Taolin. They also presented unpublished field inclusion data "from Wei." These include 3 data pairs of Th and salinity (wt.% NaCl, here converted to Tm ice) for Stage I, as follows: 285, -10.9; 300, -13.8; and 305, -12.5. Also, one pair from Stage II showed 245, -8.2.

The results of our studies on mainly P and possibly PS inclusions in a small suite of samples personally collected in 1985 from the -200 m level, -800 m west of the main shaft, are (at present) inexplicably different from the previous data. With two possibly spurious exceptions, the highest Th value found among 190 inclusions from fl, quartz and sp was 204°C, well below the lowest value previously reported, and our mean (153°C) is far below (Fig. 1). Only 81 Tm ice determinations were made. The values were -7 to -9°C (with major Ca) for stages 0 and I and were strongly bimodal between saline and essentially fresh water for Stage II (Fig. 2).

The major differences between our data and the earlier data may stem from sampling different parts of the paragenetic sequence or in the specific mine locations sampled and may eventually be clarifed, but the available data do not fit well with either proposed genetic affiliation. The lack of recognized alteration is difficult to explain if the fluids and rock have been 300°C. Many of our Th values are higher than those from most MVT deposits, and even our highest salinities (i.e., lowest Tm ice values) are less than those from most MVT deposits. Our very low salinities (for fl) are completely atypical of MVT deposits. In fact, these values are even much lower than most ordinary epithermal deposits. If the relative paragenetic assignments for our samples are correct, some of the large and enigmatic intra- and interstage Th differences found raise the question of how extensive was the natural decrepitation of earlier, lower Th inclusions by later, hotter fluids. A few large primary inclusions in Stage III fl do show clear decrepitation haloes. Obviously, a more detailed sampling of the entire paragenetic sequence will be needed to clarify these problems. (From the authors' abstract)

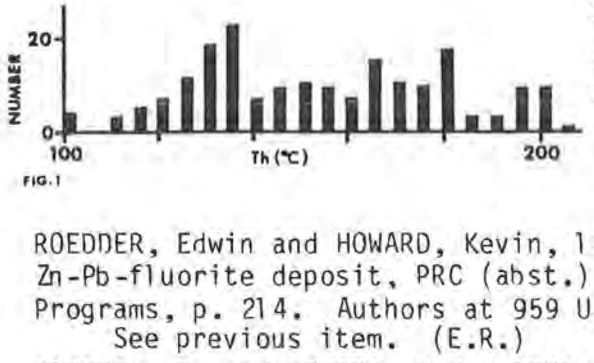


FIG. 1

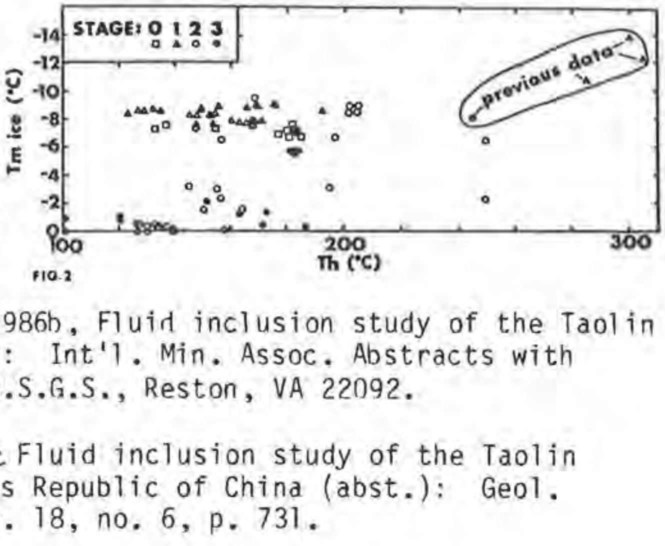


FIG. 2

ROEDDER, Edwin and HOWARD, Kevin, 1986b, Fluid inclusion study of the Taolin Zn-Pb-fluorite deposit, PRC (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 214. Authors at 959 U.S.G.S., Reston, VA 22092.

See previous item. (E.R.)

ROEDDER, E. and HOWARD, K.W., 1986c Fluid inclusion study of the Taolin zinc-lead-fluorite deposit, People's Republic of China (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 731.

See previous items. (E.R.)

ROEDDER, E. and HOWARD, K.W., 1986d, Taolin Zn-Pb-fluorite deposit, PRC: An example of some problems in fluid inclusion research on mineral deposits (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 21. Authors at 959 U.S. Geol. Survey, Reston, VA 22092, USA.

See previous items. (E.R.)

ROMANCHEV, B.P. and KOGARKO, L.N., 1985, Crystallization parameters of the Vulcano lavas: Abstracts of papers of the VI All-Union Volcanologic Symp., Petropavlovsk-Kamchatskiy, v. 2, p. 225-227 (in Russian).

Cited in Naumov, 1986 (this volume).

ROMAN'KO, Ye.F., MOGAROVSKIY, V.V. and ISHAN-SHO, G.A., 1985, Thermobaric conditions of formation of the endogenic Alpine deposits of the Eastern part of the Mediterranean belt (Central Iran): Doklady Akad. Nauk SSSR, v. 280, no. 3, p. 707-710 (in Russian).

Cited in Naumov, 1986 (this volume).

ROMANOVSKAYA, M.A., 1985, Mineral-geochemical and temperature zoning of the ore bodies of the deposit Karagayly: Vestnik Moskovsk. Univ., Ser. Geol., no. 5, p. 39-46 (in Russian).

Cited in Naumov, 1986 (this volume).

ROMANOVSKAYA, M.A. and MEL'NIKOV, S.F., 1985, Thermobarogeochemical peculiarities of the formation of the ores in the Karagayla deposit (Central Kazakhstan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 103-104 (in Russian; translation by D.A. Brown). First author at Moscow State Univ., Moscow, USSR.

Studies to clarify the physicochemical conditions of formation of the Karagayla barite-polymetallic ores have been carried out on fluid inclusions in the ore (pyrite, chalcopyrite, sphalerite, and galena) and gangue (barite and quartz) minerals and ores by the methods of Th (150 analyses) and Td (400 analyses).

Three types of inclusions have been found in translucent minerals: P, PS, and S. In the main, a detailed study has been made of complex P inclusions of elongate-prismatic and equant shape, containing mainly liquid and gas phases, and sometimes solid phases (halides and carbonates). The presence of fragments and crystallites of the same mineral, and also pyrite fragments, in the barites and sphalerites, is interesting.

The following peculiarities in the formation of the ore lodes in the deposit have been revealed. The ores were formed in two stages: hydrothermal-sedimentary and hydrothermal-metasomatic. The ore bodies were subsequently subjected to metamorphic changes.

The pyrite-sphalerite ores of the first stage reveal an initial T of mass decrepitation of 80-100°C. Td of barite-polymetallic ores of the second stage is ~260-300°C; Th = ~200-250°C. During one of the concluding phases of ore-formation in the second stage, quartz-pyrite-chalcopyrite ores of the so-called quartzose core were formed (Td = 320-340°C, Th of gas-liquid inclusions in ore quartz = 310-330°C). The barite-polymetallic ores, regenerated by the heat of intrusive masses, have Td = 300-320°C, and Th of gas-liquid inclusions in barites = 250-280°C.

Inclusions have been identified in the barite-polymetallic ores of the hydrothermal-metasomatic stage, containing CO_2, giving a P estimate of ~600 bars.

Numerous ore-mineral fragments in the barites and sphalerites indicate a lengthy multi-phase process of ore-formation during the second stage and high pressures, leading to repeated deformation of the earlier-formed ores and those formed by the emplacement of the dome structure, the presence of which has been assumed from earlier petrophysical studies.

A concentric temperature zonation has been discerned within the ore lenses of the Main sector of the deposit. The data conform well with the results of a mineralogical-geochemical study of the ores. At the concenter, there are the highest-temperature quartz-pyrite-chalcopyrite ores, clearly defining the main solution-conduit. Td = 320-340°C, and Th for inclusions in ore quartz = 310-320°C. The next zone is made up of barite and barite-polymetallic ores, characterized by Td = 240-300°C, and Th = 200-260°C. The pyrite-sphalerite ores of the outermost zone of the lode possess the lowest Td (80-120°C). (Authors' abstract)

ROMBERGER, S.B., 1986, Theoretical aspects of gold/silver transport and deposition (abst.): J. Geochem. Explor., v. 25, p. 237.

RONCHI, L.H., 1986, Evolution and geochemistry of Volta Grande fluorite deposit (Brazil): MS thesis, Univ. Brasilia, 133 pp. (in Portuguese; English abstract). Author at the Dept. Geosc., Univ. Brasilia, CEP 70910, Brasilia, DF, Brazil.

The Volta Grande fluorite ore deposit consists of two ore bodies (I and II) associated with two metasedimentary (calc-dolomitic marble) enclaves within the Tres Corregos granitic complex. The ore body evolution was reconstructed from geologic, petrographic and geochemical data (fluid inclusion and REE analyses), which characterized five mineralization stages:

1) Stratiform ore formation by replacement of carbonate by silica and fluorite;

2) Recrystallization of the stratiform ore by regional metamorphic fluids and granitic intrusions at the end of "Brasiliano" cycle;

3) Reactivation of regional Wealdenian lineaments with circulation of low-salinity and low-T (80°-160°C) hydrothermal fluids which recrystallized the fluorite and precipitated "cryptic" (microcrystalline) silica, barite and fluorite;

4) High-salinity and high-T (320°-360°C) CO_2-rich hydrothermal fluid percolation linked to alkalic-carbonatitic pipes which precipitated carbonate and smoky quartz and, possibly, fluorite; and

5) Karstic breccia formation by dissolution and leaching of the former ores.

The REE distribution patterns in Volta Grande and Sete Barras fluorite deposits are characteristic of this type of deposit. (Author's abstract, modified by K. Fuzikawa)

ROSE, W.I., CHUAN, R.L., GIGGENBACH, W.F., KYLE, P.R. and SYMONDS, R.B., 1986, Rates of sulfur dioxide and particle emissions from White Island volcano, New Zealand, and an estimate of the total flux of major gaseous species: Bull. Volcanol., v. 48, p. 181-188. First author at Michigan Tech. Univ., Houghton, MI 49931, USA.

Airborne correlation spectrometry (COSPEC) was used to measure the rate of SO_2 emission at White Island on three dates, i.e., November 1983, 1230 ± 300 t/d; November 1984, 320 ± 120 t/d; and January 1985, 350 ± 150 t/d (t = metric tons). The lower emission rates are likely to reflect the long-term emission rates, whereas the November 1983 rate probably reflects conditions prior to the eruption of December 1983.

Gas analyses from high-temperature volcanic fumaroles collected from June 1982 through November 1984 were used together with the COSPEC data to estimate the flux of other gas species from White Island. The rates estimated are indicative of the long-term volcanic emission, i.e., 8000-9000 t/d H_2O, 900-1000 t/d CO_2, 70-80 t/d HCl, 1.5-2 t/d HF, and about 0.2 t/d NH_3. (From the authors' abstract)

ROSEN, M.R. and HOLDREN, G.R., Jr., 1986, Origin of dolomite cement in Chesapeake group (Miocene) siliciclastic sediments: An alternative model to burial dolomitization: J. Sed. Petrology, v. 56, p. 788-798. First author at Dept. Geol. Sci., Univ. Texas, Austin, Austin, TX 78713.

Some of the dolomite cement crystals have fluid-inclusion-rich cores. (E.R.)

ROSSMAN, G.R., 1986, The hydrous component in garnets (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 216.

ROVETTA, M.R., DELANEY, J.R. and BLACIC, J.D., 1986b, A record of high-temperature embrittlement of peridotite in CO_2 permeated xenoliths from basalt: J. Geophys. Res., v. 91, no. B3, p. 3841-3848. First author at Earth & Space Sci. Div., Los Alamos Nat'l. Lab., Los Alamos, New Mexico.

Four ultramafic xenoliths recovered from Hawaiian basalts contain CO_2-fluid inclusion arrays which originated as healed microcracks. These healed microcracks have been used to study the mirocracking mechanisms in the xenolith source region. Fluid inclusion arrays in olivine have a preferred crystallographic orientation which is consistent with a hypothesis of microcrack nucleation upon dislocation pileups by the Stroh mechanism on the following olivine slip system: (Okl)[100], (110)[001], and (010)[001]. Previous investigators have shown that all these slip systems of olivine are active at high stress or low T. Olivine neoblasts occur as small grains in local shear zones (0.04 mm diameter and less than 3% of total volume) and larger grains which embay porphyroclasts throughout the specimens (0.22-mm diameter and approximately 30% of total volume). Olivine neoblast diameters provide estimates of the deviatoric stress of 160-200 MPa using the smaller grains and 50-75 MPa using the larger grains. The absence of clinopyroxene mechanical twinning in the xenoliths provides an independent paleopiezometer that limits the maximum deviatoric stress in the peridotite source region to 200 MPa. Fluid inclusion arrays are parallel to each other, are perpendicular to penetrative foliation planes produced by intragranular plasticity, and have an average spacing between arrays of 0.5-2.0 mm. Recrystallized olivine grains (neoblasts) are free of fluid inclusions. Estimates of the contribution of Stroh cracks to the deformation of the xenolith source region indicate a maximum decrease of a few percent in the net energy required to produce an increment of strain, dependent upon confining P. (Authors' abstract)

ROVETTA, M.R., HOLLOWAY, J.R. and BLACIC, J.D., 1986a, Solubility of hydroxyl in natural quartz annealed in water at 900°C and 1.5 GPa: Geophys. Res. Letters, v. 13, no. 1, p. 145-148. First author at Dept. Chem., Arizona State Univ.

We have measured the infrared spectra of a natural quartz after annealing it for up to 37 hours in water at 900°-1000°C and 1.0-1.5 GPa under chemical conditions buffered through a hydrogen membrane with an assemblage of water, nickel metal, and nickel oxide. Hydrothermal annealing increased the hydroxyl content of natural quartz (A-1) from 26 to 75 ± 11 $H/10^6Si$. Microscopic examination of fractured sample showed that they contained water inclusions and healed fractures. Previous hydroxyl solubility measurements made on fractured samples may be too large due to hydroxyl contamination along fractures. At 900°C, experiments equilibrated in times consistent with a diffusivity for hydrogen impurity in quartz of 10^{-7} cm^2/s. (From the authors' abstract)

ROWAN, L. and VIETS, J., 1986, Temperatures and compositions of fluid inclusions, Viburnum Trend district, Missouri (abst.): Symp. on the Bonneterre Formation (Cambrian), southeastern Missouri, May 1 and 2, 1986, Univ. of Missouri-Rolla, Rolla, MO [Abstracts], p. 20. Authors at U.S. Geol. Survey, Box 25046, MS 912, Denver, CO 80225.

Recent studies of Mississippi Valley-type mineralization in northern Arkansas and southern Missouri have investigated fluid inclusion temperatures and compositions. In the Bonneterre Dolomite-hosted Pb-Zn deposits of the Viburnum Trend, bulk analyses of fluids extracted from inclusions in early through late stage minerals have been performed using induction coupled plasma mass spectrometry. Th and freezing points [Tm ice?] (from which salinities are estimated) have been measured for inclusions in hydrothermal, vug-lining dolomite cements. These dolomites display a well defined four-zone cathodoluminescent (CL) microstratigraphy which spans mineralization (Voss and Hagni, 1985). The ability to correlate inclusion measurements with CL zones has made it possible to place constraints on the ages of inclusions with respect to main stages of mineralization.

[Tm ice] of the inclusion fluids fall between -19° and -23°C. [Tm ice] below -20.8°C indicate highly saline fluid containing other cations in addition to Na. No significant variation in salinity has been recognized between the four CL zones which span mineralization. Th fall predominantly between 95° and 130°C with a distribution mode at ~112°C; there is no apparent increase or decrease in temperature with time. Conclusions drawn thus far from these observations are that sulfide precipitation was not due either to temperature decrease or to mixing of the metal-bearing fluid with a lower salinity, meteoric fluid, given the consistent temperatures and salinities of inclusions in the hydrothermal dolomites.

Bulk analyses of fluids extracted from inclusions in early mineral phases (octahedral galena, dark sphalerite, and early white dolomite) and in paragenetically younger phases (cubic galena, coarse brown sphalerite, and late-stage dolomite) show shift in fluid composition with time. Fluids from the earlier mineral phases are enriched in K relative to Na, while the younger fluids have lower K/Na ratios. Early mineral phases are also distinguishable by their less radiogenic lead and heavier sulfur isotopes (Sverjensky, 1981). This is interpreted to reflect a shift in predominance of the principal aquifer from the basal Lamotte Sandstone to the overlying Cambrian carbonates. Contact with arkosic facies of the Lamotte and the underlyng felsic basement is believed to have produced relative K enrichment as well as the less radiogenic Pb isotope signatures in the early octahedral galena. (Authors' abstract)

See also Viets et al., Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 362-363. (E.R.)

ROWBOTHAM, G., 1986, Metamorphic grade and the nature of the low-grade metamorphism of the Lower Palaeozoic rocks of Wales: A review, in Nesbitt, R.W. and Nichol, Ian, eds., Geology in the real world - the Kingsley Dunham volume: Inst. Mining & Metallurgy, p. 369-374. Author at Dept. Geol., Univ. Keele, Staffordshire, England.

The Lower Palaeozoic rocks of Wales have been metamorphosed in the zeolite, prehnite-pumpellyite, or greenschist facies. These facies are correlated with diagenesis, anchizone and epizone grades of metamorphism developed in metapelites. Metamorphic temperatures increase from ~150°C in the Welsh Borderland to ~400°C in the most deeply buried sequences or areas of most intense deformation (Snowdonia). The metamorphism is of a low-pressure facies series. There is often good correlation between the various grade indicators although there are exceptions. (Author's synopsis)

RUAYA, J.R. and SEWARD, T.M., 1986, The stability of chlorozinc (II) complexes in hydrothermal solutions up to 350°C: Geochimica Cosmo. Acta, v. 50, p. 651-661.

RUB, M.G., KHETCHIKOV, L.N., KOTEL'NIKOVA, Z.A. and RUB, A.K., 1986, Inclusions of the mineral-forming media in minerals of the Precambrian tin-bearing granites of the northern Ladoga region: Izvestiya Akad. Nauk SSSR, Ser. Geol., no. 1, p. 30-36 (in Russian). (See also Khetchikov et al., 1986, this volume.] First author at Inst. Geochem. & Anal. Chem., Moscow, USSR.

The studied granites form the Pitkyaran-Tulomozer massif of the south of the Baltic Shield and occupy 3000 km^2; their K-Ar isotope age ranges from 1630 Ma (I phase) to 1570 Ma (III phase). Tin and rare metal mineralization occurs in the altered granites and lime-apomagnesia skarns. Granites of the all three phases consist of the intermediate microcline (40-50%), quartz (25-35%), plagioclase An 13-15 and An 6-8 (15-25%), and Li-bearing biotite. Quartz of the I phase granites bears rare and small (~10 μm) crystallized melt inclusions (Th 890°C) and co-occurring even rarer essentially gaseous (G = 80 vol.%) inclusions. S fluid inclusions in this quartz are more abundant and they consist of two groups, with 3-5 and 30-40 vol.% of gas; sometimes these inclusions bear a halite crystal, and several inclusions were found filled only with LH_2O + halite dm, without gas bubble. One inclusion (dia. 10 μm) filled with CO_2 was identified. By cryometric method, the LH_2O inclusions are filled with NaCl solutions possibly with admixed $MgCl_2$ and/or $CaCl_2$ (Te <-31°C), solution concentration 8-8.5%. Quartz of the II phase granites bear crystallized melt inclusions (5-15 μm) with two ranges of Th, ~850°C and 890-920°C. Fluid inclusions bear ~10 vol.% of G, Th 240-245°C and other ones - ~40 vol.% of G, Th 375-400°C. Distinctly S, late inclusions bear 5 vol.% of G, Th 205-105°C. Rarely occurring inclusions with ~70 vol.% G yielded Th 500-510°C, in G phase. Three-phase inclusions LH_2O + G + halite dm are extremely rare, but two types were found: 1) G ⩽10%, decrepitation at 200-315°C before homogenization, 2) G up to 50%, Th 420°C, dm dissolves at 175°C. Individual inclusions were found, filled with two liquids (L1<<L2) ± dm, dissolving at 212°C, they open before homogenization. Te of LH_2O in inclusions of the II phase granites, especially the greisenized variety, was close to -22°C indicating in addition to NaCl the presence of NaF or KCl[sic]. This quartz also bears LCO_2 inclusions with triple point -60°C (possible admixture of CH_4 or N_2). Quartz of the III phase granites bears melt inclusions with Th 830-850°C, but some inclusions yielded Th 920°C. Albitized granites do not bear melt inclusions, only GL ones with various proportions of phases (G ranges from 5 to 40% of the vacuole volume), Th from 200 to 440°C. Certain of those inclusions are distinctly S; origin of the others is not certain. Inclusions with dm halite also were found, G bubble on homogenization runs disappeared at ~260°C, total homogenization occurred by dm dissolution at 385-400°C; thus, by the Klevtsov-Lemmlein method P of formation of these inclusions ⩾1530 bar. Small inclusions of pure CO_2 and LH_2O + LCO_2 + G were found. T of triple point of such inclusions was -60 to -59°C, Th -11 to -14°C (specific volume 1.02 and 0.99 cm^3/g). The authors evaluate that the LCO_2 inclusions are coeval with inclusions of Th 240°C and thus P = 2200 bar. Salts in LH_2O inclusions consist of NaCl, $MgCl_2$, $CaCl_2$ and NaF (or KCl). Fluorite from skarns bear crystal-fluid inclusions (G ~20 vol.%, most of inclusions filled by unspecified dms-halides plus small volume of LH_2O); most inclusions decrepitate before homogenization; a few of them homogenized at 650-680°C. Fluorite from the magnetite ores bears inclusions with G = 5 to 70 vol.%, Th 300 (in L) to 460°C (in G), as well as inclusions filled LH_2O + LCO_2 + G, Th 400°C. (Abstract by A.K.)

RUBIE, D.C., 1986, The catalysis of mineral reactions by water and restrictions on the presence of aqueous fluid during metamorphism: Mineral. Mag., v. 50, p. 399-415. Author at Dept. Geol., The Univ. Manchester, Manchester M13 9PL, UK.

The problems of characterizing intergranular regions and of estimating rates of intergranular diffusion in metamorphic rocks are discussed. Intergranular regions can be anhydrous, hydrated but undersaturated with H_2O, or saturated with H_2O, but only in the latter case can a free aqueous fluid phase be present. Estimates of intergranular diffusion coefficients (D^{IGR}) at 550°C, derived from a variety of published experimental work, vary from

$\sim 10^{-8}$ m^2s^{-1} for diffusion of species through an intergranular fluid film to $\leq 4 \times 10^{-24}$ m^2s^{-1} for diffusion of SiO_2 or O in anhydrous grain boundaries in quartzite. Estimates of D^{IGR} for hydrated grain boundaries vary from $\sim 10^{-13}$ m^2s^{-1} to $\sim 10^{-21}$ m^2s^{-1}; the concentration of H_2O in the grain boundaries and the identity of the diffusing species (generally unknown) may be important controlling factors, and there exists the possibility of a spectrum of values between these two extremes.

Using available kinetic data it is shown that a free aqueous fluid could never have been present in parts of the basement terrane of the Sesia Zone (Western Alps) during uplift from the eclogite facies, except possibly late in the cooling history. The breakdown of sodic pyroxene + quartz occurred in response to the localized infiltration of catalytic aqueous fluid, possibly over a time interval as short as 6-6000 a, and possibly under conditions remote from equilibrium. H_2O-present conditions during a dehydration reaction in metapelites of the Adula nappe (central Alps) could also have been of short duration. These examples are consistent with a model in which basement rocks at deep crustal levels are dry for long periods of time and in which the development of equilibrium mineral assemblages and microstructures generally occurs over relatively short periods of time under transitory fluid-present conditions (caused by devolatilization and/or infiltration). (Author's abstract)

RUDASHEVSKIY, N.S. and MOCHALOV, A.G., 1985, Composition of inclusions of chromian spinels in grains of platinoids from rocks of ultramafic formations: Geologiya i Geofizika, no. 8, p. 56-70 (in Russian).

Cited in Naumov, 1986 (this volume).

RUMBLE, Douglas, III, DUKE, E.F. and HOERING, T.L., 1986, Hydrothermal graphite in New Hampshire: Evidence of carbon mobility during regional metamorphism: Geology, v. 14, p. 452-455. First author at Earth Sci. Div., Nat'l. Sci. Foundation, Washington, DC 20550.

Graphite precipitated from hydrothermal fluids pervades the sillimanite-grade metasedimentary and plutonic rocks of New Hampshire. Hydrothermal graphite occurs as microscopic veinlets, halos of spherulites around shear zones, and metre-thick veins. Carbon isotope analyses of the graphite range from -25‰ to -9‰ $\delta^{13}C$(PDB), intermediate betweeen the two biogenic crustal reservoirs of reduced organic matter and carbonate. It is proposed that carbon was mobilized from sediments as CO_2 and CH_4 during metamorphic devolatilization reactions. The carbon-bearing species were transported in aqueous fluids through hydraulic fractures. Graphite precipitated when aqueous fluids with different CO_2/CH_4 ratios were mixed in fractures. (Authors' abstract)

RUMBLE, Douglas III, FERRY, J.M. and HOERING, T.C., 1986, Oxygen isotope geochemistry of hydrothermally-altered synmetamorphic granitic rocks from south-central Maine, USA: Contrib. Mineral. Petrol., v. 93, p. 420-428.

RUMBLE, Douglas, III and HOERING, T.C., 1986, Carbon isotope geochemistry of graphite vein deposits from New Hampshire, USA: Geochimica Cosmo. Acta, v. 50, p. 1239-1247. First author at Earth Sci. Div., Nat'l. Sci. Foundation, Washington, DC 20550.

Graphite veins of hydrothermal origin occur throughout central New Hampshire. Veins truncate sillimanite-grade, metasedimentary rocks of Early Devonian-Silurian age and range in size from microscopic to meters in thickness. In addition to graphite, veins may contain quartz, tourmaline, ilmenite, rutile, sillimanite, muscovite or chlorite. Vein mineralogy is generally compatible with wall rock mineral assemblages. Mineralization structures include wall-rock alteration zones, coxcomb graphite crystals on vein walls, and botryoidal, concentrically layered graphite-silicate nodules.

The $\delta^{13}C$ values of graphite in 14 deposits studied range from -28% (PDB) to -9‰. Veins whose textures give evidence of a single stage of mineralization have a narrow range of $\delta^{13}C$ values (±0.2‰). Other veins record successive episodes of graphite precipitation and have ranges of 3-6‰. In one sample, adjacent layers of graphite differ by 3‰.

The wide range of $\delta^{13}C$ may be explained by mixing carbon from two crustal reservoirs: biogenic, reduced carbon and carbonate. Precipitation of graphite results from mixing two or more aqueous fluids with different CO_2/CH_4 ratios. Parental fluids are produced by devolatilization during metamorphism. Water-rich fluids with $CH_4 > CO_2$ and low $\delta^{13}C$ are derived from pelites that contained organic matter; whereas fluids with $CO_2 > CH_4$ and high $\delta^{13}C$ come from siliceous carbonates. (Authors' abstract)

RUMYANTSEV, V.N., GANEEV, I.G. and RUDNEV, V.V., 1985, On the pulsating nature of variation in homogenization temperatures of inclusions during formation of vein ore deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 34-36 (in Russian; translation by S. Jaireth). First author at VIMS, Inst. Min. Resources, Moscow, USSR.

Thermometric information obtained from the study of fluid inclusions in gangue minerals indicates the pulsating nature of the evolution of hydrothermal solutions. This is evidenced by abrupt drops in the values of Th. Peaks on the 'Th-time' curve are usually interpreted as a result of introduction of new, relatively high-T solutions at the beginning of every new stage of mineral formation.

This concept was formulated more than 20 year ago when Th of inclusions used to be equated with Tf. Lately due to work of Balitski, V.C.; Dorgovinnayi, B.A.; Yermakov, N.P.; Naumov, V.B.; Khetchikov, L.N. and others, it has been found that this (Th = Tf) is true only for very low hydrostatic pressures (first few hundreds of meters). Study of fluid inclusions has indicated P exceeding not only hydrostatic but lithostatic P as well (V.B. Naumov, G.B. Naumov and others). In such conditions P corrections cannot be ignored.

As Th is very sensitive to changes in the density of solutions, it can be assumed that peaks on the Th-time curve at the beginning of every new stage are caused not by increase in T as such but by drop in the density of solutions triggered by partial opening up of channels. It can also be the result of introduction of lower density solutions at the beginning of each new stage.

Above fact is supported by experiments carried out by us on the growth of quartz from solutions of lowering density.

In contrast to those experiments in which crystallization is carried out from homogeneous solutions at constant T, crystallization in these experiments was carried out at gradually increasing T. T was increased from 250°C to 440°C within 3.5 days with ΔT of 10 to 15°[sic]. T was then controlled at 440°C for 2 days. Low initial degree of filling (F = 0.45) of autoclave guaranteed crystallization, at least up to 400°C, in conditions of lowering density of solutions. Parallel experiments helped to establish that growth from heterogeneous media around a nucleus is possible only from the liquid phase (growth boundary around nucleus distinctly marks phase boundary between gas and liquid)[sic].

Following are the results of thermometric studies of fluid inclusions in various growth zones: (1) Zone close to the nucleus, Th = 341-345°C (17 measurements), (2) Central part of overgrown segment (1.2 to 1.5 mm from the nucleus), Th = 350-354°C (6 measurements). All these inclusions homogenized into liquid phase. Uniformity in the Th of outer zone indicates that during growth of this zone, system had achieved state of homogeneous entrapment. In the earlier stages, the system was heterogeneous. Density of the liquid phase gradually decreased with increase in T, reflected distinctly by the increasing Th of inclusions. (From the authors' abstract)

RUSSELL, M.J., 1986, A model for the genesis of SEDEX deposits (abst.): Terra Cognita, v. 6, no. 3, p. 493. Author at Dept. Applied Geol., Univ. Strathclyde, Glasgow G1 1XJ, UK.

SEDEX deposits include amongst their number the largest ore bodies on Earth (e.g., Broken Hill, Mt. Isa, Sullivan, Navan, Meggen). They result from long-lived hydrothermal systems ($\sim10^6$ y) operating at ~250°C judging from fluid inclusion evidence and mineralogy. In any one province, the deposits are well spaced but co-eval and genetically related to large-scale basin subsidence. This subsidence encourages marine transgressions, evaporation, the formation of sabkhas, and saline stratified stagnant seas.

Fracturing affecting the seafloor allows the saline seawater access to porous sandstones and from this integrated reservoir the fluid penetrates downwards along reactivated fractures in the upper crust, especially, but not exclusively, in crystalline rock. This fluid eventually reaches the brittle-to-ductile boundary at about 250°C between 6 and 8 km. Now buoyant, the modified seawater, having dissolved Pb + Zn + Ba + FeS during open system hydrothermal metamorphism, returns to the sea bottom in a convective updraught exploiting a high permeability conduit centered on a zone of intersecting fractures. (From the author's abstract)

RUXTON, P.A. and PLUMMER, G., 1986, Geology, metal zonation and fluid inclusion history of the Scamander mineral field, northeast Tasmania: With particular reference to the Great Pyramid tin deposit (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 22. First author at Geol. Dept., Univ. Tasmania, G.P.O. Box 252C, Hobart, Tasmania 7001.

Mineral deposits of the Scamander mineral field are zoned from proximal to granite WO_3-Mo, to Sn, to Cu, to Pb-Zn-Ag in distal areas. Metals are localized in regional structures developed in the Lower Devonian, chemically inert Mathinna Bed sediments. Metal zonation is spatially related to fractionated, greisenized Upper Devonian granite. Fluid inclusion studies on quartz coexisting with metallic minerals indicate that all metals were deposited from a single fluid of low salinity 4 to 10 wt% NaCl equiv., in the H_2O-CO_2-NaCl system. Boiling textures are ubiquitous. Metal zonation is related to decreasing Th: WO_3-Mo 360 to 300°C, Sn 320 to 200°C, Cu 250 to 180°C and Pb-Zn-Ag 220 to 160°C.

The only deposit of significance in the field is the Great Pyramid tin deposit with an outlined reserve of 3.2 mt @ 0.22% Sn with a further 2.6 mt of untested ground within the ore envelope. Tin occurs as cassiterite in a quartz sheeted fracture system. Detailed homogenization temperature studies indicate a correlation between elevated tin grade and fluid temperature. The optimum temperature range for tin deposition lies between 240 and 270°C. (Authors' abstract)

RYABCHIKOV, I.D., BARANOVA, N.N., ZOTOV, A.V. and ORLOVA, G.P., 1985, The stability of $Au(OH)^0_{sol}$ in supercritical water and the metal contents of fluids in equilibrium with a granite magma: Geokhimiya, 1985, no. 2, p. 267-268 (in Russian; translated in Geochem. Int'l., v. 22, no. 6, p. 116-117, 1985).

RYABCHIKOV, I.D., SOLOVOVA, I.P., BABANSKIY, A.D. and BORSUK, A.M., 1985, Origin and conditions of differentiation of strongly reduced andesite magmas: Izvestiya Akad. Nauk SSSR, Ser. Geol., no. 10, p. 18-27 (in Russian). Cited in Naumov, 1986 (this volume).

RYABCHIKOV, I.D., SOLOVOVA, I.P., SOBOLEV, N.V., SOBOLEV, A.V., BOGATIKOV, O.A., ALESHIN, V.G. and VASHCHENKO, A.N., 1986, Nitrogen in lamproite magmas: Dokl. Akad. Nauk SSSR, v. 288, no. 4, p. 976-979 (in Russian). First author at Inst. Geol. of Ore Deposits, Petrography, Mineral., & Geochem. of Acad. Sci., Moscow, USSR.

From the authors' calculations it appears that under the conditions of the Earth's crust and uppermost mantle, nitrogen exists essentially as N_2, but for fO_2 typical for diamond-bearing lherzolite, i.e., at the deeper levels of the mantle, NH_3 becomes the more stable form [and hence is] strongly prevailent. Olivine from the diamond-bearing olivine lamproite pipe Allandale 11 (W. Australia) bears inclusions filled essentially by LCO_2 as the liquid phase plus orthopyroxene and K-richterite dms and glass. By the microanalysers "Camscan" and "Camebax," nitrogen was found in the glass phase of these inclusions (BN was used as the standard for nitrogen). Volatile phase bears also N_2 in addition to CO_2 (by gas chromatography). T of melting of CO_2 in inclusions equals -58.3°C, differing from those of pure CO_2 (-56.6°C), as may be explained by the presence of N_2 in fluid, reaching 20 mole %; maximum content of H_2O in fluid also does not exceed 20 mole %. The studied lamproite magmas are primary mantle melts rich in volatiles (CO_2, H_2O, N_2 and F). (Abstract by A.K.)

RYABENKO, S.V., GERASIMOVSKIY, V.V., KORYTOV, F.Ya., PROKOF'YEV, V.Yu. and SEMENOV, Yu.V., 1985, Conditions of formation of the cryolite-rare metal deposits of East Siberia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 175-176 (in Russian; translation by Dorothy B. Vitaliano). First author at All-Union Sci. Research Inst. of Min. Raw Materials, Moscow, USSR.

The most important mineralogical-geochemical feature of cryolite-rare metal deposits, related to alkaline metasomatites of quartz-feldspar composition, is their high content of fluorine, consisting mainly of minerals of the fluoride group. The appearance of the latter can serve as an indicator of Ta-Nb, Be and TR mineralization.

The composition of the fluorides in cryolite-rare metal deposits as a rule varies systematically in different stages of alkali-halide metasomatism and depends on how agpaitic the rocks and the composition of the substrate are. For instance, in one of the deposits in East Siberia, as the ratio of alkalies to Al in the rocks increases, from the leading to the trailing zones of the metasomatic sequences, a succession of the main mineral concentrators of fluorine is observed, in this order: fluorite → TR-fluorite (CaF_2 [TRF_3]) → gagarinite ($NaTRCaF_6$) → cryolite (Na_3AlF_6). As a rule Be (fluorite) or Ta-Nb (cryolite) mineralization accompanies it.

To elucidate the formation of these ores, thermo- and cryometric investigations were made on fluid inclusions in fluorite and cryolite. In the fluorite, P multiphase inclusions of highly concentrated solutions (47-54 wt.% NaCl equiv.) of Na and Ca chloride (Te = -55°C) were found. When they were heated, first the gas bubble disappears at 220-190°C, and then the crystals dissolve at 415-385°C. This makes it possible to estimate the pressure as 2.1-1.9 kbar[sic]. In the fluorite there also are S inclusions of a less concentrated solution of the same composition (Tm of ice = -8.5 to -7.9°C, C = 13-12 wt.% NaCl equiv.), also containing liquid CO_2 (Tm = -56.9°C; the gas hydrates dissolve at +7.9°C), which homogenizes at +5°C to the liquid phase. Complete homogenization of these inclusions occurs at 250°C, and the pressure is at least 1.7 kbar.

In cryolite, P inclusions of a low-concentration solution (2 wt.% NaCl equiv.) of sodium fluoride (Te = 3.6°C). Their Th vary from 360 to 90°C.

Thermodynamic computer calculations of mineral equilibria showed that the deciding factor in the replacement of fluorite by cryolite was a change in pH and in the chemistry of the solutions, from essentially calcic to sodic.

Thus the formation of the cryolite-rare metal ores of the deposits took place under conditions of a considerable range of T and P, when there was a sharp change in concentrations and chemistry of the ore-forming solutions. (Authors' abstract)

RYABKOV, V.N., TALANTSEV, A.S. and KOKOULIN, V.A., 1985, Genesis of the amethyst-bearing vugs at the deposit Vatikha (Urals): Izvestiya Akad. Nauk SSSR, Ser. Geol., no. 11, p. 120-129 (in Russian).
Cited in Naumov, 1986 (this volume).

RYE, R.O., DING, T.P., WHELAN, J.F. and LANDIS, G.P., 1986, Preliminary hydrogen, oxygen and sulfur isotopic study of the Xihuashan quartz-wolframite deposit, China: U.S. Geol. Survey Bull. 1622, p. 157-169.

The Xihuashan quartz-wolframite deposit in southeastern China consists of more than 600 steeply dipping quartz veins in the upper margins of a complex Mesozoic biotite granite stock that intrudes Cambrian pelitic rocks. Mineralization is confined to veins in the stock and individual veins show a pronounced zoning in both vein and alteration assemblages.

The $\delta^{18}O$ data on the stock indicate postcrystallization exchange with ^{18}O-depleted meteoric water. Whole-rock and quartz $\delta^{18}O$ values suggest that the biotite granite may have some S-type characteristics, although alteration of the stock in the mine area makes determination of primary compositions difficult. The $\delta^{18}O$ data on quartz, wolframite, sericitized potassium-feldspar, and muscovite from the veins and associated greisen envelopes indicate deposition from fluids that had a remarkably narrow range of $\delta^{18}O(H_2O)$ and T throughout vein formation and greisenization.

Preliminary measurements of Th of fluid inclusions in quartz indicate that depositional T were 250 ± 50°C and that at times the fluids boiled; at 250°C, the $\delta^{18}O(H_2O)$ of the hydrothermal fluids can be calculated to have been 1.0 ± 1.6 per mil. These values are low enough to imply that the fluids contained a substantial component of highly exchanged meteoric water. Most of the $\delta D(H_2O)$ values of the fluids are in the range typical of magmatic fluids and therefore cannot be used to distinguish magmatic- and meteoric-water components without a more detailed study. S isotopic data on sulfides, however, indicate that sulfide S was derived from a deep-seated igneous source. Many features of the geology, the mineralogy, the paragenesis, and the geochemical environment of ore deposition of the Xihuashan deposit appear to be similar to those of other quartz-wolframite deposits that have been studied in greater detail and imply fundamental processes common to the origin of such deposits. (Authors' abstract)

RYKL, D. and STEMPROK, M., 1986, Hydrothermal reaction of water and brines with the Činovec granite, Czechoslovakia, at 300 and 400°C and 50 MPa pressure: An experimental study (abst.): Terra Cognita, v. 6, no. 3, p. 531.

SAFAROV, Yu.A., NYRKOV, Ye.A., GAMOV, M.I., VALUYEV, O.V. and MAKARYUKHA, S.V., 1985, Fluid regime of the main genetic types of tungsten deposits of the Central Caucasus (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 151-152 (in Russian; translation by Dorothy B. Vitaliano). Authors at Rostov State Univ., Rostov-on-the-Don, USSR.

The main thermobarogeochemical parameters of mineralization in the tungsten deposits were studied by the methods of thermovacuum decrepitation, homogenization, gas chromatography and analysis of aqueous extracts. Scheelite, quartz of different generations, skarn and sulfide minerals were investigated in several bodies representing the above genetic types -- the

Tyrny Auz deposit and a promising part of the Subashi Kyrtyk ore district (skarn), the Ktiteberda deposit (hydrothermal-metasomatic), and the Blyb prospect (vein).

Td and Th of the fluid inclusions of the ore interval in scheelite decrease from deposits of contact-metasomatic type toward the hydrothermal type. In the Tyrny Auz deposit they are 520 and 425°C, respectively; in the Subashi sector, where the mineralization also is concentrated in skarns, 540-590°C. The colored varieties of scheelite in the Ktiteberda deposit show Td in the 360-420° range. The scheelite of the Blyb prospect gives off gases at 330-390°C.

The phase composition of the fluids also changes linearly from gaseous, essentially gaseous and highly concentrated with an abundance of solid phases, in skarn and vein minerals of the Tyrny Auz deposit, to gas-liquid and CO_2 inclusions in quartz of the Blyb prospect.

The pressure, estimated by the method of V.A. Kalyuzhnyi, vary from 55-70 MPa in the Tyrny Auz deposit to 28-33 MPa in the Ktiteberda deposit, where they are lower than in the Blyb prospects.

In the salt composition of the fluid phase, which reflects the type of metasomatism, Na and K chlorides predominate, and in the Tyrny Auz, unlike the other deposits where their proportions are about the same, Na is much higher than K. In all the deposits, the gas phase is high in H_2 and N_2.

In the light of the data we obtained, the fluid systems of the W deposits of the Central Caucasus can be interpreted as relicts of a single fluid column, the evolution and interaction of which with the specific geologic setting produced the thermobarogeochemical parameters of mineralization that are recorded. (From the authors' abstract)

SAITO, M., 1986, Growth process of gas bubble in ruby single crystals by floating zone method: J. Crys. Growth, v. 74, p. 385-390. Author at Seiko Epson Corp., Suwa-shi, Nagano, Japan.

Bubbles in ruby single crystals grown by the floating zone method were investigated. It was found that though bubbles had facets, they were not crystals but probably a gas. The bubble growth process near the interface was made visible by quenching the crystal during growth and by subsequent microphotography of bubbles near the interface. The bubble growth process was explained by the model that the gas constituent which was rejected from the solidified melt formed bubbles at the interface and the bubbles were incorporated into the crystal. (Author's abstract)

SAMSON, I.M. and BANKS, D.A., 1986, Epithermal base-metal mineralization in the Southern Uplands of Scotland: Nature and origin of the fluids (abst.): GAC-MAC Program with Abstracts, v. 11, p. 123. First author at Min. Explor. Res. Inst., C.P. 6079, Succursale 'A,' Montreal, Quebec, H3C 3AT.

The sedimentary sequences of the Southern Uplands of Scotland host numerous Pb-Zn-Cu-Ag vein deposits, the genesis of which have never been adequately explained. Fluid inclusion and stable isotope analysis of vein minerals from these deposits indicate that, for the vein stages studied, the mineralizing fluids were low T (<150°C), high salinity (~19 to 30 eq. wt.% NaCl + $CaCl_2$) modified meteoric waters. In some, and possibly all, of the systems, boiling [occurred], indicating a shallow depth for mineral precipitation. A consideration of the availability of such fluids throughout the geological history of the Southern Uplands suggests a Lower Carboniferous (Dinantian) age for the mineralization. (Authors' abstract)

SANO, Yuji, WAKITA, Hiroshi and HUANG, C.-W., 1986, Helium flux in a continental land area estimated from $^3He/^4He$ ratio in northern Taiwan: Nature,

v. 323, p. 55-57. First author at Lab. for Earthquake Chem., Faculty of Sci., Univ. Tokyo, Bunkyo-ku, Tokyo, Japan.

The helium flux and its isotopic composition may provide useful information not only on the helium budget in the atmosphere but also on the uranium and thorium contents of the rocks in the Earth's crust and mantle and the generation of heat from radioactive decay of these elements. Data have been available from oceanic areas, but those from continental areas are sparse. We report here the ^{3}He and ^{4}He fluxes derived from measurement of the ^{3}He/^{4}He ratio of natural gases in the northern part of Taiwan. The estimated ^{3}He and ^{4}He fluxes are 3.9 and 2.7×10^6 atoms $cm^{-2}s^{-1}$ at the Chinshui site, and 7.2 and 2.4×10^6 atoms $cm^{-2}s^{-1}$ at the Chuhuangkeng site. The ^{3}He fluxes are in approximate agreement with the global flux estimated from excess ^{3}He in sea water. The ^{4}He fluxes are comparable to the ^{4}He flux for the continents deduced from terrestrial heat flow data and the heat/He flux ratio, but are significantly larger than those reported for the ocean floor. The relationship observed between the He isotope ratio and CO_2 and CH_4 concentrations suggests that there is a mixing trend between the high ^{3}He/^{4}He-high CO_2-low CH_4 component and the low ^{3}He/^{4}He-low CO_2-high CH_4 component. The former may be derived from the upper mantle and the latter produced in a sedimentary environment. (Authors' abstract)

SANTOSH, M., 1986a Carbonic metamorphism of charnockites in the southwestern Indian Shield: A fluid inclusion study: Lithos, v. 19, p. 1-10. Author at Centre for Earth Sci. Studies, P.B. 2235, Sasthamangalam, Trivandrum 695 010, India.

See Santosh, 1984c, Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 295-296, 1984. (E.R.)

SANTOSH, M., 1986b, Nature and evolution of metamorphic fluids in the Precambrian khondalites of Kerala, south India: Precambrian Res., v. 33, p. 283-302. Author at Centre for Earth Sci. Studies, P.B. 2235, Sasthamangalam, Trivandrum 695 010, India.

The Precambrian charnockite-khondalite groups of rocks in the Kerala region constitute a significant part of the granulite facies terrain of south India. The khondalites comprise interlayered garnet-biotite and garnet-sillimanite gneisses. Analyses of coexisting mineral pairs from these rocks give temperatures of 869 ± 50°C (garnet-biotite) and 862 ± 75°C (garnet-cordierite). A garnet-orthopyroxene thermometer records 644°C for charnockite intercalated with the khondalites. Fluid inclusion studies show that the early fluids were high density CO_2-rich type (0.97 g/cm^{-3}). The graphite-bearing garnet-sillimanite gneisses show traces of CH_4 also. The early high density regime was followed by moderate density CO_2 (0.73-0.75 g/cm^{-3}) and mixed CO_2-H_2O (0.70 g/cm^{-3}) fluids. A dominant aqueous regime with H_2O densities in the range of 0.79-0.57 g/cm^{-3} manifested during the waning stage.

A combination of data from solid and fluid phases denote that the high density CO_2-rich inclusions, entrapped at a pressure of 6.1 kbar, represent the fluid phase present at or near the peak of metamorphism. The delineated fluid evolution path corresponds to the piezothermic array of khondalites and is similar in form to that of the charnockite. The array is characterized by high convexity towards the temperature axis which depicts a fast rate of uplift that exceeds the rate of heat transfer. (Author's abstract)

See also Santosh 1984c, and 1984d, Fluid Inclusion Research, v. 17, p. 295-296. (E.R.)

SANTOSH, M., 1986c Genesis of two zoned pegmatites of the Bihar mica belt: A fluid inclusion study: J. Geol. Soc. of India, v. 28, p. 29-40. Author at Centre for Earth Sci. Studies, P.B. 2235, Sasthamangalam, Trivandrum 695 010, India.

Two pegmatites, namely, Bandarchua and Kharonia, show ideal mineralogical zoning with a massive quartz core surrounded by a muscovite-plagioclase-perthite-quartz and muscovite-quartz zone. P aqueous two-phase inclusions with 40% vapor and P three-phase inclusions with CO_2(liquid) + CO_2(gas) + H_2O(liquid) occur in quartz from the feldspathic zone. PS aqueous three-phase inclusions with NaCl dm coexisting with gaseous inclusions with 60-80% vapor occur in quartz from the feldspathic zone and as P inclusions in quartz from the muscovite-quartz zone. Quartz from migmatitic gneisses show the common occurrence of monophase carbonic inclusions. Heating-freezing data assign CO_2 densities of 0.81-0.90 g/cm^3 for the peak metamorphic fluids which were entrapped at 4.2 Kb and 680°C. The feldspathic zone crystallized from moderate density (0.6 g/cm^3) and salinity (10 wt.% NaCl) fluids. Coexisting H_2O and CO_2-H_2O inclusions record 630°C and 2.4 Kb for the equilibration of the feldspathic zone. Subsequent adiabatic decompression resulted in the boiling of fluids with enhanced density (1.0 g/cm^3) and salinity (32 wt.% NaCl). Boiling, which precipitated bulk of the mineralization, occurred at 360°C to 320°C and 110-90 bars, corresponding to 1100-850 m depth. The fluid characters suggest a probable relationship between regional metamorphism and the genesis of the mineralized pegmatites of the Bihar mica belt. (Author's abstract)

SANTOSH, M., 1986a Ore fluids in the auriferous Champion reef of Kolar, south India: Econ. Geol., v. 81, p. 1546-1552. Author at Center for Earth Sci. Studies, P.B. 2235, Sasthamangalam, Trivandrum-695 010, India.

The Kolar gold field in south India, which is the principal gold producer of the country, occurs within Archean greenstones. This paper reports the results of fluid inclusion investigations in the auriferous quartz from the Champion reef, which are used to evaluate the nature of fluid evolution and the thermobarometic parameters of the gold precipitation. Three types of inclusions were studied: (1) scattered P inclusions comprising an aqueous liquid-rich type (P type I) coexisting with a two-phase CO_2-H_2O type (P type II), (2) aqueous liquid-rich inclusions (early S type I) coexisting with a vapor-rich type (early S type II) along early S arrays, and (3) late S liquid-rich inclusions. Thermometric measurements yield filling temperatures of 290° to 420°C with a peak at 310°C for the primary aqueous liquid-rich inclusions. The combined isochore for the two-phase CO_2-H_2O inclusions intersects the pyrite + arsenopyrite thermal limit of 491°C at 1.6 kb. P-T estimates based on coexisting P two-phase CO_2-H_2O and aqueous liquid-rich inclusions yield 435°C and 1.3 kb for simultaneous entrapment of immiscible fluids, marking the early sulfide stage thermobarometric parameters. The coexisting liquid-rich and vapor-rich inclusions of early secondary nature homogenize into different phases (liquid and vapor, respectively). Their filling temperatures show considerable overlap, at the range of 220° to 260°C, denoting heterogeneous entrapment at or near the boiling curve. The bulk of the gold with associated sulfides and rare minerals was probably deposited at this stage. The fluids evolved from early low salinity (3-5 equiv. wt.% NaCl) ones to late moderate salinity (7-12 equi. wt.% NaCl) ones. It is envisaged that CO_2-rich metamorphic fluids were effective in the extraction and transportation of gold at Kolar. (From the author's text)

SARKAR, S.C., 1984, Geology and ore mineralization of the Singhbhum copper-uranium belt, eastern India: Calcutta, Jadavpur Univ., 263 pp.

Contains a few inclusion data on p. 175. KCl and NaCl-bearing inclusions had Th 120-140°C; pyrite had Td 350-400°. (E.R.)

SASADA, Masakatsu, 1986, Anhydrite precipitation by low pressure boiling at DW-5 drill hole, Hohi geothermal area, Japan: Fluid inclusion evidence and geological significance: Geotherm. Resources Council, Transactions, v. 10, p. 149-154. Author at Geol. Survey of Japan, Tsukuba, Ibaraki 305, Japan.

The fluid inclusions in anhydrite from the DW-5 drill hole, Hohi geothermal area, were studied microthermometrically. The association of P liquid-rich inclusions with vapor-rich inclusions indicates the anhydrite formed from a boiling fluid. Minimum Th of 214° at 1343 m and 258° at 1394 m are the Tt of the boiling fluid. The hydrostatic P at which the anhydrite formed from the boiling fluid are estimated to be 21 and 45 bars, which are much lower than the hydrostatic P for the depth of the boiling water column from the surface to the samples. The anhydrite presumably precipitated by low P boiling and the resulting increase of pH in the liquid. Such low pressure conditions could be caused by a vapor-dominated reservoir above the anhydrite veins or a surface-linked open fracture filled with low-density two-phase fluid produced by a geyser or a hydrothermal eruption. (Author's abstract)

SASADA, Masakatsu, ROEDDER, Edwin and BELKIN, H.E., 1986, Fluid inclusions from drill hole DW-5, Hohi geothermal area, Japan: Evidence of boiling and procedure for estimating CO_2 content: J. Volcanol. & Geothermal Res., v. 30, p. 231-251. First author at Geol. Survey of Japan, Tsukuba, Ibaraki 305, Japan.

This is the full paper for abstract in Fluid Inclusion Research, v. 17, 1984, p. 297-298. (E.R.)

SAULAS, Daniel, BARBANSON, Luc and LOREDO-PEREZ, Jorge, 1986, The Zn-Pb-(Cu)-(Hg) lode deposits of Carboniferous limestones in the Asturo-Cantabrian zone: Fluid inclusion data: Bull. Soc. Geol. France, v. 8, no. 3, p. 521-523 (in French; English abstract). First author at Lab. de Métallogénie et Géochimie Minérale., Univ. Orléans, 45046 Orléans Cedex, France.

P fluid inclusions in quartz and sphalerite have been trapped around 11°C[sic; should be 110°C] in saline brines belonging to the system $CaCl_2$-$NaCl$-H_2O. With regard to chronological constraints, these results may hardly agree with genetic models involving basinal brines and a mixing model between hydrothermal deep seated solutions and superficial brines is preferred. (Authors' abstract)

SAUNDERS, D.M., BEATY, D.W. and THOMPSON, T.B., 1986, The geochemistry of the Park Utah West vein and the origin of the Park City district, Utah (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 409. First author at Noranda Explor., Box 15638, Denver, CO 80215.

The Park Utah West vein is mineralogically and texturally representative of most of the mineralization products at Park City, Utah. Fluid inclusion Th average 305°C for early quartz and 280°C for sphalerite. Clathration data indicate a P of ~270 bars, corresponding to formation T of 330°C and 305°C, respectively. Fluid inclusions contain little CO_2, and evolved with time from ~6.0 to zero wt% NaCl. No evidence of boiling was noted. Early ($\delta^{18}O$ = +10) and late (+14) Park Utah West vein quartz, as well as adjacent altered Ontario Porphyry (+8.8), equilibrated with fluids of $\delta^{18}O$ = +3. Lighter fluids, however, are indicated in altered carbonate wall-rocks (+4 to +6) from throughout the district: $\delta^{18}O$ (fluid) = -1 (Park Utah West), -3 (Ontario) and -2 (Daly West).

Thus many of the Park City ore deposits formed from a progressively cooling hydrothermal system at a depth of 2-4 km. The initial hydrothermal fluid is interpreted to have been composed of a mixture of magmatic and meteoric water (approximately 80 and 20% respectively). The plutonic source of the water (and metals and sulfur?) is not exposed. This conclusion may not extend to the Silver King and Mayflower areas, which are geologically somewhat different. (From the authors' abstract)

SAVAGE, David, 1986, Granite-water interactions at 100°C, 50 MPa: An experimental study: Chem. Geol., v. 54, p. 81-95.

SAVAGE, D., CAVE, M.R. and MILODOWSKI, A.E., 1985, Interaction of meteoric groundwater with Carnmenellis granite at 250°C and 50 MPa: An experimental study, in High heat production (HHP) granites, hydrothermal circulation and ore genesis: London, Inst. Mining & Metallurgy, p. 315-327.

SAVAGE, H.F.J. and FINNEY, J.L., 1986, Repulsive regularities of water structure in ices and crystalline hydrates: Nature, v. 321, p. 717-720.

SAWKINS, F.J., 1986, Some thoughts on the genesis of Kuroko-type deposits, in Nesbitt, R.W. and Nichol, Ian, eds., Geology in the real world - the Kingsley Dunham volume: Inst. Mining & Metallurgy, p. 387-394. Author at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN, USA.

Data from fluid inclusion studies indicate high salinities (relative to seawater) and consistently negative D values, and support the concept of magmatic water involvement in the formation of these ores.

A genetic model involving relatively long-lived seawater convection systems, perturbed by short-term additions of metal-rich postmagmatic fluids is suggested. Such a scenario both explains the strong seawater geochemical imprint seen in Kuroko-type systems, and demands no special pleading with respect to the data base. (From the author's synopsis)

SCARFE, C.M. and CRONIN, D.J., 1986, Viscosity-temperature relationships of melts at 1 atm in the system diopside-albite: Am. Mineral., v. 71, p. 767-771.

SCARRATT, K., HARDING, R.R. and DIN, V.K., 1986, Glass fillings in sapphire: J. Gemm., v. 20, no. 4, p. 203-207. First author at Gem Testing Lab. of Great Britain, 27 Greville St., London EC1N 8SU, England.

Electron microprobe analyses of a filling at the surface of a faceted sapphire indicate that it is an aluminosilicate glass. Its composition is compared with a range of glasses found in rubies, and the possibilities of a natural or of a man-made origin are discussed. It is concluded that the glass in this sapphire is man-made. (Authors' abstract)

SCHENKER, F. and HINZE, W., 1986, Preliminary information on the gas eruption at Lake Nyos, Cameroun: Bull. Ver. Schweiz. Petrol.-Geol. u.-Ing., v. 53, no. 123, p. 75-76 (in German; English abstract).

This preliminary notice deals with the fatal gas-cloud which escaped from Lake Nyos, northwest Cameroun on August 21, 1986. It is supposed that CO_2 gas, released from raising magma, built up pressure below impermeable lake sediments until breaking through. Further studies continue. (Authors' abstract)

SCHIEBER, J. and KATSURA, K.T., 1986, Sedimentation in epithermal veins of the Bohemia mining district, Oregon, USA: Interpretations and significance: Mineral. Deposita, v. 21, p. 322-328. Authors at Dept. Geol., Univ. Oregon, Eugene, OR 97403, USA.

Open spaces in epithermal veins of the Bohemia mining district, Oregon, USA, filled with sediments during hydrothermal activity. These sediments consist mainly of chalcedony, rock fragments, and vein quartz fragments. In addition, hematite is deposited during stage three of the vein development. Observed sedimentary features include draping laminae, erosion surfaces, slumping, and graded bedding. Such sediments can be used for reconstruction of the original orientation of vein systems, because the sediment laminae are initially deposited horizontally. Vein sediments record variations in fluid flow due to self-sealing, fracturing, and cessation of hydrothermal activity. Investigation of vein sediments therefore provides an additional tool to unravel the geologic history of epithermal systems. The chalcedonic vein sediments record large temperature drops and highly silica supersaturated waters, probably due to fracturing and pressure release. Hematitic vein sediments indicate sulfide deficient hydrothermal fluids. (Authors' abstract)

SCHIFFRIES, C.M., 1986, High-temperature hydrothermal veins in the Bushveld Complex: Mineralogic evidence of chloride-rich fluids (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 741. Author at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

Fracture-controlled flow of aqueous fluids produced extensive networks of hydrothermal veins in the Bushveld Complex. One type of vein is predominately composed of calcic amphibole + calcic plagioclase, with subordinate amounts of clinopyroxene (CPX) + Fe-Ti oxides ± biotite ± orthopyroxene. This mineral assemblage is characteristic of upper amphibolite facies metamorphic conditions, and temperatures inferred from mineral chemistry are greater than 500°C.

Calcic amphibole ranges in composition from actinolite to pargasitic hornblende, and contains up to 5 wt. percent chlorine. The presence of chlorine-rich amphibole indicates that chloride-rich fluids were responsible for the formation of these veins. Plagioclase associated with these veins is fresh, with little textural evidence of incipient alteration to hydrous minerals. Some veins contain plagioclase that is much more calcic than that in the surrounding rock; gradients of up to 25 mole percent anorthite occur at the margins of these veins. Hydrothermal CPX occurs as fine-grained pseudomorphs after igneous CPX, and the replacement process is accompanied by progressive chemical and textural changes. Relative to its magmatic precursor, hydrothermal CPX is enriched in Ca but strongly depleted in nonquadrilateral components, particularly Al, Ti and Cr. Textural changes include the elimination of twinning and exsolution lamellae.

The occurrence of high-temperature, chlorine-rich hydrothermal veins in the Bushveld Complex is consistent with a new class of models that call on the involvement of a chloride-rich aqueous fluid to produce or modify platinum-group element mineralization in layered igneous intrusions. (Author's abstract)

SCHMETZER, Karl, 1986, Natural and synthetic ruby: Stuttgart, E. Schweizerbart'sche Verlag., 131 pp. (in German).

Gives a general review of the origin, characteristics and identification of natural and synthetic ruby. In this context the author discusses the occurrence of fluid and solid inclusions in ruby and their use in identification. (H.E.B.)

SCHMIDT, Wolfgang, 1986, Geological evolution and formation of deposits in the pegmatite region of Alto Ligonha, P.R. Mocambique: Dissertation B, Bergakademie Freiberg, GDR (in German).

Besides the general geological and petrographic description of the pegmatite deposits in the Alto Ligonha region, P.R. Mocambique, the author discusses in this paper the genesis of the pegmatites by means of the thermobarometric and cryometric results on melt and fluid inclusions in various pegmatitic minerals: quartz, orthoclase, cleavelandite, garnet, mica, beryl, tourmaline and microlite. (Abstract courtesy of R. Thomas)

SCHMIEDL, H.D., SCHWANDT, A., SPILKER, M., BÜTTGER, T., PILOT, J., STIEHL, G. and JORDAN, H., 1986, Possibilities and restrictions for recognizing of open and closed systems in Zechstein deposits with the aid of ^{2}H and

^{18}O: Freiberger Forschungshefte, no. 417, 1986, p. 127 (in German; English abstract).

An indirect method for determining of open and closed hydrological systems with the aid of ^{2}H and ^{18}O is described. According to the experience the method can be used in mining of Cu-bearing shale without any restrictions.

If in salt mines saline or m~~i~~arine relict waters are recognized, the hydrological system is a closed one. New methods are needed to distinguish between open systems with infiltrated solutions and closed systems with converted relict solutions if meteoric waters with high contents of $MgCl_2$ were found, especially in the potash salt mining area on Werra river (GDR). So new indications must be found to recognize the converted relict solutions of closed systems. (Authors' abstract)

SCHNEIDER, Alfred, 1986, Interaction of metasomatic fluids and basaltic melt with mantle xenoliths (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 320-322. Author at Geochem. Inst., Univ. Göttingen, D-3400 Göttingen, FRG.

Analyses of the glasses between grains in xenoliths show high Si, Al, K, and Na, and the glasses are interpreted as the result of introduction of a fluid phase bearing these elements. (E.R.)

SCHNEIDER, M.E. and EGGLER, D.H., 1986, Fluids in equilibrium with peridotite minerals: Implications for mantle metasomatism: Geochimica Cosmo. Acta, v. 50, p. 711-724. Authors at Geochem. & Mineral. Program, Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802, USA.

Solubilities of oxides in H_2O and H_2O-CO_2 fluids in equilibrium with peridotites and with several single minerals have been determined at 15-20 kbar pressure and 600-1100°C.

Solutes from H_2O fluids are rich in normative quartz and feldspars, rather than in alkalies alone, and are not enriched in Mg, Fe, or Ti. Fluids in equilibrium with phlogopite peridotite contain much more solute than fluids in equilibrium with amphibole peridotite.

Experiments on amphibole peridotite and on jadeite peridotite indicate that solutes in H_2O-CO_2 fluids have molar Na/Al >1, unlike H_2O solutes. By analogy, H_2O-CO_2 solute in equilibrium with phlogopite peridotite is less peraluminous than H_2O solutes. These relations suggest alkali-CO_3 complexing in fluids. Solute contents of H_2O-CO_2 fluids are far less than of H_2O fluids, however, even for low CO_2/H_2O ratios.

Fluids that equilibrate with peridotitic wallrocks in subsolidus continental lithosphere, at depths in excess of about 70 km, are constrained by phase equilibria to be H_2O-rich and to coexist with phlogopite and carbonate. Upward-moving solute-undersaturated hydrous fluids may leach that portion of the lithosphere; the greatest relative depletion, among major elements, will be in K. Fluids must remain saturated during precipitation reaction with wallrocks, however, and hence large fluid/rock ratios are required for mantle metasomatism at depths below 70 km. Melts are more efficient metasomatic agents, in the sense that only small ratios of crystallizing melt/rock are required.

Hydrous fluids that flow upward through the phlogopite-carbonate region of the lithosphere will precipitate, and depths shallower than about 70 km, by amphibolitization-carbonatization of peridotite wallrocks. That process will add small amounts of major elements, notably K, relative to amphibole produced (on the order of 1 K_2O to 3700 amphibole). Nevertheless, integrated over time, the process may produce a metasomatized zone that represents a possible source for alkaline magmatism. (From the authors' abstract)

SCHNORR, P.H., GORMAN, J.A. and KESLER, S.E., 1986, Gas halos in hydrothermal clays associated with ore shoots at Creede, Colorado (abst.): J. Geochem. Explor., v. 25, no. 1-2, p. 258. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

Although epithermal vein systems are extensive, mineable ore shoots, which are the actual exploration targets, are much more restricted in distribution. We report here preliminary tests on a method of locating buried ore shoots in epithrmal vein systems by gas analysis. Laboratory tests show that CO_2, N_2, and H_2O are quickly absorbed onto illite/smecite, even under conditions of low concentration and low temperature, and are released upon heating. Clays developed during the hydrothermal alteration accompanying mineralization have the potential to adsorb gases, especially in systems where the mineralizing fluid boiled, the process generally thought to cause ore deposition in these systems. We have tested this possibility at Creede, Colorado, where the host volcanics to the OH vein are extensively argillized. The clay cap to the vein system consists of a mixed-layer illite/smectite that is best developed in feldspar phenocrysts. Gas chromatographic analysis of the gases adsorbed onto this clay reveals a stong correlation between C-bearing gas species and proximity to mineralization. The ratio $CO_2:CO_2 + H_2O$ is high in the clay cap above the vein, low in the footwall, and decreases with increasing distance from the vein in the hanging wall. Other gas species detected (CH_4, C_nH_n, and CO) show this relationship less well. Analysis of clay for these gases is rapid (20 minutes per sample) and requires less than 0.5 g of material, making the technique applicable to large scale exploration surveys. (Authors' abstract)

SCHNORR, P.H., KESLER, S.E. and CLOKE, P.L., 1986, Micron gold-associated jasperoid: Fluid inclusion chemistry and geothermometry (abst.): J. Geochem. Explor., v. 25, p. 246. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

Jasperoid is commonly associated with Carlin-type or micron gold deposits. It may constitute the bulk of the ore, as at Pinson, or be developed only in isolated areas, as at Carlin. Fluid inclusion studies of jasperoid utilizing traditional methods have been largely unsuccessful due to the extremely small size of the inclusions and the opacity of jasperoid. We have attempted to obtain information on the geothermometry and chemistry of these inclusions by thermal decrepitation and analysis of the evolved gases by gas chromatography. The fluid inclusions must be heated past their Th in order to generate a sufficient internal pressure to decrepitate them. Step-heating tests indicate an optimum Td of 350°C. The fluids evolved from these decrepitated inclusions contain up to 14 mole % CO_2, 2 mole % CO, 5 mole % N_2, and negligible CH_4. Water comprises greater than 90 mole % of most inclusions. Gas equilibrium calculations for analyzed inclusions from Carlin indicate probable mineralization T of 250°C to 270°C if the fluids were in equilibrium with graphite (e.g., carbonaceous limestone). Our inclusion analyses are permissive for a greater depth of jasperoid formation than has commonly been proposed. (Authors' abstract)

SCHOLLE, P.A., 1986, Diagenetic history and petroleum potential of Permian carbonate buildups, central east Greenland (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 271. Author at Geol. Sci., Southern Methodist Univ., Dallas, TX 75275, USA.

Upper Permian (probable Zechstein equivalent) strata of the Wegener Peninsula area of Jameson Land contain carbonate buildups within an otherwise dominantly shale section. The buildups originated as small algal mounds on a shallow-marine carbonate platform which had been previously exposed to subaerial erosion. This platform apparently was rapidly drowned and only a few mounds were able to develop robust fenestrate bryozoan-brachiopod-pelmatozoan faunas. Successful mounds maintained sedimentation rates which kept up with relative sea level rise, forming mud-dominated pinnacles up to 200 m in height. The pinnacle tops were probably near sea level as indicated by oolitic grainstone caps. Eventually, however, even the successful pinnacles were drowned and were encased in Upper Permian-Lower Triassic black shale.

Petrographic and geochemical studies indicate that early marine and perhaps fresh-water bladed carbonate cementation formed a stable rock framework only in the capping strata. Early glauconite cements infilled considerable pore space in upper flank facies but spared other porosity. Typically, early cements obliterated less than 1/5 of the original pore space in the main parts of the mound interior. The minor early cements were followed by a long period of intense mechanical compaction but essentially no cement formation, presumably due to encasement in black shale and isolation from water input. Late fracturing apparently allowed renewed water circulation and led to formation of massive, late-diagenetic, ferroan-manganiferous calcite (>1.2% Mn and Fe) with oxygen isotopic values of -14 to -18 per mil (PDB). These cements yield fluid-inclusion Th in excess of 120°C and appear to obliterate virtually all remnant porosity.

Petroleum potential of these mounds depends on the relative timing of hydrocarbon migration and porosity occlusion by the "late" ferroan cements. Black residues of apparent bitumen lining pores prior to Fe-Mn cements indicate that these pinnacles may have been porous potential reservoirs at the time of oil generation and migration from nearby shales and late cementation thus postdates oil migration. (Author's abstract)

SCHRADER, H.-W, 1986, Three-phase-inclusions in emerald: Fortschritte der Min., v. 64, no. 1, p. 168 (in German).

As used in gemology, the term "three-phase-inclusions" describes - not quite correctly in the physical-chemical sense - a cavity in a host-crystal, filled with a gas, a fluid and one or several crystals. They can be of P or S nature.

Such were considered for a long time as the criterion for authenticity and locality for Columbian emeralds. In the course of the last years three-phase-inclusions have also been found in emeralds from the USSR (Ural), from Tanzania (Lake Manyara) and from India. They also have been shown in emeralds from Afghanistan (Panjir-valley), Pakistan (Swath, Ghandab), Zimbabwe, Zambia, Brazil and South Africa (Transvaal).

Even if all such inclusions are typical for their locality, there exist nevertheless an astonishing similarity between the ones from Columbia and Afghanistan. Yet the emeralds from Afghanistan show a distinctly higher Sc-content.

In the "classical" three-ph.-incl. the crystal was most often a salt crystal, but in the emeralds from Brazil it is mica.

Rounded inclusions of biotite, as a proof of metamorphic alteration of mica-schist (formerly defined as pneumatolitic) besides the three-phase-inclusion (as a proof of hydrothermal alteration) show in the example from South Africa, suggesting that this deposit must have formed in a range overlapping the two P-T-environments. (Abstract courtesy H.A. Stalder)

SCHREURS, J. and WESTRA, L., 1986, The thermotectonic evolution of a Proterozoic, low pressure, granulite dome, West Uusimaa, SW Finland: Contrib. Mineral. Petrol., v. 93, p. 236-250. Authors at Inst. Earth Sci., Free Univ., De Boelelaan 1085, NL-1081 HV Amsterdam, The Netherlands.

Three fold generations have been recognized in Svecofennian rocks (±1800 Ma) from West Uusimaa, SW Finland. The first one (F1) might be related to thrusting and imbrication tectonics at plate collision contacts. The main generation (F2) is due to a N-S horizontal crustal shortening, which created at first E-W trending upright folds in the whole region and later tightened these F2 folds in the western part of the belt, whereas conjugate shear zones and tectonic lenses of competent rock bodies developed in the eastern part. Simultaneously the metamorphic conditions rose from amphibolite- to granulite-facies in this eastern part, which is known as the West Uusimaa Complex. The amphibolite- to granulite-facies transition zone along the western boundary of the granulite-facies complex is studied in detail. A number of prograde mineral reactions are telescoped in this transition zone: the breakdown of biotite and amphibole to ortho- ±clinopyroxene in metaigneous rocks, the appearance of garnet in cordierite-bearing metapelites and the appearance of scapolite in calcareous rocks. Distinct mineralogical changes also occur in this zone which cross cuts all major structures and rock units and are only affected by late-F3 folding (open, disharmonic folds with approximately N-S trending axial planes) and young shear zones, associated with pseudotachylite generation. The absence of any evidence of block faulting and tilting of the crust that could be associated with the granulite complex suggests that the whole region represents one crustal level.

A fluid-inclusion study indicates similar pressures for the amphibolite facies and the granulite facies domains. Application of various independent geothermobarometric methods suggest a low pressure (3-5 K bar) and a temperature increase from 550-650°C to 700-825°C, associated with a decreasing water activity ($0.1 < aH_2O < 0.4$) and a general increasing CO_2 activity. Fluid inclusions strongly suggest an isobaric amphibolite/granulite transition. Therefore the granulite-facies complex is designated a thermal dome. Whole rock chemical data show that granulite-facies metamorphism is isochemical. Constraints for the Svecokarelian crustal evolution are discussed. (Authors' abstract)

SCHRIJVER, K. and BERTRAND, R., 1986, Strain-induced leakage of saturated aqueous fluid inclusions results in a strongly correlated increase in temperatures of homogenization (Th, liquid phase) and dissolution of daughter crystal (Tf) (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 124. Authors at INRS-Géoressources, Ste-Foy, Quebec, G1V 4C7, Canada.

Fluid inclusions containing salt-saturated H_2O, minute quantities of CO_2 and CH_4, a vapor bubble and a halite-like dxl occur in dolospar and quartz in (1) chlorite-grade metamorphic dolostones and (2) metamorphic dolospar-quartz veins. The minerals show strong optical evidence of strain only in the veins. The inclusions in dolospar have Tm ranging from -30 to -20°C (n = 35), Th from 225-290°C (mean of normal distribution 261°C, n = 102) in dolostones, and 265-312°C (mean of skewed distribution 284°C, n = 58) in veins. Inclusions in vein quartz have Th from 242-310°C (mean 284°C, n = 23) and Tf from 143-250°C (mean 210°C, n = 23). Th and Tf in vein quartz are strongly linearly correlated (coefficient of correlation 0.65; major axis Tf = -477.0 + 2.42 Th). Based on these data, it is proposed that P fluid inclusions in veins leaked during late strain and recrystallization and were retrapped as PS and S inclusions with increasing values of Th and Tf. The most likely (Th, Tf) value of a P fluid inclusion in the veins is that with the lowest Th: (242, 147°C). According to the equation of Potter et al. (1977, J. Res. USGS, 5, p. 389), the maximum concentration of NaCl in the fluid initially trapped would be 30 wt.% on the assumption that at most subordinate quantities of other salts were present (cf. Tm >

-30°C). It is suggested that the different responses of dolostones and veins to late strain account for the highly significant differences of $\Delta Th \approx 22°C$ between the inclusions of these two rock types. (Authors' abstract)

SCHRIJVER, K., BERTRAND, R., CHAGNON, A., TASSE, N. and CHEVE, S.R., 1986, Fluids in cupriferous dolostones and dolomite veins, Proterozoic Dunphy formation, Labrador Trough: Can. J. Earth Sci., v. 23, p. 1709-1723. Authors at INRS-Géoressources, Complexe Sci., 2700, rue Einstein, C.P. 7500, Sante-Foy, Québec, Canada G1V 4C7.

The metamorphosed, cryptalgal dolostones contain Cu-Fe sulfides in dolospar-filled fenestrae and in metamorphic dolospar-quartz veins. Locally, dolostones and veins are altered to pink dolomite, with sulfides replaced by goethite. Analyses of fluid inclusions, isotopic composition of C and O, and phyllosilicates were made to try to determine the properties of fluids involved in bringing about these features.

Dolospar and vein quartz contain "workable" fluid inclusions (2-10 μm). A crystal of salt is present in most inclusions in quartz and probably in dolospar (Tm ice -30 to -20°C). Inclusions in veins have CO_2/H_2O and CH_4/H_2O mole ratios of 0.005 and 0.0004, Th (liquid) 242-312°C, and Tf (dissolution of salt) 143-250°C. Th and Tf are linearly correlated. The range of Th in dolostones is 225-290°C, significantly lower than that of veins. This difference is probably due to strain-induced leakage in vein inclusions subsequent to trapping of the brine present during metamorphism. The pink dolomites are characterized by fluid inclusions with ~6 wt.% NaCl eq. and Th of ~160°C. Partial equilibration with oxidizing waters during a post-metamorphic event is inferred. A $\delta^{13}C$(PDB) of +15.5‰ for dolomite is ascribed to an early diagenetic stage of microbial methanogenesis. Isotopic ratios were preserved in veins and lowered by ~2‰ in portions of the pink dolomite. (Authors' abstract)

SCHRIJVER, K., CHEVÉ, S.R. and TASSÉ, N., 1986, Mineral assemblages in fenestral structures in carbonate rocks: A possible aid in exploration for copper deposits (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 124. Authors at INRS-Géoressources, 2700 rue Einstein, C.P. 7500, Sainte-Foy, Quebec, G1V 4C7, Canada.

Cupriferous carbonate rocks occur on most continents and may form portions of world-class sediment-hosted copper deposits. In some, a close association has been noted between fenestral textures and sulphides. Primary and/or PS aqueous fluid inclusions of moderate salinity (Tm = -3.5°C) in goethite-bearing dolospar, have Th's around 160°C. Most likely, a system of circulation of aqueous oxidizing fluids of surficial or shallow subsurficial origin effected these late changes at a depth of several kilometers below the paleosurface and flushed copper-bearing solutions upward. Reprecipitation of copper could occur if zones traversed by these solutions would contain suitable reducing environments, e.g., a permeable body of sediment containing organic matter, sulfate-reducing bacteria and/or early-diagenetic pyrite. The potential existence of such "late" copper deposits could thus be revealed by the presence of an underlying, thoroughly oxidized carbonate rock containing iron oxides and hydroxides in its fenestrae. (From the authors' abstract)

SCHULZ, H., BEYER, W. and THOMAS, R., 1986, The formation of quartz bodies in the metamorphites of the Erzgebirge-anticlinal-zone: Zeitschrift für angewandte Geologie, Bd. 32 (1986), Heft 5, p. 117-120 (in German; English abstract). First author at IfR (Inst. für mineralische Rohstoff-und Lagerstättenwirtschaft), 8036 Dresden, Oskar-Röder-Strasse 10, GDR.

For quartz bodies in the anticlinal zone of the Fichtel and Ore Mountains according to the geological framework and the genetic conditions two formation models are presented [in part on the basis of fluid-inclusion studies]: Model A: quartz bodies of stress-oriented formation, mainly of minor dimension but higher purity, and mica shist of the green shist facies within the formation range of about 380-500°C at 1-2 kb. Model B: quartz bodies of the T-oriented almandine-amphibolite facies, bound to areas of high heat flows with anatectic indications and formation conditions of about 500-750°C at 1.8-4.0 kb. (Authors' abstract)

SCHWARCZ, H.P., 1986a Geochronology and isotopic geochemistry of speleothems, in P. Fritz and J.Ch. Fontes, eds., Handbook of Environmental Isotope Geochemistry, Vol. 2, The terrestrial environment, B: Elsevier Publ., p. 271-303.

Includes a discussion of inclusion studies on speleothems (p. 291-293). (E.R.)

SCHWARCZ, H.P., 1986b Cyanide in gold deposits: Ontario Geol. Survey Miscellaneous Paper 130, p. 161-164. Author at Dept. Geol., McMaster Univ., Hamilton.

Fluid-inclusion-rich samples of quartz from various vein occurrences, including gold ore deposits, contain a chemical species which reacts colorimetrically like either thiocyanate or cyanide, and is present at concentrations of hundreds of ppb. It is liberated from the quartz by grinding in NaOH, and presumably occurs trapped in the fluid phase of the inclusions. This raises the possibility that the $Au(CN)_{2-}$ complex may have been partly responsible for transport of gold in hydrothermal ore deposits. (Author's abstract)

SEAL, R.R., II and KELLY, W.C., 1986, Constraints on fluid sources for carbonate-hosted Pb-Zn-Ag-F mineralization, Bayhorse district, Idaho (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 743. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Stratabound Pb-Zn-Ag-F mineralization in the Bayhorse district of south-central Idaho is hosted by silicified dolomitic breccia bodies in the upper part of the lower Paleozoic Bayhorse Formation, and exhibits many geological similarities to Mississippi Valley-type mineralization. However, fluid inclusion data from quartz associated with galena and sphalerite and from later fluorite are not consistent with typical basin-derived fluids.

Fluid inclusions hosted by quartz comprise three types: two-phase (H_2O + vapor), two-phase (CO_2 + vapor), and three-phase (H_2O + CO_2 + vapor). Local evidence for fluid immiscibility (CO_2 effervescence) is present. Triple-point melting temperatures for CO_2 (-57.0 ± 0.2°C) suggest that the CO_2-rich phase is nearly pure. Salinities are low (3.1 ± 0.4 eq. wt.% NaCl). CO_2-bearing aqueous inclusions decrepitate prior to homogenization, but yield a minimum temperature of 250°C. Fluid inclusions hosted by fluorite are two-phase (H_2O + vapor). Salinities are very low (0.3 ± 0.4 eq. wt.% NaCl) and homogenization temperatures range from 76 to 158°C (av. 132°C).

Differences in salinity, CO_2 content and temperature between these fluids suggest that the Pb-Zn-Ag and the F mineralizations were produced by two distinct fluids. Neither has a salinity compatible with a typical basin-derived source. The low salinity, the high CO_2 content and temperature of the fluid associated with early Pb-Zn-Ag mineralization are consistent with either evolved meteoric, metamorphic and/or diluted magmatic fluids, but alternatively may be interpreted as diluted basinal brines. In contrast, the usually dilute, moderate temperature fluid associated with the later fluorite probably represents heated meteoric waters. (Authors' abstract)

SEEWALD, J.S. and SEYFRIED, W.E., Jr., 1986, Ca and Na metasomatism during hydrothermal basalt alteration: An experimental study (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 744.

SEGALSTAD, T.V., JOHANSEN, H. and OHMOTO, H., 1986, Geochemistry of hydrothermal processes at the Kongsberg silver deposit, southern Norway (abst.): Terra Cognita, v. 6, no. 3, p. 511. First author at Min.-Geol. Museum, Univ. Oslo, Sars gate 1, N-0562 Oslo 5, Norway.

The native silver-bearing calcite veins at Kongsberg are known to occur where the fracture system intersects "Fahlbands", schistose zones in the Precambrian gneisses rich in iron sulfides. Microthermometric, data are reported from fluid inclusions in quartz, calcite, fluorite, sphalerite, axinite, and barite from different mineralization stages. Stable isotope data are also reported: oxygen isotopes in calcite, carbon isotopes in calcite and "coal blende" (carbonaceous material), and sulfur isotope in sulfides and barite.

Fluid inclusion T of formation range between 200 and 300°C. P correction has been applied assuming hydrostatic pressure of 350 bar at 3.5 km stratigraphic depth. Salinities range from 0 to 35 equiv. wt.% NaCl. The inclusion data reveal at least three different heating and cooling cycles with associated salinity cycling. Native silver has generally been deposited during the heating part of the cycles from 250 to 300°C associated with a decrease in salinity from about 27-22 to about 20-15 equiv. wt.% NaCl (different for different mines and different cycles). Mineralizing fluids which reached T <250°C and/or reached salinity maxima less than 22 equiv. wt.% NaCl have not been found to deposit native silver.

Thermochemical modeling shows that the hydrothermal solution was poor in sulfur (<0.01 m) and rich in carbon (>1 m). Chemical reactions between a saline solution of this kind and pyrrhotite in the fahlbands at the temperature of minimum calcite solubility (slightly >250°C) led to the deposition of native silver with coal blende. (From the authors' abstract)

SEGALSTAD, T.V. and OHMOTO, H., 1986, Magmatic and crustal waters in hydrothermal solutions associated with ore deposition in the Permian Oslo rift, Norway (abst.): Terra Cognita, v. 6, no. 3, p. 555. First author at Mineralogisk-Geologisk Museum, Univ. Oslo, Sars gate 1, N-0562 Oslo 5, Norway.

The ore mineralizations of the Oslo rift are characterized by the elements Pb, Zn, Ag, Ba, F, Fe, Cu, and Mo. These are distributed among vein, skarn, and porphyry-type deposits, many of which are clearly associated with granitic intrusions. However, some vein-type deposits are found far outside any exposed granitic intrusions, and the source of the ore-forming solutions is not clear.

The result of approximately 400 analyses of stable isotopes (O, C, S and H) from igneous rocks and ore deposit minerals in the Oslo rift will be reported in order to characterize the hydrothermal fluids in this continental rift.

The stable isotope data indicate a mantle source for most of the magmatic rocks. The data also reveal that the magmas underwent different degrees of contamination from crustal rocks, and that both magmatic and meteoric water circulated in the rift exchanging O and H isotopes with some of the rocks.

From fluid inclusion Ts, known equilibrium isotope fractionation factors, and the analyzed $\delta^{18}O$ for hydrothermal quartz in ore deposits and veins, the oxygen isotope composition of the fluids has been calculated in order to obtain a conception of the rift's paleohydrology. This shows that hydrothermal deposits of Mo and Cu generally formed from solutions dominated by magmatic water. Vein deposits of Pb, Zn, Fe, F and Ag are generally dominated by solutions which were more or less in isotopic equilibrium with crustal rocks. This "crustal water" may be either meteoric water and/or waters which have exchanged isotopes with crustal rocks.

$\delta^{34}S$ for sulfide minerals in the ore deposits reflects in most cases $\delta^{34}S$ of the host rocks. This fact, in addition to salinity data from the fluid inclusions, indicate that the solutions had enough Cl to transport the metals as chloride complexes, and that bisulfide complexing was not important in these systems. A large proportion of sulfur in the ore deposits must then have been acquired through reactions between the solutions and the host rocks.

The vein deposits of iron oxides and those of fluorite show evidence of fluid/vapor immiscibility. Thus, boiling in the hydrothermal solution led to these types of ore deposition in the Oslo rift. (Authors' abstract)

SEITZ, J.C., PASTERIS, J.D., WOPENKA, Brigitte, BODNAR, R.J. and STERNER, S.M., 1986, Using laser Raman microprobe (LRM) spectroscopy to bridge the gaps in microthermometric (MT) compositional data in the CO_2-CH_4-H_2O system (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 744. First author at Dept. Earth & Planet. Sci., Washington Univ., Box 1169, St. Louis, MO 63130.

MT and LRM analysis of ~30 synthetic fluid inclusions in quartz show them to consist of an aqueous liquid, carbonic (CO_2-CH_4) fluid, and graphite at room temperature. In contrast to considerable experimental data and equations of state for the CO_2-CH_4 system (Arai, 1971; Heyen et al., 1982), almost no data exist for CO_2-CH_4-H_2O. Of particular geological interest is the CO_2:CH_4 ratio in CO_2-CH_4-H_2O inclusions, which can be inferred from the CO_2-CH_4 system by making some simplifying assumptions (Hollister & Burruss, 1976). However, complications arise in MT analysis due to differential partitioning of CO_2 and CH_4 between clathrate hydrate and the residual (after clathrate forms) carbonic fluid. MT of our inclusions yields compositions of the residual carbonic fluid. However, MT determinations of the bulk CO_2:CH_4 ratio are much more difficult to make, particularly around the critical region (Seitz, Pasteris, Wopenka, in prep.).

In Raman spectroscopy, knowledge of Raman scattering efficiences and spectral peak areas for two species allows the determination of their ratio. This method therefore seems ideally suited to the above inclusions. However, scattering efficiencies are known only for 1-bar gases rather than high-density fluids, as above. We have developed a means of combining MT and LRM analysis at low temperature to determine bulk compositions in the critical region where P-T data are lacking for the CO_2-CH_4 system. (Authors' abstract)

SELVERSTONE, Jane, 1986, Possible consequences of CO_2-H_2O immiscibility on blueschist-facies metamorphism (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 745. Author at Dept. Earth & Planet. Sci., Harvard Univ., Cambridge, MA 02138.

CO_2-H_2O immiscibility at depths of >30 km is a direct consequence of the depression of isotherms that occurs in active subduction zones. We should thus expect two stable fluid phases (1 = dense, CO_2-rich; 2 = less dense, H_2O-rich, ± NaCl) to be generated by decarbonation and dehydration of subducted material. Blueschist-facies metamorphism of intermixed carbonate-bearing, volcanogenic, and pelitic material in many cases will occur in the 2-fluid field; "retrogression" of blueschists to greenschists (e.g., by accretion onto hanging wall) will be accompanied by mixing of the fluids to form a single supercritical fluid phase.

Consequences of fluid immiscibility during generation of blueschists include: (a) the thermodynamic variance calculated from blueschist assemblages underestimates the true variance if only a single fluid is assumed to be present; (b) metasomatic effects may result from the different solubilities of elements such as Na in CO_2-rich vs. aqueous fluids and from the different transport properties of these fluids; (c) physical separation and lateral migration of the carbonic fluid could account locally for CO_2-rich fluids observed in lower crustal rocks; (d) fluid-rock ratios calculated assuming the existence of a single aqueous fluid phase in blueschists are subject ot error.

Because transport of heterogeneous material to depth is more likely to generate two fluid phases than subduction of homogeneous, hydrated oceanic crust, the effects of CO_2-H_2O immiscibility on blueschist facies metamorphism are likely to be greatest in areas where sediment subduction is or has been important. (Author's abstract)

SEMENOV, Yu.V., PROKOF'YEV, V.Yu. and KHODAKOVSKIY, I.L., 1985, Formation of cryolite and chiolite in hydrothermal processes (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 173-174 (in Russian; translation by Dorothy B. Vitaliano). Authors at Vernadsky Inst. Geochem. & Anal. Chem., Moscow, USSR.

Recent investigations on inclusions of the mineralizing medium in cryolite from most deposits and prospects of the world have shown that the cryolite crystallized from aqueous solutions at 90-480°C (Korytov et al., 1984). According to the data of cryometric investigations of fluid inclusions in cryolite, these solutions were essentially chloride (Te = -29 to -26°C, C = 25-9 wt.% NaCl equiv.) or fluoride (Te = -3.7 to -3.4°C, C = 5-2 wt.% NaCl equiv.).

The factors controlling the formation of cryolite, chiolite and the minerals associated with them remain unstudied so far. Thermodynamic analysis of the conditions of their formation made it possible to draw the following conclusions:

1. As is seen from the diagram, the invariant point of the association topaz-cryolite-albite-chiolite-quartz at pH = 7 has the coordinates Lg $a(Na^+) = -3.25$; Lg $a(F^-) = -1.25$ (at pH = 5, respectively -1.25 and -3.25). This interval of acidity at T = 300°C evidently is the best for the formation of this mineral association, inasmuch as a rise or drop in pH requires an abrupt increase in one of the components in the solution (F or Na).

A drop in T shifts this point in the same direction as a decrease in pH.

2. The association albite-paragonite-topaz-quartz is very similar in the parameters of the conditions of formation to the association with fluoraluminates. This possibly determines the presence of paragonite in cryolite deposits and prospects. (Authors' abstract)

SENGERS, J.V. and SENGERS, J.M.H.L., 1986, Thermodynamic behavior of fluids near the critical point: Ann. Rev. Phys. Chem., v. 37, p. 189-222.

SENGERS, J.V. and WATSON, J.T.R., 1986, Improved international formulations for the viscosity and thermal conductivity of water substance: J. Phys. Chem. Ref. Data, v. 15, no. 4, p. 1291-1314. First author at Inst. Phys. Sci. & Tech., Univ. Maryland, College Park, MD 20742.

This paper describes improved international formulations for the viscosity and thermal conductivity of water substance recently adopted by the International Association for the Properties of Steam. (Authors' abstract)

SERDOBINTSEVA, V.V., VASIL'EVA, N.G., KALININ, D.V., LAPTEV, Yu.V. and STREKHLETOV, A.N., 1985, Reaction of sulfur with water and a 10% NaCl solution at increased temperatures and pressures: Geol. i Geofizika, v. 26, no. 10, p. 113-116 (in Russian; translated in Soviet Geol. & Geophys., v.

26, no. 10, p. 108-111, 1985).

The reaction of sulfur with water was studied at T = 230 and 300°C, $P(H_2O)$ = 50.6 MPa, and also at T = 300°C, $P(H_2O)$ = 50.6 MPa in a 10% NaCl solution. The equilibrium concentrations of sulfate sulfur under these conditions and the time for the reaction of sulfur hydrolysis to reach equilibrium were established by experiment. The results obtained are especially important for experimental work on sulfide-silicate reactions. (Authors' abstract)

SEREZHNIKOV, A.I., 1986, Comparative geochemical characteristics of the recent and ancient hydrothermal systems of volcanic areas: Dokl. Akad. Nauk SSSR, v. 288, no. 2, p. 457-461 (in Russian). Author at All-Union Sci.-Res. Inst. of Hydrogeology & Engrg. Geol., Zelyonyi near Moscow, USSR.

The author discusses the physico-chemical state of the hydrothermal systems, quoting some literature inclusion data on the Mississippi Valley type deposits and indicating the importance of boiling for decomposition of the metal thiocomplexes and the resulting precipitation of ores. (A.K.)

SEYFRIED, W.E., Jr., BERNDT, M.E. and JANECKY, D.R., 1986, Chloride depletions and enrichments in seafloor hydrothermal fluids: Constraints from experimental basalt alteration studies: Geochimica Cosmo. Acta, v. 50, p. 469-475. First author at Dept. Geol. & Geophys., Univ. Minnesota, Minneaplis, MN 55455, USA.

Na-K-Ca-Cl fluid was reacted with diabase at 400° and 425°C, 400 bars and fluid/rock mass ratio of 0.5 to assess the relative mobility of dissolved Cl. Fluids from the present experiments reveal relatively large time and T dependent decreases in Cl; T increase enhances Cl removal, whereas reaction progress has the opposite effect. These changes are not due to boiling and/or phase separation.

The experiments provide evidence of the non-conservative behavior of Cl during hydrothermal alteration of basalt. The data are particularly important in light of the Cl-depleted nature of some ridge crest hot spring fluids, and suggest T of formation for these fluids of ~410°C, assuming sub-seafloor P of 400 bars. In addition, the retrograde solubility of the Cl-bearing phase responsible for Cl fixation during high T basalt alteration, may help to explain Cl enrichment in hot spring fluids which have conductively cooled below 350°C. (From the authors' abstract)

SHAO, J.L. and MEI, J.M., 1986, On the study of typomorphic characteristics of mineral inclusion[s] in the gold deposits from volcanic terrain in Zhejiang and its genetic and prospecting significance: Miner. & Rocks., v. 6, no. 3, p. 103-101 (in Chinese; English abstract). Authors at Wuhan Coll. of Geol.

The problems of genetic and prospecting significance of typomorphic characteristics of mineral inclusion[s] is discussed. Data of Td and Th of main mineral [i.e., fluid] inclusions and of chemical compositions the salinity, and H ion concentration (pH value) of the ore-forming fluid of Au deposits from volcanic terrain in Zhejiang are given. The ore-forming P and depth are [also] calculated. The results of investigation of pyrite, quartz, iron-bearing sphalerite, rhodonite, galena, and rhodochrosite indicate that these Au deposits are volcanogenic hydrothermal ore deposits, and that the typomorphic characteristics of mineral [fluid] inclusions have prospecting significance. (Authors' abstract)

SHARMA, S.K., 1986, Micro-Raman spectroscopy measurements of materials under high pressure in diamond anvil cell (abst.): Bull. Minéral., v. 109 Supplement, p. 67.

SHASKIN, V.M., ANDRUSENKO, N.I. and KUCHER, M.I., 1986, Reconstruction of formation of gold-silver-base metal ores on the data of gas and isotope content of inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 66-68 (in Russian). Authors at TsNIGRI, MGRI, Moscow, USSR.

By studying thermometry and chemistry of inclusions it was established that gold-silver ores formed from NH_4-bearing, mainly sulphate solutions of moderate salinities at 370-200°C and pressure drops of 200-300 atm often with boiling. Silver-base metal ores formed from chloride bicarbonate solutions of higher salinities at 420-180°C, with smaller drops of pressure and less boiling.

Gas components of ore paragenesis of gold-silver ore were as follows (cm^3/kg): CO_2 0.078-52.6; CO 0.0014-0.0055; N_2 0.54-2.8; H_2 0.36-0.52; CH_4 0.0070-0.25; heavy hydrocarbons 0.000056-0.00274; He 0.00036-0.0052; Ar 0.037-0.28. The characteristics for quartz-adularia paragenesis: atmospheric ratio of O_2 and N_2, atmospheric isotope content of Ar, lighter isotope content of carbon in CO_2 gas: $\delta^{13}C$ 14-15‰. Quartz-rhodonite-rhodochrosite mineral paragenesis gave a higher content of organic carbon, carbon-containing gas components a positive correlation with He concentrations and the lighest isotope content of carbon in CO_2 gas: $\delta^{13}C$ is average 17-19‰.

Silver-base metal ores were characterized by mainly CO_2 or N_2-CO_2 content of gas phase, occasionally with the traces of hydrocarbon gases. Isotope composition of carbon in CO_2 is similar to that of quartz-adularia association. (From the authors' abstract, translated by I.V. Kulikov)

SHAVER, S.A., 1986, Elemental dispersion associated with alteration and mineralization at the Hall (Nevada Moly) quartz monzonite-type porphyry molybdenum deposit, with a section on comparison of dispersion patterns with those from Climax-type deposits: J. Geochem. Explor., v. 25, p. 81-98. Author at Dept. Geol., Thompson Hall, Kansas State Univ., Manhattan, KS 66506, USA.

Mapping and petrographic/fluid inclusion studies indicate that in each alteration/mineralization pulse, early quartz-molybdenite ± chalcopyrite ± pyrite veinlets with K-feldspar alteration envelopes (T = 470-750°C; wt.% NaCl eq. = 8-19%) were followed by quartz-muscovite ± pyrite ± fluorite (greisen) veinlets with envelopes of coarse-grained (1-23 mm) muscovite. Later fluids in some pulses formed quartz-magnetite veinlets or chlorite-enveloped (quartz-pyrite-chalcopyrite ± magnetite) veins, but all pulses were ultimately closed by quartz-galena-sphalerite-chalcopyrite ± tetrahedrite ± pyrite veins having no alteration envelopes (T = 370-450°C, wt.% NaCl eq. = 30-41%). (From the author's abstract)

SHAYAKUBOV, T.Sh., POLYKOVSKIY, V.S. and LAPIDUS, S.Ya., 1985, Temperature conditions for the formation of the massive-sulfide - polymetallic mineralization of Southern Uzbekistan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 108-109 (in Russian; translation by D.A. Brown). First author at Ministry of Geol. Uzbek SSR, Tashkent, USSR.

Td studies lead to the following conclusions. The earliest metasomatic quartz in the prospects examined is characterized by a slow process of formation at ~100-540°C, with a comparatively small overall decrepitation activity, of the order of 15-20 imp. The weakly-defined decrepitation occurs at ~320-340°C.

Quartz from the true massive-sulfide - polymetallic association is marked by the presence of two closely-spaced decrepitation maxima at ~280-420 and ~420-520°C, with an overall activity of 55-60 imp.

Quartz from the late phase of formation of the ore bodies of this association has typical decrepitograms, which are marked by comparatively low initial Td (140-180°C) and well-defined maxima at ~180-310°C.

The T study of the mineralization, superimposed on skarns, and revealed in the western part of the Yakkobag structure, has enabled the authors to discern two decrepitation maxima on the diagrams. The first shows up at Td = ~520-640°C and corresponds to the concluding phase of skarn formation; the second maximum (240-280°C) corresponds to the process of polymetallic mineralization, superimposed on the skarns.

The Td studies have enabled the authors to recognize the metasomatic and hydrothermal stages of formation of the massive-sulfide - polymetallic mineralization and to describe their corresponding Td. (From the authors' abstract)

SHCHERBAN', I.P. and SHUN'KO, V.V., 1985, New type of wall-rock metasomatite at uranium ore-mineralized points: Geologicheskiy Zhurnal, v. 45, no. 5, p. 47-58 (in Russian). Authors at Inst. Geochem. & Physics of Minerals of Ukrainian Acad. Sci., Kiev, Ukraine, USSR.

The metasomatites occur in an old large, 10-15 km wide fault zone of contact of granitoid massif with synclinorium of sedimentary-metamorphic rocks. Metasomatites form a series of stratiform, steeply dipping bodies from less than 1 m to over 10 m thick and occurring 30-150 m apart. Country rocks are amphibolites, gneisses and granites. Metasomatites consist of quartz, biotite or hornblende, chlorite, plagioclase, K-spar, calcite and dispersed hematite, all in variable amounts. Fluid inclusions were studied in calcite; three types of inclusions were distinguished: 1) most abundant secondary L one-phase or G/L two-phase inclusions with Th 70-80°C, 2) S and PS (G 5-7 vol.%) inclusions with Th up to 100°C, rarely up to 120°C; 3) P G/L inclusions homogenizing in L phase at 120-250°C, sometimes with LCO_2. The upper Th limit is accepted by the authors as T of formation of metasomatites, Th of S inclusions reflect the later processes of partial redistribution of uranium ores. (Abstract by A.K.)

SHCHIRITSA, A.S., DYAKONOVA, L.V. and ZVOL'SKIY, V.S., 1985, Improved heating stage for medium-temperature measurements of the process of homogenization of inclusions in minerals: Inst. Geol. Nauk Akad. Nauk Ukr. SSR - Preprints, no. 31, 21 pp. (in Russian).

Cited in Naumov, 1986 (this volume).

SHEARER, C.K. and PAPIKE, J.J., 1986, Distribution of boron in the Tip Top pegmatite, Black Hills, South Dakota: Geology, v. 14, p. 119-123.

SHEARER, C.K., PAPIKE, J.J., SIMON, S.B. and LAUL, J.C., 1986, Pegmatite-wallrock interactions, Black Hills, South Dakota: Interaction between pegmatite-derived fluids and quartz-mica schist wallrock: Am. Mineral., v. 71, p. 518-539. First author at Inst. for the Study of Mineral Deposits, South Dakota Sch. Mines & Tech., Rapid City, SD 57701-3995.

Fluid exsolution during the crystallization of a volatile-rich pegmatitic melt can result in the formation of extensive dispersion halos around the pegmatite through fluid transport of relatively incompatible elements out of the pegmatite system.

The extent of fluid infiltration into the country rock surrounding the pegmatites and fluid composition can be approximated through trace-element modeling. At the pegmatite contact, less than one equivalent mass of fluid equilibrated with the schist. The pegmatite-derived fluids have relatively high solute concentrations (>1000 ppm) and exhibit compositional differences between pegmatites. The most noticeable differences in fluid composition are the high B content and low $f(H_2O)/f(HF)$ ratio of fluids derived from the Bob Ingersoll No. 1 and Peerless pegmatites compared to the Etta pegmatite. The low $f(H_2O)/f(HF)$ ratio of the fluid phase may be responsible for the stability of lepidolite and lithia mica relative to spodumene in the Bob Ingersoll No. 1 and Peerless pegmatites. (From the authors' abstract)

SHELTON, K.L., 1986, Geochemical and stable isotope evidence of progressive meteoric water interaction in vein-type gold-silver deposits, Republic of Korea (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 127. Author at Dept. Geol., Univ. Missouri, Columbia, MO, USA, 65211.

Fluid inclusion studies suggest these deposits formed at 200° to 400°C from fluids of 3 to 15 wt.% NaCl eq. Early Cretaceous deposits (1 to 2 km deep) formed from fluids with similar T and salinities, and are composed of multiple veins containing more complex mineralogies. Late Cretaceous deposits (<1.25 km deep) are Ag-rich with complex mineralogies formed from fluids with T and salinities of 200° to 340°C, 3 to 15 wt.% and 135° to 255°C, 1 to 4 wt% NaCl eq., respectively. H and O isotope compositions of fluids in Korean Au-Ag-vein deposits (δD = -78 to -144; $\delta^{18}O$ = 7.7 to -8.8 per mil) are consistent with progressive meteoric water interaction (increasing water/rock ratios) with depth. The consistent relationships among depth, metal contents, and water/rock ratios may be indicative of the manner in which gold and silver are scavenged from cooling plutons. (From the author's abstract)

SHELTON, K.L., READER, J.M., ROSS, L.M., VIELE, G.W. and SEIDEMANN, D.E., 1986, Ba-rich adularia for the Ouachita Mountains, Arkansas: Implications for a postcollisional hydrothermal system: Am. Mineral., v. 71, p. 916-923. First author at Dept. Geol., Univ. Missouri-Columbia, Columbia, MO 65211.

Jet-black Ba-rich adularia occurs within the Womble Shale. Fluid inclusion data suggest that adularia was deposited from a hydrothermal fluid with a salinity of 3 wt% NaCl equiv. at a maximum T of 300°C and a maximum P of 1.9 kbar. This pressure corresponds to a maximum lithostatic depth of 7.6 km, considerably less than that postulated for rocks overlying the Womble Shale (>15 km). The age, composition, and depth of formation of the Ba-rich adularia place severe constraints on the postcollisional evolution of the Ouachita Mountains and may suggest a genetic tie to the formation of Mississippi Valley-type Pb-Zn-Ba deposits. (From the authors' abstract)

SHELTON, K.L., RYE, D.M., SVERJENSKY, D.A. and WASSERMAN, M.D., 1986, Carbon and oxygen isotope systematics of the Bonneterre Formation, southeast Missouri: A dynamic basin-evolution model (abst.): Symp. on the Bonneterre Formation (Cambrian), southeastern Missouri, May 1 and 2, 1986, Univ. of Missouri-Rolla, Rolla, MO [Abstracts], p. 21.

SHELTON, K.L., SO, C.-S., RYE, D.M. and PARK, M.-E., 1986, Geologic, sulfur isotope, and fluid inclusion studies of the Sannae W-Mo mine, Republic of Korea: Comparison of sulfur isotope systematics in Korea W deposits: Econ. Geol., v. 81, p. 430-446. First author at Dept. Geol., Univ. Missouri-Columbia, Columbia, MO 65211.

The Sannae W-Mo mine is located ~60 km north of Pusan within the Gyeongsang basin of the southern Korean peninsula. The hydrothermal vein-type deposits which comprise the mine occur within an Upper Cretaceous magnetite series quartz monzonite stock which intrudes Middle Cretaceous sedimentary and volcanic rocks. Mineralization can be separated into the three stages (with declining T): early Mo, main W, and late carbonate stages. Fluid inclusion data suggest that most of the molybdenite was deposited between 550° and 350°C; wolframite and scheelite, between 450° and 300°C; and carbonates, between 300° and 180°C. Salinities of mineralizing hydrothermal fluids ranged from 5 to 25 equiv. wt. % NaCl, with a marked decrease in salinity between main W and late carbonate stages. Fluid inclusion evidence of boiling suggests a range of P from about 100 to 300 bars. This range is consistent with a depth of mineralization near 1,250 m under P conditions that alternated between hydrostatic and lithostatic. (From the authors' abstract)

SHENBERGER, D.M. and BARNES. H.L., 1986, Gold solubility in aqueous sulfide solutions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 748.

SHEPHERD, T.J., 1986, Fluid inclusion volatiles in mineral exploration (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 23. Author at British Geol. Survey, 64-78 Grays Inn Road, London, WC1X 8NG, UK.

The interest shown by industry in the application of fluid inclusions to mineral exploration is now higher than ever before, despite a general worldwide recession in mining and a healthy suspicion of over optimistic claims. Some of this confidence is a reflection of the increasing reference to inclusion data across the whole spectrum of gelogy. More importantly, there has been a revolution in the theoretical and practical aspects of inclusion research which has blown away it's hitherto old-fashioned descriptive image. The application of this new "technology" to problems of metallogenesis has been particularly successful, and has revealed many physical and chemical characteristics of ore fluids which, with careful development, could be used as potential exploration guides to different types of ore deposit. An area of active interest is the use of inclusion volatiles (H_2O, CO_2, CH_4, N_2, H_2S, H_2 and CO). These are major constituents of most ore fluid and variations in their relative abundances are controlled by changes in pressure, temperature, boiling and a host of other processes which directly and indirectly influence mineral deposition in hydrothermal systems. Examples will be given showing their application to precious metal and tin-tungsten deposits, highlighting their advantages and disadvantages, and the need to carry such surveys in conjunction with thorough geological/mineralogical studies. (Author's abstract)

SHEPHERD, T.J. and DARBYSHIRE, D.P.F., 1986, Fluid inclusion Rb-Sr geochronology of mineral deposits, in Nesbitt, R.W. and Nichol, Ian, eds., Geology in the real world - the Kingsley Dunham volume: Inst. Mining & Metallurgy, p. 403-412. Authors at British Geol. Survey, London, England.

Methods of [radioactive] dating require that the systems under consideration have remained 'closed' with respect to the parent-daughter radionucleides. Failure to satisfy this condition may result in geologically meaningless ages. However, fluid inclusions (...) are by definition 'closed' systems. Using quartz containing an abundance of inclusions, isotope dilution and mass spectrometric techniques have been employed to measure the Rb-Sr isotopic systematics of these fluids. Results show that fluid inclusion Rb-Sr isochrons can be obtained for ore deposits that are comparable in precision with conventional isochrons. Several deposits in the United Kingdom have now been tested and the ages obtained are in good agreement with previous estimates, thus confirming the validity of fluid inclusions as Rb-Sr geochronometers. (From the authors' synopsis)

SHEPHERD, T.J., MILLER, M.F., SCRIVENER, R.C. and DARBYSHIRE, D.P.F., 1985, Hydrothermal fluid evolution in relation to mineralization in southwest England with special reference to the Dartmoor-Bodmin area, in High heat production (HHP) granites, hydrothermal circulation and ore genesis:

London, Inst. Mining & Metallurgy, p. 345-364. First author at British Geol. Survey, London, England.

This is the full paper for abstract with different title in Fluid Inclusion Research, v. 18, p. 373, 1985. (E.R.)

SHEPPARD, S.M.F. and CHAREF, Abdelkrim, 1986, Organic water: Isotopic characterization and evidence for its role in the Fedj-el-Adoum Pb-Zn deposit, Tunisia: C.R. Acad. Sci. Paris, v. 302, Ser. II, no. 19, p. 1189-1192 (in French; English abstract).

Organic water is defined to be a water whose D/H ratio was derived from the direct or indirect transformation--dehydration, dehydrogenation, oxidation or exchange--of organic matter, bitumen, coal, kerogen, petroleum, organic gases, etc. The hydrogen isotope compositions, δD, are estimated to be in the range -90 to -250‰ with $^{18}O/^{16}O$ ratios similar to formation or metamorphic waters. Based on D/H, $^{13}C/^{12}C$ and $^{34}S/^{32}S$ and fluid inclusion data, fluids responsible for massive Pb mineralization of Fedj-el-Adoum are interpreted to be organic waters derived from the oxidation of organic material during bacterial sulphate reduction processes at ~70°C. (Authors' abstract)

SHEPPARD, S.M.F., CHAREF, A., HALTER, G., PAGEL, M. and WEBER, F., 1986, Origin of low δD fluids in unconformity U-deposits and Pb-Zn mineralizations associated with diapirs (abst.): Terra Cognita, v. 6, no. 2, p. 132-133. Authors at CRPG, B.P. 20, 54501 Vondoeuvre Cedex, France.

Combined H- and O-isotope, fluid inclusion and mineralogical studies have demonstrated the role of warm (70 to 200°C) formation waters with δD = -35 to -75 in (1) the Proterozoic unconformity U-deposits of the Athabasca basin, Saskatchewan (e.g., Carswell) and (2) the Pb-Zn carbonate-hosted deposits in the contact zone of saliferous diapirs (Fedj-el-Adoum, Tunisia). In both types of deposits strongly deuterium depleted fluids or minerals ($-100 > \delta D$ fluid > -170) are directly associated with some mineralization. O-isotope values are not abnormally depleted in ^{18}O.

At Carswell a good correlation is observed between decreasing δD value of Mg-chlorite ($\delta D \geqslant -182$) and increasing concentration of U in rock sample (>2000 ppm U) and disturbed K-Ar ages. The low δD chlorites are interpreted to reflect exchange with subactuel[sic] low δD meteoric waters with the intense radiation flux aiding the H-iosotpe exchange processes.

At the Fedj-el-Adoum deposit saline fluids with δD ~-110, $\delta^{18}O$ ~+10 at ~70°C followed brines with δD ~-60, $\delta^{18}O$ ~+12 at ~120°C interpreted to be of formation water origin and preceded low T (<50°C) less saline fluids with δD ~-20, $\delta^{18}O$ ~+2 of inferred meteoric origin. The low D-fluids are interpreted to be of organic water [matter?] origin where the water H was derived from the oxidation of organic matter during bacterial sulphate reduction processes.

Low-D fluids are not necessarily (1) of meteoric origin or (2) meteoric waters contemporaneous with the mineralization. (From the authors' abstract)

SHI, Gang and LI, Binglun, 1986, Study of the glass inclusions of Yinshan deposit, Jiangxi Province: Acta Petrol. Sinica, v. 2, no. 3, p. 13-23 (in Chinese; English abstract). Authors at Inst. Geol, Acad. Sinica, Beijing, PRC.

This paper presents a study on glass inclusions of the Yinshan Cu-Pb-Zn deposit in Dexing country, Jiangxi Province. The features of magmatic inclusions in volcanic and subvolcanic rocks in the district were described and from that it is known that the cooling rate of the magma was [high]. Th of glass inclusions in quartz in these rocks ranges from 1110° to 1210°C. Their chemical compositions were analyzed by electron microprobe and the compositional points were projected on An-Ab-Or and Q-Ab-Or phase diagrams. Furthermore, the phenocryst species, the $P(H_2O)$ conditions in crystallization differentiation were discussed. It is concluded that there had been a potassium-enriching trend during differentiation of magmas and it had played an important role in the formation of the deposit. (Authors' abstract)

Includes 19 complete analyses of glass inclusions (10 constituents) plus the norms. (E.R.)

SHIEH, Y.-N. and ZHANG, G.-X., 1986, Stable isotope studies of vein type tungsten deposits in Dajishan, Jiangxi Province, southeast China (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 748.

SHIGLEY, J.E. and BROWN, G.E., Jr., 1986, Lithiophilite formation in granitic pegmatites: A reconnaissance experimental study of phosphate crystallization from hydrous aluminosilicate melts: Am. Mineral., v. 71, p. 356-366.

SHINOHARA, H. and MATSUO, S., 1986, Results of analyses on fumarolic gases from F-1 and F-5 fumaroles of Vulcano, Italy: Geothermics, v. 15, no. 2, p. 211-215. Authors at Dept. Chem., Tokyo Inst. Tech., Tokyo, Japan.

This paper describes the methods used to collect volcanic gases from Vulcano, and to perform the chemical and isotopic analyses. The results indicate a fluctuation of the chemical composition of the gases within a short period of time. The origin of the vapor is inferred to be a mixture of sea water and the local meteoric water with subsequent vapor-rock interactions. The origin of CO_2 is ascribed to marine carbonates. A contribution of sedimentary materials is also suggested by the high N_2/Ar ratio, and high $\delta^{15}N$ of N_2. On the other hand, most of the He is concluded to be of mantle origin. (Authors' abstract)

SHIRINBEKOV, N.K., VOZNYAK, D.K., KOZAK, S.O. and NECHAJEV, S.V., 1986, Metamorphogenic gold mineralization in a region of the Ukraine and the P-T conditions of its formation, in Dopovidi Akad. Nauk Ukrayins'koyi RSR, Ser. B: Geol. Khimichni ta Biologichni Nauk, no. 2, p. 23-25 (in Ukrainian; English Summary). First author at Akad. Nauk Ukr. RSR, Inst. Geokhim. i Fiz. Mineral., Kiev, UKR.

The gold occurrence is localized in intricately dislocated crystalline rocks. It is a system of ore-bearing quartz bodies crumpled up as isoclinal folds. The ore-forming temperatures determined by means of isotopic geothermometry are on the average 430 ± 20°C and differ essentially from those of fluid inclusions' homogenization.

Geological and isotopic-geochemical data show unambiguously the high-temperature character of metamorphic ore-forming processes. (Authors' summary)

SHIROKIKH, I.N., BORISENKO, A.S., BOROVIKOVA, G.A., 1985, Particulars of the physicochemical conditions of formation and zoning of quartz-tourmaline metasomatites (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 206-207 (In Russian; translation by Dorothy B. Vitaliano). Authors at Inst. Geol. Geophys., Siberian Branch of the USSR Acad. Sci., Novosibirsk, USSR.

Investigations of GLI in quartz and tourmaline shows that the quartz-tourmaline parageneses form in a wide range of T (550-100°C) and P (180-20 MPa). the highest T of their formation were established on Cu-Mo, Au and Sn deposits, the lowest (below 200°C) on Hg. The period of formation of quartz-tourmaline cement of explosion breccias is characterized by high P.

A distinguishing feature of quartz-tourmaline mineralization is a gradual change in time of the aggregate state of the solution, observed in all the deposits studied. This is expressed in a change from essentially gaseous, sometimes "dry gas", typical of the initial periods of the process of hydrothermal-metasomatic mineralization to gas-liquid solutions and then to highly concentrated brines. Inversion [which?] of the aggregate state of the fluids takes place at different T: from 480 to 160°C (Kariy deposit -- 480°C, Dybyksa -- 410°C, Ilinsk -- 380°C, Del'machik -- 365°C, Darasun -- 350°C, Terligkhay and Uzun-say -- 160°C). The phase composition of inclusions in quartz and tourmaline varies from gaseous to gas-liquid (G + L) and then to multiphase (G + L + halite + sylvite). In most of the deposits studied, an increase in concentrations of the mineralizing solutions toward the final period of the process of tourmalinization was established. For instance, the concentration of solutions in inclusions (G > L) homogenizing to the gas phase ranges from 1-2 to 4 wt.%; in two-phase inclusions homogenizing to the fluid phase, it increases to 25 wt.%, and in late multiphase inclusions, to 45-50 wt.%. The predominant components of the mineralizing solutions are NaCl and KCl, which form independent solid phases in the inclusions, and also $CaCl_2$, the presence of which is established on the basis of data of cryometry and aqueous extracts. It is telling, that no CO_2 is found in inclusions in early quartz and tourmaline from veins and hydrothermal-metasomatic breccia cement, formed in the pre-ore stage, while inclusions with CO_2 are very typical of quartz of later veinlets and tourmaline observed in the composition of superposed quartz-sulfide ore veins.

The established systematic linear changes in aggregate state, composition and concentration of the mineralizing fluids are typical not only of the process of tourmalinization of the deposits studied, but of other endogenetic processes of mineralization leading to the formation of tourmaline-bearing parageneses. (From the authors' abstract).

SHNYREV, G.D., OKRUGIN, V.M. and CHUBAROV, V.M., 1985, Microinclusions in minerals - products of volcanic activity: Abstracts of papers of the VI All-Union Volcanologic Symp., Petropavlovsk-Kamchatskiy, v. 2, p. 274-276 (in Russian).

Cited in Naumov, 1986 (this volume).

SHOCK, E.L., HELGESON, H.C. and SVERJENSKY, D.A., 1986, Calculation of acid dissociation constants and the aqueous solubilities of gases under hydrothermal conditions (abst.): EOS, v. 67, p. 388.

SHOJI, T., 1986, Interactive processing of fluid inclusion data (abst.): Mining Geol., v. 36, no. 1, p. 64 (in Japanese; translation courtesy K. Okano, via J. Hedenquist).

In most cases, fluid inclusion data are processed through frequency tables. It is desirable to present data from the same population in a frequency table, and data from different populations in different frequency tables. One needs to make different frequency tables for each data group and compare them, in order to determine whether a data group belongs to the same population or not. For improving efficiency of this task, I have developed an interactive processing system for fluid inclusion data. This system consists mainly of a data input section and a frequency table producing section.

One inputs data directly from measurement of recording equipment through a keyboard. Before this you select the name of the equipment used for your measurements, which have already been programmed on a CRT. Through this, a coefficient is automatically inputed to convert the recorder's measurement to temperature. One can edit the input data, such as change, add and delete, and save the data on file.

For producing frequency tables, you first get a file where the data has been saved. Through CRT you will get an individual frequency table and an integrating table. As for the individual frequency table, you will be given a frequency table of the sample which you specify through command, using sample number or letters in the same code. For instance if you give qz for quartz sample, you can obtain all the input data of quartz in the frequency table. You can transfer an individual frequency table to an integrating frequency table, or add the former to the latter, or deduct the former from the latter. You can printout an integrating frequency table later. (Author's abstract)

SHUKAYLO, L.G. and BARANOV, P.N., 1985, Typomorphism of zircon as an indicator of the attribution of neovolcanic rocks in Transcarpathians to the rock formations, in Accessory minerals of rocks, Moscow, "Nauka," p. 28-30 (in Russian).

Cited in Naumov, 1986 (this volume).

SHUKAYLO, L.G., NOSYREV, I.V. and CHEPIZHKO, A.V., 1985, Melt inclusions in zircons from quartz diorite porphyries in the Vyshkovo region in Ukrainian Carpathians, in Accessory minerals of rocks, Moscow, "Nauka," p. 30-31 (in Russian).

Cited in Naumov, 1986 (this volume).

SHVEDENKOV, G.Yu., KALININ, D.V. and NAZAROV, V.V., 1986, Thermodynamics of equilibrium liquid-gas in the system H_2O-H_2S: Geokhimiya, 1986, no. 4, p. 529-539 (in Russian; English abstract).

Compositions of liquid and gaseous phases in the system H_2O-H_2S were calculated from experimental P-V-T data for pure components and their mixtures based on Peng-Robinson equation of state. (Authors' abstract)

SIEGEL, J.I., 1986, Fluorescence microspectrophotometry: Am. Laboratory, v. 18, no. 1, p. 107-109. Author at Carl Zeiss, Inc.

A general review of pertinence to HC fluid inclusions. (E.R.)

SIGURDSSON, Haraldur, PALAIS, J.M., BROWNING, David and CAREY, Steven, 1986, Sulfur and chlorine content of Nevado del Ruiz mixed magmas (abst.): EOS, v. 67, p. 403. Authors at Graduate Sch. of Oceanography, Univ. Rhode Island, Kingston, RI 02881.

The mass of tephra ejected during the 13 November, 1985, plinian eruption of Nevado del Ruiz volcano (3.5×10^{10} kg) is anomalously low compared to the estimated mass of the sulfur-rich aerosol ($>10^8$ kg; A. Krueger, pers. comm.). The erupted magma was dominantly andesitic (60% SiO_2), mixed with minor dactite magma (SiO_2 62%). Sulfur content in glass inclusions trapped in phenocrysts shows a wide range up to 1600 ppm, but averages 675 ppm and 275 ppm for inclusions hosted in pyroxene and plagioclase, respectively. Matrix glass contains 120 ppm sulfur. Minimum yield of sulfur by degassing of erupted magma is therefore 5×10^6 to 2×10^7 kg. Total sulfur in tephra which has not been rained on is 0.45 wt.%, of which only 570 ppm is in glass and minerals. Total adsorbed sulfur on tephra particles is therefore 1.5×10^8 kg. Of the estimated total sulfur emission of 2.5×10^8 kg during the eruption, only 10% can be accounted for by degassing of the erupted magma. These relations indicate that either (a) sulfur-rich mineral phases broke down during eruption, (b) a sulfur liquid or gas phase was present in the magma system, or (c) substantial degassing of non-erupted magma occurred. Glass inclusions show a narrow range in chlorine content, with average of 2200 and 2900 ppm in plagioclase and pyroxene inclusions, respectively, and 1100 ppm in the matrix glass. These results indicate minimum chlorine emission of 4 to 6×10^7 kg. (Authors' abstract)

SILVER, L.T., WOODHEAD, J.A., WILLIAMS, I.S. and CHAPPELL, B.W., 1986, On late immiscible Fe-rich melt separation during crystallization of highly differentiated siliceous granites (abst.): GSA Abstracts with Program, v. 17, no. 7, p. 747. First author at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125.

Observational evidence pointing to late immiscible separation of an Fe-Mn-Ti-rich melt has been obtained for some siliceous granites (SiO_2 >70%; alkali oxides >7-1/2%; FeO* + MnO/FeO* + MnO + MgO >0.70). Separation is inferred when crystallization exceeded 95% (vol) and residual melts were isolated and interstitial. Effects on the distribution of incompatible elements (U, Th, REE, Nb, Ta, Ti, P, F) and the paragenesis of the host accessory minerals were immediate and profound.

The evidence derived from an exemplar granite includes: (1) diversity and complexity of the accessory mineral assemblage; (2) mappable preferred association of the accessory assemblages with Fe-Ti-Mn-oxides; (3) remarkable discontinuous compositional zonation and reaction relations in various accessory minerals; (4) presence of two distinct compositional variants of some mineral species; (5) interstitial textural and compositional relations to major minerals; (6) unusual textures for the Fe-Ti-Mn-oxide minerals; (7) isotopic evidence that the assemblage is cogenetic. Assembling these observations involved mineral separations on large samples; petrography; EMP investigations and solid source mass spectrometry.

Among several important implications are: (1) the model is suitable for experimental petrology verification; (2) incompatible element behavior during granite crystallization is more complex and more determined by kinetics and local equilibria than has been previously considered; (3) endowment of late differentiates (aplites, pegmatites) may be determined by timing of their separation relative to immiscible liquid separation; (4) separation of incompatible elements from granites by volatile processes may be controlled by volatile/Fe-rich melt equilibria. (Authors' abstract)

SIMKIV, Zh.A., 1985, Geochemical aspects of the model of the endogenic ore formations (data of water leachates): Genetic models of endogenic ore formations: Abstracts of papers of the II All-Union Symp., November 1985, Novosibirsk, v. 1, p. 62-63 (in Russian).

Cited in Naumov, 1986 (this volume).

SIMMONS, S.F. and SAWKINS, F.J., 1986, Physio-chemical nature of the mineralizing solutions of the St. Nino vein, Fresnillo, Zacatecas, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 751. Authors at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN 55455.

Ag-rich mineralization in the St. Nino vein is hosted by a tilted sequence of Cretaceous graywackes, argillites, mafic submarine volcanics, and Tertiary conglomerates. The ore occurs in a favorable horizon that extends over a vertical distance of 525 m beginning 200 m below the surface. Four stages of mineralization have been recognized which record the successive and repeated passage of solutions precipitating metal sulfide-sulfosalt (sphalerite, pyrargerite[sic; pyrargyrite?], pyrite, arsenopyrite, galena, tetrahedrite, polybasite, acanthite, chalcopyrite) and gangue (quartz, calcite, chlorite, clay) minerals.

Fluid inclusion studies on quartz, calcite and sphalerite indicate that mineralizing solutions ranged between 180°-260°C and plot along a hydrostatic boiling curve (H_2O-CO_2) with respect to depth. Salinity determinations for primary fluid inclusions in sphalerite range between 8.5 to 12 eq. wt. % NaCl. In contrast, quartz and calcite inclusion fluids are dilute and less than 5 eq. wt. % NaCl. Furthermore, observed variation in the freezing point depression from -.5° to -2.7°C in necked primary inclusions within individual quartz growth zones suggest that these solutions contained less than 3 wt. % dissolved CO_2 and no more than 2 eq. wt. % NaCl. Expansion of vapor bubbles during crushing further substantiate[s] the presence of gas. Depth estimates indicate that the top of the ore zone formed no less than 300 m below the paleo-surface.

Measured helium isotopic compositions from inclusion fluids range between 1.33 (± 11) and 2.23 (± 19) times the atmospheric value and indicate the presence of mantle derived helium, probably derived from a cooling intrusive at depth. (Authors' abstract)

SIMMONS, S.F., SCHLUTTER, D.J. and NIER, A.O., 1986, Cosmogenic and mantle helium in the St. Nino vein, a silver-bearing quartz vein in the Fresnillo district, Zacatecas, Mexico (abst.): EOS, v. 67, no. 44, p. 1268. First author at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN 55455.

The Fresnillo district is a rich Ag-Pb-Zn producing mining area located in central Mexico at an elevation of 2200 m above sea level. Sulfide-bearing epithermal quartz veins are hosted in Mesozoic shales, graywackes and greenstone basalts, and overlying Tertiary felsic volcanics. Mineralization occurred at approximately 30 ma.

Helium isotope measurements on vein quartz collected for a vertical interval of .1 to 1.1 m below the surface yield ^{3}He/^{4}He ratios that decrease from 113 Ra to 67 Ra. These values are characteristic of helium produced by spallation reactions due to bombardment of quartz by cosmic rays. Step heating experiments indicate that most of the helium is released below 800°C. Crushing experiments at room temperature on the same material yields a ^{3}He/^{4}He ratio of 54 Ra suggesting that the helium, in part, resides within fluid inclusions. The concentration of helium ranges from 6.2×10^{-9} to 3.7×10^{-9} cc STP/g and varies in a nonsystematic manner with depth. This suggests that some helium was probably lost via diffusion. Linear regression on four samples studied indicate that the helium ratio decreases to 1 Ra at a depth of less than 3 meters. Estimates of exposure time give a minimum of approximately 38,000 years.

In contrast, helium isotope measurements on samples of quartz, calcite and sulfides collected between 200 m and 425 m depth yield ^{3}He/^{4}He ratios of 1.33 ± .11 Ra to 2.07 ± .22 Ra, with helium concentrations that range between 1.7×10^{-7} cc STP/g and 1.3×10^{-8} cc STP/g. These values suggest the presence of a mantle helium component trapped within inclusion fluids. Mantle helium is considered to have emanated from a cooling intrusive at depth during the time of mineralization.

Resolution of a mantle helium component in fossil hydrothermal systems requires assurance that cosmogenic effects can be ruled out. (Authors' abstract)

SIMON, K. and HOEFS, J., 1986, Effects of meteoric water interaction on Hercynian granites from the Südschwarzwald, SW Germany (abst.): Terra Cognita, v. 6, no. 2, p. 212. Authors at Geochem. Inst. der Univ. Göttingen, Goldschmidstr. 1, D-3400 Gottingen, FRG.

Hercynian granites from the Südschwarzwald show a wide range of whole rock $\delta^{18}O$ values from 2.5‰ to 10.9‰ (SMOW). Detailed ^{18}O analysis of separate minerals indicate strong isotopic disequilibrium induced by large scale post-magmatic hydrothermal interaction of the granites with isotopically light meteoric water T <500°C. Microthermometric investigation of Th and Tm for 2-phase (vapor, liquid), S fluid inclusions in quartz indicates T between 200 to 400°C for the alteration. The aqueous fluid inclusions typically have low salinities, but reach values up to 9 wt.% (NaCl equiv.) in samples with evidence for secondary mineral development (i.e., chloritization, sericitization, etc.). Trace element variations in K-feldspar (Rb, Sr, Ba, Tl, Pb, Bi) provide a guide to elemental mobilization with increasing water/rock ratios. A gain of Rb, Tl, and Bi and a loss of Sr, Ba, and Pb is observed during alteration. Combining all data a three stage reaction scheme is proposed:

I. T ~400°C: granite(prim) + fluid 1 → granite(alter) + fluid 2,

II. T ~200-300°C: fluid 2 + granite (alter) → secondary mineralization + fluid 3, and

III. T ~200°C: fluid 3 → gangue mineralization. (Authors' abstract)

SIMONEIT, B.R.T., 1986, Organic matter maturation and petroleum genesis: The hydrothermal aspect: Paper presented at the 27th Int'l. Geol. Cong. in Moscow, Aug. 9, 1984, Symp. S.II.2.2., Geochem. Int'l., v. 23, no. 4, p. 74-93.

SIMONEIT, B.R.T., SUMMERHAYES, C.P. and MEYERS, P.A., 1986, Sources and hydrothermal alteration of organic matter in Quaternary sediments: A synthesis of studies from the Central Gulf of California: Marine & Petrol. Geol., 1986, no. 3, p. 282- .

SIMONOV, V.A., 1986, Temperature regime of crystallization of rocks in ophiolites of the ocean-continent transition zone: Geologiya i Geofizika, v. 27, no. 7, p. 142-147 (in Russian; translated in Sov. Geol. & Geophys., p. 27, no. 7, p. 124-128).

Methods of thermobarogeochemistry have been used to study ophiolite associations of the eastern USSR (Chukchi, Koryakiya, Kamchatka, Kuril Islands). The principles of evolution of crystallization points of the major rock groups in ophiolites have been established. The T decreased from 1450 to 1150°C for basite-ultrabasite series in the transition from deep to near-surface formations. In the case of granitoids we observed a decrease in formation T from 1100 to 700°C in the transition from rocks similar in composition to basic varieties of plagiogranites proper. The picrite group is characterized by a stable interval of formation T (1420-1450°C). (Author's abstract)

SIMONOVA, L.I., NOSIK, L.P., MAKSIMOVA, I.G. and KRYLOVA, T.L., 1986, Distribution of uranium and other trace elements in granites and country rocks of the Kumyshtag Massif (northern Tien-Shan): Izv. Akad. Nauk SSSR, Ser. Geol., 1986, no. 5, p. 98-110 (in Russian). Authors at IGEM, USSR.

C isotopic composition of CO_2 and CO_3^{-2} in fluid inclusions determined. (E.R.)

SINHA, A.K., HEWITT, D.A. and RIMSTIDT, J.D., 1986, Fluid interaction and element mobility in the development of ultramylonites: Geology, v. 14, p. 883-886. Authors at Dept. Geol. Sci., Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061.

Shear zones are often characterized by the presence of mylonitic fabrics. The textural development of such fabrics is enhanced by the presence of a fluid phase. In a single specimen of rock from the Brevard fault zone in North Carolina, we can demonstrate the development of ultramylonite domain by focused fluid flow. The ultramylonite interface retains a sharp textural and chemical discontinuity; this suggests that solute transport was dominantly parallel to the tectonic layering. Major chemical changes between the ultramylonite zone and the protolith include losses of SiO_2, Na_2O, and K_2O and gain of CaO, FeO, and H_2O in the high-strain domain. (Authors' abstract)

SIROTIN, S.K., 1985, Thermobarogeochemical particulars of the process of degassing of solutions as a factor in near-surface volcanogenic ore formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 259-260 (In Russian; translation by Dorothy B. Vitaliano). Author at

Saratov State Univ., Saratov, USSR.

In several volcanogenic ore fields of the Far East, we carried out detailed analysis of several thousand monomineralic [samples] of quartz formations of the same age, which in particular showed that only ore-bearing bodies are characterized by two peaks of gas liberation (gl) in vacuum and decrepitation activity (d) in the T range of ore formation and supercritical T range (T^1_{gl}- 140-320° ; T^2_{gl}- T^1_d- 260-380°; T^2_d- 440-620°). The presence of these peaks, caused by the occurrence of differently filled syngenetic groups of inclusions in quartz, indicates a sharp transformation of the solutions in the course of ore formation, when during brief crystallization of matter and its supersaturation caused by degassing of the solutions, microbatches of fluids of different density are trapped. The size of these inclusions is ultra-small (less than 0.5 μm) and they are identifiable only under the electron microscope at 15000-20000 magnification. Being trapped at the same T, they nevertheless burst in different T ranges when heated above T^0_g, which is recorded in the form of two peaks on the decrepito- and thermobarograms. As further investigations showed, the ascertained typomorphic feature of ore-bearing quartz bodies is of substantial interest in solving prospecting and genetic problems.

As follows from the relationship of the decrepitometric parameters of these peaks, this process is not uniform vertically. It takes place most intensively in the zones closest to the surface and dies out with depth. An F_1/F_2 ratio (where F = gas content) or D_1/D_2 (decrepitation activity) of 0.05-0.1 characterizes the near-surface sectors; with depth it increases, reaching 1, and at deeper horizons it increases considerably, reaching 20-25. In an ore body, if it is small, this index varies insignificantly, which in one way or another makes it possible to estimate the amount of erosional truncation qualitatively. This ratio is readily correlatable with the multiplicative coefficients of contrasting geochemical zoning such as, for instance, $L = Ag\cdot Pb\cdot Zn/Sn\cdot Mo\cdot Bi$.

The use of decrepitometric parameters of the second peak (essentially gas inclusions) made it possible to make decrepitometric maps of the surface of the country rocks (considered earlier to be "blank"), where they also showed a similar effect, with a supra-ore aureole of steaming of up to 400 m thickness (from the results of exploratory drilling), in which case a distinct correlation of the decrepitation activity of the second peak and content of ore elements was also found. (From the author's abstract)

SIROTIN, S.K., SIROTIN, K.M., SMIRNOV, V.M., GRINEVA, T.B., 1985, Use of an integrated thermobarogeochemical method in solving prospecting problems (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 246-247 (In Russian; translation by Dorothy B. Vitaliano). Authors at Saratov State Univ., Saratov, USSR.

Study of the mineralizing medium, including thermovacuum and thermoacoustic analysis, multistep gas chromatography, analysis of triple aqueous extractions from monofractions of quartz of different stages, and also semiquantitative spectral analysis, showed that the ore deposition at a gold deposit in the Amur area occurred when there was intensive mixing of ascending hydrothermal solutions with vadose waters in a slightly alkaline environment. The HCO^{-3}:Cl^- [sic; HCO_3^- probably meant] ratio in the supra-ore zone was 8:2, in the ore body 6;4, 4:6, and in the sub-ore zone, 3:7, 1:9. At the time of formation of most of the ores of gold-quartz type, at 160-190°C, the solutions underwent intensive degassing with an abrupt reduction in volumetric content of

CO_2 and enrichment in atmospheric gases.

The result of bulk thermoacoustic [i.e., decrepitation] and spectral analyses showed a clear-cut record of the ore zone on the surface by a wide decrepitometric aureole of essentially gas inclusions with an intensity of 250-300 pulses in the range 400-620°C. The decrepitometric aureole of gas-liquid inclusions is characterized by very low values of intensity of decrepitation, not more than 10-15 pulses in a T range of 260-380°C. Geochemical aureoles of Ag and Au were also faintly manifested, but multiplicative coefficients of contrasting geochemical zoning were very intensively manifested and clearly correlate in plan with the aureole of P essentially gas inclusions.

Subsequent comparison of the complex parameter obtained for the reference body and promising areas made it possible to bring out similar anomalous zones on two of them and give a favorable prognosis for hidden mineralization. (From the authors' abstract).

SISSON, V.B., 1985, Contact metamorphism and fluid evolution associated with the intrusion of the Ponder pluton, Coast Plutonic Complex, British Columbia, Canada: Ph.D. dissertation, Princeton Univ.

The Ponder pluton, 1700 km^2 in area, at the eastern margin of the Coast Plutonic Complex, B.C., intruded along a structural discontinuity between gneisses, previously metamorphosed to upper amphibolite/granulite facies, on the west (Central Gneiss Complex) and unmetamorphosed carbonaceous sediment (Bowser Lake Group) on the east. Contact metamorphic assemblages (andalusite-cordierite-biotite-garnet-sillimanite) in the sediment and reset garnet-plagioclase geobarometer in the gneiss indicate a P of 2-3 kbar. The contrast in metamorphic condition of the country rock provided a unique opportunity to examine the origin and transport history of fluids associated with a plutonic intrusion.

Fluid activity in the pluton was enhanced at its contact with the Bowser Lake sediment relative to the contact with the Central Gneiss. This is indicated by the following changes which occur only as the sediment contact is approached: (1) increased alteration of plutonic feldspar; (2) decrease of F and increase in Cl in biotite; and (3) an abundance of pegmatites. In addition, (4) O isotope value in minerals range from magmatic (Qz = 8.2‰; Plag = 7.3‰) near the gneiss, to values at the pluton/sediment contact, which approach those of the bulk sediment (10.5‰), and (5) C-rich fluid inclusions occur only in samples near the sediment contact. Collectively, these observations suggest that infiltration of fluid occurred only at the contact with the sediment and locally increased the water content of the magma.

The infiltrating fluids are inferred to be derived from dehydration and decarbonation of the sediment during contact metamorphism, rather than from a magmatic or meteoric source, because whole-rock C and water decrease with increased metamorphic grade, and O isotope values are similar between the bulk sediment and pluton at the contact with the sediment. An erratic variation in fluid inclusion compositions and in O isotope values from the sediment indicates that fluid flow was not pervasive in the contact aureole, and equilibrium was not obtained. In contrast, the effect of intrusion on the gneisses was thermal only, with no evidence for fluid flow. Following intrusion and high temperature fluid interaction, the entire region was isobarically cooled. (Author's abstract)

SISSON, V.B., HOLLISTER, L.S., KAUZMAN, W.J. and CLARE, A.K., 1986, Fluid advection as a heat source for low pressure greenschist metamorphism, Chugach Mountains, Alaska (abst.): EOS, v. 67, p. 1197. Authors at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544.

The regional distribution of greenschist facies rocks in the eastern Chugach Mountains, Alaska, indicates that the sediment of the Valdez Group was heated to about 400°C. Pressures of 2-3 kbar determined in the adjacent Chugach Metamorphic Complex imply that the depth of burial was 10 km. The source of heat to cause the high apparent geothermal gradient (40°/km) in a forearc setting may be fluid generated by dehydration of the accretionary prism sediments down dip in the subduction zone as the Chugach terrane was accreted to the composite Peninsular/Wrangellia terrane to the north. The abundance of veins (up to 5%) of quartz and calcite parallel to the regional north dipping foliation attests to voluminous fluid flow. Calculations based on quartz and calcite solubility imply that minimum fluid:rock ratios were 6:1 to 1.5:1. Adiabatic injection of 1 gram of water per 3 grams of rock from a region with a temperature of 600°C will provide sufficient heat to raise the temperature from 200°C to 400°C. The high heat capacity of supercritical water (4 times rock, by mass) is an important parameter in this calculation. Fluid inclusion observations support the model of single-pass advection of fluid within the accretionary prism. Each generation of vein has a unique fluid composition and records different trapping conditions. Some veins record homogenization temperature increases from vein wall to core indicating decreasing pressure of increasing temperature during crack sealing. Others were trapped without major pressure or temperature fluctuations. The temperatures of the fluids, pressure corrected for 2.5 kbar, range from 350°C to 450°C. These fluids may represent the medium for heat transfer for the greenschist facies metamorphism in the Chugach Mountains. (Authors' abstract)

SISSON, V.B., HOLLISTER, L.S. and PLAFKER, George, 1986, Rapid two-stage metamorphism of the eastern Chugach Mtns., southern Alaska (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 2, p. 186. First author at Dept. Geol., Princeton Univ., Princeton, NJ 08544.

The density of CO_2-rich fluid inclusions was used to help trace the metamorphic conditions in P-T space. (E.R.)

SKEWES, M.A. and ATKINSON, William, Jr., 1985, Petrology of the early formed hydrothermal veins within the central potassic alteration zone of Los Pelambres porphyry copper deposit, Chile: Revista Geol. de Chile, no. 25-26, p. 39-56, 1985. Authors at Univ. Colorado, Dept. Geol. Sci., Boulder, CO 80309, USA.

Alteration and mineralization in the Los Pelambres porphyry Cu deposit, located in the Central Andes of Chile, are associated with various types of veins. The earliest formed veins associated with Cu mineralization have been termed "Intermediate Potassic" and "Type 4" by local geologists. Intermediate Potassic veins are characterized by a mica-rich central veinlet and a narrow vein halo containing quartz and K-feldspar and are better referred to descriptively as Green Mica Veins. The first micas formed in the central veinlet of Green Mica Veins are biotite with a high TiO_2/Al_2O_3 ratio, similar to magmatic biotites. The coexistence of andalusite, K-feldspar, and sericite, along with quartz, in the central veinlet of some Green Mica Veins indicates that the T at which the materials in the central veinlets of these veins were precipitated may have exceeded 550°C. Type 4 veins are characterized by a narrow quartz and K-feldspar-rich central veinlet surrounded by a wide mica-rich halo containing the assemblage andalusite, K-feldspar, sericite and quartz, indicating T of >550°C in the host rock at the times of formation of these vein halos. Both Green Mica and Type 4 veins contain highly saline halite-bearing fluid inclusions as well as halite-free vapor-rich inclusions, indicating boiling of saline magmatic fluids at the time these veins formed, similar to conditions inferred for the early stages of development of other porphyry Cu deposits.

Later quartz-Mo veins, responsible for Mo mineralization, consist of a central fracture filled with quartz and an intermittent halo of K-feldspar or sericite. Fluid inclusions in these veins suggest both boiling of highly saline fluids and the presence of a fluid of lower salinity, perhaps related to the first influx of meteoric water into the system.

The Los Pelambres porphyry system is typical of many porphyry systems in that the first episodes of alteration and mineralization are related to magmatic fluids, and as the system evolved, meteoric fluids entered the system. In Los Pelambres, it appears that the early high-T magmatic fluids initially invaded a cool host, resulting in Green Mica veins with narrow alteration halos. As the host rock became heated, Type 4 veins with wider halos developed. Although the relation between the time of intrusion and crystallization of the host rock at Los Pelambres and the subsequent alteration and mineralization event is uncertain, this conclusion is supported by the similarity of the veins at Los Pelambres with those observed at Butte, Montana, where alteration occurred 10 million years after the intrusion of the host rock, and different from the veins at El Salvador, Chile, where intrusion and alteration of the host rock were nearly contemporaneous processes. (Authors' abstract)

SKIPPEN, G.B., 1986, Chemical potential and composition space in fluid systems: Italian Soc. Mineral. and Petrology, Seminar on Role of fluids in petrogenesis, Siena, 3-4 June, 1986, [Program and Abstracts], p. 13. Author at Ottawa Carleton Centre for Geosci. Studies, Carleton Univ, Ottawa, Canada.

A review of existing experimental data indicates that we have an inadequate understanding in either P-T-X or P-T-μ space of the model fluid system, CO_2-H_2O-NaCl. An analysis of phase relations for this ternary in P-T space demonstrates that we cannot continue to assume that petrologic processes take place in the presence of a single supercritical fluid. We must reconsider rock-water interaction in the crust to allow for the presence of two fluids, a saline aqueous fluid and a carbonic fluid. (From the author's abstract)

SKIPPEN, G.B. and TROMMSDORFF, Volkmar, 1986, Hydrothermal systems in high-grade metasomatic rocks (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 128. First author at Ottawa-Carleton Centre for Geosci. Studies, Carleton Univ., Ottawa, K1S 5B6, Canada.

Studies of the system, CO_2-H_2O-NaCl, indicate that even moderate salt contents result in the presence of two fluids, a saline brine and a CO_2-rich vapor at the pressures and temperatures of metamorphism. Devolatilization reactions during metamorphism are expected to result in dilution of salt components as reaction proceeds. The presence of salt-saturated fluids in metasomatic rocks at Campolungo, Switzerland, and other localities, requires a process that leads to salt concentration with progress in the reaction, 5 dolomite + 8 quartz + H_2O → tremolite + 3 calcite + 7 CO_2. The preferential loss of a less dense, CO_2-rich vapor from a system containing two fluids is a process that leads to concentration of salt in the residual liquid. Results of geothermometry, geobarometry and studies of fluid inclusions support the possibility of a boiling hydrothermal system during the formation of high-grade metasomatic rocks at Campolungo. (Authors' abstract)

SKIPPEN, George and TROMMSDORFF, Volkmar, 1986, The influence of NaCl and KCl on phase relations in metamorphosed carbonate rocks: Am. J. Sci., v. 286, p. 81-104. First author at Ottawa-Carleton Centre for Geosci. Studies, Carleton Univ., Ottawa, Canada K1S 5B6.

Available experimental data have been used to construct a P-T projection of the system $NaCl-CO_2-H_2O$ from 0 to 2 kb and up to 1000°C. With the aid of field information, this system has been extended to 6 kb. Chemographic relationships are shown on this P-T projection. The stability fields of carbonate-silicate mineral assemblages from metamorphic rocks have been projected onto the phase elements of the ternary $NaCl-CO_2-H_2O$. Dehydration, decarbonation, and mixed volatile reactions that model common isograds of metamorphism in dolomitic marbles are related to the elements halite, halite + vapor, halite + liquid, halite + liquid + vapor, and liquid + vapor. Phase relations are derived on isothermal, isobaric plots of the chemical potentials of CO_2 and H_2O and on composition sections in $NaCl-H_2O-CO_2$.

Studies of primary solid and fluid inclusions in metasomatic veins from Campolungo, Switzerland, show that the phase element salt + liquid + vapor for equal molar proportions of NaCl and KCl in the salt is located approximately at $T = 500°C$; $P = 2000$ bars; $inf(H_2O) \approx 3.5$; $Inf(CO_2) \approx 8.0$. (Authors' abstract)

SKIRIUS, S.A., 1986, A "poor" microscopist's hotstage (abst.): Inter/Micro-86, 21-24 July 1986, McCrone Research Inst., Chicago, Illinois (unpaginated). Author at McCrone Research Inst., Chicago, IL 60616.

Many times a forensic analyst needs to make quick measurements using a hotstage. This might include determining melting points, subliming a material to purify it, noting polymorphic transformations, or running a mixed fusion on an unknown compound. Since most commerical hotstages are very expensive, most laboratories have only one available and, if in use, the analyst has to wait to obtain the information he is seeking.

This paper will describe how an accurate and dependable hotstage can be constructed for under fifteen dollars. It will also demonstrate several applications using this hotstage and how it can provide quick, accurate, and helpful information in the area of drug, fiber, explosive, and general unknown identification. (Author's abstract)

SLY, P.G., ed., 1986, Sediments and water interactions: Springer-Verlag, New York, 521 pp.

SMITH, Leslie and CHAPMAN, D.S., 1983, On the thermal effects of groundwater flow: 1. Regional scale systems: J. Geophys. Res., v. 88, no. B1, p. 593-608.

SMITH, R.W., POPP, C.J. and NORMAN, D.I., 1986, The dissociation of oxyacids at elevated temperatures: Geochimica Cosmo. Acta, v. 50, p. 137-142.

SOBOLEV, A.V. and DANYUSHEVSKIY, L.V., 1986, Evidence of magmatic nature of H_2O and the determination of its content in residual boninite melt: Dokl. Akad. Nauk SSSR, v. 288, no. 4, p. 962-965 (in Russian). Authors at Inst. Geochem. & Anal. Chem. of Acad. Sci., Moscow, USSR.

Two specimens of boninite (in vol.%, No. 26: glass 58.3, fluid phase 13.0, microlites of orthopyroxene 15.8, olivine microlites 1.3, clinopyroxene microlites 1.8, olivine phenocrysts 8.5, orthopyroxene phenocrysts 3.0, chomian spinel 0.4; No. 28: glass 80.3, fluid phase 8.4, orthopyroxene microlites 8.1, plagioclase microlites 3.1, titanomagnetite 0.1), collected in the N end of the Tonga trench during the 16th cruise of the ship "Callisto," bear, in glass, fluid inclusions of spherical or irregular habit 0.03-0.3 mm in size. The inclusions are commonly associated with crystal phases in the glass, proving the existence of inclusions during the magmatic stage of evolution of melt. Inclusions bear G and L phase at room T; T of complete freezing of L phase -25 to -40°C, T of first melting -3.2 to -2.8°C, Tm (last ice crystal) -0.2 to -0.8°C, i.e., L phase is water solution with salt concentration 0.5-1.3 wt.% of the NaCl equiv., however, the dissolved salts are more probably hydrocarbonates. Th in G phase appears at 325-340°C (No. 26) and 300-325°C (No. 28, density of fluid 0.07-0.09 g/cm^3. P in inclusions for T of softening of glass (590-640°C) equals 250-340 bars and it is close to P of sea water above the quenched melt (300 bars); T of formation of fluid inclusions determined from the equilibrium pyroxene-melt was 1040-1100°C. The calculated water content in melt was 2.9 wt.% (No. 26) and 4.2 wt.% (No. 28); the authors assume a magmatic nature for the water in fluid inclusions. (Abstract by A.K.)

SOBOLEV, A.V., FLEROV, G.B. and SHCHERBOVSKIY, Ye.Ya., 1982, Spinels in rocks of the Great Fissure Eruption of Tolbachnik volcano 1975-1976: Vulkanologiya i Seysmologiya, no. 2, p. 22-33 (in Russian). First author at Inst. Volcanology of Far-East Sci. Center of Acad. Sci. USSR, Petropavlovsk-Kamchatskiy, USSR.

On the basis of composition of chrome picotite and chrome titanomagnetites with variable concentration of Cr_2O_3 occurring in megaplagiophyric basalts of subalkaline (sensu Soviet use, not IUGS TAS diagram, see Journ. of Petrol., v. 27, no. 3, p. 745-750, 1986, A.K.) Al-rich composition and Th of a melt inclusion in clinopyroxene equal 1180°C; fO_2 was calculated as $10^{-5.5}$ - 10^{-6}. (A.K.)

SOBOLEV, A.V. and NAUMOV, V.B., 1985, The first direct evidence of presence of water in ultramafic melt and evaluation of its concentration: Doklady Akad. Nauk SSSR, v. 280, no. 2, p. 458-461 (in Russian). Authors at Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

The studied specimen of ultramafic lava came from Cretaceous Troodos massif, Cyprus; melt inclusions were studied in phenocrysts of olivine and clinopyroxene. On fractionated crystallization of melt inclusions the primary melt changes its composition from komatiite to andesite, forming most of the compositions typical of the effusive and cumulative complexes of the Troodos massif. Presence of H_2O in the original ultramafic melt is indicated indirectly by presence of dm amphibole in melt inclusions in clinopyroxene, continuous low oxide totals in composition of the remnant dacite glasses in melt inclusions in olivines and pyroxenes, and low T of softening of glass (600-650°C). Flat P melt inclusion of dimensions 200 x 80 x 10 µm in olivine, filled by dendritic clinopyroxene + glass + fluid, was heated at 950°C (after complete melting of glass but before any change of pyroxene) during 40 min., and next quenched. In fluid bubbles after this a distinct L/G border appeared (see figure), Th of L + G → G equals

Figure. Melt inclusion in olivine phenocryst from ultramafic lava (sample Cyp-1) after quenching at 950°C, a - general view of inclusion, b - detail, fluid "bubble" with phase boundary G-LH_2O; scale bar 10 µm.

321 ± 2°C, unambiguously indicating water filling and gives the estimation of density of water fluid 0.066 g/cm^3, very close to measurements of volumes of L and G (0.060 g/cm^3); thus PH_2O at T of quenching equals 360 bar. Concentration of water in melt was 2.3 ± 0.2 wt.% at 950°C, as presented in results of calculations, and after recalculation to take into account the amount of olivine that possibly precipitated on the walls of inclusion, the authors indicate the water content in the original ultramafic melt as equal 1.3 wt.%. (Abstract by A.K.)

SOBOLEV, A.V., SOBOLEV. N.V., SMITH, C.B. and DUBESSY, J., 1986, Peculiarities in the fluid and melt compositions of the lamproites and kimberlites based on the study of inclusions in olivines (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 93-94. First author at Vernadsky Geochem. Inst., Acad. Sci. USSR, Moscow, USSR.

The discovery and study of the province of diamondiferous ultrapotassic lamproites in Western Australia (Atkinson et al., 1984) has posed a series of problems, which firstly include the following: 1) the relationship between the various lamproite types and between lamproite and kimberlites; and 2) the conditions of their formation and crystallization, and the composition of the original lamproite melt and fluid content.

The study deals with the results of direct determination of both the melt and fluid compositions, the liquidus assemblage and crystallization T in olivine lamproites from the Ellendale field and in diopside-olivine-leucite lamproite from Mt. Cedric. We also worked on typical diamondiferous kimberlite from Udachnaya kimberlite pipe, Yakutia, USSR, and lamproitic rock of the hypabyssal facies from Prairie Creek, Arkansas, USA.

P inclusions in olivine-2 (second generation) from olivine lamproites from Western Australia are partly crystallized to chromite, orthopyroxene, calcilite [kalsilite, $KAlSiO_4$], picroilmenite, apatite, perovskite, phlogopite, K-richterite, and residual glasses (by microprobe) and probable fluorite (from optics). From microthermometric data (20 determinations) fluid inclusions are represented by practically pure CO_2 (triple point -56.5 to -58.3°C) of various density (ρ = 0.88-0.20 g/cm^3). No additional phases such as liquid H_2O or reactionary phases around the fluid inclusions were observed.

Inclusions in olivine-2 from kimberlite are represented mainly by decrepitated (exploded) melt and fluid inclusions and chromite. The scarse P fluid inclusions are also represented by CO_2 (triple point -56.5 to -58.0°C from 10 determinations) with maximum density 0.75 g/cm^3. Similar fluid inclusions have been fixed also in olivine-2 from lamproitic rocks from Prairie Creek. From 4 determinations they are characterized by a triple point of -56.6 to 57.5°C, ρ = 0.85 g/cm^3.

Th of melt inclusions in olivines from olivine lamproites of Ellendale (in extra pure helium) = 950-1050°C (5 runs). All others decrepitated at 650-800°C or were decrepitated naturally. Distinct Te occurred at ~600°C. At 800°C the melt has a low viscosity. The composition of quenched homogenized melt inclusions is close to typical leucite lamproite, but with higher Na_2O (up to 2.4 wt %), BaO (up to 3.3 wt %) and exceptionally high F (up to 1.4 wt %). From Th of olivine-2 (950-1050°C) and the highest density (ρ = 0.88 g/cm^3) CO_2 inclusions, P was ≤5 kbars.

Raman microprobe studies show CO_2 (90-95% mole), plus N_2 (<3.5 mol %) and CO (≤2.5 mol %) in Australian lamproites. The upper limit of H_2O contents for the fluid phase has been fixed to be <5% mol for lamproites (3 analyses) and <7 mol % for kimberlites (2 analyses). Thus the partial P of H_2O in magmatic fluid seems to be <0.5 kbars. Such contents of H_2O cannot explain an exceptionally low T for lamproite melt; the HF component is presumably responsible.

The exceptional activity of F in lamproite melt has to be considered when postulating a hypothesis on lamproite rock formation. (Abbreviated by E.R. from authors' abstract; references deleted.)

SOBOLEV, A.V., SOBOLEV, N.V., SMITH, C.B. and KONONKOVA, N.N., 1985, New data on petrology of olivine lamproites of the Western Australia from results of studies of magmatic inclusions in olivines: Doklady Akad. Nauk SSSR, v. 284, no. 1, p. 196-201 (in Russian). First author at Inst. Geochem. & Anal. Chem., Moscow, USSR.

The sample of olivine lamproite from diamond-bearing pipe Ellendale-11 is weakly altered and consists of two generations of olivine (olivine-1, 0.5-5 mm in size and olivine-2, 150-350 μm in size) in a groundmass of clinopyroxene, apatite, perovskite, phlogopite and altered glass. P magmatic inclusions were found in olivine-2 and in a thin outer zone of olivine-1. They are melt, fluid or solid inclusions. Crystallized melt inclusions contain the following crystal phases (electon microprobe identification): kalsilite, picroilmenite, apatite, perovskite, phlogopite, K-richterite and (by optical identification) fluorite. Crystal inclusions consist of orthopyroxene, chrome spinel and possibly clinopyroxene. Fluid inclusions are filled with pure CO_2 with density 0.88-0.20 g/cm^3. Only three melt inclusions were suitable for homogenization, Th 950-970°C (inclusion size 5-15 μm). P of olivine crystallization determined from density of CO_2-filled inclusions, is close to 5 kbar. The paper presents also electron microprobe analyses of inclusion melts. (Abstract by A.K.)

SOBOLEV, A.V., TSAMERYAN, O.P., DMITRIYEV, L.V. and KONONKOVA, N.N., 1986, Water-bearing komatiites as a new type of komatiite melt and the origin of the ultrabasic lavas of the Troodos massif, Cyprus: Dokl. Akad. Nauk SSSR, v. 286, no. 2, p. 422-425 (in Russian). Authors at Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

In olivines (Fo 93-87 mole %) and clinopyroxenes the inclusions of melt, low-density fluids and trapped crystals were found; they prove the saturation of melt with fluid in the whole interval of its crystallization and make possible the detailed determination of the crystallization sequence of the liquidus phases. Th was measured with heating >1000°C in <15 min. The composition of the host minerals, Th and inclusion melts are in distinct relation, proving the fractionation mechanism of crystallization of phenocrysts. Th range from 1420 to 1090°C, composition of melt in inclusions changes from komatiitic to andesitic. The comparison of the calculated T of equilibrium of the trapped melt and host mineral under 1 atm and Th indicates the presence of water in the inclusion melts. Direct estimation of the H_2O content gave the value 1.3 wt.%. The authors conclude that the water is from the mantle. (Abstract by A.K.)

SOBOLEV, N.V., DOBRETSOV, N.L., BAKIROV, A.B. and SHATSKY, V.S., 1986, Eclogites from various types of metamorphic complexes in the USSR and the problems of their origin: Geol. Soc. Am., Memoir 164, p. 349- . First author at Inst. Geol. & Geophys., Siberian Div. USSR Acad. Sci., Novosibirsk 630090, USSR.

Eclogites in metamorphic complexes of the USSR are of different types with regard to their tectonic conditions and compositions. They are: 1) tectonic inclusions in serpentinite melanges; 2) members of eclogite-glaucophane schist complexes; 3) inclusions in blastomylonite zones; and 4) those within gneiss complexes. Based upon the study of their relationships with country rocks, chemical zoning of coexisting garnets and omphacites, and compositions of gaseous-liquid inclusions in minerals, polygene character of the eclogites has been shown. P-T equilibrium parameters for eclogites associated with glaucophane schists are commonly close to those of the latter. Eclogites of gneiss complexes tend to be characterized by variable conditions of formation, even within a single complex. (Authors' abstract)

Table 5 (p. 360) lists 22 determinations of Th of CO_2 and CH_4 inclusions (-172°C up to 0°C), calculated specific volumes, and estimated pressures, assuming T = 650 and 700°C. (E.R.)

SOBOLEV, N.V., TOMILENKO, A.A. and SHATSKII, V.S., 1985, Conditions of rock metamorphism of the Zerenda group of the Kokchetav Massif according to study of fluid inclusions: Geologiya i Geofizika, v. 26, no. 4, p. 55-58 (in Russian; translated in Soviet Geology & Geophysics, v. 26, no. 4, p. 49-52, 1985).

Abstract in Fluid Inclusion Research, v. 18, p. 388. (E.R.)

SOLÍS PICHARDO, G.N. and MACÍAS ROMO, C., 1985, Metallography, microthermometry, and sulfur isotopes in the Cuale mining district, Jalisco (Mexico): Geomimet, v. 137, p. 12-49 (in Spanish).

The volcano-sedimentary massive sulfide deposits of Cuale, Jalisco, Mexico, are in Lower Cretaceous rocks.

The sulfide paragenesis is pyrite, chalcopyrite, sphalerite, and galena, with traces of stromeyerite, and of sulfosalts including freibergite, and a gangue of quartz, sericite, chlorite, epidote, and minor barite, calcite, and gypsum. Important textures observed are those of replacement, exsolution, recrytallization, and colloform.

Fluid inclusion studies indicate quartz Tf of ~200-300°C, whereas formation of sphalerite was at ~240°C. Fluid salinities fluctuated between 3 and 8 eq. wt.% NaCl, with an average density of 0.860 g/cm^3.

The results from S isotope studies for various ore bodies indicate values in $\delta^{34}S$ of +6.11 permil (pyrite), +3.74 permil (sphalerite) and +4.36 permil (galena). It is concluded that deposition of sulfides is attributed to submarine volcanic exhalations in a deep basin or marginal sea (400-700 m depth) proximal to a volcanic vent, a part of an environment of volcanic arc or marginal sea related to subduction developed during late Triassic through a maximum intensity in Lower Cretaceous time. The isotopic composition of S observed in the sulfide mineralization is attributed to a mixture of mantle derived S and seawater sulfate S in a ratio estimated at 9:1. (From the authors' abstract, translated by G. Landis)

SOLODOVNIKOVA, N.A., 1985, Temperature of mineral formation regime at one of the gold ore deposits of East Regions of the USSR (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 58-59 (in Russian; translation by I.V. Kulikov). Author at VIMS, Moscow, USSR.

The conditions of mineral formation were studied for the first time at a near-surface volcanic Au-ore deposit connected with a Pliocene caldera type volcano.

Quartz was deposited during all stages of mineral formation of the vein, so investigation of fluid inclusions in quartz permitted reconstruction of the T° regime of the mineral formation process.

Quartz contains many submicroscopical inclusions from <1 to 3 μm, usually 2-phase, less often 1- and 3-phase inclusions. In ore minerals the inclusions are <6-7 microns. Vapor phase makes up 10-40% in quartz inclusions, and 8-33%[sic] in sphalerite inclusions. IR spectroscopy indicates liquid CO_2 and CH_4 in quartz.

During heating in all cases the homogenization occurred in the liquid phase. Mineral complex of the deposit crystallized from aqueous solutions at 360-180°C (most intensively at 260-220°C). Sphalerite was deposited at 270-210°C. The ore formation process was unstable, with inversions of 150-200°C. Hydrothermal solutions were pulsating. All these data provide evidence of complex conditions of formation of this Au-ore near-surface deposit. (From the author's abstract)

SOLOMON, M., COLLINS, P.L.F., ETHERIDGE, M.A., HALLEY, S., HELLSTEN, K.J., HIGGINS, N.C. and WALL, V.J., 1986, Formation of the Aberfoyle and Lutwylche cassiterite-wolframite veins, Tasmania, Australia (abst.): Terra Cognita, v. 6, no. 3, p. 531-532. First author at Bureau of Mineral Resources, G.P.O. 378, Canberra 2601, Australia.

Fluid inclusions in quartz are of five types: (A) 3-phase with $CO_{2(l)}$, $CO_{2(v)}$ and an aqueous solution of about 3.5 equiv. wt.% NaCl; (B) 2-phase with $CO_{2(v)}$ and aqueous solution; (C) 2-phase with aqueous solution and vapor; (D) multiphase with aqueous solution, vapor and daughter salts; (E) vapor with aqueous solution. Where types A and B coexist, Th (270-360°C) and compositional data (mole% CO_2) define CO_2-H_2O-NaCl solvii. Ps estimated from experimental data are between 200 and 500 ± 100 bars. Types D and E also coexist locally and represent the components of a CO_2-poor, 2-phase H_2O-NaCl system (Th = 304-489°C). $\delta^{34}S$ values of sulphides range from +3.6 to -0.1 per mil and $\delta^{18}O$ values of quartz from +10.5 to +14.0 per mil, indicating magmatic solutions throughout quartz and sulphide precipitation. Late carbonate coating quartz may be nonmagmatic.

The history of vein formation commenced with a highly fractionated biotite granite, partly crystalline, almost saturated with water and exsolving CO_2, lying several kilometers below the surface. Local steps and bulges in the upper surface probably formed at weak points in the roof. At water saturation, fluid pressure in the granite and wall rocks rose and at $P = \sigma_3 + T$ led to tensile fracture at points of weakness (e.g., faults, cupolas). (From the authors' abstract)

SOLOVOVA, I.P., BABANSKIY, A.D. and RYABCHIKOV, I.D., 1986, Microimmiscibility in melt inclusions in the andesite mesostasis: Dokl. Akad. Nauk SSSR, v. 288, no. 5, p. 1209-1211 (in Russian). Authors at Inst. Geol. of Ore Deposits, Petrography, Mineral. & Geochem. of Acad. Sci., Moscow, USSR.

The authors found and studied immiscibility in glass of mesostasis and melt inclusions in plagioclase phenocrysts (An 50-52) from andesite of the basalt-andesite-trachyandesite formation in Great Caucasus, Kuban' River basin, near the tributary Khudes. Phenocrysts consist of plagioclase and orthopyroxene, matrix of An43, clinopyroxene, ilmenite and glass in lighter glass. Darker glass globules were found near plagioclase phenocrysts. Inclusions in plagioclase bear two immiscible glasses, plagioclase on the walls of vacuole, and large (up to 18 vol.%) G bubble. Size of the dark globules in inclusions reaches 15 μm, and in mesostasis 30 μm, but the much smaller globules prevail. Melt of matrix frequently crystallizes with formation of K-Na-feldspar and melt of globules with formation of pyroxene and spinel. Th of inclusions in plagioclase ranges from 1200 to 1220°C; two glasses homogenize in inclusions at 1155-1165°C and in the mesostasis at 1120-1135°C. Specimens were heated until crystal phases completely dissolved but below T of melt miscibility, and the quenched melt phases were analyzed. Glass matrix contains 74-75% SiO_2, 0.6-0.8 TiO_2, 10-15% Al_2O_3, 1.1-2.3% FeO (total Fe), 0.05-0.5% MgO, 0.8-2.0% CaO, 0.14-0.47% Na_2O, 2.2-4.8% K_2O, globules - 41-42% SiO_2, 6.8-11.3% TiO_2, 3.5-4.2 Al_2O_3, 25-29% FeO (total Fe), 3.8-11.3% MgO, 9.0-9.6% CaO, 0.08-0.7% Na_2O, 0.3-0.6% K_2O. Experimental melting and crystallization of this andesite under atmospheric P and dry conditions with the buffer Ni-bunsenite did not lead to immiscibility but to early crystallization of magnetite, whereas the use of the buffer Fe-wüstite gave immiscibility in mesostasis due to low oxygen fugacity. Thus immiscibility similar to the described, may be the indicator of redox conditions. (Abstract by A.K.)

SOLOVOVA, I.P., KOVALENKO, V.I., NAUMOV, V.B., RYABCHIKOV, I.D., IONOV, D.A. and TSEPIN, A.I., 1985, Carbon dioxide-sulfide-silicate inclusions in clinopyroxenes from mantle xenoliths: Doklady Akad. Nauk SSSR, v. 285, no. 1., p. 199-202 (in Russian). First author at Inst. Geol. of Ore Deposits, Petrography, Mineralogy & Geochem. of Acad. Sci. USSR, Moscow, USSR.

In alkali basalts of the region Shavaryn-Tsaram, Khangay Mts. (Mongolia), some unique specimens were found: inclusion-bearing (or vesiculated) megacrystals of clinopyroxene and druse of large, well-crystallized minerals typical of lherzolite: olivine, clino- and orthopyroxene, garnet. Neither megacrystal nor drusy crystals indicate the reactions with magma of alkali basalt. Megacrystal bears large pores parallel to cleavage and smaller G-filled vacuoles. The following types of inclusions were found in all the crystals studied: 1) fluid, 2) sulfide and silicate sulfide (with fluid), 3) silicate with fluid. Type 1 was found extremely rarely and all inclusions, even those of size 2-6 µm, were distinctly leaked. The filling is CO_2 (T of triple point -56.6°C), Th from +3 to -31°C, indicates CO_2 density 0.91-1.07 g/cm^3. Pressure calculation for 1100°C gives value 5.9 to 8.1 kbar. Earlier non-leaked CO_2 inclusions in clinopyroxene of another region gave P 10-11 kbar. If one takes into account the partial leaking of all fluid inclusions, P should be evaluated as >> 11 kbar, possibly 15-20 kbar. Inclusions of type 2, of size 40 x 90 to 100 x 200 µm, are distributed as regular chains and genetically are not connected with fractures in host mineral; sulfides are chalcopyrite and pyrrhotite. Around most of the inclusions, haloes of tiny sulfide inclusions are observed, proving the high P inside inclusions forcing the substance migration through fractures in host mineral and the liquid state of sulfide melt. Heating of the opened inclusion in argon causes melting at 940-960°C. Sulfide inclusions frequently are surrounded by rim of silicate material consisting of clinopyroxene, potassium-rich glass and skeletal spinel. Several times elliptical inclusions were observed with uniform distribution of silicate and sulfide components, indicating immiscibility. Calculation of CO_2 and sulfide volumes in inclusions suggests that original homogeneous melt would contain 5.5 wt.% CO_2, 10.3 wt.% S and have density 3.2 g/cm^3. Inclusions of type 3 have 30-60 µm of dia. and bear dms: euhedral pyroxene and granular spinel; fluid phase is CO_2 of density 0.9 to 0.3 g/cm^3. Sulfide component occurs rarely, inclusions are mostly decrepitated. Volumes of decrepitation haloes exceed the former inclusion volumes 4-7 times for sulfide inclusions, 50-60 times for silicate ones and 100-125 times for fluid inclusions. All the inclusions are supposed to be of mantle origin. (Abstract by A.K.)

SOMAN, K., NAIR, N.G.K. and DRUZHININ, A.V., 1986, Chrysoberyl pegmatites of South Kerala and their metallogenic implications: J. Geol. Soc. of India, v. 27, p. 411-418. First author at Centre for Earth Sci. Studies, Trivandrum 695010.

See Fluid Inclusion Research, v. 17, p. 325, 1984. (E.R.)

SOMAYAJULU, G.R., 1986, New vapor pressure equations from triple point to critical point and a predictive procedure for vapor pressure: J. Chem. Eng. Data, v. 31, p. 438-447.

SOMMER, M.A., II and GIBSON, E.K., Jr., 1986, Volatile determinations of individual fluid inclusions within the 3.4 b.y. North Pole barites from the Warrawoona group, northwestern Australia: Lunar Plan. Sci. XVII, p. 815-816. First author at LEMSCO/JSC, 2400 NASA Rd. 1, Houston, TX 77058.

To analyze individual inclusions, we have interfaced a Nd-glass, Q-switched laser microprobe to a computer controlled quadrupole mass spectrometer. Samples are evacuated to less than 10^{-7} torr in a small chamber with sapphire windows. Samples are "zapped" with the laser (producing decrepitation fractured pits ~30 micrometers in diameter), the evolved gases introduced directly into the ion source of the mass spectrometer. In addition, bulk fluid inclusion determinations were made using vacuum crushing, the evolved gases introduced into the mass spectrometer. Standards are various hydrous carbonate minerals and pure gases. Standard minerals yield reproducibilities of about ± 5%. Minimum detection limits are about 10^{-11} moles of gas. (From the authors' abstract)

Four types of inclusions (Rankin and Shepherd, 1978) were analyzed in terms of C, O, and H; all fall in system H_2O-CH_4-CO_2-CO. (E.R.)

SONG, Pengsheng and DU, Xianhui, 1986, Phase equilibrium and properties of the saturated solution in the quaternary system $Li_2B_4O_7$-Li_2SO_4-LiCl-H_2O at 25°C: Kexue Tongbao, v. 31, no. 19, p. 1338-1343 (in English).

SOOM, M., 1986, Geology and petrology of Ausserberg. Fissure mineralizations at the SW-rim of the Aarmassive, Switzerland: Dissertation, Mineral.-Petrol. Inst. of Univ. Bern, 135 pp. (in German; abstract courtesy H.A. Stalder).

During alpine orogenesis all rocks have been overprinted (only to greenschist-facies) by at least 3 synmetamorphic deformations. The formation of the alpine fissures is integrated in the tectonic happening and has occurred in three different stages.

Microthermometric examinations in fluid inclusions from fissure quartz of stage 2 have shown the following results:

- The salinity of the hydrothermal hydrous solutions lies between 4.2 and 7.6 eq. weight % NaCl in the crystalline basement, Triassic quartz and the Liassic. The values in Triassic dolomite and in the Keuper (Upper Triassic) are higher, 6.7 to 12.7 eq. weight % NaCl. Up to 5 mole % CO_2 appears in carbonaceous sediments (Triassic dolomite, Liassic).

By means of isochore construction a T range of 260 to 380°C and hydrostatic P of 0.8 to 1.3 kbar, corresponding to a rock superposition of 8-13 km, was estimated for stage 2 fissures. K-Ar-dating on fissure-adularia has proved a radiogenic overpressure of argon in the fluid phase and a minimal formation age of 8-10 million years for this stage.

SØRENSEN, Henning, 1986, The alkaline rocks: A review: Fortschr. Miner., v. 64, no. 1, p. 63-86. Author at Inst. Petrologi, Geol. Centralinstitut, Københavns Univ., Øster Voldgade 10, DK-1350 København K.

Includes about one page (p. 80-81) dealing with volatiles and fluid inclusions. (E.R.)

SOTNIKOV, V.I. and BERZINA, A.P., 1986, Ore-magmatic systems of copper-molybdenum deposits, in Geol. & Metallogeny of Copper Deposits, G.H. Friedrich et al., eds.: Springer-Verlag Berling Heidelberg, p. 291-302.

A review including fluid inclusion data from the literature. (E.R.)

SOTNIKOV, V.I., POLIVEEV, A.G. and BERZINA, A.N., 1985, Physico-chemical conditions of formation of granitoids of the ore-bearing complex at the Zhireken copper-molybdenum deposit: Doklady Akad. Nauk SSSR, v. 283, no. 6, p. 1463-1465 (in Russian).

Cited in Naumov, 1986 (this volume).

SOUTHGATE, P.N., LAMBERT, I.B., DONNELLY, T.H., ETMINAN, Hashem, SUMMONS, R.E., HENRY, R. and WESTE, G., 1986, Sedimentological, isotopic and fluid inclusion studies of Lake Byilkaoora, a Cambrian alkaline playa, Officer

Basin, S.A. (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 285. First author at Baas Becking Lab., G.P.O. Box 378, Canberra, 2601, Australia.

Four lithofacies have been recognized from center to edge of the lake: 1. alkaline playa lake - black, fissile dolomite mudstones with evaporite (trona, shortite, halite) pseudomorphs; 2. saline mud flat - laminated, dolomitic and silty mudstones disrupted by evaporite pseudomorphs, many of which occur along desiccation cracks; chert nodules, stromatolitic crusts and intraclast gravels are locally abundant; 3. dry mud flat - discontinuously laminated silty dolomitic mudstones containing desiccation cracks, stromatolites, sinter and dolomite crusts, intraclast gravels and teepees; 4. sand flat - desiccated, cross bedded and laminated dolomitic quartz sands, dolomitic siltstone and mudstone. Cycles of tens of meters thickness record the sequential dominance of one lithofacies over another, while superimposed smaller cycles of tens of centimeters thickness record minor oscillations in the position of the strandline.

The high $\delta^{18}O$ values of primary to early diagenetic carbonates, between 24 and 28‰ (SMOW) indicate strong evaporation of ground and surface waters entering the lake system. Calcite pseudomorphs of the sodium carbonate minerals have $\delta^{18}O$ values concentrated between 19 and 22.5‰ and fluid inclusions with variable salinities and Th up to ca. 110°C. These features imply dissolution and pseudomorphing of the trona and shortite as a result of extensive influx of heated waters which mixed to varying degrees with the relatively saline interstitial brines. TOC in Lake Byilkaoora varies from 0.5-1%; it is characterized by a consistent archaeobacterial lipid biomarker.

The Lake Byilkaoora strata exhibit some basic similarities to the Eocene Green River Formation of the western U.S.A., a lacustrine sequence containing trona, oil shale and oil. However, in addition to pervasive loss of evaporite minerals during burial, the Byilkaoora sequence is distinguished by thinner cycles, lower $\delta^{13}C$ carbonate values and lower TOC. Evidently the Cambrian lake system was characterized by relatively low productivity and/or extensive degradation of organic matter by oxidizing meteoric waters. (Authors' abstract)

SPASENNYKH, M.Yu. and BANNIKOVA, L.A., 1986, Model of isotopic exchange in the process of fluid filtration through the rock and possibility of its application to interpretation of oxygen isotopic variations in hydrothermal systems: Geokhimiya, 1986, no. 10, p. 1389-1401 (in Russian; English abstract).

SPIRAKIS, C.S., 1986, The valence of sulfur in disulfides - An overlooked clue to the genesis of Mississippi Valley-type lead-zinc deposits: Econ. Geol., v. 81, p. 1544-1545. Author at U.S. Geol. Survey, Mail Stop 916, Box 25046, Denver Fed. Center, Denver, CO 80225.

Involves a discussion of the conditions of deposition. (E.R.)

SPRY, P.G., 1986, Geological, fluid inclusion and sulfur isotopic studies of Au-Ag-Pb-Zn-Cu breccia pipe deposits, Central City, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 4, p. 325. Author at Dept. Earth Sci., 253 Science Hall I, Iowa State Univ., Ames, IA 50011.

The Central city district, Colorado, has been the largest precious metal producer in the Front Range mineral belt. Au-Ag-Pb-Zn-Cu occur in sulfide veins and breccia pipes of late Laramide age. The two largest breccia pipe deposits, Gold Cup and Patch, are composed of angular fragments of various Precambrian rocks in a matrix of Tertiary monzonite porphyry. Mineralization consists of quartz, calcite, dolomite, pyrite, sphalerite, galena, chalcopyrite, tetrahedrite, tennantite, rhodocrosite, and gold. Alteration is dominated by sericite. $\delta^{34}S$ values of sulfides from the Gold Cup and Patch deposits and two precious metal veins adjacent to the Gold Cup deposit range from +0.69 to +4.50 per mil for sphalerite, -1.65 to -0.88 per mil for galena, and +2.31 to +2.61 for pyrite. These data along with field relations are consistent with an igneous source of sulfur. Fluid inclusion studies show that the breccia pipe mineralization formed between 322° and 367°C from boiling, CO_2-poor fluids with salinities ranging from 10 to 18 eq. wt. % NaCl. These deposits formed at depths between 1025 and 1270 m, assuming hydrostatic P. Geological relations suggest the following development: 1. intrusion of monzonite porphyrys with accompanied brecciation and incorporation of Precambrian country rock; 2. emplacement of east-west trending dikes; 3. faulting and development of vein fissures; and 4. alteration and mineralization. Intrusive related breccia pipe deposits commonly form from boiling, CO_2-poor, saline (1-50 eq. wt. % NaCl) fluids at shallow depths, between 130 and 470°C. Sulfur is generally derived from a single igneous sulfur source. Geological and geochemical data show that the Gold Cup and Patch deposits are similar to other breccia pipe deposits. (Author's abstract)

SRIKANTAPPA, C., 1985, Fluid inclusion evidence for possible evaporites in the Archaean Sargur terrane, Karnataka, India: The Indian Mineralogist, v. 26, p. 12-16, 1985 (copyright 1986). Author at Dept. Geol., Univ. Mysore, Manasa Gangotri, Mysore, India.

Fluid inclusion studies were carried out on quartz grains in quartzites from the Sargur Group of supracrustal rocks. Fluid inclusions in general are <12 μm in diameter with an aqueous fluid and/or liquid CO_2 ± a vapor phase. Many of the fluid inclusions have halite cubes of 1-15 μm in diameter ± sylvite. Based on Tm of halite crystals and Th of L + V phase, it is estimated that the NaCl content of inclusions is about 30-40 wt% and the bulk density of the homogenized brine was about 1.09 g/cm.

The presence of highly saline inclusions apart from the $H_2O + CO_2$ phases from the Sargur terrane suggest the dissolution of an NaCl-rich evaporite unit during the prograde regional metamorphism. (Author's abstract)

STAKES, Debra, 1986, Magma-hydrothermal coupling: Evidence from oceanic and ophiolitic metagabbroic rocks (abst.): EOS, v. 67, p. 393. Author at Dept. Geol., Univ. South Carolina, Columbia, SC 29208.

Non-cumulate gabbroic rocks collected from the Semail Ophiolite, Oman and the Troodos Ophiolite, Cyprus characteristically occur between relatively pristine intrusive rocks and intensely altered country rock. Oxygen and hydrogen isotopic compositions combined with fluid inclusion data of secondary mineral phases suggest that fluid temperatures vary from above 500°C to lower greenschist. These gabbroic rocks are apparently the boundary between magmatic and hydrothermal circulation systems, the zone of metal sulfide mobilization, and site of very high-T hydrothermal fluids. (From the author's abstract)

STAKES, Debra and VANKO, D.A., 1986, Multistage hydrothermal alteration of gabbroic rocks from the failed Mathematician Ridge: Earth & Planet. Sci. Letters, v. 79, p. 75-92. First author at Dept. Geol., Univ. South Carolina, Columbia, SC 29285, USA.

Oxygen isotopic, mineralogical and fluid inclusion data are presented for fresh and hydrothermally altered gabbroic rocks from the failed Mathematician Ridge. The Mathematician Ridge, though initially a fast-spreading ridge presently has a deep central rift valley more typical of slow-spreading rifts. The inner rift walls expose rare plutonic rocks uncomplicated by proximity to deep large-offset fracture zones. Undeformed Mathematician

Ridge gabbros preserve most of the original texture and phase compositions and have been only slightly mineralogically or isotopically modified by post-crystallization hydrothermal alteration. Metagabbros have been subjected to a pervasive ductile deformation and recrystallization to foliated rocks composed of aluminous amphibole, low-calcium plagioclase and ilmenite. Oxygen isotope and phase chemical data suggest this event began at temperatures of up to 700°C, water-rock ratios of less than one, and produced modified seawater fluids with isotopic compositions of 3.5-6.0‰. The amphibolites are cross-cut by multiple generation quartz-epidote veins forming a network. Replacement of the amphibole-grade mineralogies by greenschist-grade mineralogies, fluid oxygen isotopic compositions of 2-4‰, and a two-phase separation in the fluid captured in conjugate vapor-fluid inclusions are all associated with the formation of this network. Fluid inclusion data for the quartz indicate initial temperatures of over 500°C. These samples may represent rocks from the 1-2 km deep plumbing system of black-smoker-type venting. (Authors' abstract)

STALDER, H.A., 1986, Description of protected mineral-fissure from Gerstenegg, Grimsel, Bern, Switzerland: Mitt. natf. Ges. Bern (1986), NF v. 43, p. 41-60 and Schweizer Strahler (1987), v. 7, no. 10, p. 433-472 (in German; abstract courtesy the author).

The alpine fissure contains crystals of quartz, calcite, pink fluorite, adularia and 8 other species.

The inclusions in quartz have been measured by microthermometry: Th = 198 to 168°C; Tm = -6.5 to -5.5°C; Tt = 430°C(?). Geochemical data (major and trace-elements) from the alteration of the fissure surrounding rock are given. (Author's abstract)

STALEY, G.H.S., 1986, The diagenesis of the Cretaceous Cardium and Viking formations, Alberta Basin, Canada (abst.): Terra Cognita, v. 6, no. 2, p. 107-108. Author at Dept. Geol., Univ. Sheffield, Sheffield, UK.

The findings of fluid inclusion work (in progress) will also be presented. (From the author's abstract)

STAPLES, B.R., GARVIN, D., SMITH-MAGOWAN, D., JOBE, T.L., Jr., CRENCA, J., JACKSON, C.R., WOBBEKING, T.F., JOSEPH, R., BRIER, A., SCHUMM, R.H. and GOLDBERG, R.N., 1986, Bibliographies of industrial interest: Thermodynamic measurements on the systems CO_2-H_2O, $CuCl_2$-H_2O, H_2SO_4-H_2O, NH_3-H_2O, H_2S-H_2O, $ZnCl_2$-H_2O, and H_3PO_4-H_2O: U.S. Dept. Commerce, Natl. Bureau of Standards, NBS Spec. Publ. 718, 146 pp.

Contained herein are bibliographies of sources of experimental and correlated thermodynamic data for seven binary aqueous mixtures of industrial importance, namely, mixtures of CO_2, H_2S, NH_3, H_2SO_4, H_3PO_4, $CuCl_2$, and $ZnCl_2$ with water. The categories of equilibrium data included in the bibliographies are activity and osmotic coefficients, equilibria in solution, enthalpies and heat capacity data, vapor-liquid equilibria, and phase equilibrium data.

STAUDACHER, Thomas and ALLEGRE, C.J., 1986, The Earth's mantle seen from the noble gas point of view (abst.): EOS, v. 67, no. 44, p. 1257. Authors at I.P.G.P. - Labo. de Géochimie et Cosmo., Tour 14-24 (E3), 4, Place Jussieu 75252 Paris Cedex 05, France.

The isotopic composition of noble gases in the Earth's mantle is today well known due to analysis of fresh MORB glasses. Especially the xenon isotopic composition - which was suspected by several authors to be more or less atmospheric, due to reinjection of sediments - shows high systematic ^{129}Xe and fission xenon excesses (table). The isotopic signature of MORB is in fact completely different to the signature of atmosphere or continental crust, but identical, except for He, with noble gases from Hardin

County CO_2 well gases.

We will discuss the CO_2 well gas data and implications for mantle models and the so called "subduction barrier" for volatiles which keeps the Earth's mantle inaccessible to atmosphere derived noble gases. (Authors' abstract)

	$\frac{4}{3}$	$\frac{20}{22}$	$\frac{21}{22}$	$\frac{40}{36}$	$\frac{129}{130}$	$\frac{136}{130}$
cont. crust	2.5×10^7	9-0.2	0.03-0.7	2000-140000	6.48	2.3-7.9
CO_2 well gas	228000	11.6	0.062	16200	7.18	2.45
MORB	82000	10-13	0.03-0.07	13000-28000	6.6-7.5	2.25-2.55
LOIHI	25000	--	--	390	6.47 ± .04	2.19 ± .02
atm	722500	9.8	0.029	296	6.48	2.17

STAUDACHER, Thomas, KURZ, M.D. and ALLEGRE, C.J., 1986, New noble-gas data on glass samples from Loihi Seamount and Hualalai and on dunite samples from Loihi and Réunion Island: Chem. Geol., v. 56, p. 193-205. Authors at Lab. Geochimie et Cosmochimie, Inst. Physique du Globe, Dépt. Sci. de la Terre, Univ. Paris VI et VII, F-75230 Paris Cédex, France.

Ultra high-vacuum crushing and stepwise heating experiments on six Loihi Seamount and Hualalai glass samples, and on one Loihi Seamount dunite and two Réunion dunites were performed. The noble gases were measured on ARESIBO I. The low $^4He/^3He$ and $^{40}Ar/^{36}Ar$ ratios of 20,000-40,000 and 360-410, respectively, and the atmosphere-type Xe isotopic composition for Hawaiian glasses confirm previously published analyses and the existence of an undegassed lower-mantle reservoir. The noble-gas pattern of the glass samples makes contamination of the samples by atmospheric noble gases dissolved in seawater unlikely.

Dunites brought up from lithospheric upper mantle in the hotspot magma show high $^{40}Ar/^{36}Ar$ ratios, a signature of the degassed upper mantle, but intermediate $^4He/^3He$ ratios. This indicates that dunite residence time in contact with the hotspot magma was sufficiently short that complete noble-gas equilibration was not possible.

Based on the pattern for heavy noble gases of Hawaiian samples we suggest that the primitive Earth and no chondritic noble-gas pattern and that the so-called "missing xenon" problem does not exist. (Authors' abstract)

STEED, G.M., 1986, The geology and genesis of the Gortdrum Cu-Ag-Hg orebody, in Geology and genesis of mineral deposits in Ireland, C.J. Andrew et al., eds.: Irish Assoc. Econ. Geol., p. 481-499. Author at Inst. of Materials, Univ. College, Cardiff, CF1 1XL, Wales.

The Gortdrum Cu-Ag-Hg orebody is the strangest, and in some respects the most interesting, of all the base metal deposits in Irish Carboniferous rocks. It lies in a superficially similar structural setting to the major Zn-Pb orebodies at Tynagh and Silvermines in basal Carboniferous (Courceyan) limestones on the northern side of an ENE-trending normal fault adjacent to a pre-Carboniferous inlier. Uniquely at Gortdrum, however, there is a close spatial association between epigenetic mineralization and high level basic intrusions.

Fluid inclusion results show that the main tennantite-chalcopyrite mineralization was deposited within a T range of ~140 to 180°C from mildly saline fluids. Later phases of mineralization were formed as T declined to less than 100°C.

It is considered that the ores were formed as a consequence of convective water circulation, mainly above the unconformity between Devonian and

Silurian rocks, due to high geothermal gradients related to, but postdating, the Carboniferous volcanic activity in the area. The presence of hydrocarbons in some fluid inclusions indicates that these may have catalyzed abiogenic reduction of seawater-derived sulphate, thus causing preferential deposition of metallic sulphides within the organic-rich Courceyan marine beds. (From the author's abstract)

STEIN, C.L. and KRUMHANSL, J.L., 1986, Chemistry of brines in salt from the Waste Isolation Pilot Plant (WIPP), southeastern New Mexico: A preliminary investigation: U.S. Dept. Energy, Sandia Rpt. SAND85-0897, 37 pp.

The Waste Isolation Pilot Plant (WIPP) is a US Department of Energy-sponsored facility for the eventual disposal of defense-related transuranic nuclear waste, located in the Delaware Basin near Carlsbad, New Mexico. We present here analyses of macro- and microscopic (intracrystalline) brines observed within the WIPP facility and in the surrounding halite, with interpretations regarding the origin and history of these fluids and their potential effect(s) on long-term waste storage.

During excavation, several large (~10 μm to several millimeters) fluid inclusions were recovered from an area of highly recrystallized halite in a thick salt bed at the repository horizon (2150 ft below ground level). Two populations of inclusions were distinguished on the basis of major element content, using analyses for Mg, Ca, K, Na, Cl, Br, and SO_4. We propose that the inclusion compositions arise from the alteration of calcium sulfate to polyhalite and calcium carbonate to magnesite, respectively. Overall, the inclusion compositions suggest a significant departure from a simple seawater evaporation model.

In addition, 52 samples of brine "weeps" were collected from walls of recently excavated drifts at the same stratigraphic horizon from which the fluid inclusion samples are assumed to have been taken. Analyses of these fluids show that they differ substantially in composition from the inclusion fluids (mainly by depletion of Mg relative to K) and cannot be explained by mixing of the fluid inclusion populations. Since weeps are associated with argillaceous or anhydritic halite, these fluids may have originated by dewatering of clays and/or gypsum. Their compositions may have also been modified by selective uptake of Mg during clay diagenesis and by the formation of authigenic magnesite and magnesium silicates.

Finally, holes in the facility floor that filled with brine were sampled but with no stratigraphic control; therefore, it is not possible to interpret the compositions of these brines with any accuracy, except insofar as they resemble the weep compositions but with greater variation in both K/Mg and Na/Cl ratios. However, the Ca and SO_4 values for the floor holes are relatively close to the gypsum saturation curve, suggesting that brines filling floor holes have been modified by the presence of gypsum or anhydrite, possibly even originating in one or more of the laterally continuous anhydrite units referred to in the WIPP literature as marker beds.

In conclusion, the wide compositional variety of fluids found in the WIPP workings suggests that (1) an interconnected hydrologic system which could effectively transport radionuclides away from the repository does not exist; (2) brine migration studies and experiments must consider the mobility of intergranular fluids as well as those in inclusions; and (3) near- and far-field radionuclide migration testing programs need to consider a wide range of brine compositions rather than a few reference brines. (Authors' abstract)

See also same authors, 1984, Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 330-331, 1984. (E.R.)

STERN, L.A., BROWN, G.E., Jr., BIRD, D.K., JAHNS, R.H., FOORD, E.E., SHIGLEY, J.E. and SPAULDING, L.B., Jr., 1986, Mineralogy and geochemical evolution of the Little Three pegmatite-aplite layered intrusive, Ramona, California: Am. Mineral., v. 71, p. 406-427.

STERNBACH, C.A., 1984, Deep-burial diagenesis and dolomitization in the Hunton Group carbonate rocks (Upper Ordovician to Lower Devonian) in the Anadarko Basin of Oklahoma and Texas: Ph.D. thesis, Rensselaer Polytechnic Inst., 144 pp.

STERNER, S.M. and BODNAR, R.J., 1986a Experimental determination of phase relations in the system NaCl-KCl-H_2O at 1 kbar and 700° and 800°C using synthetic fluid inclusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 763. Authors at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

Solution-mineral equilibria calculations often incorporate results obtained from microthermometric analysis of fluid inclusions, which provide such information as temperature, salinity, and ratios of various ionic species in solution. In the porphyry copper environment Na/K ratios of mineralizing fluids obtained from inclusion studies, combined with observed alteration patterns, have been used to calculate the pH of ore-depositing fluids and metal solubilities in these fluids. Na/K ratios used in these calculations are obtained by measuring the temperatures of dissolution of halite and sylvite in high-salinity inclusions and referring these values to known solubility relations in the NaCl-KCl-H_2O ternary. However, Na/K ratios of these high salinity fluids may not be the same as Na/K ratios in the bulk fluid responsible for alteration and mineralization because of unequal partitioning of sodium and potassium between the coexisting liquid and vapor phases produced when an aqueous phase separates from a crystallizing magma.

Compositions of coexisting liquid and vapor phases in the NaCl-KCl-H_2O system at 1 kbar and 700 and 800°C have been determined using synthetic fluid inclusions trapped in the two-phase region in the presence of fluids of 20 wt. % (NaCl + KCl) bulk composition. Synthetic inclusions formed at these conditions are of two types: (1) low-salinity, vapor-rich inclusions and (2) high-salinity, liquid-rich inclusions that contain halite and/or sylvite at room temperature. Compositions of the high-salinity inclusions were determined by measuring the dissolution temperatures of halite and/or sylvite, and compositions of the vapor-rich inclusions were determined using total salinities obtained from freezing-point depression measurements and Na/K ratios defined by mass balance calculations.

At 800°C and 1 kbar the Na/K ratios of the coexisting liquids and vapor phases are identical, within experimental error. Data at 700°C and 1 kbar indicate non-ideal mixing of sodium and potassium, with sodium preferentially partitioned into the liquid phase. As a result, Na/K ratios obtained from halite + sylvite-bearing inclusions which were trapped at these conditions would be high compared to the true bulk fluid composition. (Authors' abstract)

STERNER, S.M. and BODNAR, R.J., 1986b Re-equilibration of fluid inclusions in quartz at elevated temperatures and pressures: The role of H_2O diffusion (abst.): EOS, v. 67, p. 407. Authors at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

P-T conditions inferred from fluid inclusions in metamorphic rocks often disagree with values predicted from mineral equilibria calculations. These observations suggest that inclusions formed during early stages of regional metamorphism continue to re-equilibrate during burial and subsequent uplift in response to differential P. P-T conditions accompanying uplift were experimentally simulated by forming pure H_2O inclusions in quartz, and then re-equilibrating them in the presence of a 20 wt% NaCl solution such that final confining P ranged from 1-6 kbar below the initial internal P.

In all samples inclusions having a composition of 20 wt% NaCl and densities in accord with the final P-T conditions were formed. Additionally, several inclusions in each sample contain fluids of intermediate salinities (0-20 wt% NaCl). Densities of these inclusions are consistent with formation at the re-equilibration P-T conditions.

Th of re-equilibrated pure H_2O inclusions indicated densities intermediate between the initial and final P-T conditions. In experiments where the initial internal overpressure was greater than 2 kbars, no inclusions were found which contained their original density and none were found to have totally re-equilibrated. Rather, most H_2O inclusions re-equilibrated until their internal P were between 750 and 1500 bars above the confining P, regardless of the initial P differential.

To evaluate the importance of H_2O diffusion from the inclusion as a mechanism of lowering the inclusion bulk density, inclusions formed from 10 and 41 wt% NaCl brines at 3 kbars and 600°C were re-equilibrated at 1 kbar and 600°C for one week in dry argon. Salinities obtained from freezing point depressions and halite dissolution T of re-equilibrated inclusions indicate that original compositions had been preserved to within the limits of measurement (±0.1 wt% NaCl). Density changes similar to those previously described were noted in these experiments - often in inclusions showing no visible microfractures. Because the inclusion composition remained constant, density variations observed in these inclusions are considered to result from an increase in the inclusion volume, without loss of contents by diffusion or leakage. (Authors' abstract)

STEVENSON, D.J., 1986, On the role of surface tension in the migration of melts and fluids: Geophys. Res. Letters, v. 13, no. 11, p. 1149-1152. Author at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125.

It is shown that surface tension can cause redistribution of melt in a partially molten medium, in accordance with a non-linear diffusion equation for the melt fraction. The associated diffusivity D depends on the surface energy and is positive (stable) for dihedral angle <60° and negative (unstable) for dihedral angle >60°. In the more likely stable case, $D \sim 10^{-7}$ $cm^2 \cdot s^{-1}$ is typical for mantle melts, but a value as high as 10^{-1} $cm^2 \cdot s^{-1}$ is conceivable for volatile-rich fluids. Surface tension may play an important role in creating pathways for metasomatizing fluids in the Earth, but does not appear likely to affect substantially the existing estimates of large scale melt migration (e.g., beneath mid-ocean ridges). (Author's abstract)

STOESSELL, R.K. and CARPENTER, A.B., 1986, Stoichiometric saturation tests of $NaCl_{1-x}Br_x$ and $KCl_{1-x}Br_x$: Geochimica Cosmo. Acta, v. 50, p. 1465-1474. First author at Dept. Geol. & Geophys., Univ. New Orleans, New Orleans, LA 70148, USA.

Stoichiometric saturation is examined as a possible control on Br contents of halite and sylvite during precipitation from binary salt solutions of NaCl-NaBr and KCl-KBr, respectively. Experimental data at 25°C, assumed to represent stoichiometric saturation, were used to predict mole fractions of NaBr in halite and KBr in sylvite in thermodynamic equilibrium with fluids as a function of aqueous activity ratios of $Br^- : Cl^-$. The predictions are based on the additional assumption that the aqueous activity product of the major salt component in the precipitated salt was independent of the trace Br content in the salt lattice. The extension of the predictions to diagenetic P and T is discussed.

The predicted equilibrium Br content of halite at initial halite saturation of evaporating seawater is in close agreement with that computed from the distribution coefficient of Lutz (1975), measured in slow-growth single crystal experiments. Fluid recrystallization of halite and sylvite at near-surface T is predicted to generally deplete the Br contents in the solids. Bulk Br contents in halite in cap-rock of Gulf Coast salt domes generally agree with those predicted by the recrystallization of halite in the presence of evaporative-concentrated seawater. At a constant solution composition, increasing T results in increasing the equilibrium Br content of halite, making less efficient Br depletion in halite by recrystallization. (Authors' abstract)

STOFFREGEN, R.E., 1986, The lower pH limit on advanced argillic alteration in epithermal environments (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 131.

STOUT, M.Z., CRAWFORD, M.L. and GHENT, E.D., 1986, Pressure-temperature and evolution of fluid compositions of Al_2SiO_5-bearing rocks, Mica Creek, B.C., in light of fluid inclusion data and mineral equilibria: Contrib. Mineral. Petrol., v. 92, p. 236-247. First author at Dept. Geol. & Geophys., Univ. Calgary, Calgary, Alberta, Canada T2N 1N4.

Metamorphosed pelitic rocks from Mica Creek, British Columbia, contain sillimanite, kyanite with minor fibrolite and andalusite-bearing quartz pods. Mineral equilibria were used to infer peak P-T conditions and fluid compositions in equilibrium with the solid phases. Fluid inclusions in three schist samples appear to be good indicators of conditions affecting those rocks during and after peak metamorphic conditions. In samples from two localities, fluid inclusions from schist and quartz-rich segregations have densities appropriate to the peak metamorphic conditions. The observed compositions for these fluids (low salinity with ≅ 12 mole % dissolved CO_2) agree with calculated $X(H_2O)$ values of 0.84 to 0.85, based upon paragonite-quartz-albite-Al_2SiO_5 equilibria. The fluids unmixed as the schists were uplifted and cooled; fluid inclusions trapped during this stage outline a solvus in the CO_2-H_2O-NaCl system. A later influx of fluids containing CH_4 and N_2 accompanied formation of andalusite-bearing plagioclase-rich segregations. The restricted association of andalusite-bearing pods and low density fluids suggest a localized but pervasive fluid influx during uplift. Preservation of high density fluid inclusions during uplift and erosion, coupled with evidence for unmixing of H_2O- and CO_2-rich fluids on the solvus, provide constraints on the P-T uplift path. (Authors' abstract)

STRAŠIMIROV, Str., GEORGIEV, Vl. and MITOV, V., 1985, Mineral thermometry studies in the deposits of Batanci, Krušev Dol, Borieva and Gradište in the Madan ore field: God. VMGI-Sofia, v. 31, 1984-1985, no. 2, 1985, p. 67-68 (in Russian; English abstract).

The Madan ore field including over 30 Pb-Zn deposits lies in the western flank of the Madan-Davidkovo anticline (Central Rhodope Mts.). The country rocks consist of metamorphites of assumed Archean and Proterozoic age, Paleogene sedimentary rocks and Upper Oligocene rhyolite dikes. Fluid inclusions in quartz from quartz-pyrite and quartz-sphalerite-galena parageneses are studied. Their morphogenetic features and the regularities of their distribution are described. The T interval of ore formation is determined as 360-250°C. The deposits show a typical low salinity of the ore-forming fluids: 8-12% eq. NaCl in the Krušev Dol deposit and 6-8% eq. NaCl in the Gradište deposit. The chloride-Na-K composition of the fluids is determined by cryometry. Salinity data compared with the results of other authors support the assumption of a deep seated source of the ore-bearing fluids. (Abstract by R. Arnaudova)

STUL'CHIKOV, V.O., PASAL'SKA, L.F. and ILOVAYSKA, S.V., 1986, Gaseous components (H_2, CH_4, CO) in the rocks of Precambrian of the Verkhivtsevska syncline: Dopovidi Akad. Nauk Ukr. RSR, Ser. B, 1986, no. 2, p. 15-17 (in Ukrainian). Authors at Inst. Geochem. & Physics of Minerals of Acad. Sci. Ukrainian SSR, Kiev.

Gas components (H_2, CO, CH_4) were analyzed [by gas chromatography] in 26 samples of metamorphosed sedimentary-volcanogenic, intrusive and metasomatic rocks. The total gas volume was found to be greater in metasomatic rocks where CO prevails ($CO>H_2>CH_4$), while H_2 prevails in the original rocks ($H_2>CO>CH_4$). In areas of sulphide and other types of metallic ore occurrences the gas volume increases. (Authors' abstract)

The metamorphosed volcanic-sedimentary complex, granites, migmatites and metasomatic albitites yielded H_2 concentrations of 0.1-1.1 cm^3/g (in phyllites). The content of CO in metasomatites reaches 1.3-1.5 cm^3/g, the highest values were found in talc-carbonate rocks, listvenites and berezites, thus probably its occurrence is connected with formation of carbonates. Quartz of the gold ores contains especially high amounts of gases: H_2 up to 7.0 cm^3/g, CH_4 up to 0.32 cm^3/g, CO up to 3.73 cm^3/g in rich gold ore, whereas in gold-poor ore the concentrations are ~1, ~0.1 and ~0.2, respectively, in cm^3/g. The possible reactions of formation of gases from hydrous minerals and carbonates are presented. (A.K.)

STUMPFL, E.F., 1986, Distribution, transport and concentration of platinum group elements, in Metallogeny of basic and ultrabasic rocks: Spec. Pub. Inst. Mining & Metallurgy, p. 379-394. Author at Inst. Mineral. & Petrology, Mining Univ., Leoben, Austria.

Late- to post-magmatic fluids and volatiles [have participated] in the concentration of platinum metals in the major layered igneous complexes, such as the Bushveld and Stillwater. We know now that transport and deposition of PGE is influenced by the evolution of a wide spectrum of volatiles and fluids, ranging from C-O-H-S-Cl system at 500 to 600°C to chlorine brines at around 300°C and, finally seawater at 4°C in the deeper parts of the world's oceans. This contribution is intended to summarize these new developments and to underlie the close links which have emerged between the transport and deposition of PGE, and the availability of fluid phases over a wide spectrum of temperatures. (From the author's Introduction)

STUMPFL, E.F. and BALLHAUS, C.G., 1986, Stratiform platinum deposits: New data concepts: Fortschr. Miner., v. 64, no. 2, p. 205-214. Authors at Inst. Mineral. & Petr., Mining Univ., A-8700 Leoben.

New field and laboratory evidence is at variance with "ortho-magmatic" concepts of stratiform PGE concentration in layered igneous complexes, such as scavenging of PGE by sulphides and magma mixing. Potholes which disturb the magmatic stratigraphy in the Bushveld and Stillwater Complexes represent loci where high concentrations of volatiles have impeded normal crystallization; they are not products of magmatic erosion or fumarolic activity. Postcumulus hydrosilicates are widespread in the platiniferous reefs; they are closely associated with sulphides and PGM. Graphite is an important constituent of potholes and of pyroxenitic pegmatoids in the footwall of the reefs. Significant chlorine contents occur in both, hydrosilicates and graphite. They point to a common genetic denominator, i.e., the system C-O-H-S-Cl. Relics of volatiles of this system are preserved in a complex pattern of fluid inclusions in quartz in the Merensky Reef. Maximum temperature of formation was 650-750°C. Upward crystallization was responsible for concentration of metals and volatiles in the reefs. The evolution of the intercumulus melt-volatile system thus emerges as the single most important factor for base and precious metal mineralization in layered igneous complexes. (Authors' abstract)

SUGAKI, Asahiko, KIM, O.J. and KIM, W.J., 1986, Gold and silver ores from the Geumwang mine in South Korea and their mineralization: Mining Geol., v. 36, no. 6, p. 555-572. First author at Kadan 4-30-503, Sendai 980, Japan.

Au- and Ag-bearing quartz veins of the Geumwang mine in South Korea occur in Cretaceous granite altered hydrothermally. Ores from the mine are exceptionally Ag-rich as[is?] the Korean type Ag deposit. The ore minerals occur in two or three sulfide bands formed at early to middle stages and a sulfosalt band at the late stage of mineralization. Electrum and Ag minerals of polybasite, pyrargyrite and argentian tetrahedrite appears in sulfide band or stringer consisting of pyrite, arsenopyrite, galena, sphalerite, chalcopyrite and quartz in the vein. Also Ag-Sb sulfosalt minerals such as pyrargyrite, polybasite, miargyrite, diaphorite and argentian tetrahedrite with native Ag occur as a band in central portion of the quartz vein in association with some amounts of pyrite, sphalerite, arsenopyrite and quartz. Composition of electrum is 48.4 to 52.7 wt% Ag (63.0 to 67.4 at% Ag). Meanwhile sphalerite has 2.2 to 4.2 mole% FeS. Th of fluid inclusion (two phases) in quartz of the sulfide band are from 183° to 310°C (240°C in average) with a peak at 240°C, commonly 220° to 270°C. The ore mineralogy suggests that temperature (T) and sulfur fugacity (fS_2) of the formation of the sulfide and sulfosalt bands are estimated as T: 190° to 240°C, fS_2: $10^{-15.5}$ to $10^{-13.5}$ atm, and T: 130° to 170°C, fS_2: $10^{-19.5}$ to $10^{-17.0}$ atm, respectively. Such low T and low S fugacity mineralization crystallized Ag-Sb sulfosalts are considered to be singular as the Korean type Au deposit. (Authors' abstract)

SUGAKI, Asahiko, KITAKAZE, Arashi and ISOBE, Kiyoshi, 1986, Silver mineralization of the Karuizawa mine, Fukushima Prefecture, Japan: Mining Geol., v. 36, no. 6, p. 535-544. First author at Inst. Mineral., Petrol. & Econ. Geol., Faculty of Sci., Tohoku Univ., Sendai 980, Japan.

Ag deposits of the Karuizawa mine are network and vein types developed in fracture zone of Miocene rhyolite lava dome altered hydrothermally. The network ore body consists of veinlets along fracture and spots of ore filled spherulite cavities in rhyolite. The ore is principally composed of barite, sphalerite and galena in association with small amounts of quartz, pyrite, marcasite, chalcopyrite, polybasite, pyrargyrite and argentian tetrahedrite (12 to 18 wt% Ag). On the other hand, the vein along fissure in silicified rhyolite consists mainly of galena, sphalerite, pyrite, marcasite and barite associated with quartz, chalcopyrite and small amounts of bournonite, argentian tetrahedrite, polybasite and pyrargyrite. These mineral assemblages in ores are similar to those of kuroko ore. In high Ag ore, fine grained Ag minerals such a polybasite, pyrargyrite and argentian tetrahedrite are usually found as inclusion in galena, and often show a pseudo-micrographic texture with galena. These Ag minerals were crystallized at late stage of the mineralization as shown in Fig. 9. Th and salinity of fluid inclusion in barite are 230° to 320°C and 3.6 to 5.0 wt% NaCl. eq., respectively. Hydrothermal alteration [including] silicification and adularization are conspicuously observed in or around the ore deposit. K-Ar age for adularia of the alteration product is 12.8 ± 0.6 Ma which is approximately same as that of alteration rock of the kuroko deposits. The ore deposits of the Karuizawa mine are thought to have been produced by mineralization in the relation to formation of the kuroko deposits. (Authors' abstract)

SULEIMENOV, O.M., ZOLOTOV, M.Yu. and KHODAKOVSKY, I.L., 1986, Stability of salt hydrates in Martian regolith: Lunar Plan. Sci. XVII, p. 845-846. Authors at Vernadsky Inst. Geochem. & Anal. Chem., Acad. Sci., Moscow, USSR.

Data on the stabilities of various hydrated soluble salts (Mg, Fe, K, Ca, etc.) are given that may be pertinent. (E.R.)

SUN, S.-S., DONG, Y.-B., BOTH, R.A. and BARNES, R.G., 1985, Sulphur, carbon, oxygen and lead isotope study of Thackaringa vein-type mineralization in the Broken Hill Block, New South Wales* (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 69-71. First author at Div. Petro. & Geochem., Bureau of Min. Resources, G.P.O. Box 378, Canberra, A.C.T., 2601, Australia.

In contrast to earlier studies, which suggested that remobilization of the Broken Hill-type stratiform Pb-Zg-Zn mineralization played an important role in the formation of the Thackaringa-type Ag-Pb-bearing siderite-quartz vein mineralization, a reinterpretation of existing Pb isotope data along with new S and C isotope data (Table 1) indicate that the Broken Hill-type mineralization played a minor role.

A fluid inclusion study of the Thackaringa vein quartz indicates a formation temperature of 180-200°C and that the fluids are rich in NaCl and KCl (10-20 wt%).

Estimated $\delta^{18}O$(SMOW) values for the mineralizing fluid range from -4 to 1 per mil suggesting a surface-derived origin.

An integrated interpretation of the S, C, O and Pb isotope data is consistent with the idea that Thackaringa vein mineralization was locally derived from the country rocks, rather than pre-existing stratiform sulphides and is closely associated with retrograde schist zones, or areas of pervasive regional retrogression (mid to upper greenschist facies). Mineralization may have resulted from fluid movement during retrograde metamorphism. Published K-Ar, Rb-Sr age data and Pb isotope data from the Broken Hill Block suggest a thermal pulse up to 350°C took place at about 500 Ma ago.

Paleogeographic reconstruction of the Broken Hill area suggests that, at about 500 Ma ago, this area was equatorial, probably very close to the sea level and became more terrestrial at 450 Ma ago. Consequently, both meteoric water and sea water could have been involved in the retrograde metamorphism and formation of the vein-type mineralization. [Cited references deleted by E.R.] (From the authors' abstract)

*Stable isotope and fluid inclusion data used in this abstract are based on a paper by Dong, Both, Barnes and Sun (to be submitted).

SUSHCHEVSKAYA, T.M., 1985, The geochemistry of the ore-forming fluids of the cassiterite-silicate association (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 124-126 (in Russian; translation by D.A. Brown). Author at Vernadskiy Inst. Geochem. & Anal. Chem. (GEOKhI AN SSSR), Moscow, USSR.

The principal geochemical features of fluids that have formed the cassiterite-silicate mineralization are described from original and literature data on deposits in the Soviet Far East, Primor'ye, Southern England, and Bolivia.

Comparison of the Th data reveals a wide range of possible conditions for the formation of normal tin mineralization: deposition of the bulk of the cassiterite ores during the productive quartz-cassiterite phase takes place at T >500°C (certain Bolivian deposits), and equally, at significantly lower T (<300-280°C). The range of mineralization (S) of the mineral-forming solutions, forming the normal deposits and normal mineral associations, (2-3 - 50 wt %), is just as significant. However, the most typical values are ~5-10%. All the cases examined are marked by lowering of S from the early to late stages.

The salt composition of the mineralizing solutions of this type is characterized by the following ratios of the principal components: Na > K > Ca, and Cl ≥ HCO_3. The total concentrations of the minor components (Li, NH_4, Mg, Ca, F, and S) 0, and On - 0, n m[sic] are lower than those of the principal components by an order and more. The concentrations of rare and ore elements, based on a small number of data, occur at the 10^{-3}-10^{-5} m level for the appropriate mineralization. Significant increases in concentration have been recorded in a number of cases for Li and Fe (0.1-1.0 m), related to the conditions of formation of the actual deposits.

According to the calculations based on equilibrium fluid inclusions-mineral systems (mineral association), carried out according to the 'Gibbs' Program (Ryzhenko, 1976; Shvarov, 1976) for T <300°C, element complexes, typical even for single-charge ions, predominate in the mineral-forming solutions. In the high-T solutions, more than 60% of the alkali elements consist of neutral species of the $NaCl^\circ$, KCl°, $NaHCO_3^\circ$, and $KHCO_3^\circ$, and the proportion of Na^+ and K^+ is <30%. The proportion of Ca^{2+} and Mg^{2+} is significantly lower (by ~2 orders) than the activity of the predominant complexes such as $MgCl^+$, $CaCl^+$, $CaHCO^{3+}$, and $MgHCO^{3+}$[sic; probably $CaHCO_3^+$ and $MgHCO_3^+$ meant]. The complex-forming capacity of Cl_2 is in most cases 50% (at the expense of $NaCl^\circ$ and KCl°, and the proportion of $CaCl^+$ and $MgCl^+$ is <1%. The same capacity of F_2 exceeds 90%, so that the activity of the F^- ion is 10^{-3} - 10^{-4} m. Dissolved undissociated forms are predominant for carbonic and silicic acids in solutions related to ore-deposition. Sulfur is marked by the predominance of the H_2S form, and the activity of the HS^- ion is lower on average by one order. The acidity of the mineral-forming solutions calculated from the composition of inclusions in quartz from the productive phase of the deposits (allowing for complex-formation) is 6.0-7.5 (±1) for T = 300-350°C.

The predominance of CO_2 over the remaining gases in the fluids is normal ($CO_2 > N_2 > CH_4 > CO > H_2$). It has been established from a large number of data that $CO_2/CH_4 \approx 10$ for the quartz-cassiterite phase. A decrease in this value (≥~1) has been noted in individual items for solutions that formed the pre-ore mineral associations (quartz-tourmaline metasomatites), and also the sulfide associations with stannite. Since the CO_2/CH_4 ratio defines the redox state of the mineral-forming solutions, the following trend in redox conditions is generally regarded as likely: from the early, more-reduced (ensuring occurrence and transport of Sn mainly in the divalent form), to the more oxidized ($\log f(O_2) = -33$ to -34), when an increase in the Sn^{IV}/Sn^{II} ratio occurs along with the precipitation of the bulk of the tin in the cassiterite ores, and then again to the more reduced state, when tin-sulfide minerals are formed in the ores. (From the author's abstract)

SUSHCHEVSKAYA, T.M., GONEVCHUK, V.G., KNYAZEVA, S.N., ZAMOKINA, N.S., KRIGMAN, L.V. and KHOTEYEV, A.D., 1985, Determination of the composition of pre-ore fluids of the Komsomol' tin district (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 136-137 (in Russian; translation by Dorothy B. Vitaliano). First author at Inst. Geochem. & Anal. Chem. (GEOKHI), Acad. Sci., Moscow, USSR.

Analysis of the chemical composition of the inclusions was done on small batches of quartz using the method of gas chromatography, and potentiometry and atomic absorption on aqueous extracts. The fluids are spatially and possibly genetically related to the formation of the magmatic rocks of the two magmatic complexes of the region (Chalba and Silinka), characterized by the following particulars. They have a low and relatively uniform concentration of gas components (<1.0 m)[sic] and some tendency for methane to predominate over carbon dioxide, carbon monoxide and nitrogen. The salt composition of these solutions is characterized by a high chlorine content and a stable ratio of Na/K ≈ 3.5. The concentrations of Ca, and especially Mg, are much lower than the two main cations (Na and K). Li is 2-3 times lower than magnesium. HCO_3 and F are insignificant (Cl/F > 10).

Inclusions in metasomatites generally have methane predominant; N_2 and CO play a minor role, and CO_2 rarely exceeds 1.0 m. In the salts, Na and Cl predominate; their ratios to K and HCO_3 are close to 4-5.

In comparison to the well studied solutions forming the quartz-cassiterite and quartz-sulfide mineral associations of the tin deposits of the region, the average chemical characteristics based on the pre-ore fluids indicate two main features: high Cl content and highly reduced solutions. (From the authors' abstract)

SUSHCHEVSKAYA, T.M., KONONKOVA, N.N., KOLESOV, G.M., PROKOPTSEV, N.G. and REZNIK, V.P., 1986, Evolution of tholeiitic magmatism of western part of the Indian Ocean (according to data of study of the quenched glasses): Geokhimiya, 1986, no. 2, p. 157-169 (in Russian, English abstract; translated in Geochem. Int'l., v. 23, no. 6, p. 139-151, 1986). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

New data on petrologic-geochemical study of the quenched glasses dredged from the Arabian-Indian and Central-Indian ridges and in western part of the Central basin as well as their comparison with the published data have shown that the primary melts of the rift magmatism, formed at the area of Arabian-Indian ridge, are of the tholeiitic type $MORB_2$ widely distributed at the central parts of the Mid-Atlantic ridge. Geodynamic evolution of rift magmatism in the Indian Ocean was similar to that of the Atlantic Ocean: initial stages of opening of oceanic basin were characterized by the depth-derived magmatism changing in the last 20 to 30 m.y. in the central part of Arabian-Indian ridge (15°N to 30°S) into the shallow type $MORB_2$ which represents differentiates of primary melts separated from lherzolite mantle in dry conditions at the depth ≤30 km at T = 1270 to 1250°C and having the specific petrogeochemical characteristics. (Authors' abstract)

SVEINBJORNSDOTTIR, A.E., COLEMAN, M.L. and YARDLEY, B.W.D., 1986, Origin and history of hydrothermal fluids of the Reykjanes and Krafla geothermal fields, Iceland: Contrib. Mineral. Petrol., v. 94, p. 99-109. First author at Sci. Inst., Univ. Iceland, Dunhagi 3, 107, Reykjavik, Iceland.

The Reykjanes and Krafla geothermal fields are both examples of active high temperature systems and show similar assemblages of alteration minerals, but the fluid at Reykjanes is dominantly sea water whereas that at Krafla is meteoric. Oxygen isotope analyses of surface rock and of drill chip samples from different depths are presented, together with results for the Krafla fluid, which is close to local precipitation ($\delta^{18}O = -11.9‰$, $\delta D = -86.8‰$).

Calcite in both systems is apparently in equilibrium with the present deep fluid at the present field temperature, except for the upper 250 m at Reykjanes where the fluid may be more meteoric than at depth. Feldspar gives similar results. Quartz separates at Reykjanes are anomalously lighter than coexisting feldspar and give exceptionally high quartz-fluid temperatures. It is suggested that quartz originally grew when the fluid was more nearly meteoric (? glacial period) and has not reequilibrated.

Bulk-rock ^{18}O depletion supports this interpretation of the history of the Reykjanes system.

Quartz in the Krafla system is mostly in equilibrium at the present field conditions but anomalies occur near the boundary between the upper and lower parts of the system, suggesting that this is not entirely stable. A high fluid:rock ratio (10-100 minimum) is indicated for the Krafla field. (Authors' abstract)

SVERJENSKY, D.A., 1986a. Chemical evolution of basinal brines that form sediment-hosted Cu-Pb-Zn deposits (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 132.

SVERJENSKY, D.A., 1986b. Genesis of Mississippi Valley-type lead-zinc deposits: Ann. Rev. Earth Planet. Sci., v. 14, p. 177-199. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218.

An extensive review (~90 refs.). (E.R.)

SVOREN', I.M., 1985a. Hydrogen chloride in sylvite and halite (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 227-228. (In Russian; translation by Dorothy B. Vitaliano). Author at IGGGI, Ukrainian Acad. Sci., L'vov, USSR.

Ratio of intensity of peaks in mass spectra of water to acid given off from fluid inclusions at room T from the lattice of minerals, and when heated.

No.	Mineral, origin	I_{H_2O}/I_{HA}†		Acid (HA)
		293°K	1123°K	
1	*KCl, Natural (Berezinkovsk potash salt deposit, Perm.)	1.04	-	HCl
2	* NaCl, synthetic	-	5.43	HCl
3	NaCl, synthetic	13,000.00	24.15	CH_3COOH
4	" "	16,430.00	0.03	$C_4O_6H_6$
5	KCl, synthetic	19,796.48	232.61	H_2SO_4
6	" "	1.90	360.71	HCl
7	NaCl, synthetic	not found	17.57	H_2SO_4
8	" "	-	32.41	HCl

*O. I. Petrichenko's samples (IGGGI AN USSR)

†[Sic; Cyrillic "HA" only--presumably refers to "acid", in view of usage in last column on right]

The results given in the above table were obtained by mass-spectrometric investigations of the differentiation of water and acids given off from inclusions in samples at room T and from powders when heated. The synthetic NaCl and KCl crystals were obtained at room T from aqueous acid solution the pH of which was controlled during growth. Depending on the intended purpose the growth of the crystals was accomplished in some cases in a few days, in others in a few months. In the first case crystals with macroinclusions were obtained, in the second, with no inclusions. Hydrogen chloride, identified in samples #6 and #8, was formed by chemical reaction of potassium and sodium salts (samples #5 and #7) with sulfuric acid during the formation of the crystals [sic].

Thus the property of natural minerals (KCl, NaCl) and their synthetic analogs to selectively (with respect to H_2O) trap acids from the mineralizing environment during crystallization has been established experimentally. The presence of HCl (only in isolated cases) in inclusions in minerals indicates the presence in nature of special physicochemical conditions and processes, for instance electrochemical, arising and transpiring in specific mineral-forming systems. [Sic] (Author's abstract)

SVOREN', I.M., 1985b. Physicochemical model of hydrogen absorption of solid bodies (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 224-226 (in Russian; translation by Dorothy B. Vitaliano). Author at IGGGI, Acad. Sci. Ukrainian SSR, USSR.

The problem of H_2 in fluid inclusions is one of the main problems in geochemistry. Results obtained earlier showed that individual inclusions in the investigated minerals contain no H_2. However, heating of powdered minerals, for instance quartz, leads to desorption of gases containing substantial amounts of H_2, the content of which increases with T. In view of the fact that the physicochemical processes of formation and the conditions of preservation of minerals in nature are rather complex, and H_2 can exist in different forms (H^+, H, H_2, H_2^+, etc.), the purpose of this investigation is to work out a model of H_2 absorption [by] solid bodies, particularly as illustrated by metals (iron, cobalt) and minerals (quartz), [with] atomic hydrogen introduced into dislocation defects or submicrocracks, [as protons?].

The proposed model is based on the fact that the outer surface of metallic solid bodies and also the space within dislocation tubes or submicroscopic cracks are negatively charged. If atoms of H from the external environment are introduced into bodies in only one constant orientation, forming a connected proton-electron chain in a defect, three different cases of its behavior within such defects are possible: 1) a weak physical bond is formed between H and S^x; 2) a chemical bond exists between H and S^x, without the formation of chemical compounds [where S^x is the surface of the body]; 3) hydrides are formed.

The systems "Fe-H" and "Co-H" should be considered ideal for such investigations, as they do not interact chemically at any T -- Fe and Co hydrides have not yet been obtained synthetically. Investigation of the composition of gases liberated from samples of Fe and Co, hydrogen-charged in chemical or electrochemical processes and aged in closed systems (ampules) in an environment of chemically active gases, for instance in an atmospheric environment, should not only confirm the atomic state of the hydrogen, but also establish our suggested orientation of its dipole in the voids of the defects in question. During desorption of H atoms from dislocations in the opposite direction (electron component of the dipole) and their interaction with oxygen adsorbed on the outer surface of the metal, water will be formed, and this should be traced in a wide range of T. Atomic H diffusing through the thickness of a metal during H absorption, for instance through the wall of a metal ampule in an atmosphere of air, will not react chemically with O_2 under similar conditions, as it is not energy-efficient. In the volume of the ampule in question, each individual pair of H atoms will form H_2 despite the presence of O_2 in it.

The case considered below is indicative of the process of H adsorption of trapping of H in minerals in nature, and finding its state in them. For H absorption of minerals with atomic H in the required orientation, it is necessary that the outer surface of the samples be covered with a dense layer of metal. In view of the fact that in the course of H absorption by the samples, high P is created in the defects in question, the metal coating would adhere tightly to the surface of the mineral. Apparently, in most cases when metal is applied to the outer surface of a mineral, the geometry of defects in it will continue into the metal coating.

Diffusion of H in a mineral with a metal coating can be represented by the expression

$$J = -D_d \cdot q \cdot \frac{dC_d}{d_x} + \beta^\circ \cdot D_d \cdot C_d \frac{e}{kT} \cdot E_c$$

where D_d is the coefficient of diffusion of atoms in dislocation tubes, q is the time of residence of an atom within a dislocation tube, d in this case is a partial derivative, C_d is the concentration of atoms in the dislocation tube, e is the electron charge, k is Boltzman's constant, T is the absolute T, E_c is the potential of the metal under conditions of corrosion, and β° is a coefficient ($0 < \beta^{\circ} < 0.5$) taking into account only the portion of atomic H absorbed by the metal and liberated during corrosion.

In connection with the high chemical activity both of the defect surface and of the (H) atoms themselves, migration of H along dislocation tubes and its behavior in a macrodefect, for instance in an inclusion in the mineral, will differ substantially from the behavior in the metal (Fe, Co). In one case H atoms will be chemically sorbed on vacant sites; in others, coercive desorption of previously sorbed compounds with bond energies in the system "solid phase - substance" lower than those in the system "solid phase - H" will be traced. In that process, the percentage content of a compound in the composition of the gases given off from the inclusions and coercively desorbed by atomic H will increase.

Thus the proposed physicochemical model of H absorption of solid bodies helps clarify both the problem of H in fluid inclusions and the problem of H in bodies, as a whole. (Author's abstract) [Translator's note: The meaning was somewhat obscure in parts of this abstract.]

SWANSON, S.E. and FENN, P.M., 1986, Quartz crystallization in igneous rocks: Am. Mineral., v. 71, p. 331-342. First author at Geophys. Inst. & Geol./Geophys. Program, Univ. Alaska, Fairbanks, AK 99701.

Pertinent to the problems of the origin of inclusions in quartz. (E.R.)

SWEENEY, M., TURNER, P. and VAUGHAN, D.J., 1986, Stable isotope and geochemical studies of the role of early diagenesis in ore formation, Konkola basin, Zambian copper belt: Econ. Geol., v. 81, p. 1838-1852.

SWEENEY, R.L. and RUIZ, J., 1986, Stable isotope geochemistry of calcite and limestone at Naica, Chihuahua, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 767. Authors at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

Carbonate-hosted massive sulfide deposits comprise a class of deposits which have yielded a large percentage of the silver, lead and zinc produced in the western United States and Mexico. Naica, Mexico, is an example of one such deposit. The ore is found in a thick sequence of marbleized Cretaceous limestone that has been folded into an elongate dome approximately 12 km long and 7 km wide. The dome is cut by felsic dikes, which seem to control some of the ore bodies. The surface expression of this dome is a stockwork of calcite veinlets varying in size from less than 1 mm to 3 m with little, if any, quartz present.

Stable isotope analyses were done on these veinlets, and also on the host rock at depth to determine the origin and evolution of ore-bearing fluid(s), and the interaction of the fluid(s) with the wall rock. The vein-filling calcite on the surface showed a range of delta 13-C(PDB) from -4.76 to -8.97 and a range in delta 18-O(SMOW) from +20.00 to +21.93. The gangue calcite associated with the ore showed a range of -1.2 to -6.28 in delta 13-C(PDB) and +7.5 to +15.7 in delta 18-O(SMOW). There appears to be a general trend of isotopic carbon and oxygen values in the ore getting lighter with increasing depth, indicating an evolution of the ore fluid from a possible original magmatic water as suggested by previous workers. Using fractionation factors between calcite and water gives a temperature range of formation from 500°- -350° which agrees with fluid inclusion work. The limestone host gave delta 13-C(PDB) values from -1.2 to -6.05 and delta 18-O(SMOW) values from +9.66 to +15.7. There appears to be some difference in the isotopic values of the limestone with depth of the system, however a direct relationship does not appear to be present with distance from the ore body. In general, there appears to be greater interaction of the fluids with the limestone closer to the surface. (Authors' abstract)

TABUKO, Hiroshi, 1979, Characteristics of synthetic hydrothermal emeralds from USA and USSR: J. Gemmological Soc. Japan, v. 6, no. 4, p. 3-18 (in Japanese; English abstract).

Includes considerable discussion of solid and fluid 2- and 3-phase inclusions and their probable compositins. [Full English translation available from the Editor.] (E.R.)

TADA, Ryuji, 1986, Pressure solution during diagenesis: Experiment, theory and nature (abst.): 12th Int'l. Sedimentological Cong., 24-30 August, Canberra, Australia, Abstracts, p. 297.

TADA, R. and SIEVER, R., 1986, Experimental knife-edge pressure solution of halite: Geochimica Cosmo. Acta, v. 50, p. 29-36. First author at Geol. Inst., Univ. Tokyo, Hongo 7-3-1, Tokyo 133, Japan.

Pertinent to the formation of inclusions during recrystallization of salt. (E.R.)

TAGUCHI, Sachihiro, IRIE, Atsushi, HAYASHI, Masao and TAKAGI, Hiroshi, 1985, Subsurface thermal structure revealed by fluid inclusion thermometer at the Otake geothermal field, Kyushu: J. Geotherm. Res. Soc. of Japan, v. 7, no. 5, p. 401-413 (in Japanese; English abstract). First author at Res. Inst. of Industrial Sci., Kyushu Univ.

Full paper for abstract in Fluid Inclusion Research, v. 18, p. 409, 1985. (E.R.)

TAGUCHI, Sachihiro, NAKAMURA, Motohiko, TAKAGI, Hiroshi and HAYASHI, Masao, 1986, Fracture control of fluid flow revealed by fluid inclusions at the Hatchobaru geothermal field: Geother. Resources Council, Transactions, v. 10, p. 199-202. First author at Res. Inst. Ind. Sci., Kyushu Univ. 86, Kasuga-shi 816, Japan.

Fluid inclusion thermometry has been applied to hydrothermal minerals of quartz and anhydrite collected from cores and cuttings from the Hatchobaru geothermal field, Kyushu, Japan. The minimum value of Th at each depth indicates the present subsurface T. T distribution at the productive depths (about 1000 m below surface) estimated using the minimum Th shows an elongated high T zone: the high T zone at 270°C is 600 m long and about 100 m wide. The direction of this high T zone is concordant with the NW-trending Komatsuike fault which is accompanied by many thermal manifestations. The above facts suggest the fracture control of fluid flow by the NW-trending fault. (Authors' abstract)

TAIB, N.I. and RIPLEY, E.M., 1986, Carbon isotopic studies of the Babbitt Cu-Ni deposit, Duluth Complex, Minnesota (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 768.

TAKASHIMA, Isao, KAWAGISHI, Hideki and HONDA, Sakuro, 1986, Rock alteration of granodiorite around Shirabuonsen area, northwestern part of Azumayama, northeast Japan - Application to analysis of fluid movement in the basement rocks: Report of the Research Inst. of Underground Resources, Mining College, Akita Univ., v. 51, p. 1-11. First author at Res. Inst. of Underground Resources, Mining College, Akita Univ., Japan.

Recently, the evaluation of reservoir structure in granitic and metamorphic basement rocks is important because the wells of geothermal power plants tend more deeply and approach to above rocks which widely developed under the conventional reservoirs in Tertiary formations. Within the studied area, granodiorite is widely distributed and many alteration halos are observed.

In order to elucidate above problem, character and distribution of alteration halos are studied. In addition, mineral paragenesis, fluid inclusion, and scanning electron microscope studies were carried out for the determination of character of hydrothermal activities. The results obtained in this study are as follows:

(1) Alteration of this area is divided regionally developed green colored zone and locally distributed white colored zone. Former one was formed by regional neutral or alkaline alteration and was cut by latter alteration halos which were formed by weak acid fluid.

(2) The shape and distribution pattern of white colored alteration halos coincide with N-S directional faults and NE-SW directional row of Azuma volcanic group. White colored alteration halos tend to form near the boundary of different geologic units.

(3) Mineralogically, green colored alteration zone is characterized by chlorite and sericite. In this zone, sericite-rich areas where hydrothermal solution may ascending sporadically distributed.

(4) White colored alteration halos have zonal structure of kaolinite zone to montmorillonite zone from center to margin. However, central part of montmorillonite zone may be formed by weathering or retrogressive process because the temperature of this zone is too high to form montmorillonite. Halloysite and sericite/montmorillonite mixed layer clay minerals identified in some places.

(5) Fluid inclusion data indicate that the temperature of green colored alteration was estimated about 240-250°C and that of white colored alteration was 250-270°C. At the Shirabuonsen area, low temperature (190-200°C) activity is overlapped to the later alteration zones. The temperature of halloysite-bearing montmorillonite zone was about 210°C.

(6) Based on the size and distribution pattern of white colored alteration halos, granodiorite body can become the reservoir rock for hydrothermal fluid. (Authors' abstract)

TAKATORI, I., SATO, N. and KIZAWA, Y., 1986, Development of the improved decrepitation measurement system and its application for the mineral exploration (abst.): Mining Geol., v. 36, no. 1, p. 64 (in Japanese; translation courtesy K. Okano, via J. Hedenquist).

Decrepitation is one of the geological thermometers to measure the formation temperature of a mineral by making use of fluid inclusions in the mineral. The method presents such advantages as being quick and convenient and demanding no substantial skills. The disadvantage has been that it amplified minor decrepitation sounds and thus measured surrounding noises as well. We have attempted to develop a new decrepitation measurement system by overcoming the above mentioned shortcomings.

The system consists of 3 parts: a sound collecting body of sound insulation which is vibration proof, with an electric furnace and a microphone; measurement equipment with a signal transaction circuit and a counter circuit; and recording equipment. When mineral grains are heated in the electric furnace, internal pressures of the inclusions increase and decrepitation sounds are created. The microphone collects and amplifies these sounds, and the signal transaction circuit selects signals above a certain level. Further, a variable filter selects signals of decrepitation sounds in a secific frequency band range. These selected decrepitation sounds are measured by the counter circuit, and automatically recorded. Sample grains for each measurement are 1 ~ 2 g in weight and -65/+100 mesh.

The systems reproducibility is reasonable. Repetitive experiments using quartz from the Takatori deposit produced decrepitation graphs of clear normal distribution, and these graphs matched one another. Experiments using quartz from Au-Ag veins of Akinobe deposit and the Hazawa deposit produced decrepitation graphs of several peaks, indicating different conditions for various periods of inclusion formation.

This method enables us to obtain information about the temperature and physical characteristics of minerals, even with a small number of inclusions whose Th cannot be measured. However, we cannot distingish P inclusions from S inclusions. It will improve measurement accuracy if one closely compares Th and observe inclusions during decrepitation (while examining graphs). It is also important to obtain pure sample grains.

The system is of small size and portable into the field, which can increase information. We believe that the system will contribute to exploration. (Authors' abstract)

TAKENOUCHI, S., 1986a Gas composition of fluid inclusions from epithermal gold silver deposits (abst.): Mining Geol., v. 36, no. 1, p. 48 (in Japanese; translation courtesy K. Okano, via J. Hedenquist).

Gas compositions of fluid inclusions in quartz from epithermal gold and silver deposits of the Tertiary were analyzed by gas chromatography, and the compositions compared with those of fluid inclusions from other deposits.

We used 3 g of quartz grains of 0.5-2 mm size, and a vacuum ball mill (Tokyo Institute of Technology model) for obtaining fluid inclusion contents. First, H_2O was frozen and separated under vacuum, and the gas amount was measured by Toefler pump and McLeod vacuum gauge. Then we conducted a quantitative analysis. The gas chromatography analysis was conducted under the following conditions: the flow of carrier gas He = 80 ml/min.; parallel column of molecular sieve 5A and Poropak (Shimalite Q[sic]); column temperature = 60°C and heat transfer detector voltaic current = 110 mA. After the gas was collected, H_2O was reduced by heated Zn, and the amount of H_2O was calculated by measuring the amount of H_2.

Our study on quartz samples from Chitose, Kotaku, Nebazawa and Seietsu provided the following results. 100 ~ 390 cm^3 (S.T.P.) of gas was present per mole of H_2O; with composition $CH_4 > N_2 > CO_2$; the mole fraction was CH_4 0.56-0.67, N_2 0.21-0.35, and CO_2 0.04-0.29. In terms of H_2O-CO_2-CH_4 composition, the mole fractions were 0.99 H_2O, 0.001 CO_2, 0.001-0.009 CH_4.

In silicified samples from Akita, 2,150 cm^3 of gas was found per mole H_2O with the proportion of 0.925 H_2O, 0.017 CO_2, 0.058 CH_4. An anhydrite sample from the Nishiyama geothermal system, Fukushima, included gas of 607 cm^3 per mole H_2O with the ratio of 0.978 H_2O, 0.021 CO_2, 0.001 CH_4. Quartz samples from the Ogontsubo Au-Ag deposit, Iwate, included 5,690 cm^3 of gas per mole H_2O with the ratio of 0.814 H_2O, 0.178 CO_2, 0.008 CH_4. The high concentration of CO_2 in the above sample indicated similarities with the gas composition of the Kyuho gold deposit associated with granites in Korea.

Thus, the gas concentration in fluid inclusions from the Tertiary Au-Ag deposits is low, with CH_4 being prominent among the gases. (Author's abstract)

TAKENOUCHI, S., 1986b Fluid inclusion studies of some epithermal gold deposits and geothermal areas in Japan (abst.): Terra Cognita, v. 6, no. 3, p. 511-512. Author at Faculty Engrg., Univ. Tokyo, Tokyo 113, Japan.

Th, salinities and gas compositions of fluid inclusions from some epithermal gold-silver deposits and geothermal areas were determined.

Th of epithermal gold-silver veins range from about 120°C to 300°C, but those from high-grade ore parts generally range between 200°C and 250°C. Salinities are nearly 1 equiv. wt.% NaCl or less. The vertical thermal gradients obtained from the fluid inclusion study are 0.5-2.5°C/10m. In most samples, boiling phenomena were not recognized. The Nansatsu-type massive gold deposits, which are considered to be a kind of hot spring-type gold deposit, occur in highly silicified rocks. These silicified bodies form a mushroom-like shape and are surrounded by alunite-kaolinite zones suggesting an acid hydrothermal activity. Fluid inclusions in quartz from veinlets and small cavities in these deposits show a similar T range to that of the vein-type deposits. T estimates for the formation of the silicified bodies were not made because of the absence of fluid inclusions in the silicified rocks.

Fluid inclusions in a massive silicified body which occurs near a geothermal area were also studied. The shape and alteration zones of the body suggest a similar genesis to that of the silicified bodies of the Nansatsu-type gold deposits, although the body has no gold mineralization and the alteration zones are thin, suggesting activity of less acid or lesser amounts of hydrothermal solutions. The original rocks of the silicified body are quartz-rich felsic tuff and quartz porphyry. Secondary fluid inclusions formed in the pyrogenic quartz grains were studied. Th range between 180°C and 290°C, and boiling phenomena were observed in many samples. T of the hydrothermal activity were estimated to be 215°-285°C, and the depth of the formation inferred to be about 230 m.

Th and salinities of fluid inclusions in calcite veinlets and quartz grains of rocks from drill cores of the same area were measured. Fluid inclusions from the high-T zone show a good correlation between the Th and the measured well T, but the Th of the relatively low-T zone are spread over a much larger range than the well T. This suggests that the present hydrothermal activity at the low-T zone has already declined. The studied T and alteration profiles of this area suggest that the silicified body was formed by a plume of acid hydrothermal solutions, but that the solutions outside the body were neutral or weakly alkaline.

Fluid inclusion studies show that the thermal conditions of the epithermal gold mineralization and recent geothermal activity are similar. However, hydrothermal alteration suggests a difference of chemical conditions within these two hydrothermal systems, since adularia is often reported from the epithermal gold-silver mineralization but, in the geothermal areas, laumontite or wairakite is common instead of adularia. (Author's abstract)

TALKINGTON, R.W., 1986, Platinum-group element potential of the chromitite deposits, Lewis Hills, Bay of Islands ophiolites, Newfoundland (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 1, p. 70. Author at Geol. Program-NAMS, Stockton State College, Pomona, NJ 08240.

Fluid and solid silicate inclusions are abundant in the chromitites. (From the author's abstract)

TARAN, Yu.A., 1986, Gas geothermometers for hydrothermal systems: Geokhimiya, no. 3, p. 339-354 (in Russian; translated in Geochem. Int'l., v., 23, no. 7, p. 111-126, 1986). Author at Inst. Volcan., Far East Sci. Center, Acad. Sci. USSR, Petropavlovsk-Kamchatskiy, USSR.

Gas geothermometer formulas have been derived in a form convenient for practical calculations for the major components of geothermal gases: CO_2, H_2S, H_2, CH_4, N_2, and NH_3. T have been calculated from these for 50 gas analyses of borehole solutions from water-dominated hydrothermal systems in Kamchatka and other regions. The deep T or solution enthalpies are known for these systems, as well as the hydrochemical indicator components Na^+, K^+, Ca^{2+}, and SiO_2, from which we can estimate the deep T independently. The H geothermometer is shown to have the least error in the range 100-350°C. The data in the other geothermometers indicate that in the C-H-O-N system the gases do not equilibrate below 250°C in natural hydrothermal systems, and that satisfactory geothermometer readings are obtained from them because of the specific T dependence, where the main contribution comes from the H_2/H_2O ratio. (Author's abstract)

TARASENKO, V.S., 1986, Contact effect of rapakivi granites on anorthosites of the Korosten plutons: Dokl. Akad. Nauk SSSR, v. 289, no. 2, p. 466-470 (in Russian).

Th suggests a high T (830-810°C) for emplacement of rapakivi granites. (A.K.)

TAUSON, V.L., PARADINA, L.F. and ANDRULAITIS, L.D., 1986, The entry of mercury into galena and the new galena-sphalerite geothermometer: Geokhimiya, no. 1, p. 63-69 (in Russian; translated in Geochem. Int'l., v., 23, no. 6, p. 55-61, 1986).

TAYLOR, B.E. and BUCHER-NURMINEN, Kurt, 1986, Oxygen and carbon isotope and cation geochemistry of metasomatic carbonates and fluids - Bergell aureole, northern Italy: Geochimica Cosmo. Acta, v. 50, p. 1267-1279. First author at Dept. Geol., Univ. California, Davis, CA 95616, USA.

Oxygen and carbon isotope geochemistry and Ca-Mg geothermometry are used to investigate temperatures, fluid compositions, and mechanisms of vein formation in dolomitic marble roof pendants of the Bergell intrusive complex, northern Italy. The veins formed over a range of T of ~520 to 380°C. Most veins apparently formed near 400°C from H_2O-rich C-O-H fluids ($X(CO_2) = 0.1-0.25$). (From the authors' abstract)

TAYLOR, D.T., 1986, Geology and mineralization of the Atlanta mining district and adjacent areas, Elmore County, Idaho: MS thesis, Univ. Idaho, 158 pp.

The Atlanta mining district is underlain by the Cretaceous granitic rocks of the Idaho batholith. These granitic rocks have been intruded by genetically related aplite and pegmatite dikes. The area was later intruded by mid-Tertiary, subvolcanic, porphyritic diorite, rhyolite, and andesite dikes. The lode is a large silicified and brecciated shear zone. The major ore minerals in the Atlanta mining district are Au and sulfosalts of Ag, notably miargyrite, pyrargyrite, proustite, and polybasite. The veins show four different stages of mineralization and brecciation. The first two stages are composed predominantly of quartz without any associated ore minerals. The third stage is composed of coarsely crystalline quartz with Au, sulfosalts of Ag, the base metal sulfides. The fourth stage is composed entirely of calcite. Hydrothermal alteration types surrounding the veins consists of inner zones of silicification and sericitic alteration; an intermediate argillic alteration; and outer chlorite-sericite alteration.

Studies on P, two-phase fluid inclusions in quartz show average Th of 243°C for Stage 1, 255°C for Stage 2, and 262°C for Stage 3. Average salinities (wt. % NaCl eq.) were 4.78 in Stage 1, 5.24 in Stage 2, and 4.32 in Stage 3. The calcite in Stage 4 proved unsatisfactory for fluid inclusion studies. (From the author's abstract)

TAYLOR, H.P., Jr., 1986, $^{18}O/^{16}O$ evidence for deep circulation of surface waters and formation of low-^{18}O magmas in regional rift-zone hydrothermal environments (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 770.

TAYLOR, W.R., 1985, A reappraisal of the nature of fluids included by diamond: A window to deep-seated mantle fluids and redox conditions (abst.): Abstracts of Conf. on Stable Isotopes and Fluid Processes in Mineralization, Queensland, 10-12 July, 1985, p. 72-73. Author at Dept. Geol., The Univ. Tasmania, Hobart, Tas., 7001, Australia.

The nature of deep-seated mantle fluids, particularly those involved in magmatic processes, has usually been sought indirectly by analysis of volcanic gases. However, such fluids can yield only limited information because of a poorly constrained and complex evolution during movement to the surface. Perhaps one of the few direct examples of upper mantle fluids is to be found a volatile components trapped in fluid inclusions or other structural sites in natural diamond. Provided a syngenetic or synmetamorphic host-inclusion relationship can be demonstrated, diamond-derived fluids are potentially valuable sources of information concerning the mantle redox regime and volatile species activities prevailing during diamond formation or during some later recrystallization event.

Because diamond has been subject to a complex P-T history, culminating in rapid transport to the Earth's surface, there is a need to critically test the simple interpretation that the compositions of fluids as analyzed are the same as those originally trapped. This is illustrated by 21 analyses of diamond-derived fluids taken from the literature which give apparent average trapping pressures lying in the range 2-15 kb. None of the analyzed fluids could thus have been in equilibrium with diamond under typical formation conditions ($P \approx 55$kb, $T \approx 1400$ K). By using a thermodynamic model for the C-O-H fluids at high pressures, and recognizing that the fluids have been open to carbon exchange via the inclusion walls, a correction may be applied to bring all compositions back onto the diamond saturation surface at $P > 45$ kb. It turns out that all equilibrium fluids are water-rich (>50 mol% H_2O) and fall into two groups: diamonds of non-cubic morphology (the majority on a world-wide basis) have equilibrated with reduced H_2O-CH_4-H_2 fluids at fO_2s in the range iron-wustite (IW) to IW + 1.5 log (FO_2) units while the rare cubic morphology contain H_2O-CO_2 fluids equilibrated at fO_2s near magnetite-wustite (MW).

To determine whether fluid inclusions in diamond can actually survive transport from mantle depths, a simple elastic model to describe crack propagation about spherical fluid inclusions was developed. It was found that inclusions with diameters >10 microns are likely to decrepitate during transport to the surface. Furthermore, those inclusions surviving are expected to develop large crack halos causing a decrease in internal fluid pressures and a corresponding shift in C-O-H equilibria toward a low pressure regime. Preservation of such fluids will result in observed low apparent trapping pressures. That this process represents a viable model for explaining the fluids analyzed today can be demonstrated by the fact that most fluids lie on well defined pressure relaxation curves with a species distribution that can be matched theoretically. Diamond-derived fluids are thus consistent with a primary mantle origin.

While the present analytical data set may not yet be of statistically significant size, a number of preliminary conclusions can be drawn from this study:

(a) The majority of diamonds have equilibrated with mantle fluids of H_2O-CH_4 composition during growth and/or residence in the upper mantle. A genetic link between methane-bearing fluids and diamond is suggested; a hypothesis also indicated from carbon isotope studies.

(b) Mantle redox conditions appropriate to the formation of most diamonds are consistent with low intrinsic fO_2 measurements of type "A" spinel and peridotite samples. This is well below the stability limit of a crystalline carbonate phase and provides a marked fO_2 contrast with host kimberlite. Most diamonds therefore appear to be of xenocrystic origin.

(c) Apparent Archaean ages for diamond hosted by much younger kimberlites suggests that relatively reduced, diamond-source regions of the mantle have persisted through time with little modification.

(d) Redox interactions between reduced methane-bearing deep mantle fluids and overlying mantle (lithosphere) of higher fO_2 is inferred to be an important mechanism for diamond precipitation. (Author's abstract)

TAYLOR, W.R. and GREEN, D.H., 1986, The role of reduced C-O-H fluids in mantle partial melting (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 211-213. Authors at Geol. Dept., Univ. Tasmania, Hobart 7001, Australia.

Until very recently, many petrogenetic models were based on the assumption that fO_2-conditions in magma source-regions of the upper mantle were relatively oxidized, lying near the fO_2 defined by the synthetic assemblage fayalite-magnetite-quartz (FMQ). This was consistent with the petrogenetic role inferred for oxidized CO_2-H_2O volatiles and carbonated peridotite. However, if magma generation involving volatile components takes place in a reduced environment, for example at fO_2's near the iron-wustite (IW) oxygen buffer - as suggested by intrinsic fO_2 measurement on mantle-derived minerals - then in the model system "peridotite"-C-O-H, volatiles will be dominantly $CH_4 > H_2O > H_2 > C_2H_6$ mixtures and crystalline carbonates will not be stable relative to diamond or graphite. The nature of mantle melting under reduced conditions is expected to be very different from that occurring in an oxidized environment. (From the authors' abstract)

TELEPKO, L.F., MATVIYENKO, A.D. and VASILISHIN, I.S., 1985, Some mineralogic-genetic particulars of the fluorite mineralization from the pegmatites of Volhynia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 167-169 (in Russian; translation by Dorothy B. Vitaliano). First author at IGGGI of Acad. Sci., Ukrainian SSR, USSR.

The following features of fluorite distribution and nature were established. Almost throughout the vertical sections studied, a tendency is observed for the fluorite content to increase from the host granites toward the pegmatites. The maximum concentration of the mineral (up to 4 kg/t) are confined to zones of K-feldspathized biotitized granites under the pegmatites. In the pegmatites (especially completely differentiated ones), fluorite occurs more rarely than in the host granites (in about 2 bodies out of 3)[sic]. In the pegmatite-bearing granites, fluorite usually fills microfractures and small cavities. Primary G/L fluid inclusions in fluorite have Th = 250°C to the liquid phase.

The gas phase (determined by I.M. Svorenya on the MX-1303 mass spectrometer), has predominantly CO_2 (up to 83%). Other gases were also found: N_2 (9.1%), CH_4 (4.9%), H_2 (3.8%). The high CO_2:CH_4 ratio (17) indicates an acid potential of the mineralizing fluids.

The pH, determined by the microcolorimetric method, is 5.8-6.0 for the P inclusions and 6.5 for the S. Thus in the course of growth of the crystals of fluorite and later healing of the microfractures, a change in pH of the mineralizing solutions occurred toward a decrease[sic] in pH.

The results could be used in economic grading of bodies penetrated by drilling. (Abbreviated by E.R. from the authors' abstract)

THEODORE, T.G., HOWE, S.S., BLAKE, D.W. and WOTRUBA, P.R., 1986, Geochemical and fluid zonation in the skarn environment at the Tomboy-Minnie gold deposits, Lander County, Nevada: J. Geochem. Explor., v. 25, p. 99-128. First author at U.S. Geol. Survey, Br. Resource Analysis, Menlo Park, CA 94025, USA.

The Tomboy-Minnie gold deposits are related to the middle Tertiary porphyry copper system centered at Copper Canyon. Fluid-inclusion studies suggest wide variations in T and chemistry prevailed in the fluids associated with mineralization at the Tomboy. Early fluids associated with diopside-quartz assemblages probably were dominantly $CaCl_2$-rich brines and were boiling at >500°C. These fluids were progressively enriched in Na and K over time, and during the hydrosilicate stages, T probably ranged from 320 to 500°C at the time actinolite formed, and from 220 to 320°C at the time chlorite was dominant. Sulfur isotopic data suggest that sulfur, mostly from a magmatic or deep-seated crustal source, was transported by hydrothermal fluids as aqueous H_2S with a $\delta^{34}S$ of about 4 ± 1‰ to the West, East, and Tomboy deposits. (From the authors' abstract)

THOMAS, Rainer and BLANKENBURG, H.-J., 1986, Thermometric analyses of silicic glass inclusions in rhyolitic quartzes: Freiberger Forschungshefte, v. C402, p. 69-103 (in German).

This is an extended form of an earlier paper published by the same authors [Fluid Inclusion Research, v. 18, p. 413].

The results of the microthermometric examination of 24 rhyolitic quartz samples mainly from the southern part of the G.D.R. are presented. The following three Th groups were determined: I. 840 ± 30°C, II. 1035 ± 55°C and III. 1180 ± 45°C. The formation of these groups is discussed.

The existence of these three groups seems to be characeristic of samples having passed through different depths of formation. Another interpretation suggests that they are the result of natural decrepitation at a defined depth.

Based on the results and the preliminary data on granitic silicate melt inclusions an attempt is made to delineate the conditions for the genesis of disseminated quartzes. The best accord is obtained using a model of the intramagmatic formation of the high-temperature quartz phenocrysts under conditions which correspond to those prevailing in the (recent) Conrad discontinuity. (Abstract courtesy R. Thomas)

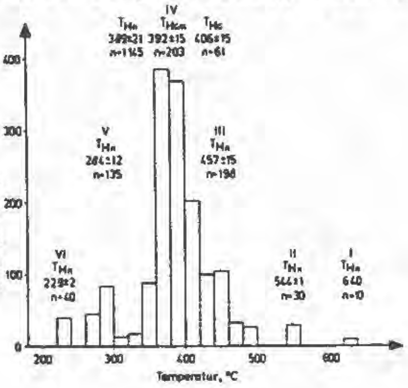
THOMAS, Rainer and LEEDER, Otto, 1986, On the physico-chemical evolution of mineral-forming solutions according to thermobarometric investigations: Zeitschr. Geol. Wissensch. Berlin, v. 14, no. 1, p. 51-60 (in German; English abstract).

Starting from thermometric and chemical results on fluid inclusions in 90 samples of cassiterite (see Figure 1) as well as previously published

Figure 1

Frequency distribution of the homogenization temperature for fluid inclusions in cassiterite from deposits in the Erzgebirge and Vogtland.

T_H - homogenization temperature
T_{Hfl} - homogenization in the liquid phase
$T_{HG/fl}$ - homogenization with critical phenomenon (critical boiling)
T_{HG} - homogenization in the gas-phase
n - number of determinations



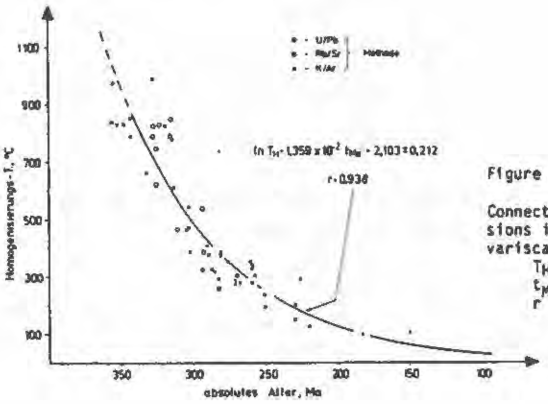


Figure 2

Connection between the homogenization temperature of fluid and melt inclusions in minerals from the Erzgebirge and Vogtland (granite, Variscan/post-variscan mineralizations) and age-data.

T_H - homogenization temperature
t_{Ma} - age in 10^6 years
r - coefficient of correlation

data from thermobarometric, chemical, and isotope-geochemical investigations of gas-liquid-inclusions in minerals of Erzgebirgian ore-associations (pneumatolytic cassiterites, hydrothermal sulphide veins) as well as from age data of accompanying magmatites and tectonic events, a model of the physico-chemical and genetic evolution of the mineral-forming media is represented. The existing regular relations between T of formation, age data (see Figure 2) and oxygen isotope proportions which can be correlated mathematically, lead to the conclusion, that the deposits are connected with a process of tectono-magmatic activation in the Late Palaezoic. Beginning from an initial "thermal event," which evolved magmatism and volcanism, the investigated parameters over a period more than 150 mill. years change in the following sequence: granite - pneumatolytic tin deposits - katathermal sulphide deposits - mesothermal ore free (fluorite) deposits.

The analysis of fluid inclusions in minerals in relation with other geochemical investigations supply additional data throwing new light on formation of deposits and the general T evolution in the Variscan/post-Variscan time period in the Erzgebirge and calls into question some of the accepted geological notions. (Modified English abstract courtesy R. Thomas)

THOMAS, Rainer and SCHMIDT, Wolfgang, 1986, First results of thermobarometric analysis of inclusions of mineral-forming media in minerals of pegmatites of the Republic of Mocambique and some remarks on methodological problems: Freiberger Forschungshefte, v. C402, p. 31-48 (in German). First author at 9200 Freiberg/Sa., Lomonossowstrasse 14, GDR.

The first part of this report presents preliminary results on inclusions in quartz, orthoclase and garnet from zoned Nb-Ta-REE-U-pegmatites with beryl, lepidolite and spodumene mineralization that encompass the principal modes of occurrence (Muiane, Naipa and Nuaparra) of the pegmatites in Mocambique.

The following types of inclusions were recognized: (I) P silicate melt inclusions, sometimes with <3.6 wt.% CO_2 (Th >700-720°C). (II) P and S CO_2-rich inclusions with liquid and gaseous CO_2 at room T. The homogenization of the CO_2 phases occurs in the liquid phase. The average CO_2-densities for the two types were calculated from Th: PCO_2-inclusions - 0.78 ± 0.06 g/cm^3, and SCO_2-inclusions - 0.63 ± 0.02 g/cm^3. Noteworthy is the continuous increase of CO_2 densities (and pressure also) from the outer border of the pegmatite shell to the pegmatite quartz core (0.74 g/cm^3 to 0.86 g/cm^3). (III) P and PS inclusions containing at room T H_2O-rich liquid and vapor (sometimes CO_2-rich vapor) and a complex assemblage of crystalline phases (halite, sylvite, specularite, alkali carbonates/bicarbonates and many unidentified birefringent anisotropic minerals. (IV) P, PS and S liquid-vapor inclusions. The P and PS type-IV inclusions occur in hydrothermal minerals (130°C $<$ Th $<$ 350°C) and the S liquid-vapor type-IV inclusions occur along cross-cutting fractures in most samples.

On the basis of microthermometric data of all types of inclusions the following P-T data of entrapment for inclusions in the pegmatitic and hydrothermal minerals were estimated: pegmatitic stages - 1980 bars $<$ P $<$ 4000 bars, 440°C $<$ T $<$ 730°C; hydrothermal stages - 455 bars $<$ P $<$ 1000 bars, 160°C $<$ T $<$ 323°C.

In the second part the five major assumptions of geothermobarometry (Roedder, 1979) are discussed. (Abstract courtesy R. Thomas)

THOMPSON, T.B., 1986, Precious metals in the Leadville district, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 773. Author at Dept. Earth Resources, Colorado State Univ., Fort Collins, CO 80523.

Production from 1859 to 1986 in the Leadville district has been approximately 3.25 x 10^6 oz Au and 2.56 x 10^8 oz Ag, won principally from carbonate-hosted replacement bodies and, to a much lesser extent, from lodes and placers. The veins are focused near Breece Hill, the thermal center of the district, and along major faults away from the center. Carbonate-hosted replacement bodies with more than 60 vol % sulfides occur where favorable dolomite is cut by veins. Precious metals occur as electrum and argentian tetrahedrite, forming after base metal sulfides. Fission-track dates on zircon and apatite in preore, zonally-altered igneous rocks indicate the ore event occurred 34.0 m.y.a.

Fluid inclusions in quartz and sphalerite with pressure-corrections yield a range of temperatures for the veins of 378 to 469°C while the replacement bodies on the southeastern part of the district formed at 310 to 410°C. The salinities are less than 5.2 wt % equiv. NaCl. The ore fluids were generated by a magmatic source beneath Breece Hill as calculated from oxygen isotope analyses (6 ± 2 permil) and hydrogen isotope analyses (-60 ± 10 permil) of altered igneous rocks and ore-related quartz. Sulfur isotope analyses (pyrite: 1.2-3.2 permil; sphalerite: -0.5 to +2.2 permil; galena: -2.4 to +0.7 permil) yield temperatures from galena-sphalerite of 450° ± 23°C and pyrite-sphalerite of 420° ± 21°C. Ore fluid sulfur isotope composition for the replacement bodies was 1.9 permil. Galena and preore Tertiary K-feldspar have virtually identical Pb isotope ratios. All data support a magma to hydrothermal origin for the metals and sulfur in the Leadville vein and sulfide replacement bodies. (Author's abstract)

THURMOND, V.L. and BRASS, G.W., 1986, Thermodynamic properties of the system NaCl-H_2O from 25°C to -40°C (abst.): EOS, v. 67, no. 44, p. 1280. Authors at Rosenstiel Sch. of Marine & Atmos. Sci., Univ. Miami, Miami, FL 33149.

Thermodynamic properties of electrolyte solutions change rapidly below 25°C but these properties are seldom measured over the low temperature range (below 0°C) even though some salt solutions can remain unfrozen to -50°C. Heat capacities of concentrated solutions (0.5 to 6.0 molal) of NaCl-H_2O were measured from 25°C to -40°C as part of a study to provide thermodynamic data of salt solutions for use in cold regions chemical and geophysical studies.

A differential scanning calorimeter was used to measure specific heat capacity from cooling scans as a function of a temperature and concentration. The heat capacity data were fit to the equations of Pitzer and coworkers to obtain activity and osmotic coefficients of NaCl and H_2O respectively. Supercooling of the solutions was encouraged by using a fast scan rate (10°/minute) so that specific heat could be measured to lower temperatures than would be possible if the solutions were allowed to equilibrate with the solid phases. The standard error of the measurements is about 1%.

Solubilities of halite and ice were calculated and compared to experimental solubilities. Results show that the low temperature heat capacity measurements significantly improve the predicted solubilities below 25°C. The average deviation between the predicted and experimental solubility is 0.02% for halite and 0.7% for ice. (Authors' abstract)

TINGLE, T.N., GREEN, H.W. and FINNERTY, A.A., 1986, The solubility and diffusivity of carbon in olivine: Implications for carbon in the Earth's upper mantle (abst.): Fourth Int'l. Kimberlite Conf. Extended Absts., Geol. Soc. Australia Abst. Series No. 16, p. 349-351. Authors at Dept. Geol., Univ. California, Davis, CA 95616, USA.

These experiments on C solublity and diffusion in olivine are consistent with observations on natural rocks in several respects. 1) Solubilities greater than 100 wt. ppm C are in rough agreement with deductions from mantle xenoliths. 2) The apparent insolubility of C in olivine at low P confirms the P dependence of the solubility. 3) High diffusivities of C and H in olivine predict that analyses of mantle-derived olivines will underestimate their concentrations in the mantle. Condensed C on grain boundaries and cracks may represent C dissolved in the crystals that exsolved during diapiric uprise in the mantle and eruption. 4) The significant solubility of both C and H in olivine establishes that the nominally volatile-free silicates of the mantle potentialy constitute a large reservoir for fluids. This would explain the origin of present-day C associated with volcanism and resolve the paradox that the absence of carbonate in mantle xenoliths presents without excluding the possiblity that carbonate minerals may exist in the mantle.

C diffusivities of 10^{-9} mm^2/sec are similar to Fe-Mg interdiffusivities in olivine at 1200°C reported by Buening and Buseck (1973). These diffusivities are rapid in their geologic context, but they contrast with the high mobilities attributed to solute C by Knobel and Freund (1986). (Abbreviated from the authors' abstract by E.R.; references deleted.)

TITLEY, S.R., 1986, The evolution of fracture permeability in fossil hydrothermal systems (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 774.

TITLEY, S.R., THOMPSON, R.C., HAYNES, F.M., MANSKE, S.L., ROBISON, L.C. and WHITE, J.L., 1986, Evolution of fractures and alteration in the Sierrita-Esperanza hydrothermal system, Pima County, Arizona: Econ. Geol., v. 81, p. 343-370. First author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

Considerable Th data are presented (p. 353-354) from the literature and new work; Th of P inclusions in quartz-orthoclase veins ranges 280-400°C and quartz-sulfide veins 190-360°C. (E.R.)

TIVEY, M.K. and DELANEY, J.R., 1986, Growth of large sulfide structures on the Endeavour Segment of the Juan de Fuca Ridge: Earth & Planet. Sci. Letters, v. 77, p. 303-317.

TODOROV, Todor and KRAŠTEVA, Margarita, 1985, Temperature of formation of the Slavjanka fluorite deposit, southwest Bulgaria: Rudoobraz. Procesi i Miner. Nahodišta, no. 22, 1985, p. 30-40 (in Russian; English abstract).

Medium- to low-T conditions of mineral formation (272 - <100°C) have been determined by mineral thermometry. Fluid inclusions are homogenized in a Koffler-type thermocell using plates 0.3-0.5 mm thick. Td in the 0.2-0.5 mm grain-size fraction is measured and the impulses recorded on a single-channel decrepitometer. The Th of P inclusions in the 1st generation of green octahedral fluorite is 220-160°C, most often 190-170°C, and that of the inclusions in the 2nd generation of fluorite crystals (pale green, colorless or white, usually grainy) is 210-120°C, most often 160-140°C. Apparently, the pale-violet metacolloidal fluorite of the 3rd generation and the 4th generation of fluorite (fine cubic crystals produced [from] "fluorite gels") contain no inclusions. Inclusions in the 1st generation of quartz homogenize in the interval 272-235°C. (Abstract by S. Aslanjan)

TOMILENKO, A.A. and KEPEZHINSKAS, K.B., 1985, Estimation of the composition and fluid pressure in metamorphism by methods of thermobarogeochemistry (illustrated by the eastern Hubsugul' area, Mongolia) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 202-204 (in Russian; translation by Dorothy B. Vitaliano). Authors at Inst. Geol. & Geophys. Siberian Br., Acad. Sci. USSR, Novosibirsk, USSR.

The rocks of the pre-Riphean basement in the eastern Hubsugul' area (outside of zones of faulting and compression) are characterized by metamorphogenic inclusions containing water, CO_2 and CH_4 in different proportions. Within one and the same stage of metamorphism, the evolution of the composition of the fluid is observed, manifested in oxidation of CH_4 with the formation of water and CO_2. Samples containing quartz of at least two generations predominate statistically in zones of faulting and compression: one generation with predominance of water-CH_4 inclusions and the other with predominance of water-CO_2 inclusions. Probably this is related to the effect of a superposed stage of metamorphism, producing P in these tectonically active fault zones and considerable oxidation of the more reduced fluid of the early stage of metamorphism.

Metamorphogenic inclusions of N_2-water composition are very typical of the basic metavolcanics and layered gabbroids of the ophiolite complex. These inclusions apparently reflect the last stage of metamorphism, which was regressive for these rocks, and progressive for the rocks of the upper layers of the volcanogenic-sedimentary sequence. The presence of relict quartz in the basic lava and gabbroids, containing relict (for the last metamorphism) water-CO_2 inclusions, confirms this idea, as do inclusions of silicate melts with Th = 880-900°C, in pegmatoid segregations in the gabbros. In the quartz from the lavas of intermediate composition and in the volcanogenic-sedimentary sequence of the upper layer, only CO_2-water inclusions are found.

The fluid P during metamorphism of the rocks of the pre-Riphean basement, calculated from the metamorphogenic inclusions, was 5-7 kbar. This is in agreement with the data of paragenetic analysis, which suggest that the metamorphism of the basement rocks occurred predominantly under conditions of the amphibolite and epidote-amphibolite facies, at moderate P. This also is indicated by the limited development of muscovite pegmatites and the formation of garnet and diopside amphibolites.

The fluid P of the final, chiefly greenschist, stage of regional metamorphism, which also involved retrograding of the basement rocks and especially the rocks of the ophiolite complex, is estimated as 4-6 kbar for the metavolcanics of basic and intermediate composition, 4-4.5 kbar for the rocks of the upper volcanogenic-sedimentary sequence, and 5-7 kbar for the lower layered gabbroids.

The considerable range of variation of the density of CO_2 and CH_4 in the inclusions from the rocks of the pre-Riphean basement, and as a result, variations in estimated fluid P, may be caused by various factors: primarily by a change in PT conditions at different stages of the metamorphic processes both within the same stage of metamorphism and possibly under the influence of superposed stages. In this connection, the observed variations present a somewhat composite picture, related to variations in PT conditions. (From the authors' abstract)

TOURET, J., 1984, Fluid distribution in the lithosphere as indicated by fluid inclusions: Mitt. Osterreich. Mineralog. Gesel., v. 129, p. 31-38.

A review. See also Touret, 1985a, Fluid Inclusion Research, v. 18, p. 418-419, 1985. (E.R.)

TOURET, Jacques, 1986a, Fluids in the lower continental crust: Italian Soc. Mineral. and Petrology, Seminar on Role of fluids in petrogenesis, Siena, 3-4 June, 1986, [Program and Abstracts], p. 11. Author at Inst. vor Aardwetenschrappen, Vrije Univ. Amsterdam.

A review. See Touret, 1985a, Fluid Inclusion Research, v. 18, p. 418-419. (E.R.)

TOURET, J., 1986b, Fluid inclusions in rocks from the lower continental crust, in The nature of the lower continental crust, J.B. Dawson, D.A. Carswell, J. Hall and K.H. Wedepohl, eds.: Geol. Soc. Special Publ., no. 24, p. 161-172.

A review. See previous item. (E.R.)

TOURET, Jacques and VAN DEN KERKHOF, A.M., 1986, High density fluids in the lower crust and upper mantle: Physica, v. 139 & 140B, p. 834-840. Authors at Inst. voor Aardwetenschappen, Vrije Univ., De Boelelan 1085, 1081 HV Amsterdam, The Netherlands.

The deepest fluids contained in rocks (fluid inclusions) are essentially pure CO_2 with a maximum density of 1.178 g/cm^3. Higher densities (up to 1.26 g/cm^3) have been reported, but there is a distinct possibility that they are in fact N_2-CO_2-mixtures of much lower density. (Authors' abstract)

TRAORÉ, Ibrahima, 1986, On the metallogeny of gold with special consideration of the gold-deposits in Mali: Freiberger Forschungshefte, v. C 404, 95 pp. (in German).

This paper is the shortened version of a 1984 dissertation; see Fluid Inclusion Research--Proceedings of COFFI, v. 18, p. 421.

TRAORÉ, Ibrahima, SCHRÖN, Werner and BAUMANN, Ludwig, 1986, Geochemical investigations at gold-bearing vein quartzes: Z. Geol. Wiss., v. 14, no. 3, p. 297-305 (in German; English Summary).

Systematic geochemical investigations of 22 quartz-veins of the individual successions of the gold-ore deposit of Kalana/Mali, together with analogous investigations of 31 quartz-samples of the world, were compared and discussed. Under consideration of the already found relationships at quartz-veins of different hydrothermal ore deposits, new geochemical features and characteristics are found, which are interesting for the prospecting and the exploration of ore deposits. (Authors' summary)

See also previous paper. (E.R.)

TRAORÉ, Ibrahim, THOMAS, Rainer and BAUMANN, Ludwig, 1986, Thermobarometric, cryometric and isotopic-geochemical investigations of gold-quartz of the gold-ore deposit of Kalana/Mali: Z. Geol. Wiss., v. 14, no. 4, p. 473-487 (in German; English Summary).

Thermobarometric, cryometric and isotopic-geochemical investigations of gold-quartz of the gold-ore deposit of Kalana/Mali were carried out and discussed.

The productive phases of the mineralization range in temperature from 270°C-410°C (average 383°C). Under consideration of the paragenesis of minerals and the results of the cryometric investigations, the calculations of physical-chemical conditions demonstrate that the mineral-forming solutions show an alkaline reaction. The enrichment and the precipitation of gold occurred in two or several stages. (Authors' summary)

TRAVNIKOVA, L.G. and PRASOLOV, E.M., 1985, Gas compositions in salt beds: Geokhimiya, no. 12, p. 1766-1778 (in Russian; translated in Geochem. Int'l., v., 23, no. 5, p. 132-143, 1986). Authors at All-Union Petroleum Geol. Res. Inst., Leningrad, USSR.

Measurements have been made on ~220 samples of gases with various modes of occurrence (in the lattice and in microscopic inclusions) in salt rocks from various geotectonic settings, of various ages, etc. The lattice gases in stratified salt rocks with relatively undisturbed attitudes show identical compositions, but the average is substantially different from the characteristics of oil and gas pools. A unified geochemistry is thus characteristic of gases in salt beds generally, which implies specific formation conditions. As a rule, the gases in the microscopic and macroscopic inclusions differ in composition from those in the lattice, which may be due to fractionation during migration and the injection of secondary fluids.

The possible compositions for gases from various sources are used in identifying genetic types. The gases from salt rocks are relicts from the surface salt basin or are formed in the salts (authigenic) or are epigenetic. One of the sources for the authigenic gases is fossilized organic matter. The screening behavior of salt rocks is weakened in regions of salt tectonics. (Authors' abstract)

TREIMAN, A.H., 1986, Carbonatite magma properties and processes (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 138.

TROMMSDORFF, V. and SKIPPEN, G.B., 1986a, Brines and metamorphism: Italian Soc. Mineral. and Petrology, Seminar on Role of fluids in petrogenesis, Siena, 3-4 June, 1986, [Program and Abstracts], p. 12. First author at Inst. für Mineral. & Petrogr. der ETH, CH-8092 Zürich, Switzerland.

Available experimental data permit construction of a quantitative P-T projection of the system CO_2-H_2O-NaCl to 900°C and 2 kb. Extrapolation of this diagram to higher pressures shows that even at moderate salt contents two fluids, i.e., an aqueous brine and a CO_2-rich "vapor" coexist over a wide range of metamorphic conditions. Careful petrographic and fluid- and solid-inclusion studies from a number of localities in the Adamello and in the Central Alps confirm the existence of not only two fluids but also of salt-saturated brines during high grade metamorphism and metasomatism.

Prograde or retrograde reactions that hydrate solid phases and segregation of metamorphic fluids are processes that concentrate salt components in the liquid phase. These processes as well as temperature decrease and pressure increase can lead to the saturation of fluid phases with salt components.

The interaction of a rock mass with two-phase fluids in CO_2-H_2O-NaCl is considered for both closed and open systems. It is discussed for different stoichiometries of mixed volatile, CO_2-H_2O reactions. Two cases are considered: one in which two fluids remain in physical contact so that the solids react simultaneously with the coexisting liquid and "vapor." In the second case fluid phase segregation (boiling) occurs with the phase of lesser density, the CO_2-rich "vapor," leaving the system. Considerable variations in reaction rate are expected from the different processes involved in brine-rock interaction. This may explain some of the characteristic textures observed in metasomatic rocks. (Authors' abstract)

TROMMSDORFF, Volkmar and SKIPPEN, George, 1986b, Vapor loss ("boiling") as a mechanism for fluid evolution in metamorphic rocks: Contrib. Mineral. Petrol., v. 94, p. 317-322. First author at Inst. Mineral. und Petrogr., ETH-Zetrum, CH-8092 Zürich, Switzerland.

The calculation of fluid evolution paths during reaction progress is considered for multicomponent systems and the results applied to the ternary system, CO_2-H_2O-NaCl. Fluid evolution paths are considered for systems in which a CO_2-rich phase of lesser density (vapor) is preferentially removed from the system leaving behind a saline aqueous phase (liquid). Such "boiling" leads to enrichment of the residual aqueous phase in dissolved components and, for certain reaction stoichiometries, to eventual saturation of the fluids in salt components. Distinctive textures, particularly radiating growths of prismatic minerals such as tremolite or diopside, are associated with saline fluid inclusions and solid syngenetic salt inclusions at a number of field localities. The most thoroughly studied of these localities is Campolungo, Switzerland, where metasomatic rocks have developed in association with fractures and veins at 500°C and 2000 bars P. The petrography of these rocks suggests that fluid phase separation into liquid and vapor has been an important process during metasomatism. Fracture systems with fluids at P<lithostatic may facilitate the loss of the less dense vapor phase to conditions of the amphibolite facies. (Authors' abstract)

TROTSYUK, V.Ya. and NEMIROVSKAYA, N.A., 1985, Hydrocarbon gas-hydrate formation beneath the sea floor: Doklady AN SSSR, v. 284, no. 4, p. 976-978 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 11, p. 1325-1328). Authors at Shirshov Inst. Oceanology, USSR Acad. Sci., Moscow, USSR.

This work suggests that upward migration of deep-seated catagenic hydrocarbons may be an important factor in the formation of shallower gas-hydrate zones. (Authors' abstract)

TRUESDELL, A.H. and JANIK, C.J., 1986, Reservoir processes and fluid origins in the Baca geothermal system, Valles Caldera, New Mexico: J. Geophys. Res., v. 91, no. B2, p. 1817-1833.

TRUSCOTT, M.G., SHAW, D.M. and CRAMER, J.J., 1986, Boron abundance and localization in granulites and the lower continental crust: Bull. Geol. Soc. Finland, v. 58, Part 1, p. 169-177. Authors at Dept. Geol., McMaster Univ., Hamilton, Ontario L8S 4M1, Canada.

Fifty-five Precambrian ultramafic to felsic granulites from Pikwitonei, Westport, Adirondack Mountains, Orissa, Madras, and Minnesota and granulite xenoliths from Montana have been analyzed by Prompt Gamma Neutron Activation Analysis and alpha-track mapping.

Boron contents vary between <0.1 and 14 ppm, except for 3 rocks containing >100 ppm, and do not show any relationship to other major or trace elements. The B abundance is proportional to the abundance of hydrous alteration products (sericite, saussurite, chlorite) which contain up to 500 ppm, in a given rock. B also is concentrated in some cases in mineral cleavages, along grain boundaries and along rock fractures: in some samples it is localized at points within plagioclase grains which might represent fluid inclusions.

The rock-forming minerals also contain a little homogeneously distributed B, with abundance decreasing from: biotite > clinopyroxene > orthopyroxene, amphibole, plagioclase > perthite, quartz.

The average abundance of B in the lower continental crust may be approximated by the average granulite. With a weighting of 54 : 13 : 31 : 2 for silicic : intermediate : basic : anorthosite + sedimentary gneiss, the lower crust averages 9.3 ppm, close to our 9.2 ppm average for the upper crust. If samples which show a anomalously high alteration of plagioclase are eliminated, the lower crust averages only 2.8 ppm: this latter figure is more representative of fresh lower crustal material. (Authors' abstract)

TSUCHIYA, Nobutaka, 1986, Cl and F contents of apatite in the Matsumae plutonic rocks, southwestern Hokkaido, Japan - A useful indicator of vapor saturation: J. Japan. Assoc. Min. Petr. Econ. Geol., v. 81, p. 67-76. Author at The College of Arts & Sci. at Sapporo, Tokai Univ., Sapporo 061-21, Japan.

Chlorine and fluorine contents of apatite in the Matsumae plutonic rocks were analyzed with electron microprobe. The Matsumae plutonic rocks are divided into Am and Pl series in terms of crystallization sequence and mineralogy. The petrological evidence suggests that the Am series rocks have crystallized under the conditions richer in water than the Pl series. Chlorine content of apatite in the Am series is generally low, whereas that in the Pl series is rather high in less differentiated rocks and abruptly decreases at about D.I. = 45. On the other hand, fluorine content of apatite in both series slightly increases as differentiation proceeds.

Such behavior of Cl and F in apatite can be explained in terms of the degassing process; when a magma is saturated with vapor and exsolves free vapor phase, Cl is more strongly partitioned into the vapor relative to F and removed from the magma. Therefore, judging from low Cl content of apatite, the Am series magma may have been saturated with vapor in earlier stage than the Pl series one. This is consistent with the previous suggestion that the Am series magma have crystallized under the conditions richer in water than the Pl series. Such abrupt decrease in Cl without decrease in F may be a useful indicator of vapor exsolution or vapor saturation of magma. Recognition of vapor saturation gives valuable information on water content of magma. ·(Author's abstract)

TSYURUPA, A.I. and ROMANCHEV, B.P., 1985, Crystallization history of plagioclases of the Southern Break of the Tolbachik eruption 1975-1976 and origin of the megaplagiophyric rocks of Kamchatka: Geokhimiya, no. 3, p. 360-372 (in Russian).

Cited in Naumov, 1986 (this volume).

TU, Kan, 1986, Hydrothermal alteration and molybdenum mineralization of the Dawan molybdenum deposit, Laiyuan County, Hebei province: Min. Deposits, v. 5, no. 4 (Ser. No. 18), p. 49-61 (in Chinese; English abstract). Author at Dept. Geol., Beijing Univ., Beijing, PRC.

The Dawan porphyry molybdenum deposit is located in a rather small rhyolite porphyry body that contains extremely high K_2O and has dolomite as its wall rock. [The alteration minerals are very fine grained.]

At the earlier stage, the quartz inclusions of ore-bearing veinlets had Th 460-260°C, salinity 50-16 NaCl wt%, $\delta^{18}O_Q$ 10.7-8.7‰, and $\delta^{18}O(H_2O)$ 5.7-4.6‰, indicating that molybdenite had been precipitated from hydrothermal solution mainly composed of magmatic water. At the late stage, Th was 260-120°C, salinity 11.8-0.3%, $\delta^{18}O_Q$ 0.8-0.5‰ and $\delta^{18}O(H_2O)$ under -10.9‰, suggesting that by this stage, meteoric water had probably played a predominant role in the hydrothermal solutions and $\delta^{18}O$ of whole rock had also been more or less reduced. (From the author's abstract)

TUCKER, R.M. and CANN, J.R., 1986, A model to estimate the depositional brine depth of ancient halite rocks: Implications for ancient subaqueous evaporite depositional environments: Sedimentology, v. 33, p& W01-412. First author at Esso Exploration & Prod., U.K., Bitwater House, Portsmouth Rd., Esher, Surrey KT10 9SJ, UK.

New modelling of influx and reflux of saline basins permit much shallower brine depths to explain Br profiles. (E.R.)

TURNER, D.R. and BOWMAN, J.R., 1986, Physico-chemical evolution of skarn-forming fluids, Empire and Pewabic sphalerite skarns, Hanover, New Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 776. Authors at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

Integrated petrologic and fluid inclusion studies, coupled with theoretical geochemical analysis, have defined intensive parameters during the evolution of multi-stage sphalerite (Sph) skarns associated with the southern lobe of the Hanover-Fierro stock near Hanover, NM. Fluid inclusion thermometry has established that the initial stage (I) of skarn formation (andraditic garnet and hedenbergitic pyroxene) took place at nearly constant T = 350° ± 20°C up to 300 m away from the igneous contact. Subsequent Stage II [amphibole (Amp) + epidote (Ep) + quartz (Qz) + calcite (Cc) + pyrite

(Py) ± magnetite (Mt)] and Stage III [Cc + Qz + Sph ± Py ± hematite (Hm)] formed at somewhat lower temperatures (325°, 315°C). Fluid inclusion evidence, combined with stratigraphic estimates of overburden, indicate that the initial stage I of skarn development began at water pressure close to load pressure (400-450 bars) or near lithostatic conditions. Boiling, and a subsequent drop in fluid pressure to hydrostatic conditions (160 bars), occurred prior to the completion of garnet development in Stage I. On average, the salinity (Wt. % NaCl equiv.) of the skarn-forming fluids decreases from Stage I (15 + 5%) to Stage III (9 + 7%)[sic]. Throughout skarn development, the hydrothermal fluids were characterized by low $X(CO_2)$ values of <0.03 and comparatively oxidized conditions ($\log f(O_2) = -30$ at 315°C in Stage III, for example). Limits to $\log f(S_2)$ are low throughout skarn development (<-8.5); thermodynamic calculations indicate that most (>90 mole %) of the dissolved sulfur is sulfate unless m(Total S) <0.01 moles/kg H_2O. Thermodynamic calculations show that the activity ratio of Mg++ to H ion increases (3.3 + 0.3 to 4.5 + 0.4 log units)[sic], and the ratio of Ca^{++} to H ion decreases slightly (from 7.5 ± 0.5 to 7.0 ± 0.5 log units), from early (I) to later (III) stages of skarn development. Fluctuations in the activity ratio of Ca^{++} to H ion may explain the alternating deposition of garnet and pyroxene on a small scale (<10 cm) inferred for some parts of the skarns. Quantitative definition of these parameters will now allow better evaluation of the mechansims of sphalerite deposition proposed for the area, including: 1) decreasing T and accompanying changes in aqueous ion activities; 2) an increase in pH resulting from the progressive reaction of skarn fluids with carbonate wallrock; 3) boiling. (Authors' abstract)

TURNER, Stephen, 1986, Fluid inclusion, alteration and ore mineral studies of an epithermal vein system: Mount Kasi, Vanua Levu, Fiji, in Int'l. Volcan. Congress, Proc. Symp. 5: Volcanism, Hydrothermal Systems & Related Mineralization, Auckland, N.Z., p. 87-94. Author at Geol. Dept., Univ. Auckland, Auckland, New Zealand. [Also a MS thesis at Univ. Auckland, New Zealand (E.R.).]

The Mount Kasi Au (Cu, Te) mineralization occurs within strongly fractured and faulted Middle to Upper Miocene volcanics with intercalated basic andesite to basaltic flows, associated pyroclastics and later acid andesite intrusives.

Results show that an initial sub-regional propylitic assemblage has been overprinted by strong argillic and silicic alteration which culminated in an intense acid leaching episode. The higher grade Au mineralization was introduced in narrow (commonly <1 cm.) quartz veins produced by late-stage hydraulic fracturing. The ore mineral assemblage includes luzonite-enargite, tetrahedrite-tennantite, tellurides, gold and barite at higher levels, and base metal sulphides in deeper and peripheral areas. Precipitation was by a combination mechanism of P release, boiling, T decrease, and oxidation by mixing with meteoric water. Fluid inclusion data confirm the fluids were of low salinity (<2 wt.% NaCl equiv.) at, or above, a boiling horizon, and that the main ore zone formed at 195 to 220°C. (Author's abstract)

TURPIN, Laurent, 1984, Hydrothermal alteration and isotopic characterization (O-H-C) of the minerals and fluids in the uraniferous massif of St. Sylvestre--extension to other French intragranitic uranium deposits: Ph.D. dissertation for L'Inst. Natl. Polytech. de Lorraine, CREGU Memoire No. 6, 190 pp. (in French; English abstract).

Petrographic, mineralogical, geochemical and stable isotope ($^{18}O/^{16}O$, D/H, $^{13}C/^{12}C$) studies have been performed on the leucogranitic massif of

St. Sylvestre (Limousin, French Massif Central), particularly on the different hydrothermal alterations.

The O isotope geochemistry of granites confirms (1) the unicity [uniformity?] of the different facies (Brame, St. Sylvestre, St. Goussaud) and (2) their sialic origin ($\delta^{18}O$ whole rocks = +11.0 ± 0.5‰), with a major contribution (>30-40%) of detrital sediments rich in organic matter and poor in carbonate ($\delta^{13}C$ magm. CO_2 = 10.6‰). Late lamprophyres have a deep-seated origin ($\delta^{18}O$ = +6‰).

The pervasive chloritization of granitic biotites occurs during the convective circulation of a fluid of meteoric origin, at ~350-450°C. The chemical composition of chlorite which is buffered by that of biotite and the large ^{18}O-shift of fluid towards high δ values indicate that water-rock ratio was not very high. Chloritization takes place in high permeability zones, and the rate of isotopic reequilibration of granitic minerals follows a systematic rule. In regions where porosity is generally low, fluids are "canalized" in localized micro-fissured zones. Very high water/rock ratios lead to the dissolution of quartz, and the formation of the "feldspathic episyenite" alteration facies. The isotopic features of this fluid ($\delta^{18}O \approx -8‰$, $\delta D \approx -50‰$) indicate an elevated altitude given the low latitude assumed for the region during Carboniferous times.

An isotopically similar fluid is responsible for the later "micaceous episyenite" alteration facies found in fractured zones. Mixing of this fluid with a sedimentary fluid ($\delta^{18}O \approx +10‰$, $\delta D \approx -30‰$, $\delta^{13}C \approx -18‰$) yielded the conditions necessary for the deposit of primary economic ore.

Such fluids, sedimentary or metamorphic in origin, have been recognized in most Hercynian intragranitic U and Sn-W deposits, for example in the French Massif Central (U: Marche, Millevaches, Mt. Lozère), Massif Armoricain (Sn-W: Abbaretz, La Villeder), Central Morocco (Sn-W: Zäer). (Author's abstract)

TYLER, N., 1986, The origin of gold mineralization in the Pilgrim's Rest Goldfield, eastern Transvaal: Econ. Geol. Research Unit Info. Cir. No. 179, 34 pp. Author at Bureau of Econ. Geol., Univ. Texas, Austin, TX, USA.

More than 15 metric tonnes (five million ounces) of gold and a significant amount of silver have been won from ore-deposits in the Pilgrim's Rest Goldfield over more than a century of mining. The principal ore bodies in the district are found in the Malmani Dolomite, where they occur as peneconcordant, tabular bodies restricted to three stratigraphic zones. These correspond to three, discrete, mineralized areas, separated by expanses of dolomite devoid of mineralization. In the Sabie area, ore bodies are found in the Black Reef and in the overlying transition-zone with the main mass of dolomite. The prolific Pilgrim's Rest mines exploited gold-silver veins located in the top portion of the dolomite column and in the Pretoria shales that rest on the Bevets conglomerate. To the north, ores in the Vaalhoek Mine are found in the lower dolomite-and-chert zone.

Sedimentological analysis of the host-dolomites indicates that they were deposited under supratidal-to-deep-subtidal (midshelf) conditions on a broad platform. Two transgressive cycles, from supratidal/lagoonal to subtidal carbonates (the transition and lower dolomite-and-chert zones) and from intertidal to midshelf carbonates (chert-poor zone), respectively, are capped by a third phase of carbonate sedimentation, characterized by short-lived and rapid shoaling and deepening events, rather than by overall transgression and regression (the upper dolomite-and-chert zone). A strong relation between ore body location and environment of deposition of the host-sediment has emerged. Mineralization is restricted to sediments deposited in shallow water (intertidal-to-shallow-subtidal zones); deeper-water carbonates are barren. More specifically, the ores appear to be closely related to carbonaceous, terrigenous sediments.

Fluid inclusion analysis of quartz gangue in the quartz-pyrite-gold-silver veins indicates that the mineralizing solutions were saline and rich in CO_2. The inclusions were trapped under a temperature-of-formation gradient of 100°C/km. Preliminary geobarometry suggests depths of formation of 5.5-7.0 km. A range of homogenization- and decrepitation-temperatures in each sample indicates that mineralization was a multiphase event. Tightly-clustered sulphur-isotope data ($\delta^{34}S$ of +0.5 - +4.0 per mil) obtained from pyrite are non-diagnostic. Oxygen-isotopic compositions of the mineralizing fluids, recalculated from $\delta^{18}O$ quartz (+12.1 - +19.5), point to a magmatic source and subsequent mixing with saline, evolved formation-water. A magmatic origin is supported by the high, homogenization-temperature-gradient displayed by the fluid inclusions. Reconnaissance fluid-inclusion barometry suggests that the ores were emplaced during late-Transvaal volcanism. (Author's abstract)

See also Ash and Tyler (this volume). (E.R.)

URAI, J.L., SPIERS, C.J., ZWART, H.J. and LISTER, G.S., 1986, Weakening of rock salt by water during long-term creep: Nature, v. 324, p. 554-557. First author at Inst. Earth Sci., Univ. Utrecht, Budapestlaan 4, 3508 TA Utrecht, The Netherlands.

The rheological properties of rock salt are of fundamental importance in predicting the long-term evolution of salt-based radioactive waste repositories and strategic storage caverns, and in modelling the formation of salt diapirs and associated oil traps. The short-term, high-stress rheology of rock salt is well known from laboratory experiments; however, extrapolation to appropriately low stresses fails to predict the rapid flow seen in certain natural structures. Furthermore, experiments have failed to reproduce the recrystallized microstructure of naturally deformed salt. Here we report experiments indicating that the above discrepancies can be explained by taking into account the influence of trace amounts of brine. Trace brine is always present in natural salt but sometimes escapes during experiments. Our tests on dry dilated salt show more or less conventional dislocation creep behavior, but brine-bearing samples show marked weakening at low strain rates. This is associated with dynamic recrystallization and a change of deformation mechanism to solution transfer creep. Because natural rock salt always contains some brine, these results cast substantial doubt on the validity of presently accepted dislocation creep laws for predicting the long-term rheological behavior of salt in nature. (Authors' abstract)

See also Jenyon, 1986 (this volume). (E.R.)

URASHIMA, Y. and IZAWA, E., 1986, Genetic models for epithermal gold deposits (abst.): Mining Geol., v. 36, no. 1, p. 49-50 (in Japanese; translation courtesy K. Okano, via J. Hedenquist).

We estimate temperature conditions for mineralization through examining fluid inclusions and hydrothermal alteration minerals. We find that high temperature thermal water (>250°C) at depth was necessary for gold mineralization of an economic deposit scale, and that deposition took place around 200°C. (From the authors' abstract)

USPENSKAYA, A.B., GASOYAN, M.S. and TYUTNEVA, G.K., 1985, Influence of oxyhydrile groups in structural defects and in gas-liquid inclusions on physical properties of rocks: Doklady Akad. Nauk SSSR, v. 281, no. 5, p. 1185-1187 (in Russian). Authors at the Moscow Mining Inst., Moscow, USSR.

Oxyhydrile groups OmHn (most frequently OH, OH_2 and OH_3) occur in quartz and nepheline structures as OH/Na, OH/K, OH/Li and OH/Al associations and in gas-liquid inclusions. They were detected by IR absorption and it was found that the piezoelectic effect increases proportionally to the amount of OmHn in the minerals. (A.K.)

USPENSKAYA, A.B., GRIGOR'EV, I.F., DOLOMANOVA, Ye.I. and RUSAKOVA, Ye.I., 1986, Dependence of the type of the piezoelectric texture and anisotropy of the elastic and piezoelectric properties of quartz on its origin: Dokl. Akad. Nauk SSSR, v. 286, no. 1, p. 185-189 (in Russian). First author at the Moscow Mining Inst., Moscow, USSR.

Presence of fluid inclusions in quartz causes a significant decrease of the velocity of the elastic waves. (A.K.)

USPENSKAYA, A.B. and NOSIK, L.P., 1986, Effect of physicochemical conditions of quartz formation in tin-tungsten deposits on its specific electrical resistivity: Dokl. Akad. Nauk SSSR, v. 291, no. 2, p. 434-437 (in Russian). Authors at Mosk. Gorn. Inst., Moscow, USSR.

The $\delta^{13}C$, CO_2, and H_2O contents, and Th of fluid inclusions were determined in quartz (Q) from Sn-W ore deposits of (1) cassiterite-pegmatite, (2) cassiterite-feldspar-Q, and (3) cassiterite-Q formations. Q from type-3 formations crystallized under oxidizing conditions (resulting in the oxidation of C to CO_3^{2-}); Q from 2 formed in a reducing medium. Q from cassiterite-pegmatite deposits formed under oxidizing conditions. Measurements of sp. electrical resistance (ρ) of Q (A.B. Uspenskaya, et al., 1981; A.B. Uspenskaya, 1985) show 2 intervals: 250-500° and 550-900°. The pH of mineral-forming medium controlled the CO_2 and H_2O contents in Q; these contents were maximum in Q formed under strongly oxidizing conditions. The ρ decreases with increased Tf from 250 to 500° and at >500° it decreased rapidly with the growth of defects. Changes in ρ reflect the formation conditions of Q in ore deposits. (C.A. 106: 53375q)

USPENSKAYA, A.B., NOSIK, V.L. and NOSIK, L.P., 1986, Relation between specific electrical resistance of quartz from tin-tungsten ore deposits and their physicochemical formation conditions: Izv. Vyssh. Uchebn. Zaved., Geol. Razved., 1986, no. 9, p. 34-43 (in Russian). Authors at Mosk. Gorn. Inst., Moscow, USSR.

The elec. resistance was measured of quartz (Q) from cassiterite-pegmatite, cassiterite-feldspar-Q, and cassiterite-Q deposits. The $\delta^{13}C$ values of CO_2 and reduced C, the CO_2 and water contents (as Pa/cm^3), and the Th were also determined, for the fluid inclusions in Q of 3 deposits; this data is used to interpret the formation conditions. The sp. elec. resistance (ρ, in Ω mm) of the Q was controlled by the physicochemical conditions of mineral formation. The Q, crystallizing under nonequilibrium oxidizing conditions, has lower ρ values than the Q formed in a reducing environment. The ρ value of Q crystallizing under reducing conditions changes greatly during heating. (C.A. 105: 194714r)

VALLEY, J.W., LAMB, W.M. and MORRISON, Jean, 1986, Granulite facies metamorphism in the Adirondacks, N.Y., U.S.A. (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 139. Authors at Dept. Geol. & Geophys., 1215 W. Dayton St., Univ. Wisconsin, Madison, WI 53706, USA.

At present there is no evidence that we interpret to support pervasive CO_2 infiltration in the Adirondacks. High density, CO_2-rich fluid inclusions are found in many gneisses including some where fO_2 is too low for CO_2 to be stable indicating a post-metamorphic origin. (From the authors' abstract)

VALLEY, J.W., TAYLOR, H.P. and O'NEIL, J.R., eds., 1986, Stable isotopes in high temperature geological processes: Reviews in Mineralogy, v. 16, 570 pp.

Includes chapters dealing with isotopic fractionation and exchange and stable isotope compositions and their variations for various environments. (E.R.)

VALUYEV, O.V., GAMOV, M.I. and NYRKOV, Ye.A., 1985, Temperature conditions of formation of the skarns of the Subashi tungsten prospect (Central Caucasus) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 223-224 (in Russian; translation by Dorothy B. Vitaliano). Authors at Rostov State Univ., Rostov-on-the-Don, USSR.

Thermovacuum decrepitometric analysis of the skarn minerals and scheelite made it possible to ascertain two intervals of gas liberation in them -- low T (100-220°C) with a maximum at 170-180°C, and high-T (540-660°C) with a maximum at 590°C. The intensity of gas liberation in the low-T interval was about the same for all the minerals studied. More intensive liberation of gas in the high-T interval is characteristic of scheelite and vesuvianite.

Quartz in cross-cutting and conformable veins and veinlets in the enclosing schists and gneisses differs from the quartz of the skarns in polymodal gas liberation in a broad T range (90-530°C). The general maximums of gas liberation correspond to 120, 210 and 370°C.

The indices of fluid-bearing capability for scheelite and vesuvianite, calculated by the procedure of V.N. Trufanov, are 440 and 280 arbitrary units, respectively, and are comparable to the analogous characteristics of minerals from the Tyrny Auz deposit.

Anomalously high Td compared to other W deposits of the Central Caucasus are recorded for the skarn minerals and scheelite of the Subashi W prospect. (From the authors' abstract)

VALYAYEV, B.M. and GRINCHENKO, Yu.I., 1985, The origin of isotopically ultraheavy carbon dioxide: Byul. Mosk. Obshch. Ispyt. Prirody, Otdeleniye Geologii, 1985, no. 3, p. 121-132 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 11, p. 1315-1324). Authors at Geol. Inst., USSR Acad. Sci., Moscow, USSR.

Presents a large amount of data on the isotopic composition of CO_2 from mud volcanoes, as well as an interpretation in terms of the hypothesis of hydrocarbon generation by deep-source outgassing of the earth. (Authors' abstract)

VANDELANOOTE, R., 1984, Trace element geochemistry in thermal waters (E. Pyrenees) and in waters related to hidden Zn-Pb-S ore deposits (Finistère): Ph.D. dissertation, Univ. Instelling Antwerpen, 1984.

VAN DEN BOGAARD, Paul and SCHMINCKE, H.-U., 1986, Pyroclast morphology and vesicle fabric from magmatic and phreatomagmatic eruptions of Laacher See Volcano (Eifel, West Germany) (abst.): Int'l. Volcan. Congress, Auckland, N. Z, Abstracts, p. 125. First author at Geol. Dept., Univ. Toronto, Scarborough Campus, Scarborough Ontario M1C 1A4, Canada.

Includes discussion of various bubble nucleation and growth phenomena. (E.R.)

VAN DEN KERKHOF, A.M., 1986, Phase transitions in the CO_2-N_2 system at constant molar volume (abst.): Bull. Minéral., v. 109 Supplement, p. 69. Author at Inst. Earth Sci., Free Univ., De Boelelaan 1085, 1081 HV Amsterdam, Pays-Bas.

By doing routine measurements on single cavities in rocks, the Raman microspectrometer has brought a decisive advance in fluid inclusion studies. Natural gaseous fluids appear to show a wider compositional variation than first assumed. Especially nitrogen is found more and more in metamorphic and magmatic rocks. Most fluids consist of mixtures rather than pure compounds. Recent fluid analyses showed that most fluid inclusions can be approached as binary systems. The system CO_2-N_2 is representative for many natural fluids.

Microthermometry is the study of phase transitions under microscope at varying temperature. This method remains most basic for fluid inclusion studies. The combination of both Raman analysis and microthermometry is most powerful. Phase transitions in CO_2-N_2-inclusions have been studied during cooling and subsequent heating. Three important types of phase behavior can be distinguished: 1) homogenization of the liquid and vapor phases at a higher temperature than melting; 2) two homogenizations, respectively below and above the melting point; 3) homogenization at low temperature and subsequent sublimation at higher temperature.

Fluid inclusions represent isochoric systems, as their density (and molar volume) is constant. Models of isochoric systems have been compiled from (scarce) experimental data taken from literature. Theoretical models were affirmed by means of the study of fluids in rock samples and further refinement could be done. Empirically obtained TX-diagrams are about isochoric as the fluid density variation in one sample is very limited. The phase behavior of CO_2-N_2-bearing inclusions can satisfactorily be explained now. Determinations of the molar volume have become more reliable as the composition can be taken into account for the calculations. Better interpretations on the geological conditions at which the fluids were trapped can therefore be made. (Author's abstract)

VAN DER MOLEN, I. and VAN ROERMUND, H.L.M., 1986, The pressure path of solid inclusions in minerals: The retention of coesite inclusions during uplift: Lithos, v. 19, p. 317-324.

VAN REENEN, D.D., 1986, Hydration of cordierite and hypersthene and a description of the retrograde orthoamphibole isograd in the Limpopo belt, South Africa: Am. Mineral., v. 71, p. 900-915. Author at Dept. Geol., Rand Afrikaans Univ., Johannesburg 2000, South Africa.

A modified Redlich-Kwong equation of state for nonideal mixing of H_2O and CO_2 was used to calculate the mole fraction of CO_2 (abut 0.8) in the fluid phase necessary to displace the equilibrium curve anthophyllite = 7 enstatite + quartz + water to the estimated P-T conditions on the isograd. The presence of a systematic T gradient in the Limpopo belt suggests that the influx of the CO_2-rich fluid occurred at a fixed T during hydration. (From the author's abstract)

VAPNIK, E.A. and SEDOVA, I.S., 1986, Pressure and fluid composition during ultrametamorphism in the Aldan megablock: Zap. Vses. Mineral. O-va, v. 115, no. 4, p. 410-422 (in Russian; English abstract). Authors at Inst. Geol. Geokhronol. Dokembr., Leningrad, USSR.

For the established sequence of migmatite and granitoid leucosome formation during granulitic and amphibolitic facies, the evolution of P conditions and fluid composition is studied on the basis of cryometry of CO_2 inclusions (3330 analyses) and gas chromatography. Within each cycle the formation of successively appearing generations of leucosomes occur under a fall of P from 6.5 kbar to 4.5 kbar. The maximum of the melting and crystallization corresponds to the range of 4.5-3.5 kbar[sic]. Investigation of inclusion density shows that during ultrametamorphism processes, the P fell up to 3 kbar; it means that uplift (10-11 km) of the region occurs. (From the authors' abstract)

VAPNIK, Ye.A., 1986, Conditions of decrepitation of the CO_2 inclusions in natural quartz of the metamorphic rocks: Dokl. Akad. Nauk SSSR, v. 288, no. 4, p. 966-969 (in Russian). Author at Inst. Geol. & Geochronology of Precambrian, Leningrad, USSR.

Polished plates of metamorphic rocks from regions of the Nyukzha River and the Aldan River bear abundant CO_2 one-phase inclusions; the CO_2 density was found from Th, then P for T of peak metamorphism was calculated (700°C, 5.50-7.25 kbar for Nyukzha River rocks, 850°C, 3.75-4.15 kbar for Aldan River rocks). Next the specimen of quartz was heated, again Th was determined and further heating up to higher T was performed, until the inclusion decrepitated; then P of decrepitation was calculated as average of P for the last run before decrepitation and for the run when decrepitation was stated. For T 600-650°C the error of P determination was ± 0.15 kbar, for 150-200°C - ± 0.30 kbar. The inclusions of >10 to 20 µm in size decrepitate when P was about 2 kbar, but inclusions <10 µm decrepitated when P achieved the ranges 3-4 kbar or even they didn't decrepitate up to 5.5 kbar (at 150°C). The results indicate that part of LCO_2 inclusions in metamorphic rocks may decrepitate on retrograde metamorphism; this process would strongly affect inclusions >5 µm in size. (Abstract by A.K.)

VAREKAMP, J.C. and BUSECK, P.R., 1986, Global mercury flux from volcanic and geothermal sources: Applied Geochem., v. 1, p. 65-75.

VAR'YASH, L.N., 1985, Hydrolysis of Cu(II) at 25-350°C: Geokhimiya, no. 7, p. 1003-1013 (in Russian; translated in Geochem. Int'l., v., 23, no. 1, p. 82-92, 1986).

VASILENKO, V.N., 1985, Thermobarogeochemical ore-bearing criteria at massive sulfide deposits of Urals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 72-74 (in Russian; translation by I.V. Kulikov). Author at RGU, Rostov-on-Don, USSR.

Massive sulfide ["kolchedan"] ores in sedimentary-volcanic rocks of the Middle Devonian of the west limb of the Magnitogorsk megasynclinorium are characterized by Td = 340-420°C (intraore quartz); and the minerals of the productive stage give Td = 120-320°C. The sulphides are abundant in relics of metacolloidal texture.

The deposits of Kirovograd region in the Middle Urals are located in folded Silurian rocks (Kolchedan volcanogenic formation). Intraore quartz of the ores gives Td = 480-500°C, and the minerals of productive stage - 140-360°C, more rarely up to 400°C, which was brought about by later intensive hydrothermal-metasomatic reworking of the ores in the Middle Urals. These sulphides are also of combined volcanic-sedimentary genesis: colloidal structures, typical rythmic structure, stratification and zoning of the ores, organic relics in the ores, etc.

At every studied Urals deposit intraore linear zones were discovered along the strike of the ore bodies, in which massive sulfide ores underwent natural decrepitation. Tracing these zones of higher permeability for the hydrotherms of later stages could yield some positive results in exploration. At the deeper levels of the deposits, post-ore vein bodies of massive quartz occur, in which the main part of the microinclusions were naturally decrepitated under the influence of subvolcanic bodies at depth. The presence of such bodies indicates the absence of ores at deeper levels. Prospects of encountering ore-bearing deep levels are connected with the presence of hydrothermal alteration zones, extracts of which give pH from

9.5 to 10.3. Asymmetry of thermobarogeochemical parameters is observed in such places, both in the hanging walls and footwalls of the zones. On nearing the ore bodies the content of sulphate-ion increases in water extracts from 10 to 90.6%. The cation part becomes richer in Ca -- from 19.4 to 41.9%.

On approaching the ore bodies the content of typomorphic elements increases in fluid inclusions of postore veinlets. And in the altered surrounding rocks, fluid-bearing and ore-bearing coefficients increase, as calculated from data on mineral thermometry. This permits outlining lithologic-stratigraphic ore levels in the drill cores in the deeper levels of the deposits and the studied areas. (From the author's abstract)

VASILENKO, V.N. and ROZHKOV, S.Y., 1985, Morphology and typomorphic peculiarities of quartz and gold at gold-ore deposits from southern Siberia and the Far East (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 61-62 (in Russian; translation by I.V. Kulikov). Authors at RGU, Rostov-on-Don, USSR.

The formation of gold and gold-bearing quartz in deposits of the gold-quartz type, as well as epithermal gold-silver deposits, bears some similarities. The ore is associated with the latest and lowest temperature formations, which were locally developed among hydrothermal-metasomatic rocks. The deposition of minerals of the gold-bearing association was preceded by some increase in concentration and CO_2 content of the ore-bearing solutions.

At the gold deposits of Kuznetsky Alatau, Tuva, North-East regions and other regions the ore-bearing quartzes differ in their typomorphic features from barren quartzes. The most obvious differences are established by Td, and the composition of gas components and their relative quantities. Maxima of gas evolution from native gold during its heating in vacuum are of typomorphous significance for deposits of different types (70-130°; 160-200°; 240°C). The highest Td of gold-bearing quartz are in the Malo-Aniujsky region (360-400°C). Here the native gold decrepitates at 160-180°C. In contrast to the above regions, a number of differences were established for gold-bearing quartz of Yakutia. It's deposits (low-sulfide gold-quartz type) are connected with terrigenous formations. The ores are located in zones of folding and silicification, and also in flat stratiform veins. But their decrepitation activity could not be used as an exploration criterion for gold ores, because the main mass of quartz samples decrepitates at 180-360°C, with a maximum at 280-300°C.

Gas chromatography indicates that one of the typomorphic features of gold-bearing quartzes is the sharp increase in the volume of gas [other than H_2O?] in the inclusions. Chromatographic analysis shows the content of CO_2 ranges from 43.1% (Malo-Aniujsky region) up to 94% (Yakutia). In ore-bearing quartz CH_4 appears and CO disappears. Higher temperature barren quartz sometime contains higher quantities of CH_4.

Gold-bearing vein types of quartz contain a complex of various inclusions, which are very small and of unbalanced form. The composition of inclusion ranges from monophase liquid to almost totally vapor. They often contain a daughter-mineral and salty deposition at the vacuole walls[sic]. Different phase composition inclusions can coexist in adjacent growth zones. Some peculiarities suggest the effect of boiling of hydrothermal solutions in the process of regeneration of fissures in earlier quartz.

On the borders with gold grains the quartz grains contain many more inclusions, and these regions also show saturated polyphase inclusions with crystals of halite, as well as newly formed liquid inclusions of leakage origin. Composition of inclusions and aqueous extracts indicate the existence in the solutions of gold-chlorine complexes. Typomorphic features, with which the identification of gold-bearing quartz from barren quartz could be made, can be used for prospecting goals at poorly studied areas. (From the authors' abstract)

VAUGHAN, P.J., 1986, Compaction model using pressure solution (abst.): EOS, v. 67, p. 381.

VENTSLOVAYTE, Ye.I. and VALYASHKO, L.M., 1985, Water content of gas-liquid inclusions in quartz and depth of its formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 232-233. (In Russian; translation by Dorothy B. Vitaliano). Authors at Moscow State Univ., Moscow USSR

Among the gangue minerals of the Kizil-Dore hydrothermal Cu-pyrrhotite deposit and adjacent ore shows, quartz is very extensively developed. It was deposited throughout, from the very beginning to the final stages of their formation.

Along with physico-optical methods of investigating the quartz, gas chromatography was used in a broad range of Td (100-700°C). To compare and describe the amounts of gases in the inclusions, the 320-500°C T range of decrepitation was chosen.

The total volume of gases liberated from the quartz in that T range varied from 31 to 460 cm^3 per kilogram of monomineralic fraction, averaging 300-400 cm^3/kg. Some higher contents of gases were observed in quartz accompanying the ore deposition.

The inclusions in the investigated quartz are essentially liquid. The total amount of water per kilogram of pure quartz is 300-400 mg. Essentially aqueous inclusions indicate the hydrothermal origin of this quartz. CO_2 constitutes 2.1 to 25% (average 7.2%) of the total content of gases in the inclusions, i.e., from 16 to 110 mg (average 47 mg) per kilogram of pure quartz. The highest CO_2 contents are observed in quartz which occurs in the form of pockets in the pyrrhotite-pyrite ores (128 mg/kg). Other cases, such as CH_4, O_2 and N_2 taken together, constitute a negligible volume (0.2 to 5 cm^3) per kilogram of quartz.

Comparing similar data on gas-liquid inclusions in quartz from other deposits formed at different depths, we conclude that their water content depends on the depth of formation of the minerals carrying the GLI. For instance, in deposits formed at greater depths (5 km) the water content of the GLI ranges from 60 to 150 mg/kg; in those formed at moderate depths (2-3 km) -- 300-400 mg/kg, and those formed near the surface -- 600-1000 mg/kg. (From the authors' abstract)

VERKHOVSKY, A.B., YURGINA, E.K., SUSHCHEVSKAYA, N.M., GUDKOVA, I.V. and SHUKOLYUKOV, Yu.A., 1986, Distribution of noble gases in glasses of basalts of the mid-ocean ridges: Geokhimiya, 1986, no. 5, p. 679-689 (in Russian; English abstract).

Isotopic and elemental composition of noble gases was studied in the oceanic tholeiitic basalts belonging to two types: TOR_1 and TOR_2. Under study were mainly the quenched glasses because the gas contents in them are higher by an order of magnitude than in the holocrystalline varieties. It was determined that for TOR, comparing to the atmospheric distribution, a simultaneous enrichment in light (He and Ne) and heavy (Kr, Xe) gases in relation to Ar is typical. The distinguished types are practically the same in isotopic composition of He. The differences between them are observed: 1) in ^4He content, it is by an order of magnitude higher in TOR_2; 2) in isotope composition of Ar, it is close to the atmospheric one in TOR_1, and in TOR_2 $^{40}Ar/^{36}Ar$ ratio is more than 1000, as a rule. Some difference between the types is also observed in the value of $^4He/^{40}Ar$ ratio. The latter is somewhat higher in TOR_2. Based on the data obtained a conclusion was made on the single mantle source for both TOR_1 and TOR_2. The difference between them in some studied parameters are due only to the difference in the character of upwelling and solidification of the magmas that led to the different degree of their degassing. TOR_1 melted out at larger depths than TOR_2 are more degassed. As a result, even at the equal degree of the subsequent atmospheric contamination the latter will have more effect on the composition of noble gases in TOR_1 because juvenile gases remained in them in smaller contents. Hence the low values of $^{40}Ar/^{36}Ar$ and exclusively rare determination of excess of ^{129}Xe in TOR_1 are not a result of weak degassing of the mantle source of TOR_1 but the result of strong degassing of the melt itself in which the juvenile component is not seen on the background of atmospheric gases captured in the cooling process. (Authors' abstract)

VETÖ, É., 1986, Fluid inclusion and petrographic study of the late Alpine Gyöngyösoroszi Pb-Zn deposit, northern Hungary (abst.): Terra Cognita, v. 6, no. 3, p. 512. Author at Hungarian Geol. Survey, H 1442 Budapest, Népstadion ut 14, Hungary.

The vein-type Pb-Zn polymetallic mineralization of the Gyöngyösoroszi mine is developed in a sub- and stratovolcanic andesitic sequence.

The main minerals are sphalerite, galena, quartz and calcite. Beside the different veins, there are many pipe breccias. The transparent minerals, containing the fluid-gas inclusions studied by thermometric and cryoscopic techniques, came from a 400-m range of depth.

The ore-mineralization appears to be meso- and epithermal, and, according to the inclusion study data and the geologic features of the deposit, took place in several stages. In the main mineralization stage, quartz, calcite and sphalerite formed at the same temperature, but the range of Th of fluid inclusions in quartz is approximately 200-300°C while that for calcite is 210-250°C. No substantial difference of Th was recognized between the lower and higher levels of the deposit and no evidence of boiling of the fluids was observed. The salinity of fluid inclusions ranged from 0 to 14 equiv. wt.% NaCl; no halite daughter crystals were seen. Traces of fluorescent organic matter were found in many samples, and CO_2 is probably present. The cryoscopic measurements show the important role of H_2O-NaCl and hydrocarbon(?) fluids in the ore-mineralization process. (From the author's abstract)

VIKRE, P.G., 1986, Precious metal vein systems in the National district, Humboldt County, Nevada - A reply: Econ. Geol., v. 81, p. 1023-1024. Author at ASARCO Inc., 510 E. Plumb Lane, Reno, NV 89502.

A reply to Hedenquist (1986, this volume). (E.R.)

VILLASECA, C. and NUEZ, J., 1986, Camptonite dikes in the Sistema Central Espanol: Estudios Geol., v. 42, p. 69-77 (in Spanish; English abstract). First author at Depart. Petrologia & Geoquímica, Fac. Geol., Univ. Complutense, 28040-Madrid, Spain.

Immiscibility between syenitic and lamprophyric magmas is proposed to explain ocellar textures. (E.R.)

VILOR, N.V., 1985, Water-hydrogen zones of granite-gneiss domes: Doklady Akad. Nauk SSSR, v. 280, no. 4, p. 998-1003 (in Russian). Author at Inst. Earth's Crust of Siberian Br. of Acad. Sci. USSR, Irkutsk, USSR.

Analyses by gas chromatography of gases present in granitoid-gneiss complexes of the Kukul'bey and other complexes were used for considerations on possible mineral parageneses and redox regime of volatiles. Source of the used T ranges is not specified. (A.K.)

VINOGRADOV, A.I., VINOGRADOVA, G.V., PRIPACHKIN, V.A., 1985, Distribution of hydrogen, methane and helium in fluid aureoles of zones of sodic and silicic-potassic metasomatites in the northeastern part of the Baltic shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 212-213 (In Russian; translation by Dorothy B. Vitaliano). Authors at Geochem. Inst., Kola Affiliate USSR Acad. Scil, Apatity, USSR.

The distribution of gases in the unaltered Archean gneisses and migmatites and in the metasomatites superposed on them was investigated by the bulk method, with extraction of gases from the rocks by crushing the samples in vacuum mills and subsequent chromatographic analysis of the evolved gases. The total concentration of H, He and CH_4 in the unaltered gneisses and granites is not more than 3 cm^3 per kg of rock, but in the metasomatites it rises to 6-40 cm^3/kg. The proportion of the components of the gas mixture is specific for each type of metasomatite. In the Early Proterozoic silicic-potassic metasomatites the background concentrations of H in the altered rocks and in the original substrate are the same, but CH_4 and He together accumulate in the most reworked places. The same kind of behavior of all three gases and a distinct correlation of their content with the effective porosity of the rocks is typical of the Paleozoic epidote-clinochlore-albite metasomatites. In zones where carbonate-ripidolite albitites are developed, areas of maximally altered substrate are enriched in H and He, but in contrast, CH_4 accumulates in the aureole of steaming, located outside the zone of metasomatic alteration.

These particulars of the behavior of the secondary components of the fluid systems which formed the aureoles of steaming around the zones of metasomatic alteration show that the use of bulk gas analysis in conjunction with traditional methods of decrepitometry can substantially enhance the efficiency of geochemical prospecting and prediction of metasomatic zones from endogenetic auroles, especially in places where metasomatites of different formational type occur together. (From the authors' abstract).

VISHNEVSKIY, A.A., KOLESNIK, Yu.N., VISHNEVSKIY, A.S., TKACH, V.N. and MATSYUK, S.S., 1985, Pyrope with crystalline inclusions from the Baltian deposits of the Middle Pobuzh'ye: Doklady AN Ukr. SSR, ser. B, no. 4, p. 10-14 (in Russian).

Cited in Naumov, 1986 (this volume).

VOEVODIN, V.N., GRANOVSKIY, A.G. and PROKOPOV, N.S., 1986, Physico-chemical parameters of hydrothermal solutions during the formation of wolframite ore deposits: Izvestiya Vyssh. Uchebn. Zaved.-Geologiya i Razvedka, no. 1, p. 48-55 (in Russian). First author at Far-East Inst. Minerals Raw Materials, Khabarovsk, USSR.

The specimens of wolframite ores were collected at the deposits of Chukotka (Iul'tin, Svetloe, Skalistoe, El'veneyskoe), Kolyma Basin (Nyarka), Primor'ye (Zabytoe, Tigrinoe) and Priamur'ye (Uchama, Sudulune). Gas-liquid inclusions in minerals of the various deposits differ in habit, size, and volume percent of the mineral, but they are similar in phase filling. In the meso-abyssal deposits minerals usually bear relatively large inclusions with high CO_2 content. Hypabyssal and subsurface deposits have minerals with very small size inclusions of variable filling. T of crystallization (Th and Td) of wolframites and quartz in meso-abyssal deposits is higher (180-360°C) than in hypabyssal and subsurface deposits (160-320°C). P ranges from 130-90 MPa at the meso-abyssal deposits, through 90-70 MPa at the hypabyssal ones to 80-56 MPa at the subsurface ones (P determined by Kalyuzhnyi's method, and by the Naumov and Malinin method using inclusions in quartz). All specimens yielded similar gas compositions in inclusions, indicating the close chemical parameters of the wolframite-forming solution at every deposit. Ratios of gases ($CO + CH_4 + NH_3 + H_2S$)/CO_2 (by gas chromatography) are constant for samples from each deposit and they are close for similar deposits, however, they differ for genetically different deposit groups. The ratio ($CO_2 + CO + CH_4 + NH_3 + H_2S$)/$H_2O$ shows similar regularities. At the meso-abyssal deposits (Iul'tin, Svetloe, Zabytoe) long, sulfide-low quartz-wolframite veins formed from CO_2-rich solutions under high P and at constant T in a relatively closed system, over a long period of time. At the hypabyssal deposits (Tigrinoe, Uchama, Nyarka, Sudulune, etc.) due to the faster T decrease and T decreasing faster as at the meso-abyssal deposits, the mobile components were released from mineral-forming solutions, the redox potential varied, the role of H_2S and CH_4 increased and numerous minerals (sulfides inclusively) appeared. Typical forms of ore bodies are here stockworks, veinlets, nests and disseminated ores. (Abstract by A.K.)

VOINIKOV, D.M. and LKHAMSUREN, Zh., 1986, Stages and temperature conditions of localization of fluorite deposits of the Berkhinskoe ore field in Mongolia: Mineral Tadzh., 1986, no. 7, p. 58-67 (in Russian).

Hydrothermal deposits consisting of fluorite (Ft) and quartz (Q), with clay minerals and calcite in subordinate amounts, formed in 3 stages of mineral assemblages: (1) Q, (2) Ft + Q, and then (3) Ft only, at Th <200°. (C.A. 106: 53450k)

VOLFINGER, M. and ROBERT, J.-L., 1986, Questions about high chlorine micas and amphiboles (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 257.

VON DAMM, K.L., 1986, Experimental determination of quartz solubility in seawater under seafloor hydrothermal conditions (abst.): EOS, v. 67, p. 1026-1027.

VON DAMM, K.L., 1986, Submarine hot spring chemistry (abst.): EOS, v. 67, p. 391.

VOROB'YEV, Yu.K. and SERGEEV, V.I., 1985, Determination of concentration of solution in necked-down gas-liquid inclusions: Zapiski Vses. Mineral. Obshch., v. 114, no. 4, p. 502-505 (in Russian). Authors at Inst. Geol. of Ore Deposits, Mineralogy, Petrography and Geochem. of Acad. Sci. USSR (IGEM), Moscow, USSR.

The authors used, for determination of salt concentration in solutions in necked-down inclusions, Th-F curves for NaCl solutions of various concentrations, published by Lemmlein and Klevtsov (1956, Zapiski Vses. Mineral. Obshch., no. 3, p. 310-320). Measuring Th and F in the chosen group of the necked-down inclusions, one may plot the empirical curve, and comparing with standards, easily determine the salt concentration. This method was checked on quartz specimens from the Darasun Au deposit (E. Transbaikalia) and from ferriferous quartzites of the deposit Kostamuksha (Karelia). Quartz from Darasun (quartz-chalcopyrite-pyrrhotite ores) bears 1) large inclusions with 20-40% of G by vol., Th 300-350°C in the center and 2) smaller inclusions with 30-70 vol. % of G, Th 300-400°C in the periphery of crystal. 3) Healed fractures bear inclusions wih 80-90% by vol. of G, and sometimes with 100 vol. % of G, Th 390-500°C. 4) Late inclusions in healed fractures cutting usually several quartz crystals bear 20-30 vol. % of G, Th 250-330°C. Necking-down occurs essentially in inclusions of the types 2 and 4, necking not always leads to the complete separation of inclusion parts. Measurements of Th and F for the Darasun deposit indicate the concentration between the standard curves of solutions of 1 and 5 wt.

% of NaCl, close to the concentration value determined by other authors with use of different methods.

In the specimen from Kostamuksha inclusions are in size <5 µm, frequently with LCO_2. One group of 62 inclusions occurring on one fracture was studied, the results indicate concentration of solutions about 10 wt.% NaCl. However, the ranges of Th values for one filling degree value, may reach up to 200°C and for this method it is necessary to select the groups containing 30-50 inclusions. The authors studied 11 groups of inclusions, but only for 2 groups they were able to present the consistent interpretation. (Abstract by A.K.)

A Chem. Abstracts abstract of this paper was given in Fluid Inclusion Research, v. 18, p. 440. (E.R.)

VROLIJK, P.J., 1986, Channelized fluid flow along melanges of the Ghost Rocks Fm, Kodiak accretionary complex, Alaska (abst.): EOS, v. 67, p. 1205. Author at Earth Sci., UC Santa Cruz, Santa Cruz, CA 95064.

The Paleocene Ghost Rocks Fm formed as a tectonic unit underplated beneath the Kodiak accretionary complex, Alaska, and consists of melanges, interpreted as paleo-fault zones and structurally coherent blocks. Syntectonic quartz veins from melanges of the Ghost Rocks Fm have strikingly different stable isotope signatures than veins in structurally coherent blocks, suggesting that veins in melange (= fault) zones crystallize from fluids that originate at deeper levels whereas veins in coherent blocks form from fluids derived in situ. Delta ^{18}O values of melange quartz veins average 17.0 ± 0.6 per mil (SMOW) whereas coherent block veins average 14.9 ± 0.4 per mil (SMOW). Because fluid inclusion analyses of methane-rich and water-rich inclusions suggest that melange veins and coherent block veins formed at similar P-T conditions (melanges = 240-260° @ 280-310 MPa; coherent blocks = 250° @ 315 MPa), the difference in oxygen isotope values must arise from differences in the oxygen isotope composition of the fluids from which the veins crystallized. Furthermore, oxygen isotope analyses of the surrounding matrix rock show that the coherent block veins have values roughly similar to the whole rock values (12.5-14.7 per mil, SMOW); melange veins are isotopically heavier than the matrix rock. Coherent block veins appear to be in near oxygen isotope equilibrium with the surrounding rocks and probably crystallized from fluids derived in situ. In contrast, veins in melanges crystallized from isotopically heavier and more evolved fluids that probably originated at a higher temperature. The isotopically heavier fluids subsequently migrated along the melange fault zone to form veins at higher levels in the subduction complex; the isotopically heavier fluids apparently are constrained to the melange zones and rarely escape into the surrounding coherent units. (Author's abstract)

VROLIJK, Peter and MYERS, Georgiana, 1986, Fluid escape from the Kodiak accretionary complex, Alaska (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 779. Authors at Earth Sci., Univ. California, Santa Cruz, CA 95064.

Enormous volumes of water are thrust to depth in subduction complexes as pore fluids and hydrated minerals. As material is underthrust, sediment consolidation and mineral dehydration processes help cause fluid pressures to rise until the rock hydrofractures, and the fluid escapes to shallower levels. Dewatering of the underthrust rocks results from repetition of this sequence. In quartz-veined boudins in melanges of three units of the Kodiak accretionary complex, Alaska, methane-rich and water-rich fluid inclusions record fluid pressures and temperatures during the time of crystal growth and melange (= fault-zone) deformation. Two important consequences of fluid migration are recorded: 1) Fluid pressures in veined boudins drop from near-lithostatic values during initial vein opening to values 25-40% of peak values as the vein continues to grow (from 310-330 to 175-265 MPa @ 260-290°C). One plausible interpretation requires that fluid pressures drop as an interconnected fracture network grows toward increasingly shallower levels, perhaps along the decollement. Fluid inclusions may also record evidence of repeated crack opening and pulses of fluid flow. 2) Fluid pressures and temperatures in boudins (250-300 MPa @ 200-290°C) from melanges in three units delineate a thermal gradient of >20°C/km, much greater than predicted by thermal models of subduction complexes. We interpret these high temperatures as the consequence of rapid, upward migration of warm fluids along the decollement. These observations suggest that in sediment-dominated subduction complexes high fluid pressures exist and help drive deformation and that fluid is driven along faults and fractures rapidly enough that heat is transported from deeper to shallower levels. Heat flow by fluid expulsion may be an important factor in the thermal structure of subduction complexes. (Authors' abstract)

VRY, J.K. and BROWN, P.E., 1986, Fluid inclusions in Archean granulites - Pikwitonei Domain, Manitoba (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 140. Authors at Dept. Geol. & Geophys., Univ. Wisconsin, Madison, WI 53706 USA.

Fluid inclusions, from quartz grains in a variety of rock types collected along Cauchon Lake and Natawahunan Lake in the Archean Pikwitonei granulite domain (PGD), Manitoba, were examined by petrographic and microthermometric techniques.

CO_2-rich inclusions predominate in rocks from the Natawahunan Lake area. At least three generations of CO_2-rich inclusions, identified by either differing planar orientations or Th, may occur in a single rock sample. Measured CO_2 triple points cluster around -56.6°C, with some samples giving consistently low values (-59°C) suggesting the presence of methane or another component. High-density, apparently P or PS CO_2 inclusions with Th between -28°C and -15°C, (average -22°C), were observed in several samples. At an inferred average metamorphic T of 800°C, isochores for these high-density (1.06 to 1.01 g/cm^3) inclusions give P estimates of 7.5 to 6.5 kbars.

Fluid inclusions from Cauchon Lake are frequently aqueous, and may contain a number of daughter salts. High-density CO_2 inclusions were not observed. S low-density CO_2-rich inclusions occur in some samples, and in one sample exhibit elevated melt T, ranging from -56.1°C to -53.9°C, and averaging -55.1°C. The transition from aqueous to carbonic fluid inclusions does not appear to correspond to the location of the orthopyroxene isograd. High density, CO_2-rich inclusions in other granulite terrains are sometimes interpreted as indicative of massive CO_2 infiltration; however, partial melting and fluid absent metamorphism are viable alternatives (Lamb et al., 1985). (From the authors' abstract)

VUATAZ, F.D. and GOFF, Fraser, 1986, Isotope geochemistry of thermal and nonthermal waters in the Valles Caldera, Jemez Mountains, northern New Mexico: J. Geophys. Res., v. 91, no. B2, p. 1835-1853.

WALDER, I.F. and SEGALSTAD, T.V., 1986, Hydrothermal vein molybdenum deposits associated with the Drammen biotite granite in the Permian Oslo rift, Norway (abst.): Terra Cognita, v. 6, no. 3, p. 556. Authors at Mineralogisk-Geologisk Museum, Univ. Oslo, Sars gate 1, N-0562 Oslo 5, Norway.

The Drammen biotite granite contains numerous small molybdenum deposits occurring along linear fractures within three separate intrusions of granite and quartz-feldspar porphyries. The deposits carry molybdenite along thin

(0.5-5 cm) quartz veins. These veins may contain feldspar and fluorite. Wall-rock alteration associated with the quartz-molybdenite veins is sparse.

Fluid inclusion studies of vein quartz show that the primary inclusions are water-dominated and may carry both CO_2 and frequent crystals of halite at room temperature. The fluids from which the quartz-molybdenite veins precipitated were trapped at a lower temperature relative to the fluid inclusions in quartz from the granite.

The molybdenum-bearing solutions may have originated as primary late magmatic aqueous solutions released through second boiling of the magma via fractures created in the overlying already solidified granite bodies. The fluid cooled by mixing with meteoric water and precipitated molybdenite and quartz.

Sr-isotope data of fluid inclusions from quartz in the quartz-molybdenite veins plot above the whole rock isochron for the Drammen granite batholith. Further Sr- and Nd-isotope data of the fluid inclusions from quartz in mineralized veins and in the granite will be presented, and discussed in the context of the origin and evolution of the hydrothermal solutions leading to the formation of these deposits. (From the authors' abstract)

WALKER, R.J., HANSON, G.N., PAPIKE, J.J., O'NEIL, J.R. and LAUL, J.C., 1986, Internal evolution of the Tin Mountain pegmatite, Black Hills, South Dakota: Am. Mineral., v. 71, p. 440-459. First author at Dept. Earth & Space Sci., State Univ. New York, Stony Brook NY 11794.

Major and trace elements and oxygen-isotope compositions are evaluated to delineate the sequence of crystallization in the lithologically and chemically zoned Tin Mountain pegmatite. It is suggested that an aqueous-fluid film connected all crystallization fronts in the body. This aqueous fluid vertically redistributed Si, Al, K, Na, and possibly Rb and Cs in such a manner that the melt retained a ternary-minimum melt composition throughout crystallization. (From the authors' abstract)

WALLACE, A.R., 1986, Geology and origin of the Schwartzwalder uranium deposit, Front Range, Colorado, USA, in Vein type uranium deposits, IAEA - TECDOC-361, p. 159-168. Author at U.S. Geol. Survey, Denver, CO, USA.

The Schwartzwalder uranium deposit in Colorado was formed from evolved connate fluids which leached all the vein mineral components from the host metamorphic terrane. The metamorphic rocks were deposited in a Proterozoic submarine environment with associated volcanic activity. U mineralization occurred 69.3 ± 1.2 Ma ago during incipient uplift of the crystalline block of the Front Range. Carbonate-rich fluids produced successive carbonate-sericite and hematite-adularia alteration assemblages in the wall rocks around fractures in the metamorphic rocks. Three stages of subsequent vein mineralization generated massive pitchblende veins with carbonate, sulfide, and adularia gangue. Breccia dikes composed of remobilized fault gouge and ore were emplaced both before and after pitchblende deposition.

The alteration and vein assemblages were produced during repeated major movement along faults in the basement. Fault movement across a narrow zone of brittle rock in the metamorphic sequence provided a permeable conduit along which the hydrothermal fluids ascended. Episodic brecciation dramatically reduced the large confining pressure and induced CO_2 evolution [based on fluid inclusion studies]. This process simultaneously increased the pH, decreased the $f(O_2)$ and $f(CO_2)$, and led to the alteration of the wall rocks and the subsequent deposition of adularia, carbonates, and pitchblende in the veins. Reduced and intermediate sulfur species in solution reduced the U carried in solution.

Geologic evidence and C, S, O and Pb isotopic data require that the components for the vein minerals were derived almost entirely from the metamorphic terrane, and that sedimentary and magmatic sources were volumetrically insignificant at best. The fluids were probably originally of meteoric derivation and resided in deep fracture zones for much of the Mesozoic. (Author's abstract)

WALLACE, A.R. and WHELAN, J.F., 1986, The Schwartzwalder uranium deposit, III: Alteration, vein mineralization, light stable isotopes, and genesis of the deposit: Econ. Geol., v. 81, p. 872-888. Authors at U.S. Geol. Survey, Box 25046, Mail Stop 905, Federal Center, Denver, CO 80225.

Two stages of alteration and three stages of vein mineralization are recorded in the Schwartzwalder deposit. At the onset of Laramide faulting, fluids migrated along the fracture systems to zones of low hydraulic potential. These fluids contained CO_2 and had a metastably large K/Na ratio; they altered the gneissic wall rocks to a carbonate-sericite assemblage, adding K^+ and CO_2 and removing SiO_2 with little or no change in volume. As the fractures continued to open, CO_2 was evolved from the fluids, increasing the pH and superimposing a hematite-adularia alteration assemblage on the earlier alteration. (From the authors' abstract)

Th, corrected for pressure, yielded 270-290°C for early sphalerite; these values are high, perhaps due to stretching. Later amethyst yielded 168-205° after P correction. (E.R.)

WALSH, J.N. and HOWIE, R.A., 1986, Recent developments in analytical methods: Uses of inductively coupled plasma source spectrometry in applied geology and geochemistry: Applied Geochem., v. 1, p. 161-171.

WALTHER, J.V., 1986a Experimental determination of portlandite and brucite solubilities in supercritical H_2O: Geochimica Cosmo. Acta, v. 50, p. 733-739.

WALTHER, J.V., 1986b Mineral solubilities in supercritical H_2O solutions: Pure & App. Chem., v. 58, no. 12, p. 1585-1598. Author at Dept. Geol. Sci., Northwestern Univ., Evanston, IL 60201, USA.

Solubilities of minerals in supercritical H_2O and H_2O-CO_2 mixtures are of prime importance to our understanding of mineral transformations, fluid-flow interactions in the earth's crust. This paper presents a review of available data on mineral solubility and speciation in aqueous fluids at elevated T and P and with variable activities of Cl^- and CO_2.

As is to be expected from the decrease in the dielectric constant of the fluid, neutral or lower charged complexes become increasingly abundant as T and P are increased to supercritical conditions. Alkali and alkaline earth elements in aqueous solution exist primarily in chloride complexes because chloride is the most abundant complexing anion in crustal solutions. Neutral complexes that are unknown or significant only in alkaline solution at 25°C become important in near neutral solutions at elevated T and P. Of particular interest are Na and K Al and Na and K Si complexes which are apparently quite stable at T above 400°C and 1 kbar.

Hydroxyls complex with cation species to an increasing degree in near neutral solutions as T is increased. The ability of a cation to complex hydroxyls is controlled to a large extent by its surface charge density. The higher the charge density the greater is the degree of hydrolization to form lower charged or neutral complexes. Surface charge density also affects the degree of chloride complexation of cations. It can be shown that the greater the surface charge density the greater the T dependence of the chloride electrolyte dissociation. (Author's abstract)

WALTHER, J.V. and WOOD, B.J., eds., 1986, Fluid-rock interactions during metamorphism: New York Springer-Verlag, 211 pp. Continued next page.

Of general interest to anyone working on metamorphic inclusions. Individual chapters abstracted under individual authors. (E.R.)

WALTON, L. and NESBITT, B.E., 1986, Evidence for late stage Au-galena mineralization in the Venus arsenopyrite-pyrite-quartz vein, south-west Yukon (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 141. Authors at Dept. Geol., Univ. Alberta, Edmonton, Alberta, T6G 2E3, Canada.

The paragenesis can be divided into two stages: (1) early quartz-arsenopyrite-pyrite: (2) late quartz-sphalerite-galena ± Au. Fluid inclusions in Stage I minerals indicate low to moderate salinities (5-8 wt% NaCl), high Th (210-240°C, uncorrected for P), and high CO_2 contents (up to 50%), relative to lower T (180-210°C, uncorrected for P), low to moderate salinity (5-9 wt% NaCl), CO_2 depleted (<15% CO_2) Stage II mineralization. Deposition of Stage I quartz-arsenopyrite-pyrite occurred from low-moderate salinity, CO_2-rich fluids. (From the authors' abstract)

WAMPLER, J.M. and HASSANIPAK, A.A., 1986, Potassium-argon dating of rock salt for the U.S. DOE Salt Repository Project: A stepwise dissolution technique (abst.): EOS, v. 67, no. 44, p. 1248. Authors at Sch. Geophys. Sci., Georgia Inst. Tech., Atlanta, GA 30332.

Procedures for measurement of potassium and argon released during stepwise dissolution of rock-salt specimens have been developed in order to examine how potassium, ^{36}Ar, and ^{40}Ar are distributed in the salt and in fluid inclusions within the salt. In an exploratory study, five specimens of salt from the San Andres Formation (lowermost Upper Permian) of the Palo Duro Basin in Texas have been analyzed in this way. The potassium content of the dissolved salt was low (<100 mg/kg) and rather uniform from step to step, except when the opening of relatively large fluid inclusions enhanced the amount of potassium. Large variations in ^{36}Ar content were observed; the largest amounts generally came neither from the outer portions of the specimens (in the first step of dissolution) nor from the larger fluid inclusions, but appeared to come from grain boundaries or from zones where mineral impurities were concentrated within halite crystals.

A positive correlation between $^{40}Ar/^{36}Ar$ and $^{40}K/^{36}Ar$ is evident for each specimen. For three of the specimens, the data fit straight lines well, and there is no significant difference (given rather large relative errors in this work on rock of very low potassium content) in the slopes of these lines nor in their intercepts. The data from the other specimens are not well correlated. But if the data from certain steps are combined, because of probable carryover of potassium from one step to the next after large fluid inclusions opened, the data from all five specimens are well correlated and the lines are interpretable as a concordant, albeit imprecisely determined, set of isochrons for Permian rock that initially contained atmospheric argon. (The slopes correspond to ages in the range 261-291 Ma and the intercepts are from 284 to 298; the most precisely determined values are 261 Ma and 295, respectively.) The data indicate that since the Permian Period, redistribution of potassium and radiogenic argon within these specimens, including the fluid inclusions, has not extended over distances of more than a few millimeters. (Authors' abstract)

WAN, Jiamin, 1986, Geochemical studies of the Xi'an tungsten ore deposit, west Hunan, China: Geochimica, 1986, no. 2, p. 183-192 (in Chinese; English abstract). Author at Inst. Geochem., Acad. Sinica.

Detailed geochemical studies of the Xi'an W ore deposit in west Hunan have been conducted with a diversity of geochemical approaches. As deduced from analyses of more than twenty kinds of trace elements and isotopic characteristics of C, O and Pb, the Banxi Group slate of great thickness is the source bed of the deposit. H and O isotopic compositions of water isolated from fluid inclusions show that the water in ore-forming hydrothermal solutions was derived mainly from heated formation water. Various physico-chemical parameters for the hydrothermal solution have also been obtained from fluid inclusion studies.

As deduced from Pb isotopic model age and whole-rock K-Ar age, the age of ore formation falls within the range of 500-600 Ma, suggesting that the Caledonian movement is a tectonic movement which had the greatest influence on the studied region. The principal ore-controlling factors are: stratum (source bed), lithologic character (carbonate host rock), and tectonics (Caledonian tectonic movement). The available evidence suggests that this deposit is a sedimentary-reworked strata-bound deposit. (Author's abstract)

WANAMAKER, B.J., 1986, The kinetics of crack healing and the chemical and mechanical re-equilibration of fluid inclusions in San Carlos olivine: Ph.D. dissertation, Princeton Univ.

In this thesis, the kinetics of crack healing and the chemical and mechanical re-equilibration of fluid inclusions in San Carlos olivine are experimentally determined. These data are subsequently used to constrain the physical conditions accompanying the ascent of these xenocrysts from the mantle to the earth's surface.

Crack healing is a thermally activated diffusive process driven by gradients in surface energy which converts the porosity of an open crack into an array of cylindrically- and spherically-shaped pores. Crack healing in San Carlos olivine is experimentally observed at T >1000°C and has an activation energy of ~120 ± 40 kcal/mole. Both the rate and diffusive mechanism of crack healing in olivine may depend on the fO_2 or the speciation of the fluid in the crack.

Pure CO_2 fluid inclusions in San Carlos olivine re-equilibrate rapidly to mixtures of $CO-CO_2$ in response to changes in the external fO_2 at T >1000°C. The activation energy of 46 ± 8 kcal/mole and rapid diffusivities of the re-equilibration process are nearly identical to those measured for metal vacancies and suggest that the re-equilibration is controlled by the motion of point defects.

The internally pressurized fluid inclusions in San Carlos olivine also re-equilibrate mechanically by stretching in response to lower external P. Stretching is experimentally observed and theoretically modelled assuming a steady-state, power law creep mechanism. The predicted rates of stretching using both an ideal gas and Redlich-Kwong equation of state for the fluid in the inclusions bracket the actual rates of stretching at 1400°C and an external P of 1 bar.

San Carlos olivine xenocrysts contain abundant physical evidence of natural crack healing and chemical and mechanical re-equilibration during their ascent to the surface. Using the experimentally determined rates of these processes, it is shown that the fluid inclusions contained in San Carlos olivine were originally significantly more dense than at present and may have undergone changes in their chemical speciation. In addition, the average ascent rate of these xenocrysts is in the range of 1-20 cm/sec. (Author's abstract)

WANAMAKER, B.J. and EVANS, Brian, 1985, Experimental diffusional crack healing in olivine, in R.N. Schock, ed., Point Defects in Minerals, Geophys. Monograph 31, Mineral Physics 1: Am. Geophys. Union, Washington, DC, p. 194-210. First author at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544.

Both natural and laboratory produced cracks in San Carlos peridot heal by a two stage process involving the initial formation of cylindrical voids and the subsequent formation of spherical pores when subjected to heat treatments at 1250°C-1400°C; laboratory produced cracks also heal rapidly at 1000°C. In addition to being thermally activated, the kinetics of the healing process depend on the crack dimensions and apparently either the chemical speciation or the P of the fluid filling the crack. Interpretation of the results of these experiments using theories of diffusive crack healing developed for metals and ceramics indicates that surface diffusion is probably the dominant mechanism of crack healing. The effective activation energy of the break-up of the cylindrical voids is ~53 ± 22 kcal/mole and the time necessary to produce a spherical void from a cylinder is proportional to the fourth power of the radius of the cylinder. The region of healed crystal between the spherical pores contains dislocations which are apparently formed during the healing process as accommodation of strain between the free crack surfaces. (Authors' abstract)

WANG, Bixiang, 1986a. Melt and fluid inclusions in igneous rocks in central Xizang (Tibet): Scientia Sinica (Ser. B), v. 29, no. 7, p. 771-782 (in English). Author at Inst. Geol., Chinese Acd. Geol. Sci. Beijing, PRC.

Through a study of the characteristics and composition of melt and fluid inclusions in volcanic rocks and their associated granites in the subduction zone of the Tibetan plate, it has been found that the characteristics of the inclusions in quite a few minerals of various rock types are closely related to the nature of molten magmas, thickness of strata and cooling speed. Therefore, their characteristics may be used to discriminate different lithofacies types. In this paper the evolution and crystallization of magma are discussed on the basis of the glass composition of the inclusions measured using the electron probe, and the gas composition and its parameters are used in elucidating the physico-chemical conditions of rock and ore formation. (Author's abstract)

Th values range from 880 to 1070°C. Fourteen complete microprobe analyses (9 constituents) of melt inclusions and 7 analyses of gases "extracted by vacuum rupturing" for H_2O, CO_2, H_2, N_2, CH_4, and CO are presented. (E.R.)

WANG, Bixiang, 1986b. Studies of mineral inclusions, hydrogen and oxygen isotopes in the igneous rocks of the southern Xizang (Tibet): Bull. Inst. Geol. Chinese Acad. Geol. Sci., v. 15, p. 200-208 (in Chinese; English abstract).

This paper deals with the characteristics and compositions of melt inclusions in igneous rocks, fluid inclusions in granitoids and their hydrogen and oxygen isotopic compositions. The characteristics of melt inclusions reflect physico-chemical conditions under which their host rocks were formed. They can be used to determine the rock types, extrusive or intrusive facies of the host rocks and are conducive in identifying rock-forming minerals and studying their crystallization.

Fluid inclusions are of great importance for studying the mechansims of the formation of ore-forming host rocks and ore-forming fluids. For example, boiling inclusions are prevalent in small porphyroidal granite and granodiorite stocks in the Gangdise intrusive belt. The fluids belong to the system NaCl-KCl-H_2O, with NaCl predominating in the salts. The water is dominated by magmatic water, mixed with meteoric water. Among the gas components, H_2, SO_2 and CO contents are high, reflecting that their host rocks were formed at high temperatures. These characteristics are similar to those of the hydrothermal fluids of porphyry copper (molybdenum) deposits. Therefore, attention should be paid to looking for porphyry copper deposits in small stocks in this intrusive belt.

Studies of hydrogen and oxygen isotopes further confirmed that the gabbros in the Gangdise intrusive belt were derived from the upper mantle, while the granodiorite and porphyroidal granite were derived from the lower crust. There is a linear relationship between them in various diagrams, exhibiting the characteristics of I-type granites and the actions of fractional crystallization. The granitic materials in the Lagurgangri and Himalayan intrusive belts, which exhibit the characteristics of S-type granites, were derived from the crust and contaminated by sedimentary covers. On the other hand, granitoids in the Xainza and Baingoin intrusive belts exhibit the characteristics of a transitional type between I-type and S-type granites. (Author's abstract)

WANG, Daohua, 1986, On the origin of carbonate-hosted stratiform Cu deposits in the Lower Yangtze region, eastern China (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 141. Author at The Nanjing Inst. Geol. & Mineral Resources, 534 East Zhongshan Road, Nanjing, China.

Th from fluid inclusions do not show igneous T-gradients. (From the author's abstract)

WANG, Wenbin, JI, Shaoxing, XING, Wenchen, WU, Huairen, ZHOU, Hamming and XUE, Yuyi, 1986, Geological characteristics and genesis of stratabound deposits of Cu-bearing pyrite deposits in the Jiujiang-Ruichang area, Jiangxi, China (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 142. First author at Nanjing Inst. Geol. & Min. Resources, 534 East Zhongshan Road, Nanjing, China.

Investigations of the compositions of fluid inclusions show that the genesis of the ore deposits is related to submarine volcanic-exhalative sedimentation. (From the authors' abstract)

WANG, Z.-J., 1986, Features and origins of a mantle-derived hydrothermal gold-ore belt in south China: Geol. & Prospecting, v. 22, no. 7, p. 17-23 (in Chinese).

Apparently contains thermometric data on inclusions (p. 21). (E.R.)

WANG, Zhenguang, JIANG, Renyi and LIN, Shuyun, 1986, Sequential determination of some components in mineral inclusions by gas-ion chromatography: Yanshi Kuangwuxue Zashi, v. 5, no. 2, p. 162-167 (in Chinese). Authors at Beijing Inst. Miner. Deposits Geol., Beijing, PRC.

Geologic gas inclusion compounds were determined by gas chromatography with 3-columns and 2-detectors in series. A low dead volume quartz cracking tube was installed in the gas chromatograph for sample preparation. H_2O and CO_2 were separated and determined by a column (L_1) packed with GDX-105. H_2, O_2, N_2, CH_4, and CO were separated and determined by a column (L_2) packed with 5A mol. sieves. A column packed with silica gel and alkaline asbestos was connected between L_1 and L_2 for preventing H_2O and CO_2 from entering L_2. The anions (halides, NO_3, SO_2^{2-}) and cations (K^+, Na^+, Ca^{2+}, Mg^{2+}) were determined by ion chromatography on anion and cation exchanger, respectively. The method is simple and accurate. (C.A. 106: 60464w)

WATKINSON, D.H., DAHL, R. and McGORAN, J., 1986, The Coldwell Complex platinum-group-element deposit: 2. Relationships of platinum-group-elements to pegmatitic biotite-bearing gabbro and the role of a fluid phase (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 11, p. 142-143. First author at Dept. Geol., Carleton Univ., Ottawa, Ontario K1S 5B6, Canada.

Large apatite with fluid inclusions is a common accessory. The fluid inclusions provide evidence that a fluid phase is involved in the transportation and precipitation of PGE in magmas. (From the authors' abstract)

WATSON, E.B., 1986, Immobility of reduced carbon along grain boundaries in dunite: Geophys. Res. Letters, v. 13, no. 6, p. 529-532. Author at Dept. Geol., Rensselaer Polytech. Inst., Troy, NY 12180.

Carbon-14 radiotracer experiments at 10 kbar (1 GPa) and 1000°-1200°C reveal that, due to low diffusivity or low solubility (or both), carbon is immobile in the grain boundary regions of natural dunite. (From the author's abstract)

WAWERSIK, W.R., 1986, Microstructures in deformed rock salt from around old mine workings (abst.): EOS, v. 67, p. 1202. Author at Geomechanics Div., 1542, Sandia Nat'l. Labs., Albuquerque, NM 87185.

Includes a mention of relief of stress around fluid inclusions. (E.R.)

WEBER, C., BARBEY, P., CUNEY, M. and MARTIN, H., 1985, Trace element behavior during migmatization. Evidence for a complex melt-residuum-fluid interaction in the St. Malo migmatitic dome (France): Contrib. Mineral. Petrol., v. 90, p. 52-62.

WEIBEL, M. in cooperation with Ed. Gubelin, 1985, Gemstones and their mineral inclusions: Edition: ABC Verlag Zurich, 111 pages (in German). First author at Eidgenossische Technische Hochschule (ETH) in Zurich.

The book contains a lot of excellent color pictures, also from fluid inclusions - but without detailed descriptions. (H.A. Stalder)

WELTY, J.W. and SPENCER, J.E., 1986, Two types of mineralization related to Tertiary detachment faults in the southwestern United States (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 785. Authors at Arizona Geol. Survey, 845 N. Park Ave., Tucson, AZ 85719.

Cu-Fe base-metal deposits related to Tertiary detachment faults are best known in the Whipple-Buckskin-Rawhide Mountains of southeastern Calif. and western Ariz., and are characterized by massive specular hematite followed by fracture-filling chrysocolla and malachite; minor gangue minerals commonly include calcite, quartz, barite, and fluorite. Some deposits contain early Cu and Fe sulfides. Mineralization typically forms tabular open-space-filling and replacement ore bodies within or along the detachment fault and open-space-filling ores within brecciated rocks along lower- and upper-plate high-angle faults. These deposits are also characterized by a distinctive geochemical suite (Cu, Mo, Ba, K, Mg), highly saline fluid inclusions (12-20 wt. % equiv. NaCl), and moderate fluid-inclusion homogenization temperatures (200-325°C).

Precious-metal deposits thought to be related to detachment faults in southeastern Calif. (Mesquite, Picacho, and Riverside) and in western Ariz. (Copperstone, Cyclopic, and mines in the Black Mtns.) are characterized by intense brecciation and silicification along known or suspected detachment faults, low base-metal content, Sb, As, Hg anomalies, low fluid-inclusion salinities (<<5 wt. % equiv. NaCl), and possibly lower fluid-inclusion homogenization temperatures.

We suggest that the base- and precious-metal deposits resulted from different geologic histories. Cu-Fe deposits are a direct consequence of hydrothermal circulation related to the juxtaposition of hot, lower-plate rocks with cool, upper-plate rocks along the detachment fault, and are not related to magmatism. In contrast, precious-metal deposits may be related to magmatism, with the detachment fault acting as a favorable permeable zone for mineralization (mineralization during or after detachment faulting), or acting to mechanically disrupt a pre-existing ore body and allow hydrothermal fluids to mobilize and possibly further concentrate metals (initial mineralization before detachment faulting). (Authors' abstract)

WENRICH, K.J., 1986a Uranium mineralization of collapse breccia pipes in northern Arizona, western United States, in Vein type uranium deposits, IAEA - TECDOC-361, p. 395-414. Author at U.S. Geol. Survey, Denver, CO, USA.

The development of caves within the Mississippian Redwall Limestone of the western United States, accompanied by later upward stopping of overlying Palaeozoic and Triassic rock, resulted in the formation of breccia pipes. The Palaeozoic sedimentary rocks on the Colorado Plateau of northern Arizona are host to hundreds of these breccia pipes [some with Cu and U deposits]. The lack of extensive silicification within the breccia, along with the fluid-inclusion filling temperature in calcite of 60° to 110°C, suggest relatively low temperature mineralizing fluids of unknown origin. (From the author's abstract)

WENRICH, K.J., 1986b Mineralized breccia pipes of NW Arizona--an overview (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 421. Author at USGS, MS 916, Denver, CO 80225.

Extensive karst development in Late Mississippian and Triassic times promoted the formation of thousands of collapse breccia pipes in NW Arizona. Filling temperatures (80-173°C), in excess of the average geothermal gradient, and high salinities (10 - >23 wt.% NaCl equiv.) from pipe sphalerite, dolomite, quartz, and calcite conflict with the ground-water model for the Chinle U (CU) deposit. Black, glassy, S-rich pyrobitumen contrasts with organic detritus of CU deposits. Despite these contrasts, U ore from both deposit types may have formed from the same fluid. Except for pyrobitumen the MVT mineral assemblage in the pipes predates deposition of the uraninite. The higher ore grade of the breccia pipes is probably attributable to thorough reduction of U-bearing fluids by abundant sulfides present in some pipes. The barren pipes probably provided channelways for upward-moving, residual-U-bearing fluids to reach the Chinle Fm. (From the author's abstract)

WENRICH, K.J. and BILLINGSLEY, G.H., 1986, Uranium-bearing solution-collapse breccia pipes in northern Arizona (abst.): U.S. Geol. Survey Circular 974, p. 72-73.

P fluid inclusions in dolomite, quartz, and sphalerite show Th from 80° to 145°C and high salinities, averaging 15 wt % NaCl (eq). S inclusions in sphalerite have higher Th from 105° to 173°C, but similar salinities. Rock-Eval pyrolysis of pyrobitumen by L. Pratt in 1985 suggests temperatures did not exceed 150°C following pyrobitumen emplacement. (From the authors' abstract)

WERES, O., JUN, C.H. and TSAO, L., 1986, New three-phase equilibrium model (oil/gas/brine) used to interpret production of liquid hydrocarbons from a geopressured gas well: Soc. Petrol. Engineers, Golden Gate Sec., Proc. 56th Ann. California Regional Meeting, v. 1, p. 417-422, paper SPE 15084.

WHELAN, J.F., LANDIS, G.P. and COBB, J.C., 1986, Stable-isotope and inclusion-fluid composition shades of epigenetic pyrite and sphalerite from Illinois basin coals (abst.): Symp. Proc.; A national agenda for coal-quality res., USGS Circ. 979, p. 261-262. First author at U.S. Geol. Survey.

Kaolinite-pyrite-sphalerite-calcite mineralization occurs in cleats and clay dikes of mid-Pennsylvanian coals in Illinois. δD^* and $\delta^{18}O$ values of inclusion fluids in this pyrite range from -137 to -61 and -12.3 to -5.2, respectively. These compositions are D- and ^{18}O-depleted with respect to any depositional or diagenetic fluid previously known to have existed in these rocks. If, as we believe, these fluids reflect coal-pore water at the time of pyrite formation, then such waters must have exchanged with or been generated from organic compounds in the coal. Gases in pyrite-hosted inclusions contain CO_2, CO, or N_2, Ar, H_2S, SO_2, abundant hydrocarbons (CH_4, C_2H_2, C_2H_6, C_3H_8, C_4H_{10}, and so on), and exhibit alkene:alkane ratios >1. The predominance of alkenes probably reflects the differing solubilities of saturated and unsaturated hydrocarbons in aqueous fluids. $\delta^{34}S$ values of pyrite concretions, nodules, bedding-plane concentrations, and cleat fillings from Nos. 2, 5, and 6 coals in Illinois range from -12.4 to -0.1; within individual mines the range is much smaller, often <4. Pyrite $\delta^{34}S$ values do not reflect the different pyrite morphologies. Bacterial sulfate reduction is the widely accepted source of pyritic A in high-S coals. However, the comparatively small range of $\delta^{34}S$ values observed contrasts with the large ranges characteristic of bacterial activity. High-S peat and lignite may contain 10 percent or more total S, of which 1-2 percent is pyrite. High-S coals of Illinois also may contain 10 percent or more total S, but with more than half contained in pyrite. We propose that this increase in the proportion of pyritic S in sub-bituminous-(and higher ?) rank coal reflects the formation of coarse pyrite in epigenetic settings (cleat, and so on), from S released during the post-lignite-rank breakdown of S-bearing organic compounds. The isotopic and gas compositions of the fluids, and sulfide $\delta^{34}S$ values, suggest that coal-pore fluid chemistry was controlled, at times, by coal devolatilization. Sphalerite in the coals was deposited at 90-100°C from brines chemically similar to those that formed the Upper Mississippi Valley Zn-Pb district. However, δD and $\delta^{18}O$ data from the sphalerite inclusion fluids trend toward the isotopic composition of pyrite inclusion fluids, which suggests mixing between the coal-pore water and the Zn-transporting brines. $\delta^{34}S$ values of sphalerite are close to those of associated pyrite. This suggests that sphalerite also precipitated from S derived from organics, or that sphalerite inherited S by replacing pyrite. Gases trapped in sphalerite-hosted fluid inclusions are less hydrocarbon enriched than those of pyrite-hosted inclusions. (Authors' abstract) [*Original has Greek "sigma" throughout; "delta" probably intended.]

WHITE, A.F., 1986, Chemical and isotopic characteristics of fluids within the Baca geothermal reservoir, Valles Caldera, New Mexico: J. Geophys. Res., v. 91, no. B2, p. 1855-1966.

WHITE, D.E., 1986, Subsurface waters of different origins (extended abst.): Extended Abstracts, Fifth Int'l. Symp. on Water-Rock Interaction, August 8-17, 1986, Reykjavik, Iceland, p. 629-632.

WHITICAR, M.J., FABER, E. and SCHOELL, M., 1986, Biogenic methane formation in marine and freshwater environments: CO_2 reduction vs. acetate fermentation - Isotope evidence: Geochimica Cosmo. Acta, v. 50, p. 693-709. First author at Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, D-3000 Hannover 51, West Germany.

Defining the character of the methanogenic types with carbon and hydrogen isotopes not only provides information about the environment of formation, it is also most useful in distinguishing biogenic from thermogenic methane gases. (From the authors' abstract)

WHITNEY, Gene, NORTHROP, H.R. and HANSLEY, P.L., 1986, The use of mineral alteration patterns and stable isotope compositions to infer a paleohydrologic regime (abst.): U.S. Geol. Survey Circular 974, p. 73-74.

WILDE, A.R., WALL, V.J. and BLOOM, M.S., 1986, Wallrock alteration associated with unconformity-related uranium deposits, Northern Territory (abst.): Eighth Australian Geol. Conv., Geol. Soc. of Australia, "Earth Resources in Time and Space," Feb. 16-21, 1986, Flinders Univ., Adelaide, Abstracts, no. 15, p. 205-206. Authors at Dept. Earth Sci., Monash Univ., Melbourne, Australia.

The processes involved in formation of unconformity-related uranium deposits have hitherto been poorly understood. In this paper hydrothermal alteration associated with the uranium deposits of Nabarlek and Koongarra (N.T., Australia) is described. Temporal and spatial variation of various alteration parageneses are used to constrain aspects of fluid chemistry and make inferences on mineralizing processes.

During the early (quartz-depositional) event, fluid inclusion data show T were in excess of 200°C. This is consistent with fission track dating of zircon, which has an annealing T in excess of 200°C. During the mineralization phase, T of at least 160°C are suggested by application of the chlorite solid-solution model of Walshe. Fluid inclusion data on late calcite veins shows that after mineralization, T were in the range 170-50°C. Fission-track data suggests that a superincumbent pile of up to 5 km of sediments originally overlay the deposits, indicating a lithostatic P of circa 1 kb. Fluctuating fluid fO_2 during formation of the deposits is indicated by the spatial and temporal distribution of sulphide and oxide minerals. Mineralization is inferred to be the result of influx of a hot (>200°C), oxidized (i.e., in equilibrium with hematite and capable of transporting uranium), silica-undersaturated fluid (probably therefore of surface or near-surface origin), into reducing basement rocks along reverse fault zones. The removal of large volumes of silica from the inner alteration zone (especially at Nabarlek) infers fluid/rock ratios in excess of 1000:1. (From the authors' abstract)

WILKINS, Joe, Jr., BEANE, R.E. and HEIDRICK, T.L., 1986, Mineralization related to detachment faults: A model: Ariz. Geol. Soc. Digest, v. 16, p. 108-117. First author at St. Joe Am., Tucson, AZ.

Fluid inclusion data were obtained on 7 mineral deposits of this type in SW Arizona and Th and salinity data for quartz, calcite and fluorite (mostly composited for all 7) are given.Th = 90-325°C (uncorrected for P); salinity = 10-20 wt. %. A structural model is proposed on the basis of the inclusion data. (E.R.)

WILKINS, R.W.T., 1986, The mechanisms of stretching and leaking of fluid inclusions in fluorite: Econ. Geol., v. 81, p. 1003-1008. Author at CSIRO Div. Min. Physics & Mineral., P.O. Box 136, North Ryde, New South Wales 2113, Australia.

An attempt to understand the mechanism(s) of stretching of inclusions in fluorite during overheating. (E.R.)

WILLIAM-JONES, A.E., LINNEN, R.L. and SAMSON, I.M., 1986, Hydrothermal fluid evolution in the Madeleine copper deposit, Gaspé, Québec (abst.): 88th Ann. Gen. Meeting of CIM, Montreal, CIM Bull., v. 79, no. 887, p. 48. First author at Dept. Geol. Sci., McGill Univ., Montreal, Quebec, Canada.

The Madeleine copper deposit is a small stockwork hosted by biotite-hornfelses adjacent to the late Devonian McGerrigie Mountains granitic complex. Approximately 8.7 by 10^6 tonnes of ore grading 1.15% Cu and 7 g/tonne Ag were mined from 1969 to 1982. The deposit is zoned from bornite in the core to chalcopyrite-pyrrhotite at the edge. The mineralization is in quartz-biotite veins or sulphide stringers associated with local biotitization and, less commonly, in calc-silicate veins. Muscovite-chloritic alteration and veining and later quartz-carbonate veining post-dated the main mineralizing event.

Main stage mineralized samples are dominated by high salinity aqueous fluid inclusions containing halite, sylvite, Fe-chloride, and anhydrite as daughter minerals. These inclusions homogenize at temperatures of up to

400°C. Carbonic inclusions containing various mixtures of CO_2, CH_4 and H_2O occur in all stages of veining. They are most common in the calc-silicate veins and reflect decarbonation of calcareous interbeds at temperatures of at least 300°C to 400°C. Low to moderate salinity aqueous inclusions predominate in the late quartz-carbonate veins (Th = 230°C) and are also very common [in?] the post-ore muscovite-chlorite veins (Th = 240°C to 360°C).

The hydrothermal system evolved from an early orthomagmatic syncontact metamorphic ore stage to post-metamorphic, meteoric water-dominated stages. The sulphide zonation may be explained by increasing water/rock ratios toward the center of the deposit, which may have increased pH and temperature and, if the iron and sulphur had a sedimentary source, may have increased Cu/S and Cu/Fe. (Authors' abstract)

WILLIAM-JONES, A.E., SAMSON, I.M. and LINNEN, R.L., 1986, Preliminary results of a study of the ores, wall-rock alteration, and fluid inclusions at the Madeleine copper mine, Gaspé, Quebec, in Current Research, Part A, Geol. Survey of Canada, Paper 86-1A, p. 239-249. First author at Dept. Geol. Sci., McGill Univ., Montreal, Quebec H3A 2A7.

This is the full paper for the previous abstract. (E.R.)

WILLIAMS, F.M., SHEPPARD, W.A. and McARDLE, P., 1986, Avoca mine, County Wicklow: A review of geological and isotopic studies, in Geology and genesis of mineral deposits in Ireland, C.J. Andrew et al., eds.: Irish Assoc. Econ. Geol., p. 71-82. First author at Dept. Geol., Univ. College Dublin, Belfield, Dublin 4, Ireland.

Sulphur isotopes [in this stratabound Cu sulfide ore body] suggest a sulphur source derived by mixing of magmatically equilibrated and reduced seawater sulphide. An ore-bearing fluid composed of a mixture of heated seawater and magmatic water is suggested by the oxygen isotopes. The carbon isotope results suggest stable redox conditions and a constant source of carbon. A magmatic source is consistent with the carbon isotope results. (From the authors' abstract)

Some fluid inclusion data on p. 78. (E.R.)

WILLIAMS, G.E., 1986, The Acraman impact structure: Source of ejecta in late Precambrian shales, South Australia: Science, v. 233, p. 200-203.

Planar features in quartz, believed to be from impact shock, are said to be "... decorated with cavities ..." (p. 201). Thus these might be similar to the CO_2 fluid inclusions along planar features reported from the Vredefort Dome (see Fricke et al., 1984, Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 99). (E.R.)

WILLIAMS, S.N., 1986, Intrinsic magmatic water and carbon dioxide concentration of plinian airfall deposits (abst.): Int'l. Volcan. Congress, Auckland, N. Z, Abstracts, p. 86. Author at Dept. Geophys. Sci., The Univ. Chicago, Chicago, IL 60637, USA.

The dominant volatile species in magmas, H_2O and CO_2, are the two least well understood because of difficulties in their analysis. Using a newly developed vacuum fusion electronic capacitance manometry system, we are able to obtain direct analyses of intrinsic H_2O and CO_2 in individual vitric melt inclusions contained within individual phenocrysts separated from pumice deposits.

Samples from the Bishop Tuff, of eastern California, and the Bandelier Tuff (Otowi Member) of northern New Mexico, have been studied. Other plinian deposits are under investigation. Phenocrysts are polished to 100-200 µm thickness and cleaned of surface contamination by 400°C heating under vacuum. Quantitative liberation of H_2O and CO_2 occurs through vesiculation of and/or diffusion through the silicic melt during heating to 1280°C for 8 minutes. A quadrupole mass spectrometer confirms the identity of each phase associated with the sequential evaporation and resultant P increase of the separate volatile phases. SO_2, HCl, and major element concentrations can be determined on the same inclusion prior to fusion analysis; thus allowing for complete characterization of each sample.

Two samples of the Bandelier Tuff produced concentrations of 0.63 and 1.57 wt.% H_2O and 0.01 and 0.04 wt.% CO_2 (respectively, from the base and top of the deposit). Twelve samples of the Bishop Tuff show variation from 0.04 to 1.13 wt.% H_2O and 0.01 to 0.12 wt.% CO_2. The CO_2/H_2O ratio varies from 0.01 to 2.9. Careful stratigraphic sampling of the Bishop Tuff plinian deposit reveals systematic variations in grain size, sorting, and vesicularity. Analysis of individual pumice lumps indicates wide variation in vesicularity, crystal content, density and color. This variation is reflected in the size, shape, abundance, and nature of vitric melt inclusions within quartz phenocrysts from those individual pumice lumps. Five individual phenocrysts from one pumice lump reveal variation from 0.16 to 1.13 wt.% H_2O, 0.01 to 0.11 wt.% CO_2 and 0.02 to 0.13 CO_2/H_2O.

The data suggests a surprisingly wide variation in H_2O and CO_2 concentrations existed within the upper regions of these large silicic magma bodies prior to their eruption. There are clear relationships between pyroclast texture and eruptive sequence but no obvious relation to volatile content. Ultimately we should be able to use volatile P to determine the geometry of and depth to the magma bodies and to search for fundamental controls on eruption dynamics. (Author's abstract)

WILSON, P.N. and PARRY, W.T., 1986, Petrologic and fluid inclusion studies of the Ophir Hill mine Pb-Zn-(Ag) skarn deposit, Ophir district, Tooele County, Utah (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 5, p. 423. Authors at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

Pb-Zn-(Ag) mineralization at the Ophir Hill Mine occurs as veins and massive replacement of skarn and marble. Both alteration and ore are zoned about fissures and faults in the Cambrian Ophir Formation.

Five types of hornfels and skarn were identified: (1) pelitic hornfels; (2) adularia reaction skarn; (3) garnet (Gn)-diopside (Di)-adularia ± wollastonite skarn; (4) epidote skarn; and (5) phyllosilicate skarn.

Paragenesis is divided into 3 stages: Stage 1A = adularia + calcite + quartz; Stage 1B = gn + di ± wollastonite; Stage 1C = epidote ± di, phlogopite and chlorite; Stage 2 = quartz + phlogopite + fluorite + pyrite + galena + sphalerite + pyrrhotite + chalcopyrite + argentite + scheelite + chlorite + calcite + sericite; Stage 3 = fluorite + calcite + quartz + talc + sericite. Fluid inclusion data from all three stages are:

Mineral	Stage	Type	Th(avg.)	Th(range)	Salinity	XCO_2
adularia	1A	P	258.5	205-382	5.2	-
gn/di	1B	P	>400	n.d.	n.d.	n.d.
epidote	1C	P	312.6	260-362	9.5	-
scheelite	2	P	339.1	312-358	3 to 5	.04
quartz	2	P	337.4	Boiling	?	?
quartz(vein)	2	P	301.8	283-322	3 to 5	.04
fluorite	3	S	220.2	163-236	3.1	.046

A minimum P of 450 bars was determined from the two-phase curve for Stage 3 S carbon dioxide inclusions in fluorite. A boiling fluid was trapped in Stage 2 pseudosecondary quartz inclusions. Uncertainty in salinity and carbon dioxide content prevents an accurate P estimate. (Authors' abstract)

WILSON, T.P. and LONG, D.T., 1986, Constraints on the evolution of the Michigan Basin brines (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 791. Authors at Dept. Geol. Sci., Michigan State Univ., East Lansing, MI 48824-1115.

This study attempts to put constraints on models for the evolution of brines from the Michigan Basin by a study of the geochemistry of 20 chemical species. Potential origins of the brines, concentration mechanisms and chemical modification processes are considered. Chemical data from approximately 120 wells in six producing formations representing the 4.5 km stratigraphic section of the Michigan Basin have been collected to date. The formations range from the Lower Mississippian Berea to the Lower Ordovician Prairie du Chien. Selected patterns of the chemical data set include: 1) The brines are Ca, Na, Cl solutions except for the Prairie du Chien which is a Ca, K, Cl solution. 2) Most formation brines plot past halite precipitation of Cl/Br diagrams with only about half of the formations plotting along the evaporation line. The other formations plot linearly across the evaporation line indicating both Cl "enriched" and Cl "depleted" waters. 3) Ca varies linearly with Br at near 1:1 slopes in all formations. 4) In most formations Mg also shows a linear relationship with Br, with slopes that are typically less than one, but that are different among formations. 5) The Sr/Ca ratios are consistent with water/rock interactions such as the dolomitization of aragonite and the solution-reprecipitation of calcite. 6) The following chemistries are observed within most formations as a function of increasing depth in the basin: Ca, K, Cl, and TDS increase linearly, Na either decreases linearly or remains the same, Mg does not show a trend, the ratios Sr/Ca, Li/Na, K/Na, and Ca/Na increase linearly. 7) The absolute chemistries and the rates of chemical change as a function of salinity and depth are different among formations. The results are interpreted to indicate that any model for the origin of the brines in the Michigan Basin must consider: 1) the possibility of different evolutions for each formation, 2) the sinking of evaporated seawater chemically modified by dolomitization as a potential source of the brine, 3) the influx of fresh water or seawater with dissolution of evaporite as a potential source of the brine, 4) the dilution of the brines with seawater or meteoric waters, and 5) the cross formational flow of the brines. (Authors' abstract)

WINTERS, M.B., 1986, An investigation of fluid inclusions and geochemistry of ore formation in the Cedar Creek breccia pipe, North Santiam mining district, Oregon (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 2, p. 200. Author at 1959 Wedekind Rd., #4, Reno, NV 89512.

The Cedar Creek breccia pipe was emplaced in the Sardine Formation, a series of andesitic flows, breccias, tuffs, and small intrusives of Middle to Late Miocene age. It is elliptical in plan view with maximum axes of 110 and 145 m and extends downward over 350 m. A quartz diorite intrusive is located directly beneath the pipe.

Four types of fluid inclusions were distinguished and analyzed microthermometrically. Type I consists of vapor and liquid; Type II contain vapor, liquid, and halite; Type III consist of vapor, liquid, halite, and sylvite; Type IV consist of vapor, liquid, halite, sylvite, and one or more other solid phases.

Petrologic and fluid inclusion data indicate that 3 hydrothermal events occurred. The first event is represented by type III and IV inclusions, the second by type II inclusions, and the last by type I inclusions.

Fluid inclusion leachates were analyzed by ion chromatograph. Na, K, Li, NH_4, Cl, SO_4, NO_3, and Br were separated.

Data from fluid inclusion and petrologic studies were combined with available thermodynamic data to create a model for ore transportation and deposition processes. Copper and iron were carried in solution as CuCl and $FeCl^+$. Ore deposition occurred at 250° to 350°C. A decrease in T is probably the primary cause of ore deposition, but an increase in pH and decrease in chloride concentration may also be important. (Author's abstract)

WOLERY, T.J. and JACKSON, K.J., 1986, Activity coefficients in aqueous salt solutions - The ion size problem (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 793.

WOOD, B.J. and GRAHAM, C.M., 1986, Infiltration of aqueous fluid and high fluid:rock ratios during greenschist facies metamorphism: A discussion: J. Petrol., v. 27, Part 3, p. 751-761.

WOOD, B.J. and WALTHER, J.V., 1986, Fluid flow during metamorphism and its implications for fluid-rock ratios, in J.V. Walther and B.J. Wood, eds., Fluid-Rock Interactions during Metamorphism, New York, Springer-Verlag, p. 89-108.

WOOD, P.C. and SPOONER, E.T.C., 1986, Hydrogen and oxygen isotope geochemistry of Archean Au-quartz vein mineralization, Hollinger deposit, Timmins, Ontario (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 794. Authors at Dept. Geol., Univ. Toronto, Toronto, Canada M5S 1A1.

The hydrogen isotope composition of the Hollinger main stage Au mineralization has been determined by nine, to date, δD determinations directly on fluid inclusion H_2O in vein quartz (5) and scheelite (4). The δD measurements define a significant range of 35‰ from -74‰ to less negative values high as -39‰ and an arithmetic mean of -57 ± 12‰ (1σ). Six of the nine determinations lie exactly within the general magmatic δD range (-85‰ to -50‰) of Taylor (1979). Three δD values are less negative (-47‰, -43‰ and -39‰) and are presently interpreted to be a result of hydrogen isotopically light CH_4 in the inclusion. Similarly Hollinger fluid $\delta^{18}O$ values of +4.7 ± 0.5‰ (1σ; n = 24) derived from carbonate, quartz and scheelite $\delta^{18}O$ measurements are closely comparable with estimates for the $\delta^{18}O$ values of Mink Lake Au and W enriched MoS_2 fluid (+6.0 ± 1.9‰, 1σ, n = 19) which has been shown to be of magmatic origin. Hence, the Hollinger δD and $\delta^{18}O$ values are consistent with a magmatic derivation for the main stage Au fluids. These new data provide further evidence in support of a magmatic origin for the Hollinger-McIntyre Au-quartz vein ore fluids (Spooner et al., 1985; Burrows et al., in press). (Authors' abstract)

WOOD, P.C., BURROWS, D.R. and SPOONER, E.T.C., 1986, Au-quartz vein and intrusion-hosted Cu-Au-Ag-Mo mineralization, Hollinger-McIntyre mines, Timmins, Ontario: Geological characteristics, structural examination, igneous and hydrothermal alteration geochemistry, and light stable isotope (hydrogen and oxygen) geochemistry: Ontario Geol. Survey Miscellaneous Paper 130, p. 115-137. Authors at Dept. Geol., Univ. Toronto, Toronto, Canada.

Hollinger fluid $\delta^{18}O$ values of +4.7 ± 0.5‰ (1σ; n = 24) derived from carbonates, quartz, and scheelite measurements are closely comparable with estimates for the Mink Lake Au- and W-enriched MoS_2 fluid (+6.0 ± 1.9‰; n = 19) which is provably of magmatic origin. Similarly, six out of nine direct fluid inclusion H_2O δD measurements (-57 ± 12‰; 1σ) also lie within the general magmatic range (-85‰ to -50‰) of Taylor (1979) and, therefore, add further evidence in support of a magmatic origin for the Hollinger-McIntyre Au-quartz vein ore fluids. (From the authors' abstract)

WOOD, S.A., 1986, Experimental data bearing on the separation of gold and base metals in Archaean greenstone belts (abst.): GAC-MAC Program with Abstracts, v. 11, p. 146.

WOOD, W.W., JONES, B.F. and OSTERKAMP, W.R., 1986, Origin of solutes in saline lakes of the southern High Plains, Texas and New Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 794. First author at U.S. Geol. Survey, 431 National Center, Reston, VA 22092.

The observations are consistent with a source of the solutes in the saline lakes largely from the High Plains aquifer and then by concentration by evaporation. (From the authors' abstract)

WOODING, R.A. and WHITE, I., eds., 1984, Convective flows in porous media; Proceedings of a seminar at Wairakei, N.Z., 3-4 May, 1984: DSIR Sci. Info. Pub. Ctr., Wellington, N.Z., 208 pp.

WOODLAND, Alan and WALTHER, John, 1986, Experimental determination of the solubility of Na and K feldspar + mica + quartz assemblages in supercritical H_2O (abst.): EOS, v. 67, p. 388. Authors at Dept. Geol. Sci., Northwestern Univ. Evanston, IL 60201.

The results indicate Al can be readily transported in low chloride solutions to T and P as low as 350°C and 1 kbar as an alkali-Al complex. (From the authors' abstract)

WONG, Ling-bao, CHEN, Dai-zhang and WANG, Pu, 1986, Mineralogy of Fankou lead-zinc deposit in northern Guangdong province, China (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 267. Authors at Research Gr. of Mineralogy, Beijing Graduate Sch. of Wuhan College of Geol., 29 Xueyuan Road, Beijing, China.

The geological, mineralogical and geochemical studies of ore bodies and the studies of mineralizations, wall rock alterations and their mutual relations, and of fluid inclusions and carbon, oxygen, sulfur and lead isotope compositions of minerals indicate that the Fankou lead-zinc deposit is one special type of hydrothermal metasomatic deposit formed from a series of carbonate rocks replaced by an ascending polygenetic hydrothermal fluid and associated with dynamic forces in the course of formation of the mineral deposit. (From the authors' abstract)

WOPENKA, Brigitte and PASTERIS, J.D., 1986, Limitations to quantitative analysis of fluid inclusions in geological samples by laser Raman microprobe spectroscopy: Applied Spectroscopy, v. 40, no. 2, p. 144-151. Authors at Dept. Earth & Planet. Sci. & McDonnell Center for Space Sci., Washington Univ., Box 1169, St. Louis, MO 63130.

The theoretical parameters underlying quantitative Raman spectroscopy [relative normalized differential Raman scattering (RNDRS) cross sections] are discussed. A method is described [based on Placzek's polarizability theory (see text for reference)] by which relative abundances of species of geological interest (e.g., CO_2, CH_4, SO_2) in individual fluid inclusions are analyzed in practice. Whereas the precision of the analysis is determined by "practical limitations" (which include counting statistics and instrumental reproducibility), its accuracy depends on "practical" as well as "theoretical limitations." The latter are due to uncertainties in the available RNDRS cross sections. These uncertainties are so large (or even unknown to date, e.g., for liquid or high-P gas phases) that it becomes very difficult to estimate the accuracy of the final result. By making the (not very realistic) assumption that the RNDRS cross sections available in the literature apply to the individual fluid inclusion under analysis as well as to the instrumental configuration, we determined the mean composition of a set of synthetic fluid inclusions to be 14.8 ± 2.0 mole % CH_4 and 85.2 ± 2.0 mole % CO_2. (Authors' abstract)

WU, Shangquan, 1986, Main geological characteristics and genesis of the Xiaoxinancha copper-gold deposit in Jiling Province (China): Kuangchuang Dizhi, v. 5, no. 2, p. 75-84 (in Chinese; English abstract). Author at Res. Inst. Metal.-Geol. Explor. Co. of Jilin Province, PRC.

The Xiaoxinancha deposit is of mesothermal Cu-Au quartz vein type genetically related to late Hercynian intermediate-acid intrusive complexes with ore bodies occurring within quartz diorite or at its contact with

Permian horn-stone xenolith. Wall rock alterations are predominantly K-feldspathization, biotitization, silicification, and sericitization. Mineralogy, geochemistry, and isotopes of S, Pb, and O are reported. The ore-forming materials are derived from comparatively young magmatic [fluids] and the inclusions in quartz are characterized by $K^+ > Na^+$ and low contents of Ca^{+2} and Mg^{+2}, which may account to a great extent for the association of Au and Cu. (Modified from the author's abstract)

WYLLIE, P.J. and RUTTER, Mick, 1986, Experimental data on the solidus for peridotite-CO_2, with applications to alkaline magmatism and mantle metasomatism (abst.): EOS, v. 67, p. 390.

XAVIER, R.P., BARBOSA, J.F., VALARELLI, J.V., IYER, S.S., CHOUDHURI, A. and CORDANI, U.G., 1986, Late carbonic fluids in high grade metamorphism, Jequié Complex, Bahia (Brazil): XXXIV Brazilian Geol. Congress, Bull. No. 1 - Abstracts and short communications, p. 171-172, Goiania, Goias State (in Portuguese; English abstract). First author at Univ. Campinas, Campinas-SP, Brazil.

Preliminary results of fluid inclusion studies together with petrological data on granulites from the Jequié Complex, Bahia, indicate low density, CO_2-rich fluids related to late metamorphic stages.

The Jequié Complex main lithologies comprise massive and relatively homogeneous charnockites, charno-enderbites and enderbites as well as migmatitic charnockites and a few metasedimentary sequences geochemically defining a tholeiitic and calc-alkaline series. Mineral parageneses include combinations of ortho- and clinopyroxene, plagioclase, mesoperthite, quartz and hornblende; biotite and microcline are probably retrograde products.

Fluid inclusion studies in quartz from granulites (enderbite and charnockite) show one-phase carbonic inclusions as the most abundant, although subordinate two-phase inclusions ($H_2O + CO_2$) and low salinity aqueous ones also occur. All these types are located predominantly in healed microfractures and/or grouped in planar arrays, indicating their secondary origin. In the microthermometry of carbonic inclusions the Tm is in the -58.2°C/-56.0°C range, with a maximum frequency around -56.6°C, suggesting a practically pure CO_2 fluid. In the two-phase inclusions the Tm CO_2 occurs between limits which suggest the H_2O-CO_2 pure system. The Th CO_2 presents a large variation for carbonic inclusions, showing biomodal patten in their histograms: 15.4-15.8°C/27.8-28.2°C in the enderbite and 12.8-13.2°C/20.0-20.4°C in the charnockite.

In the two-phase inclusions Th CO_2 (always in liquid) is limited in the 28.0-30.2°C range. The carbonic fluids involved in metamorphism of granulite facies are generally high density (>0.95 g/cm^3), but inclusions in granulites from the Jequié Complex indicate relatively low densities (0.65-0.87 g/cm^3) giving a first indication that these carbonic fluids must have been introduced in the system after the peak of metamorphism. Other evidence supporting this hypothesis is given by isochores for carbonic fluids and $H_2O + CO_2$ inclusions. Plotted in a P-T diagram they do not intercept the field for the P-T metamorphic conditions assumed for the granulites, i.e., T = 750-850°C and P = 5.2-6.2 Kb. (Authors' abstract, translated by K. Fuzikawa)

XIA, Linqi, CHENG, Shulan and HUANG, Yuehua, 1986, Magmatic inclusions in minerals of alkali-basalts from Wudalianchi and Jining, China: Acta Min. Sinica, v. 6, no. 1, p. 51-60 (in Chinese; English abstract). First author at Xian Inst. Geol. & Min. Resources, Ministry of Geol. & Min. Resources.

This paper reports the results of the study of magmatic inclusions in minerals of modern K-rich basalts from Wudalianchi volcanos and of

Cenozoic alkali-basalts from Jining.

The magmatic inclusions studied are evolved inclusions. Their host minerals have undergone slow cooling and crystallization. In order to reveal their initial compositions, we can analyze the homogenized inclusions by means of electron microprobe.

The thermobarometric results from magmatic inclusions indicate that olivine phenocrysts in the alkali-basalts of Jining crystallized at 1295°-1310°C and 3.1-3.5 kbar; as for the K-rich basalts from Wudalianchi volcanos, the crystallization of phenocrysts took place in the course of slow ascent and cooling of the magma, as indicated by the decrease of Th from 1308° to 1178°C and CO_2 pressures (from 0.9 kbar to 0.4 kbar in the process of crystallization from olivine to clinopyroxene. (Authors' abstract)

XIA, Linqi and CLOCCHIATTI, R., 1986a Magmatic inclusions in phenocrysts of andesitic lavas, Krakatau volcano, Indonesia: Geochimica, v. 3, p. 1-13 (in Chinese; English abstract). First author at Xian Inst. Geol. & Min. Resources, Ministry of Geol. & Min. Resources.

Sequence of crystallization is established for the magmatic inclusion phenocrysts on the basis of thermometrical and chemical studies: 1) The central phase of plagioclase phenocrysts (An 83.2-72.6) containing type A inclusions, olivine. 2) Intermediate phase of plagioclase phenocrysts (An 61.3) containing type B inclusions, clinopyroxene, titanomagnetite. 3) Peripheral phase of plagioclase phenocrysts (An 54.4-42.6) with type C inclusions. This sequence is accompanied by: a) a progressive drop in Th of magmatic inclusions; b) the host plagioclase changes progressively bytownite to andesine; and c) trapped silicate liquids vary in a progressive manner from andesitic to dacitic.

Thermobarometrical studies permit us to consider that the crystallization of the central phase of plagioclase crystals trapping type A inclusions took place at about 5 kb. The absence of immiscibility in the magmatic inclusions of intermediate and peripheral zones of plagioclase phenocrysts may be interpreted as that immiscibility is favored only by high P. The high titanium contents in type A inclusions favor also the separation of immiscible fluids.

This type of evolution of magmatic inclusions and especially the presence of liquid immiscibility in the magmatic inclusions of early plagioclase phenocrysts is typical of many andesitic lavas generated in subduction regions. (Authors' abstract)

XIA, Linqi and CLOCCHIATTI, R., 1986b The history of crystallization and evolution of labrador[ite] megacryst lapilli from Tolbachik volcano, USSR: Bull. Xi'an Inst. Geol. Min. Res., Chinese Acad. Geol. Sci., 1986, no. 12, p.65-82 (in Chinese; English abstract). First author at Xian Inst. Geol. & Min. Resources, Ministry of Geol. & Min. Resources.

In this paper, the results of studies on the magmatic inclusions in labradorite megacryst lapilli of Tolbachik volcano (USSR) are reported. Based on the studies of magmatic inclusions, the authors try to reconstruct the thermal history and the formation process of this type of labradorite megacryst lapilli. The magmatic inclusions are distinguished into three types: A, B and C. Type A magmatic inclusions, which are non-evolved, are situated in the edge of labradorite megacrysts; type B magmatic inclusions, which are slightly evolved, are situated in the intermediate parts of labradorite megacrysts; type C magmatic inclusions, which are evolved inclusions, are situated in the central parts of labradorite megacrysts.

According to the studies of magmatic inclusions, the following mineral crystallization sequences are established: central parts of labradorite megacrysts (An 58.7-62.7, Txl: 1220 ± 20°C) → intermediate parts (An 58.3-

58.5, Txl: 1180 ± 10°C) → the edge of labradorite megacrysts (An 57.2-57.6, Txl: 1160 ± 5°C).

Microprobe analyses show that the chemical compositions of magmatic inclusions correspond with those of an alkali-basaltic magma. With decrease in Txl, the sodium contents increase from center to edge of the labradorite megacrysts: An 62.7 → An 57.2. At an intermediate stage of crystallization olivine, augite and labradorite crystallize simultaneously.

The study of experimental petrology of magmatic inclusions permits us to directly utilize the natural magma trapped in the magmatic inclusions for making an experiment in magma crystallization. Based on the experiment of magma reanimation and experimental crystallization of magmatic inclusions, the last thermal events undergone by the labradorite lapilli have been reconstructed, from edge to center of labradorite lapilli the maximum thermal gradient may attain 110°C. In the course of formation of the labradorite megacryst lapilli, the T and the cooling rate are the major factors controlling their crystallization and growth. (From the authors' abstract)

XIA, Weihua and CHEN, Ziying, 1984, The discovery of melt inclusions in topaz and quartz and its significance to genesis of Ta-Nb granites in southern China: Earth Sci. - J. Wuhan College Geol., no. 2 (no. 25), p. 79-83 (in Chinese; English abstract).

Melt inclusions in topaz and quartz have been first discovered by the authors in W-Sn-Nb-Ta granites Yanshan Period in Nanling. Inclusion size is 5-20 µm. The inclusions consist of crystalline [materials] + gas; some inclusions in quartz consist of semicrystalline [materials] + gas, with the ratio gas/solid is 30-40%[sic]. P gas inclusions coexist with melt inclusions in topaz, the ratio gas/liquid is 70-90%.

Starting melting temperature of melt inclusion [Te?] is 540-650°C. Th is ~700-900°C (in quartz) and 750-800°C (in topaz). For the P gas inclusions, the T is 520-550°C.

Based on characteristics of inclusions we believe that: 1. Topaz and quartz are magmatic materials; 2. The medium in which topaz and quartz crystallized [was a] coexisting system of melt an fluid; 3. Petrogenic magma may be formed in the lower part of the earth crust; 4. This massif is the result of crystallization differentiation of granitic magma; and 5. The possible origin of the Nb-Ta mineralized Li-F granites of Yanshan Period in Southern China is magmatic. (Authors' abstract)

YANG, Songnian and MIAO, Yuanxing, 1986, Geological characteristics of the Changba-Lijiagou lead-zinc deposits in Gansu Province: Mineral Deposits, v. 5, no. 2(16), p. 14-23 (in Chinese; English abstract). Authors at Beijing Inst. Geol. for Mineral Resources, CNNC.

The Changba-Lijiagou Pb-Zn deposit, one of the major Pb-Zn deposits in China, lies in the east of the Xicheng Pb-Zn ore field. There exist six main ore bodies which occur respectively in marble, crystalline limestone and biotite quartz schist and are conformable with the host rocks in stratoid forms. Ore minerals are rather simple with galena, sphalerite and pyrite as the main constituents; gangue minerals are chiefly quartz, calcite and barite. Ore possesses 8-12% Pb + Zn and has striped-laminated, massive and aphanitic colloid banded structures. The associated useful components are Ga, Ge, Cd, In, Tl and Ag and harmful components are As and Sb. Wall rock alterations are weak.

Sulfur isotopes are enriched in heavy sulfur with $\delta^{34}S$ values being 7.1-27.81‰ (Fig. 4); lead in the ore is normal lead and U-Pb ages fall within 293-508 Ma; $\delta^{18}O$ and $\delta^{13}C$ values of calcite from ore and marble are close to those of Devonian marine facies carbonate rocks. Inclusions in minerals, mostly of gaseous phases, are less in quantity and small in size and belong to Na^+-Cl^--SO^{-2}[sic] type brine, with the Th being 90-318°C (Fig. 5). The authors consider that it should belong to hot brine sedimentary-reformation type stratabound deposit. (From the authors' abstract)

YANG, Songnian, MIAO, Yuanxing, YANG, Daping and YIN, Shuli, 1986, Metallogenetic characteristics and controlling factors of Lower Proterozoic Pb-Zn deposits in Liaoning and South Jilin: Geol. & Prospecting, v. 22, no. 10, p. 6-12 (in Chinese).

Apparently includes some fluid inclusion studies. (E.R.)

YANG, Songnian, MIAO, Yuanxing, YE, Xin and WANG, Lijuan, 1985, Characteristics of fluid inclusions in minerals from Xicheng Pb-Zn ore field and its metallogenic significance: Geol. & Prospecting, v. 21, no. 7, p. 15-22 (in Chinese).

Includes many gas analyses for H_2, O_2, N_2, CH_4, CO, CO_2, and H_2O, as well as temperature histograms (100-400°C) and analyses for F, Cl, SO_4, K, Na, Ca, and Mg. (E.R.)

YARDLEY, B.W.D., 1986, Fluid migration and veining in the Connemara schists, Ireland, in J.V. Walther and B.J. Wood, eds., Fluid-Rock Interactions during Metamorphism, New York, Springer-Verlag, p. 109-131.

YARDLEY, B.W.D. and BOTTRELL, S.H., 1986, Chemistry of a magmatic-hydrothermal fluid from St. Austell (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 25. Authors at Dept. Earth Sci., University of Leeds, Leeds, LS2 9JT, UK.

Quartz grains in a topaz-tourmaline-quartz rock from St. Mewan Beacon, St. Austell, (supplied by David Manning) contain abundant aqueous fluid inclusions, many of which have a cubic isotropic dxl, and some also a birefringent dm. The variable proportion of dxls present indicates a range in total ionic strength.

Crush-leach analysis of fluid inclusions in a pure quartz separate (see accompanying poster) yielded the following results, as no. of atoms normalized to 1 Na: K = 0.186, Li = 0.017, Ca - 0.070, Mg = 0.002, Al = 0.020, Fe = 0.074, Mn = 0.014, Cl = 1.721.

In addition, preliminary data suggest Cl/F - 100.

This analysis is indicative of an acid fluid, not equilibrated with alkali feldspar, such as might be derived by retrograde boiling of crystallizing granite. The high Fe (the analyzed concentration is 20 times blank) suggests a direct genetic link with high-T specular hematite ores. The excess negative charge in the analysis is too large to be due to analytical error alone, and may indicate the presence of additional metals in significant quantities, and/or a low pH. (Authors' abstract)

YAROSHCHUK, M.A. and TERESHCHENKO, S.I., 1985, Fluid regime of formation of the ore-bearing rocks and ores of the Belaya Tserkov-Odessa zone of the Ukrainian shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 192-194 (in Russian; translation by Dorothy B. Vitaliano). Author at IGFM of Acad. Sci., Ukrainian SSR, USSR.

The iron ores are concentrated in a carbonate-metabasic ferruginous quartzite formation, progressively metamorphosed to granulite facies, and in the more permeable zones, retrograded and granitized.

CO_2 inclusions are developed mainly in the minerals of progressively metamorphosed pyroxene-magnetite quartzites, metabasites and meta-ultrabasites, and also metasomatites and silicate-magnetite ores of the high-T stage. Single-phase inclusions of CO_2 were established in the pyroxene-magnetite quartzites. In the quartz of the ferruginous quartzites, primary

CO_2 inclusions were observed from time to time. Secondary CO_2 inclusions are more abundant, confined to variously oriented cracks and grouped in chains. The pyroxene and pyroxene-plagioclase metasomatites contain most high-density, essentially CO_2 inclusions, which indicates that they were controlled by permeable zones. High-density CO_2 inclusions also were identified in the silicates of the pyroxene-magnetite and olivine-magnetite ores, but they were less abundant than in the metasomatites. Secondary, essentially liquid, gas-liquid and H_2O-CO_2 inclusions are mainly developed in the quartz of retrograde pyroxene-amphibole-magnetite and amphibole-magnetite quartzites. The extent of development of these inclusions characterizes the intensity of manifestation of retrograding. Abundant secondary, essentially liquid and GLIs are also typical of the serpentinized calciphyres, carbonate-magnetite and hydrosilicate ores. In the carbonate-magnetite and hydrosilicate ores the inclusions are essentially water and low-T gas-liquid.

Thus, study of individual gas-liquid inclusions in the minerals showed that the main components of the fluids in the metamorphic host rocks and ores were water and CO_2. In the progressive stage of metamorphism, gaseous and liquid CO_2 were of main importance, and in the processes of retrograding the role of water and liquid CO_2 increased. The high-T alkaline stage of ore formation occurred under the influence of high-density CO_2 fluids and occurred under conditions similar to the conditions of progressive metamorphism. The formation of the carbonate-magnetite and hydrosilicate ores was accomplished under the influence of gas-liquid and essentially liquid low-T fluids, with the participation of which retrograde processes in the ferruginous quartzites also took place. (From the authors' abstract)

YAROSHEVICH, V.Z., 1985, Genetic peculiarities of the deposits of the major ore formations of Caucasus from the data of the isotope studies: Summary of the Candidate of Sciences dissertation, Tbilisi, 23 pp. (in Russian).
Cited in Naumov, 1986 (this volume).

YAROSHEVICH, V.Z., AREVADZE, D.V. and CHKHAIDZE, Ts.Sh., 1985, Conditions of formation and history of the material of the Dashkesan skarn iron deposit (Azerbaydzhan SSR) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 216 (in Russian; translation by Dorothy B. Vitaliano). Authors at KIMS, Tbilisi, USSR.

The Dashkesan skarn iron deposit occurs at the contact between Middle and Upper Jurassic volcanogenic sedimentary rocks and intrusive bodies of gabbro and granodiorite composition. In the deposit, zoning of the skarns is observed, from pyroxene-garnet at the contact with the intrusive to garnet, actinolite-garnet and quartz-calcite plus sulfides (Kashkay, 1965). Magnetite-hematite ores occur in all types of skarns, in the form of stratiform bodies or disseminated. Integrated thermobarogeochemical and isotopic investigations (Th, Td, cryometry, mass-spectrometry of S, H and O in the crystal lattices of the minerals and H of the water of fluid inclusions) showed:

1. Tf of the minerals of the skarn magnetite association ranged from more than 400 to 250°C. The minerals of the late quartz-calcite association plus sulfides have Tf of 300-150°C. The minimum P, estimated from the difference in T of partial and complete homogenization of multiphase inclusions, is 600 bar.

2. The mineralizing fluids were characterized by a chloride composition with the main cations Na, K, Ca, Fe and Mg. Their concentration dropped from 800-600 g/kg in the skarn stage to 250-100 g/kg when the

quartz-calcite plus sulfides association was deposited, and a correlation is observed between the concentration and T of the solutions. In S inclusions of amethysts (Th ≈ 275°C), solutions of sulfate composition with a concentration of 15 g/kg are recorded, which is of interest in connection with the finding of the Zaglik alunite deposit near the skarn deposits.

3. In the high-T and highly concentrated multiphase inclusions in amethyst, dxls of magnetite were found, which crystallized within the inclusions after conservation of the vacuole, which made it possible to estimate the minimum concentration of Fe in the fluid as ~40 g/kg of solution.

4. The results of isotopic investigations indicate a deep source of the S and C in the fluids. In the early stages of formation of the deposit water arrived from depth, and in the late stages it was mixed with meteoric waters which were actively interacting with the host rocks. (Authors' abstract)

YIH, C.-S., 1986, Movement of liquid inclusions in soluble solids: An inverse Stokes' law: Phys. Fluid, v. 29, no. 9, p. 2785-2787. Author at Dept. Mech. Engrg. & Applied Mechanics, Univ. Michigan, Ann Arbor, MI 48109.

The T distribution in an ellipsoidal liquid inclusion in a soluble solid, with a constant gradient far away from the liquid, and the movement of the liquid inclusion as a whole, which results as a consequence, are investigated. Since the solid is soluble and its concentration in solution is T dependent, any T variation in the liquid induces a concentration variation, which will transfer mass by diffusion, eroding the wall where the T is high and depositing solid material at the wall where the T is lower. This erosion or deposition will cause the liquid inclusion to move, and will, through absorption or release of latent heat, in turn affect the T distribution. From the result obtained for the general ellipsoid, specific results for prolate and oblate ellipsoids of revolution, the sphere, and circular and elliptic cylinders are obtained. (Author's abstract)

YONOVER, R.N., SINTON, J.M. and CHRISTIE, D.M., 1986, ALVIN investigation of the petrological effects of rift failure, Galapagos Spreading Center near 95.5°W (abst.): EOS, v. 67, p. 1185-1186. First author at Hawaii Inst. Geophys., 2525 Correa Road, Honolulu, HI 96822.

Rift failure near 95.5°W occurs in a complex zone in which the failing and doomed[sic] (normal) rifts overlap by about 10 km with an overlap to offset ratio of approximately 1:1. The younger lavas recovered during our 1985 Alvin expedition were from the doomed rift, just as it enters the overlap zone. Doomed rift magmas are relatively restricted in composition, 7.5-8.2 wt. % MgO and become multiply saturated with olivine, plagioclase and cpx at 7.8% MgO, although some more magnesian samples contain cpx xenocrysts. Failing rift (FR) magmas are also differentiated and range in composition from 8.0 to 9.5% MgO with less than 10% FeO* and 1.3% TiO_2. FR magmas are plagioclase-saturated at less than 8.8% MgO, in contrast to Galapagos propagating rift magmas which become plagioclase-saturated at about 8.3% MgO. Melt inclusions analyzed by laser decrepitation mass spectrometry indicate that FR magmas have higher CO_2/H_2O ratios than do FR magmas. Resorbed and/or reversely zoned crystals are common in FR lavas, suggesting a complex thermal history that includes magma mixing. FR magmas do not represent eruption from a gradually crystallizing shallow magma chamber, but rather eruption from a declining asthenospheric upwelling zone without significant evolution in shallow chambers. Thus, magmas erupted in association with diminishing magma supply to a thermally mature environment (rift failure) have a fundamentally different thermal history than do propagating rift magmas erupted in association with increasing magma supply to an anomalously cool environment. (Authors' abstract)

YONOVER, R.N., SINTON, J.M. and SOMMER, M.A., 1986, Petrology and laser decrepitation volatile composition of the Galapagos 95.5°W propagating/dying rift system (abst.): Int'l. Volcan. Congress, Auckland, N. Z, Abstracts, p. 225. First author at Hawaii Inst. Geophys., Univ. Hawaii, 2525 Correa Rd., Honolulu, HI 96822.

A new laser decrepitation analytical system has been developed which enables quantitative volatile determinations to be performed on individual selected fluid inclusions in minerals.* The laser decrepitation capacitance manometry system is coupled with an automated mass spectrometer and a helium ionization detector gas chromatograph to obtain precise volatile (H_2O, CO_2, CO, CH_4, SO_2, noble gases, other hydrocarbons, etc.) and isotopic (carbon and oxygen) compositions. The useful limit of detection (calculated as ten times the typical background level) is about 5×10^{-11} mol of H_2O and 5×10^{-11} mol of CO_2 for inclusions on the order of 25 μ in diameter. A select suite of silicate melt inclusions from the PR/DR system exhibit CO_2/H_2O ratios ranging from .01 to .05 with trace amounts of CH_4 and Ar present. (From the authors' abstract)

*[See Yonover et al., 1984, in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 384-385, and Fluid Inclusion Research--Proceedings of COFFI, v. 18.] (E.R.)

YOULES, I.P., 1986, Mt. Painter uranium deposits, in Vein type uranium deposits, IAEA - TECDOC-361, p. 101-112. Author at Oilmin N.L., Adelaide, Australia.

The Mt. Gee, Armchair, Streiberg Ridge and Radium Ridge primary U deposits consist of uraninite, pyrite, chalcopyrite, molybdenite, monazite, fluorite and barite in a matrix of chlorite and hematite, which infilled and replaced, as layers, a potash rich (10% K_2O), partly sericitized, granitic breccia in the Radium Ridge Beds (interpreted ~700 Ma). Minor amounts of sandstone, siltstone, diamictite and arkose also occur. U content averages 0.1% along with Cu 0.05%, Mo 0.03%, Co 0.035% and Ce group 0.5%. Isotopic data indicate a magmatic origin and fluid inclusions show T of 300°C-400°C with aqueous solutions of low salinity. (From the author's abstract)

YOUNG, C.L., 1986, Phase equilibria in fluid mixtures at high pressures: Pure & App. Chem., v. 58, no. 12, p. 1561-1572. Author at Dept. Phys. Chem., Univ. Melbourne, Parkville, Victoria, 3052, Australia.

The six types of phase behavior observed in binary mixtures are described briefly. Liquid-liquid immiscibility in Type II and Type III phase behavior is discussed in terms of P-T-composition diagrams. The conditions for the coexistence of two phases and the conditions for a critical point in both binary and ternary mixtures are presented. The criticality conditions are given in terms of both the Gibbs and Helmholtz functions. Methods for calculating high P equilibrium in fluid mixtures using these conditions together with a one fluid model are discussed. The use of empirical and theoretically based equations of state to calculate the Helmholtz function are briefly reviewed and the need for caution when using this approach is pointed out. Finally the need for a classification for the phase behavior of ternary mixtures and for liquid-liquid equilibrium data of higher accuracy are considered. (Author's abstract)

YU, Huilong and CAO, Wei, 1986, The geological characteristics and stable isotope composition of the Xujiashan antimony deposit in Hubei Province and its mechanism of ore formation: Geol. Review, v. 32, no. 3, p. 264-275 (in Chinese; English abstract).

ZADNIK, M.G., SMITH, C.B., OTT, U. and BEGEMANN, F., 1986, Isotopic composition of noble gases in diamonds with silicate and sulfide inclusions (abst.): Terra Cognita, v. 6, no. 2, p. 104.

ZANTOP, Half, CHICO, Eduardo and GEMMELL, J.B., 1986, The genetic significance of contrasting metal content, mineral composition and ore textures in veins, mantos and chimneys of the Fresnillo Ag-Pb-Zn deposit, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 18, no. 6, p. 800. Authors at Dept. Earth Sci., Dartmouth College, Hanover, NH 03755.

An investigation of chemical composition, mineral distribution, ore and gangue textures and fluid inclusions from samples of veins and mantos in different parts and at different levels of the mine indicates that several phases of mineralization were involved in their formation. (From the authors' abstract)

ZASHU, S., OZIMA, M. and NITOH, O., 1986, K-Ar isochron dating of Zaire cubic diamonds: Nature, v. 323, p. 710-712. First author at Geophys. Inst., Univ. Tokyo, Tokyo 113, Japan.

U-Pb, Rb-Sr and Sm-Nd systematics in inclusions in diamonds suggest strongly that some diamonds are at least 2.0 Gyr old. Such antiquity is also inferred for some diamonds from their very primitive helium isotopic composition. However, there has been almost no direct radiometric dating of diamonds, except for conventional K-Ar dating, the results of which are questionable due to the possible presence of excess ^{40}Ar. To avoid this problem we have applied a K-Ar isochron dating method to ten diamonds from Zaire. The experimental data show good linear correlations in both the ^{40}Ar-K and ^{40}Ar/^{36}Ar-K/^{36}Ar diagrams. These correlations must reflect either an isochron-type relationship or the trapping of an unknown component in the diamonds. In the former case the anomalously high age (6.0 Gyr) casts doubt on the assumption of uniformity in the isotopic abundance of ^{40}K. (Authors' abstract)

ZATSIKHA, B.V., 1985, Crystallogenesis of accessory xenotime and monazite in post-magmatic formations, in Accessory minerals of rocks, Moscow, "Nauka," p. 73-74 (in Russian).

Cited in Naumov, 1986 (this volume).

ZENG, Yishan, WANG, Fengzhen, HE, Zongli, LIU, Guoping, WANG, Chengqiang and HAO, Jicheng, 1986, Study on composition of inclusions in minerals and simulation experiment on hydrothermal metasomatic process of the Bayan Obo iron deposit: Acta Geologica Sinica, v. 60, no. 4, p. 352-364 (in Chinese; English abstract). Authors at Dept. Geol, Peking Univ.

On the basis of the mechanism of formation of mineral inclusions, it may be assumed that a certain relation exists between the compositions of fluid inclusions in various minerals formed at the same stage of hydrothermal activity. In order to study the genetic relationships in between different minerals in the Bayan Obo iron deposit, the compositions (K^+, Na^+, Ca^+, Mg^+, F^+, Cl^+[sic], ΣCO_2, $SO_4{}^{2-}$ and pH) of inclusions in fluorite (23), hematite (13), magnetite (3), sodium pyroxene (2) and dolomite (5) from the main mine and the eastern mine were determined by using the vacuum decrepitation and leaching methods, and cluster analyses of the data on the compositions were made. The Q-mode cluster analysis indicates that some iron oxide minerals in the deposit are related to dolomite of sedimentary origin, while others are related to fluorite and sodium pyroxene--products of hydrothermal activity. The R-mode cluster analysis shows that the components of the leaching solution may be divided into two groups: one includes ΣCO_2, Mg^{2+} and H^+ (pH), which are obviously associated with dolomite; the other comprises Na^+, K^+, Ca^+, F^+, Cl^- and SO_4^{2-}, which may possibly represent the composition of hydrothermal solutions.

The reaction of the Na-F-Cl solution (pH 4.72) with hematite-dolomite at 300°C and 5 x 10^7 Pa and under alternately "static and dynamic" conditions produced large amounts of hematite and fluorite and small amounts of smectite and Na (Fe)-silicates, and the hematite-fluorite assemblage accords with the actual geological conditions in the deposit. From a comparison between the compositions of "static" and "dynamic" solution samples, it may be known that the flow reaction facilitates the migration of Fe, F, Ca and other components as well as Na-metasomatism (Na and Si are fixed in a solid phase).

The study of the compositions of mineral inclusions and simulation experiments on hydrothermal metasomatism have provided new evidence for the hypothesis of metamorphosed-sedimentary and hydrothermal-remoulding origin of the Bayan Obo deposit, and pointed out emphatically that hydrothermal metasomatism plays an important role in the formation of the mineral deposit, particularly in the main and the eastern mine. (Authors' abstract)

ZHANG, Ligang, 1986a. Stable isotope geochemistry of Mesozoic meteoric water hydrothermal deposits in eastern China (abst.): Terra Cognita, v. 6, no. 3, p. 512. Author at Yichang Inst. Geol. and Mineral Resources, Chinese Acad. Geol. Sci., Yichang City, Hubel, China.

More than 1000 stable isotopic data obtained by the present author and other workers from 40 metallic and nonmetallic deposits in eastern China indicate that the mineralizing fluids were related to Mesozoic meteoric water. (From the author's abstract)

ZHANG, Ligang, 1986b. Stable isotope study of three types of W-Sn deposits in southeastern China (abst.): Terra Cognita, v. 6, no. 3, p. 532. Author at Yichang Inst. Geol. & Mineral Resources, Chinese Acad. Geol. Sci., Yichang, Hubel, China.

The 32 W-Sn deposits in southeastern China are divided into three types based on more than 500 oxygen isotope compositions of minerals and rocks, and considerable hydrogen, sulfur, carbon and lead isotope data of minerals or fluid inclusions in the deposits:

(1) Reequilibrium magmatic water W-Sn veins closely related to W-Sn type granitoids with high ^{18}O values. In these deposits, including Xihuashan, Piaotang, etc., the $\delta^{18}O$ values in quartz samples in the main ore-forming stage are from +11 to +14 per mil; wolframites have $\delta^{18}O$ values ranging from +4.5 to +7.0 per mil. Calculated $\delta^{18}O(H_2O)$ values for fluids in equilibrium with the quartz range from +4.5 to +8.5 per mil, and the $\delta D(H_2O)$ values of fluid inclusions in the quartz range from -40 to -65 per mil. The $\delta^{34}S(\sum S)$ values of sulfides are about 0 per mil and carbonates have $\delta^{13}C$ values ranging from -6 to -9 per mil. Thus, the $\delta^{18}O(H_2O)$, $\delta D(H_2O)$, $\delta^{34}S(\sum S)$ and $\delta^{13}C(\sum C)$ values are within the limits of reequilibrated magmatic waters.

(2) Mesozoic meteoric water hydrothermal W-Sn deposits are of veinlet disseminated or breccia style. The deposits are situated in the contact zone of subvolcanic intrusions (Lianhuashan, Xiling, etc.) or in fault zones within sedimentary rocks (Dachongshan). In the former, quartz and wolframite have $\delta^{18}O$ values ranging from +10 to +7 per mil, and +2 to -2 per mil, respectively, but in the latter, the $\delta^{18}O$ values are about +17 and -2 per mil, respectively.

(3) Some of these deposits (such as Woxi, Fengling, etc.) are stratiform. The age of mineralization is Precambrian at Woxi but Devonian at Fengling. $\delta^{18}O$ values of quartz and wolframite in these deposits are about +20 and +3 per mil, respectively. The δD values of fluid inclusions in quartz at Woxi are from -60 to -80 per mil, and sulfides have $\delta^{34}S$ values ranging from +15 to -10 per mil; $\delta^{34}S$ values vary within the stratigraphic sequences. The origin of the stratiform W-Sn deposits is related to submarine exhalative activity. (Author's abstract)

ZHANG, Meidi, 1985, On ore finding method using heat released CO_2: Geol. & Prospecting, v. 21, no. 7, p. 52-58 (in Chinese).

Probably involves evolution of CO_2 from inclusions. (E.R.)

ZHANG, Ronghua, 1986, Sulfur isotopes and pyrite-anhydrite equilibria in a volcanic basin hydrothermal system of the middle to lower Yangtze River valley: Econ. Geol., v. 81, p. 32-45. Author at Chinese Acad. Geol. Sci., Baiwanthuang Road 26, Beijing, China.

If sulfur isotopes equilibrated between pyrite and anhydrite, then these fractionations imply mineralization T of 550° to 310°C. These T are roughly 100°C higher than fluid inclusion Th for the same anhydrites, suggesting probable sulfur isotope disequilibrium between coexisting pyrite and anhydrite. (From the author's abstract)

ZHANG, Wenhuai, ZHANG, Enshi and CHEN, Ziying, 1984, The research of mineral inclusions and a discussion on genesis of Tieshan iron deposit, Daye, Hubei: Earth Sci. J. Wuhan College Geol., no. 4 (no. 27), p. 89-98 (in Chinese; English abstract).

Some studies of mineral inclusions of the Tieshan Fe deposit have been made. According to [the inclusion] types, Th, Td, and data of gas analysis, the authors suggest that the mineralization process in this Fe deposit can be classified as two processes: ore magma and hydrothermal processes. There is close connection between these two processes and they have their respective characteristics. Generally speaking, the ore magma played a chief role in the formation of major Fe bodies, therefore this Fe deposit was a multiple ore deposit, containing a series of processes from magma injection to hydrothermal. (Authors' abstract)

ZHANG, Y.-G. and FRANTZ, J.D., 1986, Determination of the homogenization temperatures and densities of supercritical fluids in the system $NaCl-KCl-CaCl_2-H_2O$ using synthetic fluid inclusions (abst.): EOS, v. 67, no. 44, p. 1259. First author at Centre de Recherches Petrogr. et Geochem., 54501 Vandoeuvre les Nancy Cedex, France.

Synthetic fluid inclusions were produced experimentally by equilibrating small fractured prisms of quartz with aqueous solutions at temperatures from 300 to 700°C at pressures of 1000, 2000, and 3000 bars. Solution compositions included: 0.500, 2.000, and 4.500 molal NaCl; 0.500, 2.000, and 4.500 molal KCl; 0.50 and 2.00 molal $CaCl_2$; and H_2O. The homogenization temperatures of the synthetic fluid inclusions were analyzed by microthermometry. Plots of homogenization temperatures as a function of experimental temperature and pressure indicate that lines of constant homogenization temperatures are linear and intersect the liquid-vapor curve at the homogenization temperature. For each of the four chemical systems, a relatively simple function was developed by which the homogenization temperature can be described as a function of temperature, pressure, and molality:

$$P = A_1 + A_2T$$

$$A_1 = 6.100 \times 10^{-3} + (2.385 \times 10^{-1} - a_1)Th - (2.855 \times 10^{-3} + a_2)Th^2 - (a_3Th + a_4Th^2)m$$

$$A_2 = a_1 + a_2Th + 9.888 \times 10^{-6}Th^2 + (a_3 + a_4Th)m$$

where m is the molality, Th is the homogenization temperature, and a_1, a_2, a_3, a_4 are constants fit to the data sets of each of the four chemical systems. Ten parameter polynomial regressions are given for the densities of the solutions on their liquid-vapor surfaces as functions of temperature and composition. These functions combined with the previous equation permit calculation of the density as a function of temperature, pressure, solute, and solute concentration in the supercritical region. The results of these experiments are compared to those of Potter and Brown (1977) and Hilbert (1979). (Authors' abstract) Continued next page.

Note: In a later publication of this abstract, at the 1987 ECRFI meeting, the last term in the definition of A_2 is changed to "($a_3 + a_4Th^2$)m." (E.R.)

ZHANG, Z.Y. and ZENG, Z.R., 1986, The character of mineralizing fluid evolution of Yunlung tin ore deposit: Miner. & Rocks, v. 6, no. 2, p. 9-23 (in Chinese; English abstract). Authors at Inst. Geol. Nonferrous Prosp. Co. SW China.

Yunlung Sn ore deposit is located Western Yunnan, China. The deposit consist of vein-like ores which are rich in Sn, and constitute a megadeposit. The mineral assemblage is simple and the principal metallic mineral is coarse grained cassiterite.

The property and evolution of mineralizing fluid was understood mostly by studying the fluid inclusion. From this result, we have rated the probable mechanism of Sn ore formation. The conclusion is following:

(1) The mineralizing fluid was an inhomogeneous and immiscible system.

[Balance of abstract missing from available copy.] (Authors' abstract)

ZHAO, Xicheng, 1986, Characteristics of inclusions in some types of ore deposits: Their application to the genesis of ore deposits (abst.): Int'l. Min. Assoc. Abstracts with Programs, p. 281. Author at Lab. of Rock-forming & Ore-forming, Dept. Geol., Changchun College of Geol., PRC.

A review of fluid inclusion studies in PRC and their pertinence to ore deposition research. (E.R.)

ZHENG, M.H. and LIU, J.M., 1986, On ore-forming conditions of the Zhilingtou gold-silver ore deposits, Zhejiang province: J. Chengdu College of Geol., v. 13, no. 2, p. 16-29 (in Chinese; English abstract). Authors at Chengdu Coll. Geol., Chengdu.

The Zhilingou Au-Ag deposit consists of extensive quartz veins in Precambrian metamorphic strata. It is supposed that convecting hot rain water mobilized the Au and Ag in the surrounding rocks, and concentrated them in tensile shear fissures.

According to fluid inclusion study, the ore deposit formed in the range 160 to 350°C and at a depth of about 2 km. The average T of the early ore-forming stage is 320°C and that of the main stage is 270°C. In the ore-forming process, the decrease of P was large, and the ore fluid boiled more than once.

The ore-forming solution is acidic, oxidizing and poor in S. Both Cl activity and salinity of the solution are of intermediate magnitude.

The Au and Ag in the metamorphic rocks were mobilized and got into the solution through the following reaction:

$$M + 2Cl^- + H^+ = 1/4O_2 \rightleftharpoons MCl_2^- + 1/2H_2O$$

and migrated in the forms of $AuCl_2^-$ and $AgCl_2^-$.

When the ore-forming fluid converged into the low P zone, a tensile shear fissure, the P lowered drastically and made the fluid boil. In response, the pH value and salinity of the fluid rose, and the Cl^- activity dropped. Together with the decrease of T, ore-forming material in solution precipitated. (Authors' abstract)

ZHENG, Xiangshen and LI, Jiaju, 1986, A study of the solid inclusion composition in the pantellerite from the Baitoushan volcano: Acta Petrol. Sinica, v. 2, no. 1, p. 33-39 (in Chinese; English abstract). First author at Inst. Geol., Acad. Sinica.

In the evolving stage of the alkaline magma from Baitoushan volcano, alkaline rocks, alkali-quartz-trachyte and pantellerite appeared in proper order; in [these rocks] there are many solid-state [melt?] inclusions in the phenocrysts, especially in anorthoclase and quartz. Three kinds of inclusions from pantellerite have been analyzed by electron microprobe.

The different associations of several distinguishable phases and the different compositions in distinct inclusions show a heterogeneity of melt. The composition of solid [melt?]inclusions could have been changed by the precipitation of host mineral on the inclusion's wall and the crystallization of dxls, so that they probably represent only the composition of a residual melt when a phenocryst phase stopped crystallizing rather than that of a parent magma during initial crystallization. These compositions provide some information about the evolving trend of a magma.

The result from studying the solid [melt?] inclusion's composition, which is consistent with the conclusions from petrological and petrochemical evidences, suggests that the fractional crystallization of anorthoclase controls the evolution of Baitoushan alkaline melt from alkali-quartz-trachyte to pantellerite, and the acmite-augites have only a small effect on the evolution. (Authors' abstract)

ZHENG, Yongfei, 1986, Cooling history and its metallogenic significance on the Huangmeijian body (abst.): Kexue Tongbao, v. 31, no. 6, p. 430-431 (in Chinese; English abstract). Author at Nanjing Inst. Geol. & Mineral. Resources, China.

English abstract mentions a Td of about 190°C for a uranium deposit at the contact of the Huangmeijian quartz syenite body. (E.R.)

ZHILINSKIY, G.B., KISLITSYNA, V.P., IVANYUK, B.O. and KARABAYEV, I.B., 1985, A model for the formation of tin-ore deposits in closed systems with a temperature gradient (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 123-124 (in Russian; translation by D.A. Brown). First author at Magadan Br. of the Khar'kov [could be Khabarovsk] Polytechnic Inst., Magadan, USSR.

Detailed studies have been made of the tin-ore deposits of the Soviet Northeast and other tin-bearing provinces. These have involved thermobarogeochemistry and experimental modelling of processes, radioisotope studies of the kinetics of mass-transfer and crystallization of cassiterite with a detailed study of the T fields, and heat convection of solutions under high T-P conditions of processes in closed ore spaces, have suggested the so-called 'autoclave model' as a fundamental basis for ore deposition. It has been shown that mass-transfer and hydrothermal crystallization of cassiterite may be achieved without the involvement of halides and from extremely weakly-mineralized bicarbonate solutions, possibly even not juvenile, but vadose in origin. The active mineralizer in the hydrothermal systems studied is OH^-, which forms readily-mobile hydro-complexes of tin, extraordinarily sensitive to T-P changes.

The motive force in such a hydrothermal closed system ('natural autoclave') is the heat field in fissure cavities, in which convective mass-transfer of the solution material takes place from low (feeding) to high horizons where as a consequence of T-gradient, these solutions become supersaturated and the dissolved substances crystallize on the cavity walls. During these processes, the role of convection currents in the solution, the movements of which are predetermined by the T field, is extraordinarily important. This field has a complex configuration with crowding of isotherms near the heat source (usually intrusive stocks), and in the uppermost parts of the vein cavity being heated not from outside, but by the solution itself. Under such conditions, a 'non-gradient zone' is always formed, which plays an important role in the hydrothermal process, predetermining the nature and routes of movement of the convection currents in the closed system, and consequently, deposition and distribution of the minerals in the fissure spaces.

The T studies carried out on the Iul'ta deposit have shown that the T field corresponds in section and dip of the veins to the experimental model. Th for GLIs through vein sections indicates a T rise by 5-15°C from their axial portions to the selvages, and the isotherms bend downwards. The T-gradient along the dip of the veins is 2-40°C/100 m, and in the exposed part of the deposits, the average value is 18°C/100 m. The lowest T-gradient at 1-2°C/50-60 m along the dip of the veins corresponds to the 'non-gradient zone'. The distribution of the high- and relatively low-T minerals in the veins, according to the T-field and its gradient, is as follows: the bulk of the primary minerals (cassiterite) is located on the lower horizons along the selvages, and smaller amounts, along with wolframite and quartz are unevenly distributed in the higher horizons.

Analyses of the salts and gases in the GLIs show that crystallization of cassiterite in the peri-ore veins took place from weakly mineralized hydrocarbonate-sulfate solutions with large concentrations of Na and K. CO_2 played a leading role among the gases.

The data indicate that the ore veins in the Iul'ta deposit were formed in a closed hydrothermal system with a T-gradient. Such a model is probably characteristic for most of the tin and rare-metal deposits, located in apical rises of intrusive massifs. (Authors' abstract)

ZHIROVA, L.T. and KOVALISHIN, Z.I., 1985, Temperature of formation and chemical particulars of apatite of carbonatite deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 163-164 (in Russian; translation by Dorothy B. Vitaliano). First author at GIGKhS, Lyubertsy, USSR.

Apatite from two types of carbonatite deposit was investigated: concentrically zoned (Magan, Yessey, Yraas, and others) and linear (Chernigovsk and Tatar and others). Apatite of the first type of deposit is characterized by a multiplicity of shapes and sizes and diversity of chemical composition, and contains different types of P inclusions (liquid-gas, gas-liquid, with one, two or three solid phases). In the second type of deposit, apatite is relatively uniform, the paragenetic relationship to other components is slight, and P inclusions are rare (Tatar) or almost absent (Chernigovsk).

In bodies of concentric type Th of microinclusions in apatite occurs in a wide interval, from 135 to 1010°C. In most apatite Th is at 320 to 450°C, with fewer inclusions homogenizing to the gaseous state, more to the liquid state. Melting of the glass phases occurs >800°C.

In bodies of linear type, no essential break in time of formation of apatite is observed. Th of gas-liquid inclusions in apatite of the Tatar body sets in at 330-370°C

In the gas phase of inclusions there were identified: CO_2, CH_4, H_2, and N_2 (the last two components predominate). A high content of CO_2 (from 63.3 to 100% by volume) is typical only of inclusions in apatites from calcite carbonatites of the Chernigovsk deposit; in apatite from other deposits it is <4.5 vol.%. The highest CH_4 content (<6.0 vol.%) is typical of apatite from bodies occurring in carbonate sediments; in apatite from bodies located in gneisses, CH_4 does not exceed 2.7 vol.%. A high content of H_2O is typical of apatite concentrated in the marginal parts of the bodies (in fenites).

The temperature and geochemical investigations that were made, along with geological observations, make it possible to draw the conclusion that apatite in bodies of central type formed throughout their formation, but most of it was formed in the final stages of development of the bodies. In bodies of linear type apatite formed syngenetically with the formation of the carbonatite.

Thus the results of the investigations contribute to a solution of several genetic problems and make it possible to concentrate prospecting for apatite on certain parts of the bodies. (From the authors' abstract)

ZHU, Shouhua, 1984, Rounded mineral inclusions in xenoliths from some areas of eastern China and their bearing on the annealing time of mantle peridotites: Acta Mineral. Sinica, no. 4, p. 323-328 (in Chinese; English abstract). Author at Inst. Geochem., Acad. Sinica.

Rounded mineral inclusions in rock-forming minerals of mantle-derived peridotite xenoliths from some areas of eastern China have been examined. The calculated equilibrium temperatures of the peridotites by pyroxene geothermometry range from 958° to 1164°C. The critical radius of the maximum rounded inclusion of spinel in olivine is a function of annealing T and time. It is estimated that the annealing time of spinel lherzolites under China's continent is 100-500 m.y. In comparison to the data reported by M. Toriumi, it is suggested that [this time] seems to be longer than that of the peridotites both in the Japanese island arc and in the Hawaii Islands of the intraoceanic plate. (Author's abstract)

ZHUK-POCHEKUTOV, K.A. and OVCHINNIKOV, L.N., 1986, Conditions of formation of the Kacharsk iron ore deposit in the Turgaisk Trough, USSR (abst.): Terra Cognita, v. 6, no. 3, p. 522. Authors at Inst. Mineral., Geochem. & Crystal. of Rare Elements, Moscow, USSR.

The Kacharsk deposit is the largest contact-metasomatic iron ore deposit in the U.S.S.R. It belongs to a relatively rare pyroxene-scapolite-magnetite type.

The fabric of the pyroxene-scapolite-magnetite ores and wallrock metasomatites, as well as the composition (45-88 equiv. wt.% NaCl) and Th (500-750°C) of gas-liquid inclusions in the pyroxene, imply that the formation of the magnetite ores and pyroxene-scapolite metasomatites was affected by magnetite melt enriched in alkaline metal chlorides, and by highly concentrated iron-bearing chloride solutions.

Gradual conversion of halogenide melt into solution, as the former was being saturated with water, is responsible for poorly-defined boundaries between rocks and ores which formed during magmatic and hydrothermal events. (From the authors' abstract)

ZHUK-POCHEKUTOV, K.A., SERDOBOVA, L.I., KATAYEVA, Z.T., ANDREYEVA, I.P., RYABOVA, T.V. and LOGUNOVA, E.V., 1986, REE in anhydrites of the Kacharskoye iron-ore deposit: Geokhimiya, 1986, no. 5, p. 630-635 (in Russian; English abstract).

A Th of 500-750°C is mentioned (p. 633). (H.E.B.)

ZIERENBERG, R.A. and SHANKS, W.C., III, 1986, Isotopic constraints on the origin of the Atlantis II, Suakin and Valdivia brines, Red Sea: Geochimica Cosmo. Acta, v. 50, p. 2205-2214.

ZINCHUK, I.N. and VOVK, P.K., 1985, Conditions of formation of apatite crystals in the hydrothermal veins of the Donbass (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 182-183 (In Russian; translation by Dorothy B. Vitaliano). First author at IGGGI of the Acad. Sci. Ukrainian SSR, L'vov, USSR.

In the quartz and ankerite-quartz veins of the polymetallic shows of the Nagol'nyy Range and North anticline (Donbass), crystals and intergrowths of apatite are found. The apatite is part of the earliest quartz-ankerite association, along with galena and sphalerite, often replaced by quartz of a later generation.

Numerous GLI of water and CO_2+water occur in the crystals. P inclusions as a rule are flattened parallel to the pinacoid {0001}. The fillings of the inclusions (L = 90-95%) and proportions of water and CO_2 phases are constant, which indicates homogeneity of the fluid in the period of formation of the apatite, although in later quartz crystals signs of heterogenization of the fluids are encountered. Th of P and PS ["pseudoprimary"] inclusions in the apatite is 215-135°C; S essentially aqueous inclusions homogenize in a broad range: 145-210°C. In quartz crystals syngenetic with the apatite, a similar complex of inclusions is found. The later crystals of rock crystal were formed from heterogeneous "boiling" CO_2 water fluids at 190-210°C.

Liquid CO_2 under normal conditions constitutes up to 5 vol.% of the P inclusions in the apatite. It was established by mass-spectrometric chemical analysis of the gases (I. M. Svoren', analyst) that CO_2 constitutes 93-95% of the gaseous components of the inclusions. N_2 (3-4%) and CH_4 (up to 2%) are also present.

Microchemical investigations of aqueous extracts from quartz syngenetic with the apatite showed that Na is dominant in the composition of the solutions of the inclusions, with HCO_3, and minor Cl and SO_4. Later solutions, which formed the rock crystal veins, were characterized by an increase in the role of alkaline earths -- Ca and Mg, and sulfate. According to the data of cryometry of the PS in the apatite, the concentration of the solutions was not more than 4-6 wt.%.

The pressure of mineralization in the veins, established on the basis of CO_2-water inclusions of heterogeneous origin in rock crystal, was 40 MPa. This value can be taken as the minimum for the earlier apatite. (From the authors' abstract)

ZINDLER, Alan and HART, Stan, 1986, Helium: Problematic primordial signals: Earth & Planet. Sci. Letters, v. 79, p. 1-8. First author at Lamont-Doherty Geol. Observatory & Dept. Geol. Sci., Columbia Univ., Palisades, NY 10964, USA.

Various lines of evidence suggest that pre-eruptive degassing of basalts is not only important but may dominate the He flux from the mantle to the oceans and atmosphere. These include: (1) correlations between $U/^4He$ ratios and Mg# in volcanic suites, which suggest that $U/^4He$ increases as differentiation proceeds; (2) the observation that $U/^4He$ ratios in MORB average about a factor of 400 lower than those from Loihi Seamount, although $^3He/^4He$ ratios suggest that Loihi is derived from a source with a lower $U/^4He$ ratio than is appropriate for the MORB source; and (3) the ^3He budget of the oceans which, as defined by Craig and Lupton [6], requires that MORB is on average 70-90% outgassed in He. These observations suggest, as noted in [1], that mantle $^3He/^4He$ ratios may be subject to perturbation due to radiogenic accumulation of ^4He in systems where $U/^4He$ has been increased by pre-eruptive degassing.

Models involving continuous diffusive loss (CDL) of He from a magma chamber and exhalative loss (EL) via solution of He in a CO_2-rich gas or fluid phase are investigated. Low $U/^4He$ ratios in MORBs preclude significant pre-eruptive reduction of $^3He/^4He$ ratios; however, OIBs with $U/^4He > 10^6$ may be subject to significant reduction of $^3He/^4He$ (>10%) with pre-eruptive aging over time periods ranging from 1×10^3 to 5×10^5 years. (Authors' abstract)

ZINDLER, A. and JAGOUTZ, E., 1986, Just where is the K in the mantle? (abst.): Terra Cognita, v. 6, no. 2, p. 137-138. First author at Lamont-Doherty Geol. Observatory of Columbia Univ., Palisades, NY 10964, USA.

Geochemists have long known that anhydrous spinel lherzolites (ASLs) are too depleted in alkalis to produce basalts at significant degrees of melting (>1%).

New results from a group of isotopically equilibrated ASLs from Peridot Mesa demonstrate that material included in or associated with fluid inclusions can dominate nodule alkali (and similarly incompatible LIL element) budgets. (From the authors' abstract)

ZIYING, C., 1986, A fluid inclusions study of rare-element mineralized granites in southern China (abst.): Mineral Deposits Studies Group, Ann. Meeting, 15-16 December, 1986, Univ. Southampton, Abstracts, p. 25. Author at Wuhan College of Geol., Yujiashan, Wuhan, China.

There are a few tens of rare-element mineralized granites in southern China. Two contrary points of view on the genesis of these granites (metasomatic and magmatic differentiational) have been reported by many geologists. The following fluid inclusion data from more than fifteen mineralized granites are provided as very strong evidence to support the magmatic origin:

i) Melt inclusions in topaz and quartz have been discovered in W-Sn-Nb-Ta granites. Primary gas-rich inclusions always coexist with metal inclusions in topaz. Starting melting temperature of melt inclusions is 540-650°C. Th is 700-900°C in quartz, 750-800°C in topaz, and 520-550°C for P gas-rich inclusions.

ii) Multiphase immiscible inclusions have been observed in some granites and granite-related pegmatite.

iii) Fluid inclusions data show that fluid evolution from granite-pegmatite-hydrothermal vein was a continuous process.

iv) The medium in which topaz and quartz crystallized was a coexisting melt-fluid system.

v) The possible origin of the Nb-Ta mineralization in Li-, F-rich granites of the Yanshan period in southern China resulted from magmatic differentiation. (Author's abstract)

ZLOTNIK-HOTKEVICH, A.G. and ANDRIANOVA, N.A., 1985, Temperature of ore deposition as a main factor of mineral zoning of the massive sulfide type of ores (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 70-72 (in Russian; translation by I.V. Kulikov and A. Kozlowski). First author at TsNIGRI, Moscow, USSR.

1. Pyrite and chalcopyrite ores [Eds. note: "Kolchedan" type, here translated as "massive sulfide"] with metacolloidal sphalerite-pyrite cement were studied at the Urals deposits of Uchaly, Novii Shemur, Priorskoye, Molodezhnoye. The hydrothermal-sedimentary genesis of these ores is proposed.

2. After Solomon and Walsh (1979) it is believed that saturation of hydrothermal solutions in Cu and Zn is reached at different T: 350-300°C and less than 250°C respectively (...).

3. Upper mentioned theoretical data on the behavior of solutions in the sea "plume" were proved by measuring of T in modern hydrothermal systems of the Pacific Ocean, and by measuring of paleotemperatures of sulphide ores formation in existing deposits. After F. Spiss et al. (1980) the T of modern hydrotherms, that form sulfide ores now at the bottom of the Pacific Ocean, is between 200-380°C.

The lateral T zoning in the ores of deposits was established. At the bottom of the strata of copper or pyrite ores Th are 300-350°C (stockwork ores of Japan, Cyprus), 300-400°C (massive copper ores of the deposits of Priorskoye, Sibai, Uchaly); and in zinc ores of upper part of the stratum a decrease of T is observed - 260, 200-120°C (the deposits of Japan, [and] of the Southern Urals: Priorskoe, the Vth ore body of the [deposit] Uzel'gi [and the deposit of the name of the] XIXth Congress [of the Communist] Party).

The lateral mineral zoning is clearly expressed at the deposit of Rosebury (Solomon and Walsh, 1979), where the N-S zoning of sulfide ores was established. The same zoning is found at Uzel'ga. Th of inclusion in zinc ores at the south of Uzel'ga deposit in the IV-layer are 310°C (at the center) and 200-250°C (at the flanks); in the V-layer it is 250°C and 120-142°C respectively in the center and the upper part, and 240°C at the flanks.

4. At the deposits of the initial T of 250° sulphides of Cu and Zn are deposited together and without vertical zoning. The examples are the Filizchajskoye deposit in the Caucasus (T = 200-100°C by isotope data) and the deposits of the Red Sea rift (T <100°C). (From the authors' abstract)

ZOLOTAREV, V.G., 1986, On the genesis of luzonite-enargite veinlet mineralization in sulphide deposits of volcanic belts (abst.): Terra Cognita, v. 6, no. 3, p. 506-507. Author at Dept. Applied Geol., Univ. Strathclyde, Glasgow G1 1XJ, UK.

Deposition temperatures are unknown but are taken as 300 to 350°C from the sulphide stability fields. Homogenization temperatures are low (100°C, barite, Bor) or vary from 160 to 300°C (barite, alunite and quartz, Chinkuashih). (From the author's abstract)

ZORIN, B.I., KARSKI, B.E. and FORTUNATOV, S.P., 1985, Mineralogical criteria for prospecting for mica-bearing pegmatites (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 23-24 (in Russian; translation by S. Jaireth). Authors at MGRI, Moscow Inst. Geol. & Explor., Moscow, USSR.

Commercially important crystals of muscovite are spatially and genetically related to pegmatites with pegmatoid structure and quartz-muscovite rich country rocks. When biotite is present, muscovite is formed as a metasomatic replacement of it. Quartz, tourmaline, apatite and other minerals of mica-pegmatites are rich in GLI characterized by two main Td intervals: 540-340°C and 280-120°C; the latter interval is characteristic of only mica-pegmatites, which helps to differentiate them from barren pegmatites.

Mica-pegmatites are characterized by T zoning. High-T peaks on decrepitographs (located between 680-340°C) shows gradual shift towards lower-T from fine-grained and graphic pegmatites to those with pegmatoid structure. Low-T peaks (280-120°C) show the opposite tendency, increasing from replacement quartz to quartz-muscovite complexes and pegmatites of pegmatoid, graphic and fine-grained structure. This indirectly indicates autometasomatic nature of residual hydrothermal solutions that moved away from the axial parts towards the peripheral, generating low-T GLIs in mica pegmatites as well as in the exocontact aureoles around these bodies.

Geochemical processes acting within pegmatite bodies have also affected the exocontacts. Petrographic and geochemical aureoles are accompanied by thermal aureoles (<50 cm wide). Exocontact aureoles in rocks around mica-pegmatites show Td at 540-340°C and 280-120°C; such peaks for rocks around barren pegmatites are absent.

Distribution of thermal aureoles is determined by morphology and trend of pegmatite bodies. For steeply dipping, discordant bodies, aureoles are localized along hanging and footwall sides while for concordant and diagonally cutting bodies aureoles are parallel to the strike direction. (From the authors' abstract)

ZORIN, B.I., PAVLOV. Ye.G., 1985, Integrated use of mineralogic-thermobarogeochemical and geophysical methods in prospecting for and exploring economic mica-bearing pegmatite veins (illustrated by the Mama area) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochemistry of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 252- 253 (In Russian; translation by Dorothy B. Vitaliano). Authors at MGRI, Moscow, USSR.

CO_2 content (by gas chromatography) unequivocally establishes the mica-bearing potential of pegmatites and also the prospects of areas on the basis of aureoles of steaming around pegmatites. For instance, in eocnomic pegmatites the CO_2 content is an order of magnitude higher than in those without mica, and reaches 700 g/t. However, the method provides only a threshold, therefore it cannot be recommended for wholesale use.

[In addition to CO_2] several methods of prospecting for economically mica-bearing pegmatites were used, including:

a) large scale (1:2000 and 1:5000; 1200 samples/km^2) decrepitometric mapping (main method); b) radon emanations (by film detectors); c) Gamma-spectrometric surveying; and d) mercury absorption photometry.

These methods are simple, rapid to use and cheap, but each of them has certain limitations (effect of long-lived faults, superposition of post-pegmatite processes, etc.). Taken together, these methods effectively diagnose pegmatites with economic mica content, and their combined use can be recommended for analogous prospecting-exploration work. (From the authors' abstract)

ZOTOV, A.V., BARANOVA, N.N., DAR'YINA, T.G., BANNYKH, L.N. and KOLOTOV, V.P., 1985, The stability of $AuOH^0_{sol}$ in water at 300-500°C and 500-1000 atm: Geokhimiya, 1985, no. 1, p. 105-110 (in Russian; translated in Geochem. Int'l., v. 22, no. 5, p. 156-161, 1985).

ZOTOV, A.V., LEVIN, K.A., KHODAKOVSKIY, I.L. and KOZLOV, V.K., 1985, Thermodynamic parameters of Ag^+ in aqueous solution at 273-573°K: Geokhimiya, no. 9, p. 1300-1310 (in Russian; translated in Geochem. Int'l., v., 23, no. 3, p. 23-33, 1986).

ZOTOV, A.V., LEVIN, K.A., KHODAKOVSKY, I.L. and KOZLOV, V.K., 1986, Thermodynamic properties of Ag(I) chloride complex in aqueous solution at 273 to 623 K: Geokhimiya, 1986, no. 5, p. 690-702 (in Russian; English abstract).

ZOU, Tianren, ZHANG, Xiangchen, JIA, Fuyi, WANG, Rucong, CAO, Huizhi and WU, Boqing, 1986, The origin of No. 3 pegmatite in Altayshan, Xinjiang: Min. Deposits, v. 5, no. 4 (Ser. No. 18), p. 34-48 (in Chinese; English abstract). First author at Inst. Min. Deposits, Chinese Acad. Geol. Sci., Beijing, PRC.

Being of muscovite-microcline-albite-spodumene type, No. 3 pegmatite is composed of 80 minerals which make up 36 mineral assemblages and 10 textural zones, showing typical structure of concentric rings.

No. 3 pegmatite was formed as a result of prolonged slow crystallization differentiation with isotopic ages ranging from 330 Ma to 200 Ma, decreasing gradually from the margin towards the center of the vein.

The stable isotope values of No. 3 pegmatite are as follows: $\delta^{18}O$ (quartz) +11.84‰- +13.87‰, δD (water in fluid inclusions) -86.6‰- -48.4‰, $\delta^{13}C$(CO_2 in fluid inclusions) -6.4‰, $^{87}Sr/^{86}Sr$ (whole rock) 0.7512 and $^{87}Sr/^{86}Sr$ (apatite) 0.7522.

In outer part of the pegmatite (graphic pegmatite), the P inclusions consists of silicate aggregates containing some 20-30 vol.% gaseous phase with Th 930-1100°C. In contrast, the fluid inclusions have Th 620-500°C and salinity of 9.77-0.35 wt.%.

The spodumene-quartz assemblage seems to be the unique lithium aluminosilicate mineral assemblage in No. 3 pegmatite, implying the formation of the rocks through magmatic crystallization under comparatively high P-T conditions.

The conclusion can therefore be reached that No. 3 pegmatite was produced by differentiation of magmas formed through anatexis of upper continental crust. (Authors' abstract)

ZWAAN, P.C., 1986, Gem minerals from the Embilipitiya and Kataragama areas in Sri Lanka: The Australian Gemmol., v. 16, no. 2, p. 35-38. Author at Nat'l. Museum of Geol. & Mineral., Leiden, The Netherlands.

Two-phase inclusions are shown in kornerupine from Embilipitiya. (E.R.)

Translations

Items presented here are selected on the basis of (1) availability of a translation that has not been published elsewhere; (2) significance to inclusion research; and (3) date of publication. Thus particularly significant older items are sometimes included. Further iterations between translator (or author) and editor would make for a more polished translation, but more rapid publication was considered more important than polish. The Editors would welcome suggestions from readers as to other papers that should be translated, and would particularly appreciate copies of privately-made translations not here-to-fore published.

ARNOLD, Michel, 1986, So-called metastable monophase aqueous fluid inclusions at room temperature: C.R. Acad. Sci. Paris, v. 303, Ser. II, no. 6, p. 459-461 (in French, English abstract; translation courtesy C.J. Eastoe).

Abstract

The absence of a vapor bubble in an aqueous fluid inclusion is generally considered to be a metastable phenomenon in which the bubble fails to nucleate. The contraction of liquid water as it is cooled always permits the mechanical formation of a vapor bubble. Therefore the absence of a bubble results from trapping at surface P-T conditions.

Introduction

Single-phase brine fluid inclusions are frequently observed in crystals of quartz and barite from veins of anhydrite pseudomorphed by quartz (1). Inclusions of this type are generally associated with two-phase inclusions, and are commonly arranged in clusters parallel to the crystal faces of the host mineral. This arrangement is evidence of their primary nature. Roedder (2) considers these inclusions to be metastable, the vapor bubble having failed to nucleate during cooling. The constraint placed on certain metallogenic models by this interpretation leads us to reexamine the validity of the interpretation.

Review and Discussion

Two concepts appear to be fundamental in this discussion. The formation of a new phase -- water vapor in this case -- is a problematic phenomenon dependent on the theory of fluctuations (3). The formation of a microcavity within liquid water (a vapor nucleus) has the effect of increasing the free energy of the system. Thus, the molecular agitation of liquid water has the double role of forming microcavities and then destroying them, unless they attain a critical size (a function of temperature and specific surface energy, γ_{LV}), beyond which the growth of the vapor nucleus is matched by a reduction of the free energy of the system (4). The probability of formation of a nucleus of vapor is proportional to the number of microcavities (nuclei) formed temporarily within the liquid phase and, in short, to the size of the system. This probability may be very small if the system consists of a few cubic microns of liquid water. Thus, when a fluid inclusion containing a cube of halite is heated then brought back to 298K the solution may remain metastable, the halite crystal failing to reappear during cooling.

The variation of volume of a pure liquid, water in this case, under the influence of changing temperature and pressure is a process that does not require any inductive[?] phenomenon on the other hand.

Thus, at saturation vapor pressure, any increase in temperature of a fixed mass of liquid water results in an immediate increase in the volume of the liquid if the initial temperature is greater than or equal to 277K. This effect, the principle of the thermometer, is naturally reversible. Let us suppose that a mass M of liquid water is enclosed within a volume V, incompressible compared with the liquid, at the P-T conditions of trapping. The volume V is strictly equal to the product of the mass of the liquid and its specific volume under these conditions. Let us now bring the system to 298K and 1 atm. The system evolves at constant mass and volume, and follows the isochore corresponding to trapping conditions until it reaches the L+V cure of figure 1 (5). At this precise temperature, the system may be metastable if no vapor appears. However, beyond this point, temperature decrease results in a contraction of the liquid, establishing a volume outlined by a meniscus where the vapor pressure is fixed by the equation: $P = P_0 \exp[-2\sigma\mu/\rho RT]$ (4). Thus, although there is a morphological similarity, the bubble does not result from a problematic nucleation--but from a contraction, the systematic character of which is well known. Let us suppose for the moment that this is not so. Then the liquid would occupy the whole volume V at room conditions. The absence of a bubble of volume ν could be explained by considering it to be divided into a number of microscopic (invisible) cavities with a total volume ν. These cavities would increase the surface free energy of the fluid inclusion considerably. Indeed, dividing the bubble into n identical cavities, for example, would increase the surface area and the surface free energy by a factor of $4n(3/4n)^{2/3}$. Such a situation appears to be highly hypothetical, because a divided system evolves in such a way as to reduce its surface area and corresponding surplus free energy.

The proponents of the theory of metastability emphasize that these inclusions generally produce the "expected bubble" when they are cooled or heated. According to figure 2 (b), when the system is cooled at constant volume, the point representing the system follows the curve OA separating the field of ice I (19.61 cm^3 $mole^{-1}$) and liquid water (18 cm^3 $mole^{-1}$). The cooling takes place under conditions of increasing pressure, because of the impossibility of entering the field of ice I at constant volume. The considerable overpressure exerted by the supercooled liquid on the walls of the container (1 kb at 263K) is sufficient to deform it irreversibly. This permits the formation of a bubble when the system is brought back to room conditions. Furthermore, the formation of a bubble by heating a single-phase system is obvious proof that the system is stable at room conditions. If this were not so, any increase in temperature would tend to reduce the thermodynamic equilibrium and the probability of nucleating a bubble. The formation of a bubble under these conditions must be ascribed to the irreversible deformation of the container. Moving along the isochore on which it was trapped at 298K, the system exerts a very high pressure on the container, of the order of 100 bars/10°C (fig. 1). This interpretation is presented for the case of pure water, but applies without particular difficulties to brines.

Conclusions

The absence of a vapor bubble in certain aqueous fluid inclusions has been wrongly attributed to slow nucleation kinetics; this does not work. In fact, in the hypothesis of trapping at a temperature above room temperature, the contraction of liquid water as it cools always permits the mechanical formation of a vapor bubble. Therefore inclusions consisting of a single phase at room temperature have been trapped at P-T conditions very close to room conditions. The coexistence of contemporaneous one- and two-phase aqueous inclusions is therefore an indication of crystal growth in a very low temperature solution charged with gas bubbles. The same conclusion can be formulated when the two-phase inclusions are late, any subsequent reheating implying the disappearance of one-phase inclusions as a result of considerable internal overpressures.

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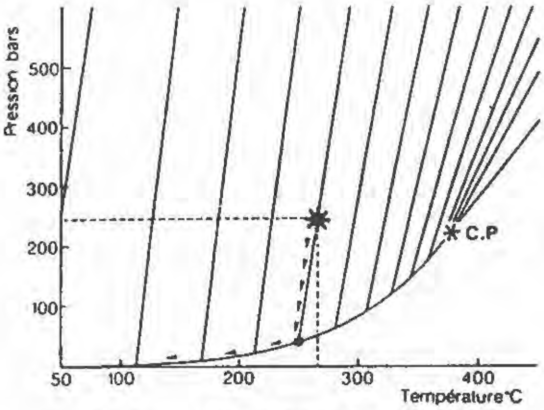

Fig. 1. — P-V-T diagram for pure water.

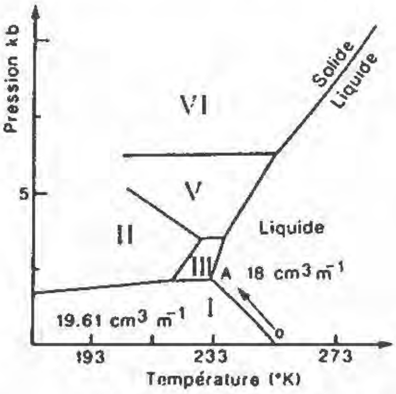

Fig. 2. — Phase diagram of water.

BORODENKO, Yu.A., KATRICH, N.P. and TIMAN, B.L., 1985, Dependence of the critical rate of gas inclusion formation in leucosapphire crystals on the melt layer thickness during horizontal zonal melting and directed growth: Kristallografiya, v. 20, no. 2, p. 407-408 (in Russian). Authors at Sci.-Producing Enterprise "Monokristallreaktiv," USSR (city not specified).

In crystals of leucosapphire grown by the method of the directed crystallization and with horizontal zonal melting, one of the defects are gas inclusions. In [1-3] it was shown that under the determined T gradients and vacuum conditions of growth, gaseous inclusions in leucosapphire crystals form when the crystallization rate exceeds a certain critical value. With increase in T gradient at the crystallization front and with improvement of the growth conditions (better vacuum in the reaction chamber), the critical rate of crystallization shifts toward the higher values. In [4] it was experimentally found that gas inclusions formed in a crystal due to concentration of impurities before the front of crystallization appear only when a substructure occurs in it, i.e., if concentrational overcooling appears in melt before the crystallization front.

Moreover, one of the factors influencing critical rate of formation of gaseous inclusions in crystals (other conditions being equal), may be the thickness of melt layer. The present paper shows regularities of this influence.

Experiments were performed in an apparatus of the type SGVK, in which by the method of the directed crystallization or horizontal zonal melting under vacuum ($P \approx 10^{-5}$ mm of Hg), crystals of leucosapphire were grown, 200 mm long and 100 mm wide. During change of crystal thickness from 5 to 30 mm the speed of the crucible movement was fixed at the moments when gas inclusions started to appear in the crystal. The obtained results are shown in the figure. It is evident that with increase of the crystal

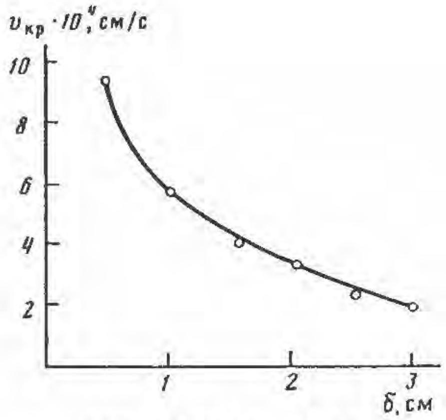

Figure. Relation between critical rate of crystallization and thickness of the grown crystal.

thickness δ , the critical rate of formation of G inclusions Vcr monotonously decreases. It is necessary to note that experimental relationship between the critical crystallization rate and the thickness of the melt layer for the directed crystallization and horizontal zonal melting are similar.

Physically, the obtained results may be explained: if the melt layer is thick (other conditions constant), the dissolved gas in distinctly smaller amount may evaporate from the melt in the process of crystallization [but] in much higher concentrations it accumulates in the crystallization front. For this reason the critical conditions should occur at lower crystallization rates.

It is necessary to mention that essentially during growth of other crystals one cannot exclude the case where the critical rate of crystallization, causing the formation of the G inclusions in crystal, would be lower than critical rate of formation of the concentrational overcooling. Qualitatively it is clear that in such case the critical rate of crystallization when G bubbles form will decrease with the increase of the thickness of melt growth. Quantitative characteristics of this case need special studies.

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CHEREPANOV, A.N. and SHARAPOV, V.N., 1986, Thermodynamic conditions of retrograde boiling phenomenon of cotectic magmas in intrusive chambers: Dokl. Akad. Nauk SSSR, v. 291, no. 4, p. 953-956 (in Russian). First author at Inst. Geol. & Geophys. of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

As thermodynamic analysis of the magma intrusion indicates [1], allochthonous plutons of igneous rocks in the Earth's crust form from melts which are undersaturated with respect to volatiles, and plutogenic hydrothermal deposits are connected seemingly with the retrograde boiling of such magmas [2]. Studies of the metallogeny of magmatic complexes proves that only a specific part of the intrusive massifs, cooled under thermodynamic conditions of different magmatic depth facies, is followed by the development of the hydrothermal processes of various scale of development. Consideration of the dynamics of the vesiculation of cotectic melts [3,4] revealed a complicated dependence of this process on a number of thermodynamic, kinetic and dynamic factors. Here the thermodynamic aspect is considered.

The general approach and the system of equations describing the dynamics of vesiculation during retrograde boiling is described by the present authors in [3,4]. The essential thermodynamic conditions of retrograde boiling of magmas in the intrusive chamber are described sufficiently completely by an equation:

$$(1) \qquad P_g = P(z_f) - \Delta P_\Sigma + 2\sigma/r_p,$$

where P_g = total partial pressure of volatiles in magma, z_f = present coordinate of the beginning of solidification of the heterophase zone, σ = surface tension of magma, r_p = initial size of the fluid bubble, $\Delta P_\Sigma = \Delta P_g + \Delta P_\mu$ = total loss of pressure caused by gravitation (ΔP_g) and by viscous flow (ΔP_μ).

Further we will consider the case of crystallization of a flat intrusive body; for it the vertical coordinate coincides with the gravitation vector. Let's suppose that the zero point occurs at the Earth's surface. Thus $\Delta P_\Sigma = \rho g(z_f - z_p) + \Delta P_\mu$, where z_p = coordinate of the front of the beginning of boiling (appearance of a gas bubble). In such case (1) may be written as follows:

$$(2) \qquad P_g = \rho g z_p - \Delta P_\mu + 2\sigma/r_p.$$

If one takes into account the earlier calculations [3,4], it is easy to see that the second and third parts in (2) are essentially smaller than the first one (more than 1-2 orders). Thus next we will use only the approximate relation (2):

$$(3) \qquad P_g = \rho g z_p.$$

Experimental data [5] indicate the existence of the gradual[sic] relation between the partial pressure of volatiles and their concentration in silicate melt:

$$(4) \qquad C_g = k_l P_g^j \quad \text{or} \quad C_g = k_l(\rho g z_p)^j.$$

For simplicity we will consider the three-component melt: C_A - solvent (lattice-forming medium), C_1 - non-volatile component-admixture (modifier), $C_2 = C_g$ - volatile component, K_i - coefficient of distribution of the i-component (i = 1,2); C_{i0} - initial concentration of the i-component. We assume also that distribution of concentration is described by the lever law:

$$(5) \qquad C_i = C_{i0}/f_l^{1-k_i}.$$

Let the crystallization in the heterophase zone follow the condition of quasi-equilibrium, when T of liquidus is determined as:

$$(6) \qquad T = T_l(C_1; C_2; P).$$

Let us approximate the value T_l by the linear function of the variables C_i and P:

$$(7) \qquad T_l = T_{l0} - \beta_1(C_1 - C_{10}) - \beta_2(C_2 - C_{20}) + \beta_p(P - P_a).$$

From (3), (6) we obtain

$$(8)\qquad T = T_{A0} - \sum_{i=1}^{2} \beta_i C_{i0} f_l^{k_i - 1} + \beta_p \rho g z_p,$$

where $T_{A0} = T_{l0} + \sum_{i=1}^{2} \beta_i C_{i0} - \beta_p P_a$. Let us use f_{lp} for the section of liquid phase where a gas bubble forms when the melt achieves saturation with a volatile. Considering (4) and (7), we obtain:

$$(9)\qquad (C_{20}/k_i f_{lp}^{1-k_2})^i = \rho g z_p.$$

From this equation one may evaluate the equilibrium thermodynamic conditions of appearance of the retrograde boiling, depending on their [volatiles? - A.K.] initial concentration in magma, size of the flat intrusive and depth of its occurrence:

$$(10)\qquad f_{lp} = \left[\frac{C_{20}/k_i}{(\rho g z_p)^{1/i}}\right]^{1/(1-k_2)}$$

From analysis of (10) it follows that in the magma initially undersaturated with volatiles in a large intrusive body there should exist an area of retrograde boiling, smaller than its vertical dimension. In other words, during crystallization of the intrusive bodies the area between the saturation front f_{lp} and cessation of boiling f_{lp}^* is the area of the retrograde boiling of a melt. The front of the boiling cessation will coincide with the rear of the solidification zone f_{lE}. Let's suppose that $T = T_E$:

$$(11)\qquad T_E = T_{A0} - \sum_{i=1}^{2} \beta_i C_{i0} f_{lE}^{k_i - 1} + \beta_p \rho g z_p.$$

For the numerical calculations below experimental data on the systems SiO_2 + Ab + H_2O and An + Di + H_2O [5] will be used. The relation T_E for those systems may be presented as follows:

$$(12)\qquad T_E = T_{E0} - \sum_{i=1}^{2} \alpha_i C_{i0}^{i} + \beta_p \rho g z_p.$$

Equating the right sides of (11) and (12), we will obtain the expression for determination of f_{lE}:

$$(13)\qquad \sum_{i=1}^{2} \beta_i C_{i0} f_{lE}^{k_i - 1} - T_{A0} + T_{E0} - \sum_{i=1}^{2} \alpha_i C_{i0}^{i} = 0.$$

Because for the above indicated systems $k_i \ll 1$, thus putting $k_i = 0$ in (13), we obtain the explicit expression for f_{lE}:

$$(14)\qquad f_{lE} = \left(T_{A0} - T_{E0} + \sum_{i=1}^{2} \alpha_i C_{i0}^{i}\right) \Big/ \sum_{i=1}^{2} \beta_i C_{i0}.$$

From (9) it appears that the initial volatile content, when retrograde boiling is possible under the considered P in an intrusive, may be determined from the expression:

$$(15)\qquad C_{20} - f_{lE} K_i (\rho g z_p)^{1/i} \geqslant 0.$$

The cessation of retrograde boiling will occur at depth:

$$(16)\qquad z_p^* \leqslant \frac{1}{\rho g} \left(\frac{C_{20}}{K_i f_{lE}}\right)^i.$$

From the calculations according to (15), (16), the following parameters (units in the SI system) were determined and the results of the calculations are given in Fig. 1.

1) $SiO_2 + Ab + H_2O$: $T_{A0} = 1962$ K, $T_{E0} = 1336{,}6$ K, $\beta_1 = 14{,}2$, $\beta_2 = 40$, $\rho = 2{,}2 \cdot 10^3$, $\beta_p = 1{,}25 \cdot 10^{-7}$, $j = 2$, $K_l = 3 \cdot 10^{-4}$, $\alpha_1 = 53{,}4$, $\alpha_2 = 2{,}5$; 2) $An + Di + H_2O$: $T_{A0} = 1863$ K, $T_{E0} = 1541$ K, $\beta_1 = 5{,}05$, $\beta_2 = 41{,}7$, $\beta_p = 1{,}25 \cdot 10^{-7}$, $j = 0{,}8$, $K_l = 10^{-6}$, $\alpha_1 = 21{,}36$, $\alpha_2 = 0$, $\rho = 2{,}5 \cdot 10^3$.

During practical use of these curves for evaluation of conditions of occurrence of retrograde boiling it is necessary to take into account that in case of forming of igneous rocks k_i is larger than in the model systems, because part of the volatiles enters amphiboles and micas. But these corrections are not sufficiently significant to change the relations shown. Evidence may be found by studies of melt inclusions in acid rocks [6]. Their composition is characterized by concentration and phase stage of liquids in the position f_{lE}. Such inclusions in plutonic rocks of various magmatic facies of depth bear less than 3 mass % of volatiles. Signs of boiling used to be found in subvolcanic conditions during quenching and sharp P decrease, when volume of silicate liquid is low. Observations during eruptions of the basalt volcanoes, on the contrary, prove vesiculation even when the amount of protocrysts is low and concentration of volatiles in magma is insignificant [7]. For this reason the analysis of Fig. 1 leads to a number of preliminary opinions on the thermodynamic conditions of development of retrograde boiling of cotectic magmas in intrusive chamber:

1. Large scale retrograde boiling in great granitoid plutons is doubtful, when they cool under thermodynamic conditions of subvolcanic to abyssal magmatic facies, if magma had an initial water concentration of 1-2 mass %. Even if the initial concentration of water in magma was 3-4 mass %, such plutons may have time-limited area of retrograde boiling, as it appears from the data on the crystallization rate Vf and the relation between k_i and V_f [4].

2. Process of retrograde boiling in basite melts, when other parameters are the same, is more intensive than in acid ones.

3. Special statistical data on determination of the conditions of homogenization of the P melt inclusions bearing volatiles, allows more precise determination of the critical curves for various volatiles in magmas on the diagram $Z_p - C_{i0}$. Analysis of the existing data [6] suggests that for granitoids the initial water content should be >2 mass % and for basites 0.5 mass % for the geologically established ranges of retrograde boiling of the cotectic magmas in the process of crystallization in intrusive massifs.

Thus, the plutogenic hydrothermal deposits probably are connected with specific magmas, which during intrusion from the chamber of generation had relatively high initial volatiles concentrations.

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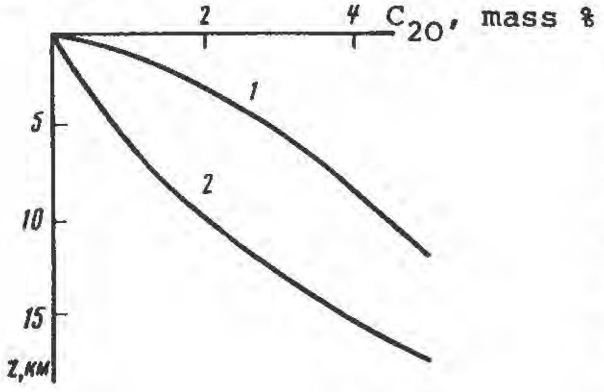

Fig. 1. Initial water contents in melts: 1 - SiO_2+Ab+H_2O, 2 - An+Di+ H_2O, critical for retrograde boiling at various depths. The position Z_p^* is determined by presence of C_{2O}, maximum vertical extension of the vesiculation area - from the thickness of the massif crust. [= overburden thickness? - A.K.]

KOSUKHIN, O.N., BAKUMENKO, I.T. and CHUPIN, V.P., 1984, Magmatic stage of formation of the granitic pegmatites: Trudy Inst. Geol. & Geophysics, v. 476, ed., Yu.A. Dolgov, 136 pp., Siberian Branch of "Nauka" Publ. House, Novosibirsk (in Russian). Ed. note: This book was listed in Fluid Inclusion Research, v. 17 (1984) with a short authors' abstract, but we thought it deserved a more extensive summary, as presented here, by A. Kozlowski.

The book consists of six chapters and eight plates of photos. Chapter 1 gives the meaning of the term "pegmatite" and of the pegmatitic process, describes the morphology of pegmatites and their zoning and describes the formation of the granitic pegmatites in three categories: shallow (rock-crystal-bearing), deep-seated (mica-bearing), and very deep-seated (so-called rare-metal or quartz-feldspathic formation) pegmatites. Pegmatite-like (pegmatoid) segregations are distinguished.

Chapter 2 reviews critically the existing hypotheses on the pegmatite origin, proposed by Fersman, Nikolaev, Korzhinskiy, Ginzburg, Nedumov, Nikitin, Jahns, Petrov, Ermakov, Dolgov and Osipov.

Chapter 3 presents details of the studies of inclusions in quartz from granitic pegmatites. The silicate inclusions in quartz from pegmatites are very small, the silicate component is completely crystallized and the density of the segregated volatiles is very high. Frequently even the recognition of the melt inclusions in the pegmatitic quartz is complicated. The most important problem to be solved in each case is the normal or anomalous (combined) nature of an inclusion. Various combinations are possible: melt + trapped crystal, melt + GL inclusions, trapped crystal + GL inclusion - all these combined inclusions may be similar to the crystallized melt inclusions. They may be distinguished by investigation of the groups consisting of many inclusions, especially during determination of the temperatures of phase changes, which differ for each inclusion in the group of the combined ones. The beginning of melting for the combined inclusions typically occurs at the boundary between the host quartz and the trapped crystal, but in the normal melt inclusions it occurs within the inclusion, between the crystallized phases. Normal melt inclusions in granitoid quartz essentially do not change their volume. The authors suppose that the muscovite + GL inclusions in quartz from granitoids described by Reyf (1976) belong to the combined type, as well as the "inclusions of the solidified melts" in pegmatitic minerals presented by Zakharchenko in many publications, which seem to be crystal inclusions refilled in various parts by G or L fluid.

Normal melt inclusions in pegmatitic quartz may be either P or S. P melt inclusions usually form groups of randomly distributed inclusions; rarely they occur along growth zones. Inclusions of melt in pegmatitic quartz usually have a high internal pressure, thus their homogenization without leakage or decrepitation is possible only when their size is <3 or 4 µm. For this reason homogenization should be gradual, with quenching between the sequential heating steps and with careful check at high magnification for recognition of possible tiny fractures. Larger melt inclusions may be homogenized in an autoclave.

The authors conclude also that usually Th of melt inclusions indicates exactly the trapping temperature, but when water content in the inclusion melt is high, a P correction for Th may be required due to the increase of the inclusion volume. If minerals crystallized under P <2 kbar, the possible correction is within the ranges of the measurement error, but for 5 kbar the correction to Th may be >30°C. Moreover, the correction for the compressibility of the silicate melt should be introduced. For granitoid melts containing 2% water under P = 5 kbar this (positive) correction is almost equal the (negative) correction due to the compressibility of the host quartz, i.e., one correction compensates for another. However, data on the compressibility of granitic melt with various water contents is lacking.

Essentially two main types of melt may be trapped: saturated and distinctly undersaturated with water. For a fluid-saturated inclusion, if homogenization is performed under the atmospheric P, Th may even slightly exceed T of trapping.

Quartz of the studied deep-seated pegmatites bear LCO_2 inclusions syngenetic with the melt ones, and quartz of the chamber pegmatites - essentially water solution inclusions coeval with the melt ones; in both cases P of trapping may be determined. In melts poor in water Naumov's method (Geokhimiya, 1979, no. 7, p. 997-1007) was used. If inclusions contained gases without a detectable water phase, the microvolumetric method of determination of G composition in individual inclusions described by Dolgov and Shugurova, was applied. Most of the thermometric determinations were performed in the Dolgov-Bazarov heating stage, accuracy (up to 1000°C ± 1%); for higher T the silite heating stage was used. Cryometric determinations were made in Bazarov's freezing stage. The small size of the inclusions precluded determinations of the chemical composition of melt or crystal phases.

Chapter 4 presents the results obtained for minerals of residual-type (chamber) pegmatites connected with granitoid bodies. Pegmatites of this type form at a depth of 1.5-7km (lithostatic pressure about 0.3-2 kbar); fluid pressure, as it appears from the authors' measurements, may exceed 2 kbar. These pegmatites occur in the endocontact zone of polyphase granite intrusions. Generally they consist of the following zones (from the wallrock): a) aggregates with aplite-like structure, b) aggregates with granophyric structure, c) aggregates with pegmatoids and blocky structure, d) feldspar zone, e) chamber (= zanorysh), sometimes with commercial mineralization. Other structures are much rarer.

Inclusions of crystallized melts in quartz of the chamber pegmatites are very small (<5 µm); the rare larger inclusions (20-30 µm) allowed the identification of the dms as quartz and feldspars, sometimes as granophyric intergrowths, and probably mica. The fluid component is two-phase at room T (LH_2O + G); quartz of the graphical intergrowths bear melt + fluid inclusions whose LH_2O phase (fluid) has the following features: Kyrinskiy massif, fluid inclusions, Th 270-280°C in L, conc. 7-8 (here and later wt.% NaCl equiv.), in melt inclusions Th 220-240°C in L, conc. 4, water content in melt incl. (here and later wt. %) 7.2-9.3; Dzheltau massif, fluid incl., Th 220-240°C in L, conc. 15, melt incl. Th 180-200°C in L, conc. 9-10, water content in melt incl. 7.5-9.8; Adun Chelon massif, fluid incl., Th 330-360 in L, conc. 10, in melt incl. Th 230-260°C in L, conc. 6, water content in melt incl. 7.0-9.1; Gorikhinskiy massif, fluid incl., Th 290-310°C in L, conc. 10, in melt incl. Th 240-250°C in L, conc. 8-9, water content in melt incl. 7.2-9.4; Borshchevochnyi massif, (here fluid = LH_2O + LCO_2 + G), fluid incl. Th 290-300°C in G, conc. 5, in melt incl. Th 240-260°C in L, conc. 10, water content in melt incl. 7.2

During total homogenization the last portion of the LH_2O and dms dissolved in the silicate melt practically simultaneously. Th (total) are higher for the melt inclusions in quartz of the wallrock granites, they decrease in the neighborhood of the pegmatitic body and they are lowest in the pegmatites, for instance in the Dungalinskiy massif 700-650, 630-600 and 600-540°C, respectively. In the pegmatitic bodies Th decreases also from the outer zones to the inner ones. The results of the Th measurements are given in the (authors') Table 2.

Aggregates bearing porphyritic quartz crystals and occurring in pegmatites are especially interesting, because such porphyritic quartz was frequently considered as a product of the recrystallization or metasomatism. The authors give Th of melt inclusions in quartz of the porphyritic crystals (p) and of the groundmass (g) (in °C): Dzhel'tau massif, in aplite, p 600-580, g 580-560; Dungalinskiy massif, in granite and in the graphic zone, p 600, g 580-560; Bektauata massif, in the graphic zone, p 640-620, g 620-600; Kaib massif, p 660-630, g inclusions not found. From the higher Th in porphyritic crystals than in the groundmass crystals the authors conclude that the porphyritic crystals crystallized earlier, i.e., their name is used properly in the genetic sense. Also quartz in the coarse graphic intergrowths bears melt inclusions, i.e., they are of magmatic origin.

Rare rhythmic-banded pegmatitic aggregates in quartz contain melt inclusions with the Th values for the Bektauata massif as follows:

Group of bands	Bands	Th, °C
1 (thickness 35-50 cm)	a. Aplite	660-650
	b. Graphic aggregate	650-640
	c. Pegmatoid and blocky aggregates	640-630
2 (thickness not given)	a. Aplite	620
	b. Graphic aggregate	620-600
	c. Pegmatoid aggregate	610-600

Quartz from "zanorysh" (central crystal lined cavity) of certain chamber pegmatites contains P GL and melt inclusions, usually in the same groups; sometimes also PS inclusions of crystallized melts were found. For every pegmatite where melt inclusions in the "zanorysh" quartz were found, their Th values are the lowest of all melt inclusions in this pegmatite. Thus, these inclusions formed from the latest portions of the pegmatitic magma. P melt inclusions in this type of quartz either form azonal groups or they occur in growth zones; their size varies from 1 to few tens of µm. Such inclusions rarely are unaffected by later post-magmatic fracturing. Melt inclusions occur only in the earliest parts of the "zanorysh" quartz, the later zones have a distinctly post-magmatic origin. Th of the melt inclusions in the "zanorysh" quartz are given in the Table 2. The authors believe that certain inclusions in the outer zone of "reticulate" quartz from the Ukrainian chamber pegmatites, described by Gigashvili, Voznyak and Kalyuzhnyi (in various publications) as crystal-fluid inclusions from heterogeneous trapping [i.e., trapping of solids and fluid], in fact are mostly PS melt inclusions (Th 620-630°C) of the last portions of the pegmatitic magma coexisting with an aqueous (± other volatiles) fluid.

P fluid (i.e., non-melt) inclusions in the magmatic quartz of pegmatites were found: a) together with crystallized melt inclusions in growth zones; b) ditto, but in the azonally distributed groups; c) in the growth zones but practically without syngenetic melt inclusions; and d) as azonally distributed groups practically without the syngenetic melt inclusions.

In cases a) and b) the appropriate combined inclusions were also found; for a magmatic origin of the host quartz in cases c) and d) the authors give as evidence the statement that the later growth zones of the same quartz grains bear melt inclusions. The fluids consist of LH_2O + salts ± LCO_2 and other volatiles. Results of the studies of these inclusions are presented in their Table 5. The density of the fluids in the above described inclusions ranged from 0.72 to 0.96 in the fluid inclusions and from 0.42-0.46 (Borshchevochnyi massif) through 0.82 to 0.96 in the fluid segregations of the melt inclusions.

The authors describe briefly inclusions in quartz of the "chamber pegmatites of the intermediate type" with low Th of melt inclusions (to 515°C) with salt-rich inclusions present; next they characterize the features of wall-rock granites and rock-forming minerals of the studied pegmatites (petrochemical characteristics, of pegmatites and granites, and chemical compositions and structures of the rock-forming minerals). In the concluding part they discuss the genesis of the chamber pegmatites, first presenting the peculiarities of the pegmatite formation and of the parent media (T from slightly exceeding 600°C to 515°C, saturation of the pegmatitic magma with water, coexistence of the water ± CO_2 fluid with melt, formation of very concentrated fluids (brines) by boiling and release of H_2O vapor during the fracture formation). They also discuss the pseudobinary system silicate phases-H_2O in inclusions. Further the factors complicating the morphology and structures of pegmatites are presented, as well as the peculiar features of the pegmatitic magmas, the reasons for the zonal formation and the processes of formation of the "zanoryshes" of the magmatic stage. Finally the authors give a short description of the model of the pegmatitic process, rejecting the hypotheses on the main role of post-magmatic processes in the formation of the chamber pegmatites. They support Ermakov's magmatic model with the modification replacing the crystallization of the monomineral quartz inner core from the "ultraacid" (silexite) melt by the "eutectic crystallization of feldspar and quartz as spatially separated blocks (or) the eutectic crystallization of the quartz core belated with respect to the feldspar phases." Chamber pegmatites formed essentially from the fluid-saturated magma frequently under conditions similar to closed systems. Post-magmatic processes occur due to the presence of fluids separated from the pegmatitic magma but not coming from other parts of the considered massif.

Chapter 5 presents data on anatectic pegmatites. First their types are described: the rare-earth pegmatites connected with the granulite-facies rocks (P 10-11 kbar, T 750°C), ceramic pegmatites of the high-T amphibolite facies (sillimanite zone), and muscovite pegmatites of the garnet-kyanite-biotite-muscovite subfacies of the almandine amphibolites (P 6-9 kbar, T 650-680°C). The authors distinguish, on the other hand, a) the autochthonous or almost autochthonous pegmatites (pegmatoid bodies) of the granulite and amphibolite facies and b) allochthonous pegmatites. Pegmatites type a) of the granulite facies, belonging to the quartz-feldspar charnockite pegmatites (Aldan River), bear in hypersthene inclusions close to the crystallized melt ones, but since hypersthene becomes opaque at T

>800°C (even in an argon atmosphere), Th was not determined; beginning of melting occurs at 750-780°C. Quartz of these pegmatites bears inclusions with several crystal phases and interstitial liquid, but due to their rarity and occurrence in combination with crystal inclusions, their exact diagnostics could not be determined. The same quartz contains abundant inclusions of dense LCO_2 frequently with a poorly visible thin rim of LH_2O. Pegmatites of the same quartz-feldspar type, from the amphibole facies (Aldan), bear in quartz the following inclusions: crystal inclusions, magmatic P inclusions of crystallized melts, magmatic P(?) inclusions of dense LCO_2 with low LH_2O content, magmatic PS crystal-fluid inclusions of residual melts and melts-brines and of dense LCO_2 + variable amount of LH_2O; other types of S inclusions (GL, sometimes with the salt dms and/or LCO_2). Th of the melt inclusions in quartz of migmatites, granites and orthotectic pegmatites (granulite facies) ranged from 800 to 900°C, and in quartz of migmatite-granites, migmatite-pegmatites, granites and muscovite pegmatites (amphibolite facies) - 640 to 840°C. Inclusions of salt melts-brines in pegmatites and leucosomes gave Th 400-640°C and P (by the Lemmlein-Klevtsov method) 3.5-6.0 kbar.

Table 2
Results of the thermometric studies of quartz from the chamber pegmatites

Massif	Zone	Th of melt incl., °C
Dzhel'tan, Kazakhstan	Wall-rock biotite granite	620-610
	Aplite	600-560
	Graphic	570-550
	Pegmatoid and blocky	560-550
Dungalinskiy, E. Kazakhstan	Wall-rock biotite granite	630-600
	Pegmatoid-granite	600-560
	Graphic, pegmatoid and blocky	550-540
Kaib, Kazakhstan	Aplite	660-640
	Graphic	660-600
	Zanorysh quartz	610-600
Bektauata, N. Pribalkhash'ye, Kazakhstan	Aplite	660-630
	Graphic	640-600
	Pegmatoid	630-600
	Bocky and feldspathic	605-600
	Zanorysh quartz	600-590
Bayan-Aul, Kazakhstan	Graphic	600-590
Kyrinskiy, E. Zabaikal'ye	Wall-rock hornbl.-biotite granite	630-600
	Aplite	620-580
	Graphic	570-550
	Pegmatoid and blocky	560-550
	Zanorysh quartz	560-550
Adun-Chelon, E. Zabaikal'ye	Wall-rock biotite granite	690-660
	Aplite	660-630
	Graphic	660-620
	Pegmatoid	630-620
Gorikhinskiy, Mongolia	Graphic	600-580
Borshchevochnyi, E. Zabaikal'ye	Graphic	670-620
	Zanorysh quartz	620-610
Savvateevskoe, E. Zabaikal'ye	Granite	550-540
	Graphic	540-515
Korostenskiy, Volyn', Ukraine		
topaz-bearing pegmatites	Graphic	660-620
	Zanorysh quartz	630-620
pegmatites without topaz	Graphic	750-660

Table 5
Measured values and calculated P in the chamber pegmatites from syngenetic melt fluid inclusions

Granitoid massif	Th of fluid in		T, °C		P of fluid, kbar		Pt minus Ps, kbar
	fluid inc., °C	melt inc., °C	of trapping of the coeval fluid and melt inc., Tt	beginning of melting in the melt inc., Ts (T of solidus)	in fluid inc. at Tt (Pt)	in melt inc. at Ts (Ps)	
Kyrinskiy	280	220	570	500-510	3.0-3.1^a 3.1^b 3.8^c	3.2-3.4^a 3.4-3.5^b 4.1-4.2^c	0.1-0.4 0.3-0.4 0.3-0.4
Dzhel'tan	220	180	560	500	3.7^a 3.7^b 4.7^c	3.8-3.9^a 3.8^b 4.8-4.9	0.1-0.2 0.1 0.1-0.2
Adun-Chelon	340	240	630	510-520	2.7^a 2.7^b 3.0-3.1^c	3.0-3.2^a 3.2-3.3^b 3.6-3.7^c	0.3-0.5 0.5-0.6 0.5-0.7
Gorikhinskiy	290	240	580	500-510	2.7^a 3.0^b 3.5^c	2.9-3.1^a 3.0^b 3.6-3.8^c	0.2-0.4 0.0 0.1-0.3
Borshchevochnyi (deposit Zolotaya Gora)	290-300	240-260	620	510-520	1.1-1.2^a (?)	2.6-2.7^a 2.7-3.1^b 3.3-3.4^d	

Note: Pressures determined by the following methods: a - Lemmlein and Klevtsov, b - from the experimental data of V.B. Naumov, c - from the experimental data of L.A. Samoylovich, d - from the data of K.I. Shmulovich et al. for the system H_2O-CO_2 in the homogeneous area.

Pegmatites type b) (allochthonous) also bear in quartz P magmatic solidified melt inclusions. Th for various types of pegmatites 780-850°C (~640°C for the mica-bearing pegmatites) and P up to 5.7-7.7 kbar. Several types of LCO_2 and LH_2O inclusions are also described. The authors discuss also the genesis of anatectic pegmatites, especially paying attention to the inclusion evidence of the anatectic phenomena and to the conditions of the crystallization of the anatectic pegmatites.

Chapter 6 gives the results of the melt inclusion studies of the pegmatoid forms. Graphic intergrowths out of the pegmatite bear in quartz melt inclusions with the following Th: in the subalkaline dike "Gusinoozerskaya" in Buryatiya - 1280-1250°C, in traps of the massif of the Vel'minskiy Porog, Podkamennaya Tunguska River - 1250-1100°C, traps of the Anakitskiy massif, Nizhnyaya Tunguska River - 1200-1080°C, hybrid rocks of the Gorbiachin River (W. Siberian Platform) 1150-940°C, dike of gabbro-diabases, Dedovets Island, Onega Lake - 640 ± 20°C, gabbro-norites of the Yurchikskiy massif (Kamchatka) - 600 ± 20°C, granites of the Dzhel'tau massif (Kazakhstan) - 640-620°C, granites rapakivi, Vyborg massif - 600-580°C. In the concluding remarks the authors summarize the obtained results and give the list of problems needing the further studies. The literature list contains 230 items in Russian and 7 western publications.

KUZNETSOVA, S.V. and KULIK, Zh.V., 1986, Chlorohydrocarbons in mineral-forming solutions: Doklady Akad. Nauk SSSR, v. 290, no. 3, p. 709-710 (in Russian). Authors at Inst. Geochem. & Physics of Minerals of Acad. Sci. of Ukrainian SSR, Kiev.

(...) During ordinary thermobarogeochemical studies of the water leachate from fluid inclusions the presence of the chloride ion is determined by the argentometric or potentiometric method [1,2]. Cl is essentially not adsorbed by powdered quartz, calcite and fluorite and it goes to the filtrate [2]. Cl also is not adsorbed by clay minerals [3].

During studies of the composition of mineral-forming solutions from inclusions in vein quartz of the explosive-hydrothermal genesis and in apogranite Na metasomatites the continuous tendency of decrease of the Cl content in solution correlating with the increasing hydrocarbon content (paraffin and aliphatic types) was found by the authors. That suggested that during the evolution of solutions causing the alkaline metasomatism and connected with the explosive-hydrothermal mineral formation, Cl and HCl present in those solutions may have reacted with hydrocarbons, forming Cl-hydrocarbon compounds. (...)

The presence of the halide-hydrocarbons in minerals has not been reported frequently. Cl- and Br-hydrocarbons were found in Iceland spar from the Lower Tunguzska deposit [4], and F-hydrocarbons in fluorite from Welsendorf [5]. Recognition of those compounds was by IR spectroscopy and mass spectrometry.

Due to the prevailing covalent bonding, the halide-hydrocarbon compounds are non-polar compounds weakly soluble in water [6]. Thus, during the traditional analysis of the water leachates from inclusions, chlorine included in these compounds is not determined. For elucidation of the role of chlorine included in hydrocarbons in mineral-forming solutions it is necessary to use additional analytic methods causing the splitting of chlorine and hydrocarbon component and transition of chlorine to the ionic form in solution. Hydrolysis is convenient for this operation [7]. Because of the very low solubility of the Cl-hydrocarbons in water, not only the filtrate but also the powdered mineral after filtration was hydrolyzed. The analytical data obtained indicate that the amount of Cl connected with hydrocarbons is significant (Table 1). The fact of the detection of the Cl-hydrocarbons in mineral-forming solutions proves the possibility of the fixing of Cl and HCl by hydrocarbons during the mineral-forming process.

The detection of the Cl-hydrocarbons in mineral-forming solutions has several important implications. The additional amounts of Cl correct the earlier determined ratios of components in solution, and may influence the ideas about the forms of transportation of elements. Formation of Cl-hydrocarbons in solutions trapped in inclusions indicates the change of the role of Cl during mineral formation. Due to the bonding of Cl and HCl by hydrocarbons, the values of pH and Eh of the mineral-forming medium change, and may cause the appearance of chemical thresholds precipitating metals in processes of the ore formation.

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(Translated by A. Kozłowski, Tübingen, 7.III.1987)

Table 1
Contents of Cl ion in mineral-forming solutions from gas-liquid inclusions ($n \cdot 10^{-6}$ g/t* of the weight of the sample in the grain class 0.5-1.0 mm)

Rock	In water leachate	In powdered mineral after hydrolysis	Total
Quartz from vein of the explosive-hydrothermal origin	5	12	17
Vuggy syenite with rock crystals in vugs	35.5	14.6	48.1
Apogranitic albitite with carbonate and sphene	not found	5	5
Apogranitic albitite with riebeckite	33.5	13	46.5
Desilicified migmatite	180	30	210
Biotite-garnet medium-grained granite	32	7.5	39.5

*seems to bear an error, most probably g/t.

NAUMOV, V.B., AKHMANOVA, M.V., SOBOLEV, A.V. and DHAMELINCOURT, P., 1986, Use of laser Raman microprobe for studying the gas phase of inclusions in minerals: Geokhimiya, no. 7, p. 1027-1034 (in Russian).

During recent years the laser Raman microprobe has been commonly applied in geochemical studies for the determination of the molecular composition of microobjects (gas, liquid or solid) without dissolution or decomposition [1-15 and others]. The spectrum of the combined scattering - the Raman spectrum of the analyzed object excited due to nonelastic scattering of light falling on atoms and molecules, is the source of information. When a substance is illuminated with monochromatic laser light, in the spectrum of the scattered light there appear spectrum lines shifted with respect to the primary radiation by a value equal the vibrational or rotational frequency of the multiatom structural complexes. The possibility of observation of the Raman spectra in visible light wavelengths allows use of a microscope as the illumination system and to obtain the spectra of microobjects visible in the field of microscope.

The present paper presents the data obtained during studies of the

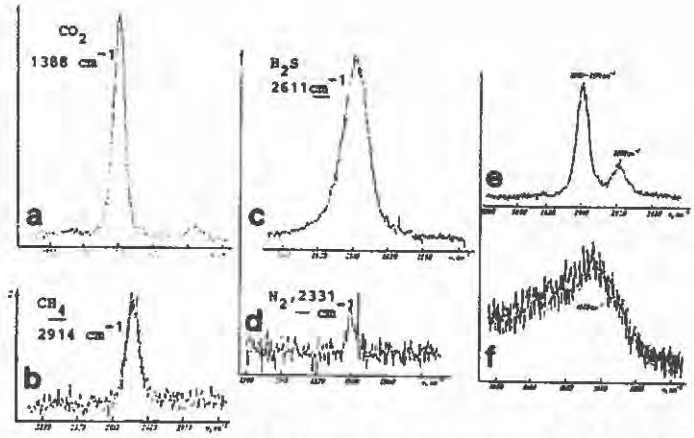

Fig. 1. Typical Raman spectra of gas phase of fluid inclusions in minerals. Specimen No. 1: a - CO_2, b - CH_4, c - H_2S, d - N_2; specimen No. 9: e - methane clathrate $CH_4 \cdot 6H_2O$ at -170°C, f - H_2O in methane clathrate at -170°C, I - intensity of the Raman spectrum.

gas phase of fluid and melt inclusions in minerals with use of the French microprobe "MOLE" in Moscow, Nancy and Lille. The device makes possible the determination of the molecular composition of inclusions with dia. >10 μm without their decomposition. The distance of the studied inclusion from the preparation surface (<100 μm) is necessary but the best results are obtained when this distance is <50 μm, because then a magnification of 800 to 1000 times may be used. All organic compounds must be removed from the surface of the preparation. The sensitivity of the method is very high - the detection limits for gas determinations are in g/cm^3: CO_2 = 0.01, CH_4 = 0.002, CO = 0.01, C_2H_6 = 0.001, C_3H_8 = 0.001, N_2 = 0.01, H_2 = 0.001, H_2S = 0.005, SO_2 = 0.002. For CO_2 and CH_4, for instance, such densities are equal minimum pressures of 5 and 2 bars, respectively. (...)

Specimen No. 1 is quartz from the quartz vein in metamorphic mica-graphite schists (50 km to NE of the Klichkino ore field, E. Transbaikalia). When the quartz is crushed, a distinct smell of H_2S is detectable. At room T in the polished sections a large number of fluid inclusions are visible, consisting of two liquids and a gas phase. Th (partial) with disappearance of G is 20.5-51.8°C, Tm varies from -56 to -67°C, proving variable but sometimes significant amounts of H_2S in the inclusions. Gas chromatography confirmed presence of CO_2, CH_4 and H_2S. Complete homogenization of fluid inclusions occurs at 236-325°C; P at these T equals 1.1-1.6 kbar. Detailed description and pictures of these inclusions were published in [16]. Raman spectra (Fig. 1 a-f) of three inclusions confirmed the presence of CO_2, CH_4, H_2S and revealed the presence of 2.4-3.0 mole % N_2 (Table). Concentration of H_2S varies from 0.7 to 19.8 mole %.

Specimens No. 2-4 characterize quartz and topaz from pegmatites of Ukraine and E. Transbaikalia. Typical, essentially gaseous inclusions (Fig. 2a) of the "reticulate" quartz have cryometric data (triple point - 56.6 ± 0.2°C) indicating pure CO_2; these were confirmed by Raman spectroscopy (CO_2 = 100 mole %). In essentially G inclusions in topaz from chamber pegmatites (Volyn', Ukraine), liquid CO_2 was detected only after cooling of the mineral <20°C (fig. 2b). Temperature of complete homogenization was 290°C. Besides CO_2 in this inclusion 0.4 mole % CH_4 was detected. In inclusions in quartz from pegmatite of Zolotaya Mt. (E. Transbaikalia) LCO_2 was found at room T. The Raman spectra showed the absence of other volatiles.

Table. Quantitative composition of gas phase of the fluid and melt microinclusions, determined by Raman spectroscopy.

No. of specimen	Characteristic and location of the samples	Mineral	No. of inclusion	Composition of gas phase, mole %					
				CO_2	CH_4	CO	N_2	H_2S	H_2
1	Quartz vein in metamorph. mica-graphite schists, E. Transbaikalia	Quartz	1	77.8	0.2	0.0	2.4	19.8	not det.
			2	91.8	3.1	0.0	3.0	2.1	"
			3	93.6	3.1	0.0	2.6	0.7	"
2	"Reliculate" quartz from chamber pegmatite, Volyn', Ukraine	do.	4	100.0	0.0	0.0	0.0	not det.	0.0
3	Transparent topaz from pegmatite, Volyn', Ukraine	Topaz	5	99.6	0.4	0.0	0.0	0.0	not det.
4	Quartz crystal from pegmatite, E. Transbaikalia	Quartz	6	100.0	0.0	not det.	0.0	0.0	"
5	Pyroxene-garnet skarn with fluorite, Tyrnyauz, N. Caucasus	Fluorite	7	0.0	0.0	"	0.0	not det.	"
6	Quartz-tourmaline-fluorite druse from vug in granite, tin-ore deposit Industrial'noe, NE USSR	Quartz	8	0.0	0.0	"	0.0	"	"
7	Eruptive breccia, Schneckenstein, GDR	Topaz	9	0.0	not det.	"	not det.	"	"
8	Rock-crystal-bearing quartz vein, W. Pamirs	Quartz	10	100.0	0.0	0.0	0.0	"	"
9	Quartz-topaz-cassiterite vein, Sn-W deposit, Svetloe, Chukotka	Cassiterite*	11	12.3	62.3	not det.	25.4	0.0	0.0
			12	33.3	35.3	"	31.4	0.0	0.0
			13	48.0	32.8	"	19.2	0.0	0.0
			14	57.3	33.3	"	9.4	0.0	0.0
10	Quartz-wolframite-fluorite vein, W deposit, Belukha, E. Transbaikalia	Fluorite	15	98.2	0.2	"	1.6	not det.	not det.
11	Polymetal deposit Dal'negorsk, Primor'ye	Sphalerite**	16	0.0	0.0	"	0.0	0.0	"
12	Salt deposit of the Dnepr-Donets depression	Halite	17	83.0	17.0	"	0.0	0.0	"
			18	81.5	18.5	"	0.0	0.0	"
			19	79.1	20.9	"	0.0	0.0	"
13	Ongorgyolite, Ourben-Dort-Ula, Mongolia	Quartz	20	0.0	0.0	"	0.0	0.0	"
14	Oceanite from volcano Piton de Furnese, Island Reunion, Indian Ocean	Olivine	21	100.0	0.0	0.0	0.0	not det.	"

*C_2H_6 not found in the inclusions; **SO_2 not found in inclusions.

Specimens No. 5-7. These specimens typically bear P polyphase inclusions with large amount of solid phases. P inclusions in fluorite from skarns (specimen No. 5) bear G, LH_2O and halite, sylvite and magnetite. These inclusions were studied earlier [17]. Total homogenization with dissolution of magnetite occurs at 625-655°C. Parent fluid of fluorite was highly concentrated: Cl up to 340 g/kg, Fe - 73 ± 21 g/kg of the fluid. Even more concentrated (up to 75 wt.% of the NaCl equiv.) were the parent solutions of the quartz-tourmaline-fluorite druse from the vug in granite of the tin-ore deposit Industrial'noe [18]. Polyphase inclusions (with halite, sylvite, magnetite and other minerals) (Fig. 2c) homogenize at high T (up to 840°C in quartz, to 710°C in fluorite); they have high density (up to 1.9 g/cm^3) and formed at high P (1.1-2.5 kbar). A large part of the inclusion volume in topaz of the early generation from the eruptive breccia (specimen No. 7) is occupied by dms (Fig. 2d), two of them are isotropic, the others (2-4) are anisotropic. Total homogenization with dissolution of the all solid phases occurs at 460-580°C [19]. CO_2, CH_4 and N_2 were not found in these specimens, as is explained by the high salt concentration.

Specimen No. 8 - quartz crystal from the rock-crystal veins of the W. Pamirs. These P polyphase inclusions were thoroughly studied earlier [20]. LCO_2 sometimes is observed at 20°C, but mostly cooling of the preparations is necessary. Th is 490-410°C; P at these T range from 2.8 to 1.1 kbar. The Raman spectra showed only the presence of CO_2 (Table).

Specimen No. 9 - cassiterite from the deposit Svetloe (Chukotka). Th of fluid inclusions, cryometric data and the Raman spectra of CH_4, CO_2 and N_2 found in the G phase, were published earlier [21]. On cooling the methane clathrate $CH_4 \cdot 6H_2O$ formed, and its Raman spectrum taken at -170°C is shown in Fig. 1e-f. The splitting of the methane molecule band is distinctly visible, revealing two components with maxima at 2910-2911 cm^{-1} and 2919 cm^{-1} (Fig. 1e), caused by the decrease of the CH_4 molecule symmetry during formation of the methane clathrate. Fig. 1f shows the Raman spectrum of the H_2O included in the methane clathrate, recorded also at -170°C. G phase of this inclusion consists only of N_2 and CH_4 and CO_2 are absent.

Specimen No. 10 - fluorite from the quartz-wolframite-fluorite vein of the deposit Belukha (E. Transbaikalia). Essentially CO_2 inclusions (Fig. 2c) have T of the partial homogenization 31°C and Tm -56.9 ± 0.2°C, somewhat lower than for pure CO_2 (-56.6°C). The Raman spectroscopy data confirm these results: besides CO_2 (98.2 mole %) N_2 (1.6 mole %) and methane (0.2 mole %) were found.

Specimen No. 11 - yellow-brownish sphalerite from the polymetal deposit Dal'negorsk (Primor'ye). The specimen bears hundreds of P two-phase fluid inclusions from a few µm to 0.8 mm with Th from 312 to 351°C. Solution concentration by cryometry is 6.0-6.5 wt. equiv. NaCl. The Raman spectra of the inclusion shown in the Fig. 2f showed the absence of CO_2, CH_4, N_2, H_2S and SO_2.

Fig. 2. Fluid inclusions in minerals; a - in "reticulate" quartz from pegmatites of Volyn', x 600, b - in topaz from the chamber pegmatite of Volyn' at +10°C, x 500, c - in quartz from tin-ore deposit Industial'noe, x 400, d - in topaz from the eruptive breccia, Schneckenstein, GDR, x 1100, e - in fluorite, tungsten deposit Belukha, x 1000, f - in sphalerite from the deposit Dal'negorsk, x 250, Th 323°C, g,h - in halite from the Dnepr-Donets depression, g - at -4°C, h - at -7°C.

Specimen No. 12 - vein halite from the Devonian salt rock of the Zapadno-Slavyanskaya structure (Dnepr-Donets depression), taken from a borehole at a depth of 1380 m. At room T the inclusions are one-phase (Fig. 2g) and they become two-phase (Fig. 2h) at T <-4.5°C. The Raman spectra of the inclusions with Th -4.5 to -5.6°C and Tm -60.8 to -61.8°C showed presence of CO_2 (79.1-83.0 mole %) and CH_4 (17.0-20.9 mole %). However, in some inclusions the amount of methane is much higher, as is inferred from the low Th (-35°C) and Tm (-66.5°C). The paper [22] presents the results of studies of these inclusions with use of the four independent methods of analysis: gas chromatography with various modes of inclusion opening, mass spectrometry, Raman spectroscopy and volumometry.

Specimen No. 13 is quartz from an ongorhyolite (a magmatic acid rock rich in F, Rb and B). Melt inclusions bear G, glass, K-spar, biotite, fluorite, quartz and magnetite. Studies of these inclusions [23] yielded Th 830-760°C, PH_2O 0.5-1.8 kbar and water content in melt 2.0-5.4 wt. %. H_2O, F and Cl were the essential volatiles, since other gases were not found.

Specimen No. 14 - olivine of oceanite from the volcano Piton de Furnese (Reunion Island, Indian Ocean). P low-density isometric inclusions were studied. No phase boundaries inside inclusions were discernible at room T. Cryometric studies showed the presence of CO_2 (triple point at -56.8 ± 0.2°C). LCO_2 appears only on cooling to 10°C (≈ Th of LCO_2 + GCO_2 → G), LH_2O and GH_2O, CH_4, CO and N_2 are absent. On heating of inclusions up to 360°C, in addition to CO_2 a plainly visible Raman line of H_2O (G) appeared. Calculations of mole relations H_2O:CO_2 gives the value 3:5, showing that a H_2O-CO_2 type of the fluid was trapped.

The determination of composition of the low-density inclusions in which no phase boundaries were visible by optical methods were established from -190 to +400°C represents another example of use of the Raman microprobe.

In such inclusions syngenetic to the high-T melt inclusions (Th 1550-1600°C) in the olivine phenocrysts from the Siberian meymechites [24] the Raman spectrum of nitrogen was recorded and the spectra of CH_4 and H_2S were recorded in the fluid phase of the crystallized inclusions in olivines from dunites associating with meymechites.

Thus, studies of the quantitative composition of gas phase of the fluid and melt microinclusions without their opening prove the extensive possibilities of the Raman spectroscopy during the investigation of the various geochemical processes.

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NAUMOV, V.B., KOVALENKO, V.I., SOBOLEV, A.V., TIKHONENKOV, P.I. and SAMOYLOV, V.S., 1986, Immiscibility of silicate and salt melts according to inclusion study data in high-temperature fluorite: Dokl. Akad. Nauk SSSR, v. 288, no. 2, p. 453-456 (in Russian). First author at the Vernadsky Inst. Geochem. & Analy. Chem. of Acad. Sci. USSR, Moscow.

During microscope studies of the polished sections of a number of magmatic rocks the authors found inclusions of mineral-forming media proving that crystal growth occurred under conditions of immiscibility of two melts, silicate and salt [1]. In the present paper the first data are published about the crystallization of fluorite from salt fluoride melt at T typical of magmatic processes (1100-1200°C).

Melanephelinites and their pyroclastic derivatives in the region of the carbonatite complex Mushugay-Khuduk (Mongolia) bear round or ellipsoid segregations of the size 1-5 cm, resembling amygdules. They are filled with calcite and fluorite, rarely with clinopyroxene, garnet and mica, and calcite is usually enriched in the central parts of those segregations. On the basis of the zoned structure and relation with the host rock, the segregations are either syngenetic or insignificantly later than the host melanephelinites. The rocks are of Upper Mesozoic age and they form a small sheet in the base of a sequence of alkaline volcanic rocks [2]. They are greenish-gray to black porphyric rocks with up to 30% of phenocrysts. The later consist of pyroxene, Mg-biotite, apatite and ore mineral. Pyroxene is diopside-augite or aegirine diopside-augite. Matrix consists of the same minerals plus leucite, nepheline and glass. Carbonate is also a frequent component of the matrix. Average rock composition (eight analyses) [2] is shown in Table 1.

The authors studied in detail inclusions in fluorite from the calcite-fluorite segregations. Fluorite is colorless to pale violet and transparent. The following types of inclusions were found: 1) gas, 2) solid, 3) crystallized salt melts. It is necessary to mention the absence of P and S water-bearing inclusions, that proves first, that fluorite crystallized from a "dry" (anhydrous) system and second, that later hydrothermal alteration of the rock did not occur.

G inclusions are distinctly S and occur along [healed] cross cutting fractures. On freezing down to -195°C phase changes were not observed, indicating a low density of filling. Solid inclusions, on the basis of

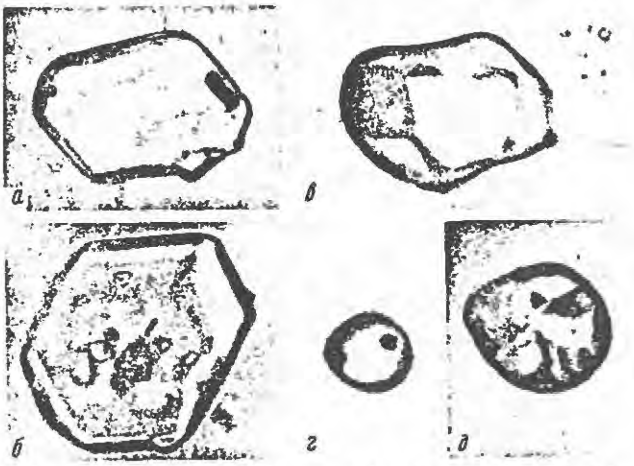

Fig. 1. Inclusions in fluorite; a,b,c - inclusions of fluoride melt, x 700 (a,b - fluid + hauyne + carbonate at 20°C, c - fluid + hauyne + melt at 1060°C); d - inclusion of carbonate melt before homogenization; e - inclusion of carbonate melt after homogenization (900°C) and quenching at 20°C, x 1250.

the optical features and electron microprobe analysis, are pyroxene, calcite, phlogopite and apatite (i.e., except for calcite, the same minerals as phenocrysts). Crystallization of these minerals occurred before or during fluorite formation. Microprobe analyses of three grains of pyroxene (60 x 100, 30 x 30 and 20 x 30 μm) performed in the central and marginal parts (Table 1) proved the homogeneity of pyroxene. Inclusions filled in various proportions between types 2 and 3 were frequently observed; especially common are inclusions of melt + calcite and melt + pyroxene.

Inclusions of type 3 are most interesting. They are uniformly distributed in the whole volume of fluorite and they are P. Phase ratios at room T and during thermometric studies are constant. These inclusions (Fig. 1a, b) consist of 90 vol.% of transparent isotropic mineral, 5% of carbonate, 4% of weakly anisotropic mineral (possibly apatite) and <1% of low-density G phase, usually strongly deformed and poorly discernible. Electron microprobe analysis proved that isotropic mineral is hauyne (Table 1). Thermometric observations were performed up to 850°C in Kalyuzhnyi's microscope heating stage [3] in a helium atmosphere, specially purified, because during heating in air at T >800°C fluorite darkens intensively and becomes opaque. About 25 runs were made and in 10 runs complete homogenization was achieved. The first phase changes were observed at 600-640°C, when melting of carbonate occurred and G bubble obtained spherical shape.

Table 1

Chemical composition of melanephelinites and [phases from] inclusions in fluorite (wt.%)

Oxide	Melanephelinite (8)	Fluorite (4)	Pyroxene center (4)	Pyroxene margin (4)	Calcite (5)	Phlogopite (2)	Hauyne (3)
SiO_2	43.84	--	51.24	51.26	--	42.92	35.72
TiO_2	1.30	--	0.10	0.11	--	0.64	0.00
Al_2O_3	14.23	0.00	1.03	1.01	0.00	10.86	30.28
FeO	8.47	0.00	11.82	11.63	0.06	8.32	0.10
MnO	0.15	--	0.33	0.38	--	0.40	0.00
MgO	6.44	0.00	10.38	10.47	0.04	21.02	0.00
CaO	10.11	71.76	21.25	21.53	54.95	0.10	6.04
Na_2O	4.34	--	2.19	2.01	--	0.26	10.00
K_2O	3.26	--	0.01	0.01	--	10.76	0.37
P_2O_5	1.51	--	0.00	0.01	--	0.11	0.00
SO_4	--	--	0.14	0.10	--	0.11	12.96
F	0.80	--	--	--	--	--	--
Ignition loss	5.12	--	--	--	--	--	--

Note: total iron as FeO; in melanephelinite Fe_2O_3 = 4.55; in parentheses no. of analyses.

The second anisotropic phase (apatite?) melts at 950-980°C and next hauyne starts to melt (Fig. 1c), finishing its melting at 1020-1120°C. In all inclusions only two phases remain then: melt and G bubble. T decrease causes rapid growth of hauyne. The very low viscosity of this melt is noteworthy, as evidenced by frequently very rapid (1-2 sec.) movement of the gas bubble inside the inclusion. Total homogenization with dissolution of G phase in melt occurs at 1090-1200°C in a few minutes. Even very rapid (1-2 sec.) cooling does not cause the quenching of melt - it always crystallizes. For inclusions of silicate melt in pyroxene from melanephelinites of Mushugay-Khuduk, V.A. Turkov has obtained [1] close Th 1190-1200°C. High Th was found also [5] for inclusions of silicate melts in apatite from trachytes and syenites of the same massif (1150-1100°C) and for silicate-salt melts in apatite from magnetite-apatite-carbonate rocks (1100-1000°C).

From the series of photographs taken during homogenization the significant increase of inclusion volume was found due to melting of the host mineral (fluorite). When a homogeneous state is achieved, inclusion volume increases three times if compared with the volume before run. This allowed calculation of the approximate composition and density of the original salt melt, from which fluorite crystallized (wt.%) - Ca 39.7, F 35.6, SiO_2 9.3, Al_2O_3 7.8, SO_4 3.4, P_2O_5 0.8, CO_2 0.8, Na_2O 2.5, K_2O 0.1, density 3.0 g/cm^3.

In addition to the P inclusions of essentially fluoride composition, later inclusions of carbonate composition were found in fluorite (Fig. 1d, e). The spatial connection of these inclusions with the low-density G inclusions was apparent. Th of carbonate inclusions are 800-920°C, and during the further T increase all carbonate melt inclusions decrepitate. Calculations from photographs indicated the volume increase to be 70%, thus, in carbonate melt 22.7 wt.% of fluorine is dissolved. The density of such a melt is 2.8 g/cm^3. One may mention that the density of carbonate melt significantly enriched in water (26.2 vol.% or 11.4 wt.% of H_2O) is lowered to 2.3-2.2 g/cm^3 (the Magnet Cove carbonatites, Arkansas, USA [6]).

The lowermost Th of essentially carbonate inclusions in fluorite were measured for P inclusions from stockwork carbonatites of Mushugay-Khuduk. They are 600°C. PS inclusions with lower Th (560-360°C) in this fluorite are distinctly rich in water, i.e., water-bearing brines were the mineral-forming medium.

Thus, the data obtained prove that melanephelinite and high-temperature (1200-1100°C) salt fluoride melts are syngenetic and they formed, seemingly, by liquation. Salt melts are originally rich in fluorine with admixture of carbonate-sulfate and silicate components, [but] on T decrease they become higher in carbonate component to form the essentially carbonate melt (920-600°C) with admixture of other components, and next with water, altering to relatively low-T (530-360°C) water brines. (Received by the Redaction 15 IV 1985).

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POLYAKOV, A.I., TURKOV, V.A. and IGNATENKO, K.I., 1986, Composition of the primary melts of the trachyte-basalt series of the Udokan Ridge, (Baykal rift) from data of fluid inclusion studies: Dokl. Akad. Nauk SSSR, v. 286, no. 3, p. 691-695 (in Russian). Authors at the Inst. Geochem. & Anal. Chem. of Acad. Sci., Moscow, USSR.

(...) The objects of the present study were the Neogene-Quaternary effusives of the volcanic field of the Udokan Ridge in the Baykal rift zone. Alkaline olivine basalts are the prevailing type of rocks for the Baykal rift. In lesser amounts the more alkaline varieties (basanites and melaleucitites) and subalkaline basalts were found. Average composition of the alkaline olivine basalts of the individual volcanic fields is relatively invariable [1,2]. Differentiation of melt is most typical of the Udokan volcanic field. Here rocks of the trachyte-basalt series occur (alkaline basalts, trachybasalts, trachyandesites, alkaline trachytes).

Thermobarometric studies of the last years [3,4] show that differentiated volcanic series rhyolite-basalt, trachyte-basalt and phonolite-basalt form due to the crystallization differentiation in shallow (5-15 km) magmatic chambers. This is exactly where phenocrysts grow and the processes of fractionation take place, changing the composition of the primary melts.

Composition of melts flowing to the magmatic chambers may be reconstructed by analysis of inclusions in liquidus and sub-liquidus phenocrysts. Such inclusions were found in olivine and clinopyroxene from basalts and in clinopyroxene and plagioclase from cumulates in volcanic rocks. Composition of inclusions in minerals of trachyandesites, from which olivine was studied, provides the possibility to answer the question, whether the leucocratic rocks of the series are connected with the initial basalt melt or have another origin.

Chemical composition of magmatic inclusions in phenocrysts was determined with use of the X-ray microanalyzers "Hitachi" XMA-5B and "Camebax microbeam." The size of inclusions selected for studies was >20 µm. All were primary, partly crystallized, with high Th (1200-1320°C). Before analysis homogenization of inclusions was performed in a heating stage with a Pt heating unit, and next the inclusion was opened for the microprobe analysis. Also the composition of the host mineral was determined.

Table 1.
Chemical composition of the primary magmatic microinclusions and host phenocrysts and rocks*

Component	Basalt, specimen No. 13385					Ol-Cpx-Pl-cumulate, specimen No. 13306						Trachyandesite, specimen No. 13299		
	Rock	host mineral		inclusions		Rock	host mineral			inclusions		Rock	host mineral	inclusions
		Ol	Cpx	in Ol	in Cpx		Ol	Cpx	Pl	in Cpx	in Pl		Ol	in Ol
SiO_2	46.30	39.3	46.5	44.6	50.1	46.30	39.2	49.8	49.3	49.9	47.7	55.80	38.1	46.4
TiO_2	2.11		1.6	3.7	2.1	1.34	--	1.1	0.1	1.3	2.5	1.07	--	2.1
Al_2O_3	15.64	--	8.0	18.3	18.6	17.47	--	5.9	31.0	16.3	25.4	17.55	--	14.4
Total Fe as FeO	11.84	17.6	8.7	9.3	10.1	7.60	24.3	9.5	0.4	11.7	8.4	6.91	22.3	14.0
MnO	0.15	0.3	0.3	0.1	0.2	0.11	0.1	0.3	--	0.3	0.2	0.16	0.4	0.5
MgO	8.49	41.8	13.4	9.1	5.9	9.17	38.5	13.2	0.1	5.9	4.0	1.99	39.4	11.3
CaO	9.18	0.3	19.6	10.2	10.7	13.23	0.5	20.0	13.7	10.2	3.2	3.68	0.4	8.8
Na_2O	3.10	--	0.9	2.7	1.9	2.68	--	0.8	3.3	1.6	2.1	6.71	--	0.8
K_2O	1.04	--	--	1.8	1.4	0.53	--	--	0.2	1.8	2.0	4.47	--	1.9
Total	98.63	99.3	99.0	99.8	101.0	98.43	102.6	100.6	98.2	99.0	95.5	100.11	100.6	100.2
Composition of the host mineral		Fo 80.8	Fs 15.1, En 41.1				Fo 73.5	Fs 16.2, En 40.1	An 69.1				Fo 75.9	
Mg**	0.59			0.66	0.55					0.50	0.49	0.37		0.61
$K_D \frac{Fe\text{-}Mg}{Ol\text{-}L}$	0.34			0.41	0.27					0.35	0.33	0.18		0.47
Th, °C				1320	1260					1260	1200			1250
No. of inclusions studied				2	1					1	2			2

* Rock compositions determined by the x-ray fluorescence method; composition of inclusions and phenocrysts - electron microprobe determinations.

** $Mg = \frac{MgO}{MgO + 0.9\Sigma FeO}$ (atomic amounts); Ol - olivine, Cpx - clinopyroxene, Pl - plagioclase, L - melt.

Analyses (Table 1 and Fig. 1) indicate the basaltic composition of rocks and inclusion melts. The composition of inclusions in olivine is closest to the host basalt (sample 13385). Melt inclusions in pyroxene from the same rock bear higher SiO_2 and lower MgO contents, if compared with inclusions in olivine and the bulk host basalt composition. It is connected probably with the later crystallization of clinopyroxene than olivine from already fractionated melt.

The chemical composition of minerals from the cumulate is the same as the composition of phenocrysts from basalts. Compositions of inclusions in plagioclase and clinopyroxene correspond to basalt with a low degree of fractionation. High content of Al_2O_3 in inclusion from plagioclase is possibly connected with partial dissolution of the host mineral on homogenization.

For trachyandesites the composition of the olivine phenocrysts varies over unusually wide ranges (Fo 40-Fo 80). The studied inclusions occur in Mg-olivine Fo 72.4. Chemical composition of inclusions in the studied grain is exactly the same as the composition of basalt. This fact and presence of the Mg-olivines in rocks with 54-56% SiO_2 is an important indication of the connection of trachyte and trachyandesite melts with the primary basalt magmas.

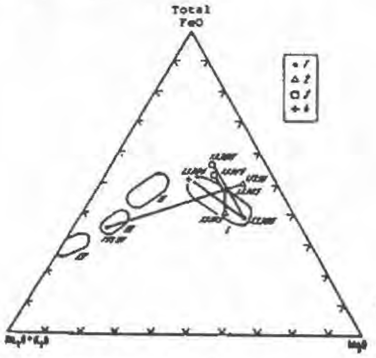

Fig.1

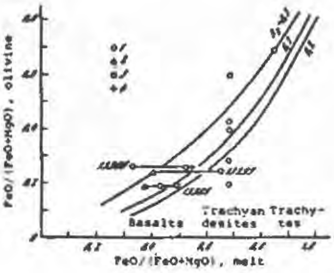

Fig.2

Fig. 1. Plot of the compositions of the volcanic rocks from the Udokan Ridge and P magmatic inclusions in phenocrysts: I - alkaline olivine basalts, II - trachybasalts, III - trachyandesites, IV - trachytes; 1 - bulk composition of rock; composition of P magmatic inclusions: 2 - in olivine, 3 - in clinopyroxene, 4 - in plagioclase. Lines join the compositions of rocks and inclusions of the same specimen.

Fig. 2. Curves of olivine-melt equilibrium. FeO and MgO in mole proportions, for melt (rock) FeO = 0.9 ($FeO + Fe_2O_3$). Composition of the melt: 1 - bulk rock; inclusions in olivine (2), pyroxene (3) and plagioclase (4). Lines join points for individual specimens.

Equilibrium of phenocrysts and melt in inclusions and as the parent melt (bulk rock) (...) for olivine is characterized by the coefficient of crystallization (K_D) for iron and magnesium:

$$K_D = \frac{X_{Ol}^{FeO} \cdot X_L^{MgO}}{X_{Ol}^{MgO} \cdot X_L^{FeO}},$$

where X - mole concentration of Mg and Fe in olivine (Ol) and in melt (L). The value K_D for liquidus olivine in basalt, on the basis of numerous experiments [5,6] is 0.3 ± 0.03. There occur deviations from this value, but the prevailing number of results fall in the range 0.26-0.37 [7]. (...) For more acid compositions the equilibrium value K_D is not known sufficiently exactly, but is higher than 0.3 [8,9]. Fig. 2 presents the curves of olivine-melt equilibrium with compositions of rocks and inclusions. For basalts most K_D falls in the interval of the equilibrium values, along with the data for the pairs olivine-basalt and olivine-inclusion melt in the inclusions in clinopyroxene and plagioclase from cumulate. The value K_D Fe-Mg for the pair olivine-inclusion in olivine is 0.41. This high deviation from the equilibrium value may be explained by the supposition that this olivine did not crystallize under liquidus conditions.

For trachyandesite (sample 13299) the value K_D Fe-Mg is 0.18 for the pair olivine-rock. One may suppose that olivine phenocrysts with such composition are of cumulative type and they are connected with crystallization of more basic melt. Mechanism of mixing of melts: basalt + trachyte, in this case is not probable, because the olivine composition changes gradually from Mg-rich to Fe-rich ones. The value K_D Fe-Mg for the pair olivine-inclusion also differs from the equilibrium value but toward higher numbers

(0.51). Maybe here also this deviation is caused [not] by a non-liquidus origin of the olivine, but by its crystallization from a melt fractionated by crystallization of other Fe-Mg minerals. Also, overheating of the inclusion on homogenization is not excluded. Especially this is probable for the specimen of basalt, where Th was unusually high - 1320°C. Another possible reason of the high K_D values for the pair olivine-inclusion may be contamination of the analysis results of inclusion by host olivine material.

The studies prove that in the crustal shallow chambers of the volcanic field in the Udokan Ridge there were magmas with MgO content 8-10%. Existence of Mg-rich picritic melts is possible only at deeper levels. Processes of fractionation of basalt melts lead to formation of the trachyte-basalt series.

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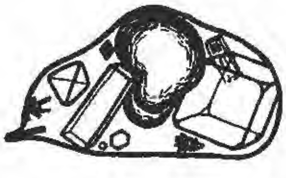


Indices

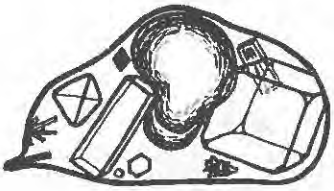
The user should keep in mind the following features of these indices. The indexing procedures and entries are continuously evolving and hence are not uniform from one volume of Fluid Inclusion Research to the next, and even within a given volume consistency cannot be claimed. In some entries, only the more significant items are listed. Where several different items in the given category occur on the same page, the number of such items (or "x," for multiple entries) is put in parentheses after the page reference. Some items may continue on to following pages.

SUBJECT INDEX

See general notes above. I have tried to make this a user-oriented index rather than a documentalist's type index. Only data in the title and abstract are indexed, and then only if they appear to be of more than incidental mention. Misleading or erroneous translations may have resulted in occasional incorrect or omitted entries. Some entries are included under a given subject heading even though the index word does not occur in the abstract. The deposit type is indexed only where it is evident without research. The aim has been to err on the side of completeness and convenience to the user. Thus I have attempted to index some related or possible pertinent items, and even ones involving negative data or evidence, under each category. The ore type terms such as porphyry copper and Mississippi Valley are used loosely. Analyses for specific elements are indexed only when they are particularly unusual or significant; thus semiquantitative spectrographic analyses and statements of analyses as "Na-Ca-Cl fluids" are generally ignored. The mineral host for the inclusions studied is indexed except for quartz and decrepitation studies. Entries that would include too many page references are listed without page numbers. Some entries with broad and diffuse applicability (e.g., "Geobarometry, methods and comparisons") have only a few of the most pertinent page references.

LOCALITY INDEX

Notes: See page 523. Individual deposit place names are indexed only when significant data are presented. Inexact place names (e.g., "Soviet Far East") are not entered, nor are individual mines in districts known by a district name, although some may be so entered, in error. Cyrillic (and Chinese) place names are listed as they were given in the original transliteration; various transliteration procedures yield different spellings: Began and Began'skii, Blyava and Blyavinsk, Kochkar and Kochkarskoje, Volhynia and Volyn, Kirin and Jilin.



Errata

Note: This errata section includes corrections to any published volume, but does not reproduce errata published earlier. The editors would appreciate notice of any other errors or omissions. In particular, we would appreciate corrections of citations which have been erroneously entered under the given name rather than the family name.

TEXT Volume	Page	Item†	Line	
13	123	2	1	Change KITLYK to KITYK.
14	xiii			Symbol for parts per thousand should be % .
17	xiii			Symbol for parts per thousand should be % .
18	xiii			Symbols for parts per thousand and parts per hundred should be exchanged.
18	152	2	1	Change DOLOMANOV to DOLOMANOVA.
18	190	3	3	Add: Materials Research Society Symposium Proceedings, v. 50.
18	217	3	1	Change KOTEEV to KHOTEEV, and move to p. 206.
18	218	3	8	Change HCOOH to $(COOH)_2 \cdot 2H_2O$.
18	279	3	1	Change VASYNTA to VASYŪTA.
18	288	3	1	Change L985 to 1985.
18	434	2	6	Change VESEGEI to VSEGEI.

†Partial items are also counted.

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