FLUID INCLUSION RESEARCH

Edwin Roedder, *Editor*

Andrzej Kozlowski and Harvey E. Belkin,
Associate Editors

Volume 18

1985

Harvey E Belkin

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Camera-ready copy for this volume
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. As the publication is completely independent of COFFI, and does not actually serve as a "Proceedings" volume, that subtitle is being dropped with this issue.

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 291 items from Russian sources in this volume, 96 were translated or abstracted by Associate Editor Kozlowski and 79 by David A. Brown of Australia; these translations represent an enormous contribution toward achieving the aims of Fluid Inclusion Research. There are 1050 items from other foreign language sources (including 64 from the Chinese literature) and the English language literature for a total of 1341 abstracts, citations, or annotated citations, plus subject and locality indices. One 219-page Russian book has been translated in full (see Kalyuzhnyi, 1985), but as it consisted of 143 individual abstracts, these have been included alphabetically; some of these translations had to be shortened by the editor.

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 COFFI. 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); R. Bodnar (Blacksburg, VA); C. Eastoe (Tucson, AZ); K. Fuzikawa (Belo Horizonte, Brazil); J. Hedenquist (Taupo, N.Z.); E. Horn (Göttingen, FRG); S. Jaireth (Canberra, Australia); R. Kreulen (Utrecht, The Netherlands); I. Kulikov (Moscow, USSR); P. Lattanzi (Firenze, Italy); M.J. Logsdon (Denver, CO); Huan-Zhang Lu (Chicoutimi, Que.); K. Okano (Taupo, N.Z.); H.A. Stalder (Bern, Switz.); R. Thomas (Freiberg, DDR); and D. Vitaliano (Bloomington, IN). Many other individuals, too numerous to list here, have helped by sending books, reprints, references, and abstracts. I am also indebted to Kevin Howard (U.S.G.S.) for library searches and, most particularly, to coeditors Kozlowski and 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 with each recent volume; in the last 28 months six volumes (13 through 18) have been sent to press.

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.

October 10, 1986 Edwin Roedder, Editor

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Translations

Kalyuzhnyi, 1985 (This 219-page Russian book consists of 143 individually authored abstracts; translations of these are entered alphabetically in the Abstracts section.)

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Notices of Meetings and Symposia

Past Meetings

The eighth meeting on European Current Research on Fluid Inclusions ("ECRFI"), was held 10-12 April, 1985, at the University of Göttingen, Göttingen, F.R.G., convened by Dr. E.E. Horn of the Geological Institute at the University of Göttingen. 108 attendees, from 21 countries, heard or presented 69 papers. Abstracts will be found in this volume.

A symposium on Occurrence and Genesis of Brines and Gases in Crystalline Rocks was held 15-17 May, 1985, in connection with the GAC/MAC Joint Annual Meeting at Frederickton, New Brunswick, Canada. Abstracts will be found in this volume.

The Seventh All-Union Conference on Thermobarogeochemistry was held in L'vov, USSR, September 1985. The abstracts were published in two volumes (see Kalyuzhnyi, 1985, this volume). All have been translated, but only those of Volume 1 could be printed in this volume; those of Volume 2 will be found in Volume 19 (1986).

A Fluid Inclusion User School was held July 9-12, 1986, at New Mexico Institute of Mining and Technology, convened by Dr. D.I. Norman, N.M.I.M.T., Department Geoscience, Socorro, NM 87801.

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 Volume 19.

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 Volume 19.

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 Volume 19. At this meeting a 16-mm film was shown entitled "Magma inclusions in crystals and volcanic processes," produced by R. Clocchiatti and J. Weiss (Saclay, France). The film is an excellent teaching device, and is available in two versions, with French or English sound track (price about $500.00 US).

The Fifth International Symposium on Water-Rock Interaction was held in Reykjavik, Iceland, August 8-17, 1986. Pertinent abstracts will be found in Volume 19.

The Seventh IAGOD Symposium was held at Lulea, Sweden, August 18-22, 1986. A fluid inclusion session was convened by E. Roedder. Pertinent abstracts will be found in Volume 19.

An international symposium on the Geology of Gold Deposits was held in Toronto, Canada, September 28 - October 1, 1986.

A Conf. on Isotope Geochemistry of Groundwater and Fracture Material in Plutonic Rock was held October 1-3, 1986, at Mont. Ste. Marie, Quebec.

Future Meetings

A meeting on Fluid Inclusion Studies: Advances in Metallogenesis and Exploration will be held at University of Southampton, under the auspices of the Mineral Deposits Studies Group of the (British) Geological Society, 15-16 December, 1986. For details contact Dr. R.P. Foster, Department of Geology, University of Southampton, SO9 5NH, U.K.

The initial conference of American Current Research on Fluid Inclusions (ACROFI) will be 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. Contact Dr. A. Campbell, Department of Geoscience, N.M. Institute of Mining and Technology, Socorro, NM 87801, to be placed on the mailing list for future notices.

There will be a NATO Advance Study Institute: Geochemistry of Hydrothermal Ore-Forming Processes, Madrid and Salamanca, Spain, January 7-23, 1987. For details contact Prof. H.L. Barnes, 235 Deike Bldg., Penn State Univ., University Park, PA 16802.

A GSA Penrose Conference "Geochemistry of Waters in Deep Sedimentary Basins," will be held March 16-20, 1987, at the Casa Sirena Resort, Oxnard, California. Conveners are J.S. Hanor (LSU), Y.K. Kharaka (USGS) and L.S. Land (U. Texas).

The Ninth ECRFI Symposium on Fluid Inclusions will be held 4-6 May, 1987, at University of Oporto, Portugal. For details contact Dr. F. Noronha, Centro de Geologia da Universidade do Porto, Fac. Ciências, 4000 Porto, Portugal.

A symposium on Proterozoic Geochemistry, under the aegis of the IUGS, will be held at Lund, Sweden, June 3-6, 1987. For details contact Prof. Roland Gorbatschev, Geol. Inst., Lund University, S-223-62 Lund, Sweden.

The First International Congress on Geochemistry and Cosmochemistry, under the aegis of the IAGC, will be held June 30 - July 6, 1987, in Paris. For details contact Dr. C.J. Allegre, Lab. de Géochem., 4, place Jussieu, 75252 Paris Cedex, France.

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.

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.

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

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 COFFI 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,
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L'vov, Ukr. SSR, USSR

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, for singular or plural:

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 pressure. 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.

Equiv. 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, 1985

Note: Some items from previous years that were missed earlier are included, as are items for which a full English translation has become available during the year, 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.

ADAM, J.-F. and WEBER, Klaus, 1985, Orientation and morphology of microcracks in quartzites of the Rheinisches Schiefergebirge (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 2. Authors at Inst. Geol. und Dynamik der Lithosphäre, Goldschmidt-StraBe 3, D-3400 Göttingen.

Microcracks in fine-grained quartzites have been investigated in samples from different positions in folds (limbs, hinge) to uncover the relationships between microcracks and other structural features.

The samples were analyzed with the universal stage and the following parameters have been recorded:

1) Orientation of microcracks and quartz c-axes;
2) Strike of the apparent long axis of quartz grains;
3) Apparent length of microcracks; and
4) Apparent length of the long and short axes of quartz grains.

Results of these investigations and a scanning electron microscope survey of the samples will be presented together with a descriptive terminology of microcracks. (Authors' abstract)

AFIFI, A.M., KELLY, W.C. and RYE, R.O., 1985, Fluid inclusion and stable isotope study of telluride mineralization at Mahd Adh Dhahab, Saudi Arabia (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 510. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Mahd Adh Dhahab is unique among Precambrian gold deposits in that it displays many characteristics of epithermal precious metal districts. Au-Ag-Cu-Zn-Pb mineralization occurs principally in the third of five generations of quartz veins. Sulfur isotopic equilibrium was generally maintained among sulfides which range in $\delta^{34}S$ from -1.8 (galena) to 6.4 (pyrite). The narrow range in $\delta^{34}S$ of sulfides is inconsistent with large variations in fO_2 calculated from chlorite ± pyrite ± hematite assemblages. Galena-sphalerite pairs yield temperatures in the range 160-270°C for stage 3 veins, which fall within the 120-300°C range defined by fluid inclusion thermometry. Fluid salinities are in the range 0-5 wt.% NaCl equivalent. $\delta^{18}O$ of waters in equilibrium with quartz, feldspar, and chlorite from vein generations 1-3 fall within the narrow range -3 to 0. $\delta^{34}S$ and $\delta^{18}O$

values of stage 4 barite are inversely correlated, and range from 27.6 to 11.9 and 6.2 to 13.1, respectively. Likewise, $\delta^{18}O$ of stage 4 carbonates ranges from 8.5 to 16.5, while $\delta^{13}C$ remains in the range of -5 to -7. These trends indicate mixing of $\delta^{18}O \approx 0$ waters with heavier ($\delta^{18}O>5$) more oxidized waters during stage 4 deposition which led to non-equilibrium oxidation of H_2S. δD values of vein chlorites fall within a narrow range of -65 to -75, while δD measurements of inclusion fluids in quartz display a wider spread from -13 to -43; the lighter values may reflect contamination by secondary inclusions. The stable isotope data indicate probable derivation of both sulfur and carbon from igneous sources. Districtwide variation in sulfur and oxygen isotopes indicate the presence of several hydrothermal centers, which has possible significance to exploration. (Authors' abstract)

AHRENS, L.J., SISSON, V.B. and HOLLISTER, L.S., 1985, CO_2-rich metamorphic fluids, south-central Maine (abst.): EOS, v. 66, no. 18, p. 389. Authors at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544.

Many studies of fluid inclusions in metamorphic rocks have shown that metamorphic fluids can be trapped as fluid inclusions. Several studies have also presented evidence that fluid immiscibility (CO_2-rich fluid plus aqueous brine, or CO_2-rich fluid plus melt) occurs during metamorphism. The documentation by J. Ferry of the temperature gradient, and his predictions of fluid compositions, make the Waterville area of south-central Maine an ideal place to study fluid phase immiscibility in metamorphic rocks by comparing and evaluating the similarities and differences between predicted fluid compositions and those actually present in fluid inclusions. The temperature gradient during progressive metamorphism includes the interval of probable CO_2 and aqueous brine immiscibility, and the rock associations are appropriate for producing the necessary fluid compositions. Ferry's major conclusion can be generalized by the statement that CO_2 is produced from metamorphism of carbonates, but that there was pervasive infiltration of an H_2O-rich fluid during metamorphism.

Fluid inclusion densities from the Waterville area are consistent with metamorphic conditions, and they change systematically with grade. However, the most abundant, and earliest trapped, fluid represented in fluid inclusions is CO_2-rich. For example, in medium grade calc-silicate, Ferry predicted $XCO_2 = 0.55$ to 0.63, and we found $XCO_2 = 0.70$-1.0. In a higher grade pelite Ferry predicted $XCO_2 = 0.2$-0.38, and we found $XCO_2 =$ 0.67-1.0. Our results imply that either the infiltrating fluid during metamorphism was CO_2-rich, or that only the CO_2-rich phase of an immiscible, synmetamorphic fluid is represented in the inclusions. (Authors' abstract)

AI, Yongde, LI, Xiangming and CHEN, Yuchuan, 1985, A discussion on the genesis of the Xiertala iron-zinc deposit: Bull. of the Inst. Min. Deposits, Chinese Acad. Geol. Sci., Series II, 1985, no. 3, Serial no. 15, p. 62-86 (in Chinese; English abstract). First author at Inst. Min. Deposits, Chinese Acad. Geol. Sci., PRC.

Includes many determinations of Td of various skarn minerals. (E.R.)

AINES, R.D. and ROSSMAN, G.R., 1985, The high temperature behavior of trace hydrous components in silicate minerals: Am. Mineralogist, v. 70, p. 1169-1179. First author at Univ. California, Lawrence Livermore Nat'l. Lab., Earth Sci. Dept., P.O. Box 808, Livermore, CA 94550.

We have studied the high temperature behavior of water and hydroxide in quartz, feldspar, topaz, zircon, muscovite, cordierite, and beryl using high temperature infrared spectroscopy. We have directly observed processes such as dehydration and changes in hydrogen speciation. In some minerals trace hydroxyl and water speciation and properties at temperatures of geologic interest can be dramatically different from those at 25°C. In muscovite, no changes in speciation occur prior to dehydration at 750°C, whereas in topaz hydroxyl sites interconvert at 500°C. In metamict zircon strongly hydrogen-bonded hydroxyl is preferentially lost from a continuum of sites during continuous dehydration occurring from 400° to 900°C. There are only minor changes in O-H region spectrum of natural quartz at the α-β transition point. In feldspar one type of molecular water is lost at ~200°C, and at 600° to 800° a second water type converts irreversibly to a new hydrous species. Changes at high temperature common to the infrared absorption bands of all minerals studied are: broadening, a shift to lower wavenumbers, and a slight decrease in integral intensity. Temperature coefficients for O-H stretching peak shifts range from 0 to $-0.045\ cm^{-1}/°C$. Lattice modes also broaden and shift to lower wavenumbers, typically with temperature coefficients of about $-0.03\ cm^{-1}/°C$. (Authors' abstract)

AKANDE, S.O., HORN, E.E. and REUTEL, C., 1985, Textural, mineralogical and fluid inclusion studies of the lead-zinc-fluorite veins in the Nigerian Benue Trough: - metallogenic relationships (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 4. First author at Dept. Geol., Univ. Ilorin, Ilorin, Nigeria.

Lead-zinc-fluorite deposits occur as fracture controlled bodies in Nigeria at Arufu and Akwana within the Lower Cretaceous (Albian) carbonate sequence of the middle Benue Valley.

The principal ore minerals are galena, sphalerite, tetrahedrite, native silver and fluorite, plus minor marcasite and chalcopyrite, commonly intergrown with quartz and covered by supergene minerals. Ore minerals also occur as stratiform stringers and open space fillings of the interstitial, intragranular, fracture and channel porosity of the carbonate host. Filled vugs and pore spaces are in close proximity to the mineralized fractures within the carbonate host. This relationship suggests that the fracture controlled veins acted as feeders to the open space sulphide infillings. The carbonate wall rocks are silicified in areas adjacent to veins to varying degrees.

Fluid inclusion studies in fluorite and quartz from the deposits suggest that the ore minerals precipitate from low temperature saline fluids. Te data indicate high values of $CaCl_2$ in the mineral-forming solutions. The melting temperatures of ice are in a range from -23° to -17°C. Whereas the temperature of formation of fluorite lies betwen 110° and 145°C, the Th of quartz ranges from 125° to 200°C. Lower temperatures were reported from sphalerite and quartz inclusions in the Ishiagu Pb + Zn (-Ag, -F) in southern Benue Valley. The presence of silver and fluorite in the Arufu and Akwana deposits constrast mineralogically with those deposits in the southern Benue Valley where the mineralization is dominantly sphalerite and galena. (From the authors' abstract)

AKHMANOVA, M.V., NAUMOV, V.B. and SOBOLEV, A.V., 1985, Use of laser Raman microprobe for studies of inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 74-75 (in Russian). Authors at GEOKHI, Moscow, USSR.

Studies were performed with use of French microprobe "MOLE" in Moscow, Nancy and Lille. The device may be used on inclusions ≥10 µm, and it detects (in g/cm^3) the amounts of gases beginning from: CO_2 0.01, CH_4 0.002, CO 0.01, C_2H_6 and C_3H_8 0.001, N_2 0.01, H_2S 0.005, H_2 0.001, SO_2 0.002; ions SO_4 and PO_4 are detected in solutions when concentration ≥200 ppm. Distance of inclusion from polished preparation should be ≤100 µm, but best results are obtained if it is 50 µm. All organic impurities should be removed from the surface. Over 20 samples were investigated. Quartz from veins from metamorphic rocks (with organic matter) of E. Transbaikalia bears in inclusions CO_2, CH_4, N_2 and H_2S, the later up to 20 mole %. P inclusions in cassiterite from the deposit Svetloe (NE USSR) bear CH_4, CO_2, N_2 but not C_2H_6, H_2, H_2S; CH_4 reaches 62 mole %, nitrogen 31 mole %. Raman spectra of cryohydrate of $CH_4 \cdot 6H_2O$ were recorded at -170°C for the first time. G inclusions from reticulate quartz from Volyn' bear only CO_2; topaz from the Volynian pegmatites bears in inclusions 99.6 mole % of CO_2 and 0.4 mole % of CH_4. G phase of inclusions with halite, sylvite and magnetite in fluorite (Tyrnyauz, N. Caucasus) shows no CO_2, CH_4 or N_2. Inclusions of dense gases in halite from Dnepr-Donets depression (density 0.96 g/cm^3) bear 82 mole % CO_2 and 18 mole % CH_4. G bubble in melt inclusions in quartz from ongoryolites (Mongolia) was filled only by H_2O; some in olivine (Reunion Island) were filled by CO_2 (62.5%) and H_2O (37.5%); water was detected when inclusion was heated to 360°C. (Authors' abstract; translated and shortened by A.K.)

AKRIGHT, R.L., 1985, Victorine (Sumich) gold mine (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 206. Author at 7221 S. Yarrow St., Littleton, CO 80123.

Gold mineralization in the Victorine mine occurs in a shallow dipping (15°-16°), quartz vein system associated with pyrite, sphalerite, galena, chalcopyrite and tetrahedrite. Fluid inclusion studies indicate at 320°C temperature for the auriferous quartz. The quartz vein system follows the trace of a thrust fault which cuts a series of rocks locally described as the Broad Canyon sequence of middle Cambrian to early Ordovician. (From the author's abstract)

ALBERS, J.P., 1985, A special issue devoted to massive sulfide deposits, West Shasta district, California, Introduction: Ec. Geol., v. 80, no. 8, p. 2067-2071.

This number of the journal includes 14 papers on the district, many dealing with isotopic analyses of H, O, and S in solid phases (and possible fluid compositions). (E.R.)

ALEKHIN, Yu.V., 1985, About the various degrees of representation of the parameters of mineral-forming medium by gas-liquid inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 6-8 (in Russian). Author at State Univ., Moscow, USSR.

As much as 92-94% of the inclusions in minerals of hydrothermal origin homogenize in L phase, even if saturation with gas is high for such inclusions. These data prove, however, the greater probability of trapping of L phase than G phase. The essential parameters that would not stimulate trapping of G phase are trivial:

1. Most mineral surfaces are hydrophilic, i.e., the wetting phase is water-salt solution, even if its volume is subordinate.

2. Liquid phase of hydrothermal fluid carries the prevailing amount of mineral substance, causing its prevailing trapping.

Although data on homogenization of inclusions in quartz are most common, there exists a significant amount of observations of homogenization in various other minerals. The connection of type of homogenization with the value of the limiting angle of wetting may be shown. This is the reason for doubt concerning reports about a specific gas medium for the formation of certain minerals. The obtainable data on physico-chemical properties of post-magmatic fluids lead to the conclusion that most commonly hydrothermal solutions are two-phase fluids. More complete information about bulk composition of such solutions may be obtained from inclusions in minerals which may form from supersaturated solutions, pass through stages of formation of colloids and gels, and then recrystallize. Inclusion solutions may be the dispersed phase of colloid solution, later transformed into water-bearing gel. However, also for these cases trapping of G phase is rare. Frequently the striking uniformity of all characteristics of the prevailing number of inclusions in a mineral or in a mineral zone is observed. (...) (Author's abstract shortened and translated by A.K.)

ALEXANDROV, I.V., KRASOV, A.M. and KOCHNOVA, L.N., 1985, On the effect of potassium, sodium and fluorine on associations of rock-forming minerals and formation of Ta-Nb ore mineralization in the rare-metal granite pegmatities: Geokhimiya, 1985, no. 5, p. 620-629 (in Russian).

ALLAKHVERDIYEV, Sh.I. and SIMONOV, V.A., 1985, Temperature of formation of peridotites and gabbroids in the ophiolites of the Lesser Caucasus (based on inclusions of mineral-forming media) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 149 (in Russian; translation by D.A. Brown). Author at Inst. Geol. Acad. Sci. Azerb. SSR, Baku, USSR.

Thermobarogeochemical studies have been used to examine the peridotites (harzburgites, lherzolites, and wehrlites) and gabbroids (gabbro-norites and diorites) in the ophiolite association of the Lesser Caucasus.

Inclusions of mineral-forming media have turned out to be most informative in ol and cpx from the peridotites, and also in the hnb and quartz from the gabbroids.

Peridotites. The inclusions in ol in every external aspect and behavior during the heating process completely match the characteristics of melt inclusions. Th = 1300-1350°C (and above). The melt inclusions in the cpx contain a significant amount of volatiles. Th - 1250-1300°C.

Gabbroids. Th of multiphase inclusions in hnb = 1150-1160°C. In quartz, these inclusions have Th 1190-1200°C.

The results have shown that certain peridotites from the Lesser Caucasian ophiolites were possibly formed from melts at T = 1250-1350°C and above. Crystallization of the hnb gabbroids (gabbro-diorites) took place at ~1150-1200°C. (Authors' abstract)

ALLARD, P., CLOCHIATTI, R. and JEHANNO, C., 1985, Carbonate xenoliths in Etnaean lavas: Chemistry, mineralogy and isotopic composition (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

ALLARD, P. and TEDESCO, D., 1985, Chemical abundance and isotopic composition of water, carbon, and sulfur in high temperature gases from Mt. Etna: Genetic and volcanic implications (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

ALLEN, G.B., 1985, Economic geology of the Big Horn Mountains of west-central Arizona: Masters thesis, The Univ. of Arizona.

Three districts are present: the Tiger Wash barite-fluorite district;

the Aguila manganese district; and the Osborne base and precious metal district. Fluid inclusions from Tiger Wash fluorite (Th 120 to 210°C, NaCl wt. equiv. 17 to 18% not corrected for CO_2) and nearby detachment-fault-hosted Harquahala district fluorite (Th 150 to 230°C, NaCl wt. equiv. 15.5 to 20% not corrected for CO_2) suggest cooling and dilution of fluids as they are presumed to evolve. Mass-balance calculations suggest that the proposed evolution of fluids is sufficient to account for the observed tonnage of barite and fluorite. The Tiger Wash occurrences grade directly into calcite-gangue-dominated manganese oxides of the Aguila district. A wide range of Th (200 to 370°C), an absence of CO_2 and low salinities (NaCl wt. equiv. 1 to 2%) in the Aguila district calcite-hosted fluid inclusions argue for distillation of fluids during boiling or boiling of non saline-meteoric waters. Mass-balance calculations modeling the evolution of Ca and Mn during potassium metasomatism of plagioclase in basalt suggest that little if any influx of these cations is necessary to form the calcite-dominated manganese oxide tonnage observed. The Aguila district grades directly to the east into the base-metal and precious-metal occurrences of the Osborne district. Preliminary data suggest that the Osborne district has a continuum between Au-rich to Ag-rich epithermal occurrences. The Au-rich systems have dominantly quartz gangue, with or without fluorite, and are hosted in a variety of rocks. Fluid inclusions from two occurrences representative of the Au-rich systems spread across a minor range (Th 190 to 230°C, NaCl wt. equiv. 17 to 23% not corrected for CO_2). Dilution of highly saline fluids is the inferred mechanism for precipitation of Au in the gold-quartz systems.

The silver-rich systems have dominantly calcite gangue with or without quartz, and are hosted in mid-Tertiary basalt. Calcite fluid inclusions from a representative high-Ag occurrence display a wide range of Th (120 to 370°C), and salinity NaCl wt. equiv. 7 to 23%). Boiling and consequent neutralization of acidic solutions is the inferred mechanism for the Au-rich, calcite gangue systems.

A model inferring a regional fluid-flow regime and local sources of metals is proposed, and four possible causes of fluid flow. (From the author's abstract)

ALMEDA, R.L., ISHIKAWA, Y., MATSUEDA, H. and MATSUKUMA, T., 1985, Mineralization of the Uwamuki No. 2 West Network ore deposit, Kosaka mine, Akita prefecture, Japan: J. Min. Coll. Akita Univ., Ser. A, v. 6, no. 4, p. 293-321. Authors at Inst. Mining Geol., Mining College, Akita Univ., No. 273.

The Uwamuki No. 2 West Network ore body is one of the satellite ore deposits of the Kosaka mine. This ore body is a network or stock work type Kuroko ore deposit consisting of pyrite-chalcopyrite and gradually changing to barite-sphalerite-galena ore from its lower to upper portion successively. This paper is concerned primarily on the alteration of the "white rhyolite" wall rock and partially on some aspects of its mineralization.

Th of fluid inclusions in barite is higher at the lower level, with a range from 300° to 370°C, than at the upper level which is widely distributed, ranging from 230° to 360°C [using a Union MHS-3 heating stage]. The salinity of fluid inclusions is equal to 20% NaCl equivalent weight.

Based on the mineral assemblage of the alteration, chemical composition of ore minerals and fluid inclusion study, the environment of ore formation is estimated as follows: T = 230° ~ 370°C; $fO_2 = 10^{-37.5}$ to $10^{-30.5}$ atm; and $fO_2 = 10^{-13}$ to 10^{-6} atm.[sic; fS_2 meant?]. (From the authors' abstract)

ALSTON, R.B., KOKOLIS, G.P. and JAMES, C.F., 1985, CO_2 minimum miscibility pressure: A correlation of impure CO_2 streams and live oil systems: Soc. Petrol. Engrs. J., v. 25, no. 2, p. 268-274. First author at SPE, Texaco Inc.

This paper presents an empirically derived correlation for estimating the minimum pressure required for multicontact miscible (MCM) displacement of live oil systems by pure or impure CO_2 streams. Minimum miscibility pressure (MMP) has been correlated with temperature, oil C_{5+} molecular weight, volatile oil fraction, intermediate oil fraction, and composition of the CO_2 stream.

The effects of temperature and oil C_{5+} molecular weight on pure CO_2 MMP have been well documented. However, CO_2 sources are rarely pure, and solution gas usually is present in reservoir oils. The correlation presented in this paper accounts for the additional effects on MMP caused by the presence of volatile components (methane, C_1; and N_2) and intermediate components (ethane, C_2; propane, C_3; butane, C_4; hydrogen sulfide, H_2S; and CO_2) in the reservoir oil. This correlation also is capable of estimating MMP for a contaminated or enriched CO_2 stream on the basis of the pure CO_2 MMP. (Authors' abstract)

AMIRKHANOV, K.I., BATYRMURZAEV, A.S., BRANDT, S.B., MAGOMEDOV, S.A. and GARGATSEV, I.O., 1985, Influence of plastic flow and stresses in minerals on the content of radiogenic argon in them: Dokl. Akad. Nauk SSSR, v. 281, no. 3, p. 681-683 (in Russian).

ANAN'YEV, V.V. and SHNYREV, G.D., 1984, Garnet in melt inclusions in olivine from olivine-anorthite segregations in rocks of the Ksudach Volcano, Kamchatka: Dokl. Akad. Nauk SSSR, v. 275, no. 2, p. 402-406 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 2, p. 153-157, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 6. (E.R.)

ANDERSON, G.M., PASCAL, M.L. and RAO, J., 1985, Aluminum speciation in metamorphic fluids (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A1.

ANDRÉE, M., BEER, J., LÖTSCHER, H.P., OESCHGER, H., BONANI, G., HOFMANN, H.J., MORENZONI, E., NESSI, M., SUTER, M. and WÖLFLI, W., 1985, Dating polar ice by ^{14}C accelerator mass spectrometry (abst.): 12th Int'l. Radiocarbon Conf., The Norwegian Inst. of Tech., Trondheim, Norway, S. Gulliksen and R. Nydal, eds., p. 113. First author at Physics Inst., Univ. Bern, Switzerland.

Results of $^{14}C/^{12}C$ ratio measurements on CO_2 extracted from air bubbles in polar ice are presented. The samples investigated originate from the Dye 3 (South Greenland) deep ice core and span approximately the last 13,000 years. The results will be calibrated with tree-ring ^{14}C records. The ^{14}C ages are compared with those obtained for simultaneous events on the continent and with information obtained from seasonal variations and rheological model calculation. (Authors' abstract)

ANDREHS, Gerhard, 1985, Microthermometry of the Brekzienkorper breccia body in the Erzgebirge: Z. Geol. Wiss. (Berlin), v. 13, no. 5, p. 629-637 (in German; English abstract).

Liquid gas inclusions in quartz from the Gottesberg breccia body in the Erzgebirge were investigated by microthermometry. First, supercritical solutions which followed the brecciation had temperatures near 530°C. Further events with ranges of Th from 470-450°C, 430-400°C, 400-340°C and at still lower temperatures are outlined. On account of the superimposition of the older brecciation by the younger, these ranges of Th cannot be coordinated with a distinct brecciation process. From the distribution of the inclusions with high NaCl (type IV) in ranges from 463-410°C, 395-340°C and 297-184°C a sequence of repeated quick pressure and pressure rises are indicated.

A comparison of the results with the results from Krupka shows very good agreement in the ranges of Th in middle to high temperatures, but according to the distribution of the NaCl contents only two quick pressure drops with following pressure rises were counted.

From the inclusions which homogenized at critical points, a pressure of 460 bar was determined. The highest pressure of formation, deduced from the isochore method and CO_2-bearing inclusions is nearly 1420 bar. The question of whether pressures of this order of magnitude could lead to brecciation is discussed briefly. (Author's abstract)

ANDREHS, Gerhard, 1985, Microthermometric investigations at the breccia body from Gottesberg in the Ore Mountains (Ezgebirge, G.D.R.): Zeitschrift fur Geologische Wissenschaften, v. 13, no. 5, p. 629-637 (in German; English abstract).

Liquid-gas-inclusions in quartzes from the breccia body Gottesberg in the Ore Mountains were investigated by microthermometry.

First of all, the supercritical solutions which followed the brecciation, had T nearly 530°C. Further events with ranges of Th from 470-450°C, 430-400°C, 400-340°C and at still deeper T are outlined. On account of the superimposition of the older brecciation by the younger, these ranges of Th may hardly be coordinated with a distinct brecciation process. From the distribution of the inclusions with high content of NaCl (type IV) in ranges from 463-410°C, 395-340°C and 297-184°C it is concluded that there were repeated quick pressure releases and pressure rises in sequence.

A comparison of the results with the results of Krupka shows a very good accord of the ranges of Th in middle to high T, but according to the distribution of the contents of NaCl is counted only with two quick pressure reliefs with following pressure rises.

From the inclusions which are homogenized at critical events, a pressure P(TH G/Fl)[sic] of 460 bar was determined. The greatest pressure P(B) of formation deduced from CO_2-bearing inclusions is nearly 1420 bar (isochore method).

The question is discussed briefly whether pressures of this order of magnitude could lead to brecciation. (Author's abstract)

ANDREWS, J.N., 1985, The isotopic composition of radiogenic helium and its use to study groundwater movement in confined aquifers: Chem. Geol., v. 49, p. 339-351.

ANDREWS, J., FONTES, J.C., FRITZ, P., MOSER, H., NORDSTROM, K. and OLSSON, T., 1985, Hydrogeological and hydrogeochemical investigations in boreholes - geochemical investigations of the Stripa groundwaters, part 1: Stripa Project Tech. Rept. 85-06, 250 pp., issued by Swedish Nuclear Fuel and Waste Management Co., Stockholm, Sweden.

The geochemistry of the groundwaters, bedrock and fracture mineralogy at the Stripa test site is being investigated to understand the origin and evolution of the groundwaters in a granite bedrock. These investigations have contributed substantially to our understanding of geologically both old and modern water-rock-gas interactions occurring within crystalline bedrock.

Several lines of evidence strongly suggest that the groundwater system at Stripa has evolved from fresh meteoric waters, typical of central Sweden, interacting with the Proterozoic crystalline bedrock composed dominantly of feldspars and quartz and fracture-fill minerals, such as calcite, chlorite, epidote, sericite, pyrite, fluorite, and hematite. A viable hypothesis for the source of the Na-Ca-Cl type water found at depth is salt associated with the crystalline rock itself, i.e., fluid inclusions and associated grain boundary salts or salty fluids. Many of the water-rock interactions can be related to weathering processes and solubility equilibria such that a firm basis for predicting the effect of perturbations, like radioactive waste storage, can be made with greater reliability. For example, thermal stress will clearly affect the water chemistry and could actually increase chloride concentrations significantly in the near-field by extruding saline fluids from the micropores and/or microfracturing fluid inclusions. Increased salt concentrations can both increase and decrease the solubility of various minerals, depending on the mineral, the temperature, and the composition of the salt components. Changes in solubility can, in turn, affect the permeability of the bedrock.

Identification of active processes, such as calcite, fluorite, ferric hydroxide, and possibly barite precipitation, provides favorable conditions for radionuclide retardation in the far-field by coprecipitation or adsorption. When these processes are linked to other processes, such as silica dissolution and reprecipitation through a temperature gradient in the near-field, possible clay mineral formation, and the absorbing properties of the backfill, then the outlook for long-term radioactive waste storage looks even more favorable. (Authors' summary)

Includes chapters on the geology; hydrology; groundwater chemistry; water-rock interactions; O and H isotopes; S isotopes in various compounds; C and O isotopes in carbonates; in-situ production of radioisotopes and the ^{3}H and ^{36}Cl contents of groundwaters; radioelements in the Stripa granite and groundwaters; and atmospheric and radiogenic gases in solution. (E.R.)

ANDREWS, J.N., GOLDBRUNNER, J.E., DARLING, W.G., HOOKER, P.J., WILSON, G.B., YOUNGMAN, M.J., EICHINGER, L., RAUERT, W. and STICHLER, W., 1985, A radiochemical, hydrochemical and dissolved gas study of groundwaters in the Molasse basin of Upper Austria: Earth & Planet. Sci. Letters, v. 73, p. 317-332. First author at Sch. Chem., Univ. Bath, Claverton Down, Bath, BA2 7AY, UK.

Groundwater residence times have been estimated from hydrological data, radiogenic ^{4}He accumulation rates and palaeotemperatures of recharge which were estimated from noble gas contents. The ^{3}He/^{4}He ratio shows that most radiogenic He diffuses from the basement granite and the He flux was estimated on the basis of diffusion theory. Groundwater residence times were assessed from this diffusive flux of helium and together with the recharge temperatures, indicate that the evolved groundwaters of the Innviertel were recharged during the interstadial which preceded the last glaciation. (From the authors' abstract)

ANDREYCHIKOV, B.M., PORSHNEV, N.V. and BONDAREV, V.B., 1985, Relations between components of vapor-gas mixture in high-temperature hydrotherms: Dokl. Akad. Nauk SSSR, v. 280, no. 1, p. 206-211 (in Russian). Authors at Inst. of Space Studies of Acad. Sci., Moscow, USSR.

The authors investigated theoretically the possible reactions in the system H_2O-CO_2-H_2S (with H_2, CH_4 and C_2H_6) at T 180-340°C and under P 15-50 atm. They used data from the hot waters in boreholes in Cerro Preto (Mexico), and Koshelevo and Severo-Mutnovskiye (Kamchatka). The obtained systems of reactions satisfactorily describe the composition of natural hydrotherms. (A.K.)

ANFILOGOV, V.N., ANFILOGOVA, G.I., BOBYLEV, I.B. and ZYUZEVA, N.A., 1984, The forms taken by fluorine and chlorine in silicate melts: Geokhimiya, 1984, no. 5, p. 751-756 (in Russian; translated in Geoch. Int'l., v. 21, no. 5, p. 129-134, 1984, pub. 1985).

ANFILOGOV, V.N. and BOBYLEV, I.B., 1985, Thermodynamical analysis of water dissolution in silicate melt: Geokhimiya 1985, no. 9, p. 1277-1285 (in Russian; English abstract).

Structural-thermodynamical model of dissolution of water in silicate melts is suggested. The model is based on supposition that H_2O interacts with melt like metal oxides. A constant of equilibrium of reaction of interaction of H_2O with the bridge atoms of oxygen of silicte polyanions was determined from thermodynamical data. The values obtained evidences that depolymerizing action of H_2O is by an order of magnitude less than of such weak base as FeO. This is why in the system silicate-H_2O a significant amount of water [is] always present. Moreover a mole fraction of free water, determined as a fraction of molecules of H_2O of the sum of H_2O molecules and silicate polymer complexes, is higher than a mole fraction of H_2O in the sum of all oxides composing the melt. Calculations of concentration of water in a free form and in a form of OH-groups in the melts of albite-H_2O are given. (Authors' abstract)

ANIEL, Brigitte and LEROY, Jacques, 1985, The reduced uraniferous mineralizations associated with the volcanic rocks of the Sierra Pena Blanca (Chihuahua, Mexico): Am. Mineralogist, v. 70, p. 1290-1297. Authors at Centre Recherches sur la Géol. de l'Uranium, BP 23, 54501, Vandoeuvre-les-Nancy Cédex, France.

The uraniferous mineralizations of the Nopal I deposit (Sierra Pena Blanca, Chihuahua, Mexico) are related to a breccia pipe in a Tertiary vitroclastic tuff (Nopal Formation). Detailed mineralogical and fluid inclusion studies led to the discovery of a primary mineralization stage of tetravalent uranium as part of an ilmenite-hematite phase. This stage occurs soon after the deposition of the tuff and is related to H_2O-CO_2-N_2 fluids, similar to those of the vapor phase, under temperatures ranging from 300 to 350°C. The well developed kaolinization of the Nopal tuff is associated with a second tetravalent uranium stage (pitchblende-pyrite association). Fluids are aqueous and their temperature ranges from 250 to 200°C. The precipitation of pitchblende with pyrite within the pipe is due to a H_2S activity increase strictly limited to this structure. The remainder of mineralizing events, either hydrothermal or supergene, led to the hexavalent uranium minerals that prevail today. (Authors' abstract)

ANONYMOUS, 1984, The scientific career of Academician V.S. Sobolev: Geol. i Geofizika, v. 25, no. 12, p. 3-18, 1984 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 12, p. 1-17, 1984).

A review of the many important investigations of V.S. Sobolev, including those on melt inclusions (p. 4), and a listing of his 363 publications. The same journal also has a series of papers by various authors dealing with various aspects of petrology studied by Sobolev. Some of these were abstracted in volume 17. (E.R.)

ANTONOV, A.Ye., 1984, Types of deposits of gold-silver formation: Sovetskaya Geologiya, no. 2, p. 27-32 (in Russian).

Commercial gold associations usually yield Th and Td in range 180-250°C. (A.K.)

APLIN, A.C. and SHEPPARD, S.M.F., 1985, Concentration and isotopic composition of sulfur in sulfides, sulfates and basalts from the 13°N EPR hydrothermal site (abst.): Terra Cognita, v. 5, p. 152 (in French).

Isotopic composition of sulfur in 31 sulfides and 3 sulfates from 14 hydrothermal sites at 13°N EPR have been analyzed. The average values for the sulfide minerals are: chalcopyrite: 3.2‰ (s = 0.5); pyrite: 2.6‰ (s = 0.9); sphalerite: 2.7‰ (s = 1.0), indicating that basalt (delta S-34 = 0‰) dominates sea water (delta S-34 = 20‰) as the source of sulfur for the mineralizing system. The isotopic fractionation between the sulfides indicated disequilibrium at any temperature. The variation of less than 1.4‰ indicates the importance of micro-environmental factors during sulfide precipitation. Three anhydrites have delta S-34 values between 21.2 and 23.3‰, slightly, but significantly, elevated above marine sulfate values. This could indicate an isotopic fractionation between aqueous sulfate and anhydrite, but could equally and perhaps more probably result from a loss of light sulfur as a result of partial reduction of sulfates in the hydrothermal plume.

The sulfur concentration of five unaltered and non-vitreous basalts is between 0.061 and 0.131%, with a positive correlation between S and PQF but with no correlation between S and Fe. These facts suggest either that the samples were subjected to variable degassing of volatiles or that the initial sulfur concentrations were heterogeneous. (Authors' abstract, translated by M. Logsdon)

APPS, J.A., 1985, Methane formation during hydrolysis by mafic rock: U.S. Dept. Energy, DOE Contract No. DE-AC03-76SF00098, Annual Rpt. 1984, Earth Sci. Div., Lawrence Berkeley Lab., Univ. California, Berkeley, CA, p. 13-17.

The author argues that methane of abiogenic origin is most probably generated in the crust at relatively shallow depths, at intermediate temperatures (100-500°C), and under the strongly reducing conditions resulting from hydrolysis by mafic and ultramafic rocks. The source of the carbon may lie either in the mantle or in the crust. (From the author's text)

ARAI, Shoji and HIRAI, Hisako, 1985, Relics of H_2O fluid inclusions in mantle-derived olivine: Nature, v. 318, p. 276-277. Authors at Inst. Geosci., Univ. Tsukuba, Ibaraki 305, Japan.

In olivine of upper mantle derivation, CO_2 is the most commonly reported species of fluid. Despite its great importance in the upper mantle, H_2O has rarely been reported. Here we report that possible relics of H_2O-rich fluid inclusions have been found in olivine of dunite from the alpine-type Iwanai-dake complex, northern Japan. These inclusions now consist mainly of serpentine and brucite, which may be the products of the reaction, olivine + H_2O = serpentine + brucite, in a closed system. The abundance of such inclusions suggests that the Iwanai-dake complex may have been derived from the upper mantle in conditions in which some free H_2O was available, such as the mantle wedge above a subduction zone. (Authors' abstract)

ARCHER, D.G. and WOOD, R.H., 1985, Chemical equilibrium model applied to aqueous magnesium sulfate solutions: J. Solution Chem., v. 14, no. 11, p. 757-780.

ARCULUS, R.J., 1985, Oxidation status of the mantle: Past and present: Ann. Rev. Earth Sci., v. 13, p. 75-95. Author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Includes a discussion of fluid inclusion evidence. (E.R.)

ARMBRUSTER, Thomas, 1985, Ar, N_2, and CO_2 in the structural cavities of cordierite, an optical and X-ray single-crystal study: Phys. Chem. Minerals, v. 12, p. 233-245. Author at Lab. für Chem. und Mineral. Kristallographie, Univ. Bern, Freiestr. 3, CH-3012 Bern, Switzerland.

Ar, N_2 and CO_2 were introduced into the structural cavities of channel-evacuated single-crystals of cordierite in conventional hydrothermal bombs at 6-7 kbar and 600-700°C. Site occupancy refinements of the channel position are in good agreement with the optically derived values for the volatile concentrations, both indicating about 70% and 60% filled cavities for Ar- and N_2-cordierite, respectively. Chemical analyses and point-dipole calculations confirm that about 45% of the cavities are occupied in the CO_2-treated crystal. The structural framework of cordierite is slightly but specifically altered by the various channel occupants. (From the author's abstract)

ARNETH, J.D., SCHIDLOWSKI, M., SARBAS, B., GOERG, U. and AMSTUTZ, G.C., 1985, Graphite content and isotopic fractionation between calcite-graphite pairs in metasediments from the Mgama Hills, southern Kenya: Geochimica Cosmo. Acta., v. 49, p. 1553-1560. First author at Max-Planck-Inst. Chemie (Otto-Hahn-Inst.), D-6500 Heidelberg, W-Germany.

Amphibolite-grade metasediments from the Mgama Hills region, Kenya, contain conspicuous quantities of graphite, most probably derived from organic progenitor materials. The highest graphite contents (5.1-20.4%) are found in schists whereas calcite marbles intercalated in the sequence contain relatively low amounts (0.1-2.0%). The graphitic constituents are consistently enriched in ^{13}C relative to common sedimentary organic material, with the highest isotopic ratios in graphite from the marbles ($\delta^{13}C = -7.3 \pm 5.0‰$; $n = 10$). Carbon isotope fractionations between calcite and graphite mostly vary between 3.3 and 7.1‰, which comes close to both empirically recorded and thermodynamically calculated fractionations in the temperature range of the upper amphibolite facies (550-650°C). However, larger values occasionally encountered in the marbles suggest that complete isotopic equilibrium is not always attained in amphibolite-facies metamorphism. (Authors' abstract)

ARNOLD, M. and VELEZ, C., 1985, The conditions of emplacement and the origin of sulfur for La Caridad porphyry Cu-Mo (Sonora, Mexico): Terra Cognita, v. 5, p. 322 (in French).

The La Caridad porphyry Cu-Mo, located in Sonora, Mexico, intrudes Paleozoic formations and a suite of post-Laramide intrusives. The copper mineralization appears in the transition zone between the biotite and the phyllitic zones, expressed in isolated crystals of pyrite (py I) or in microveinlets of quartz-chalcopyrite-pyrite (py II). The py I crystals contain inclusions of pyrrhotite and cubanite; crystals of py II enclose inclusions of bornite-chalcopyrite or of hematite. Hematite, typically absent from the silicate matrix, is also observed in fluid inclusions in quartz crystals associated with py II. Fluid-phase analyses were conducted on both crystals of quartz in the rhyolite (Qz I, prior to the mineralizing phase) and in vein quartz (Qz II). In Qz I, the fluids homogenize at the critical T that corresponds to their salinity (5% wt. eq. NaCl). In Qz II, the salinities of contemporaneous fluid inclusions (one of a L-V type and the other of S-V type) range from very low for the vapor-dominated inclusions to 35% wt. eq. NaCl for the solid-bearing inclusions. The maximum Th is about 350°C. These data indicate that the premineralization conditions were characterized by a super-critical and reducing fluid. The isenthalpic relaxation, at the same time that first phase of fracturing occurred, led to a rapid decrease in T of the fluid phase and a temporary increase in the relative fugacities of sulfur and oxygen (evidence by the formation of bornite and hematite). Based on these estimates of the conditions of deposition, the delta S-34 of py II (+1 to +6‰; average of +3‰) allows one to calculate the isotopic composition of sulfur for the system. The calculated value for system sulfur between +10 and +15‰ is not compatible with a magmatic origin for the sulfur, but is in better accord with an hypothesis of contamination of the magma with sulfur from the Paleozoic sequence into which the porphyry intruded. (Authors abstract, translated by M. Logsdon)

ARNORSSON, Stefan, 1985a Gas pressures in geothermal systems: Chem. Geol., v. 49, p. 319-328. Author at Sci. Inst., Univ. Iceland, 107 Reykjavik, Iceland.

The partial pressures of CO_2, H_2S and H_2 in geothermal reservoir waters are fixed by temperature-dependent mineral equilibria. (From the author's abstract)

ARNORSSON, Stefan, 1985b The use of mixing models and chemical geothermometers for estimating underground temperatures in geothermal systems: J. Volcanol. Geotherm. Res., v. 23, p. 299-335. Author at Sci. Inst., Univ. Iceland, Dunhagi 3, 107 Reykjavik, Iceland.

Application of various chemical geothermometers and mixing models indicate underground temperatures of 260°C, 280°C and 265°C in the Geysir, Hveravellir and Landmannalaugar geothermal fields in Iceland, respectively. Mixing of the hot water with cold water occurs in the upflow zones of all these geothermal systems. Linear relations between chloride, boron and $\delta^{18}O$ constitute the main evidence for mixing, which is further substantiated by chloride, silica and sulphate relations in the Geysir and Hveravellir fields.

A new carbonate-silica mixing model is proposed which is useful in distinguishing boiled and non-boiled geothermal waters. This model can also be used to estimate underground temperatures using data from warm springs. This model, as well as the chloride-enthalpy model and the Na-Li, and CO_2-gas geothermometers, invariably yield similar results as the quartz geothermometer sometimes also does. By contrast, the Na-K and the Na-K-Ca geothermometers yield low values in the case of boiling hot springs, largely due to loss of potassium from solution in the upflow. The results of these geothermometers are unreliable for mixed waters due to leaching subsequent to mixing. (Authors's abstract)

ARNORSSON, Stefán and GUNNLAUGSSON, Einar, 1985, New gas geothermometers for geothermal exploration - Calibration and application: Geochimica Cosmo. Acta, v. 49, p. 1307-1325. First author at Sci. Inst., Univ. Iceland, Dunhagi 3, Reykjavik, Iceland.

Calibration of five gas geothermometers is presented, three of which used CO_2, H_2S and H_2 concentrations in fumarole steam, respectively. The remaining two use CO_2/H_2 and H_2S/H_2 ratios. The calibration is based on the relation between gas content of drillhole discharges and measured aquifer temperatures. After establishing the gas content in the aquifer, gas concentrations were calculated in steam formed by adiabatic boiling of this water to atmospheric pressure to obtain the gas geothermometry functions. It is shown that the concentrations of CO_2, H_2S and H_2 in geothermal reservoir waters are fixed through equilibria with mineral buffers. At temperatures above 230°C epidote + prehnite + calcite + quartz are considered to buffer CO_2. Two buffers are involved for H_2S and H_2 and two functions are, therefore, presented for the geothermometers involving these gases. For waters containing less than about 500 ppm chloride and in the range 230-300°C pyrite + pyrrhotite + epidote + prehnite seem to be involved but pyrite + epidote + prehnite + magnetite or chlorite for waters above 300°C and waters in the range 230-300°C, if containing over about 500 ppm.

The gas geothermometers are useful for predicting subsurface temperatures in high-temperature geothermal systems. They are applicable to systems in basaltic to acidic rocks and in sediments with similar composition, but should be used with reservation for systems located in rocks which differ much in composition from the basaltic to acidic ones. The geothermometry results may be used to obtain information and steam condensation in upflow zones, or phase separation at elevated pressures.

Measured aquifer temperatures in drillholes and gas geothermometry temperatures, based on data from nearby fumaroles, compare well in the five fields in Iceland considered specifically for the present study as well as in several fields in other countries for which data were inspected. The results of the gas geothermometers also compare well with the results of solute geothermometers and mixing models in three undrilled Icelandic fields. (Authors' abstract)

ARVANITIDIS, N.D. and KATIRTZOGLOU, C., 1985, A proposed genetic model of Tertiary polymetallic Pb-Zn-Cu-Ag sulfide mineral deposits of the Esimi area, NE Greece (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 12.

Polymetallic vein-disseminated Zn-Pb-Cu (-Ag) and semimassive "stratiform" Pb-Zn-Ag sulfide mineralizations in the area are in alternating calcareous mudstones and sandstones. The veins, originating usually from the basement, grade stratigraphically upward to the semimassive ores. This gradation is accompanied by the following zonation in the dominant ore-mineral assemblages: py + cpy → py + sph → sph + ga + py → py. Lateral ore zonation has been observed to date only with respect to the pyrite distribution.

Fluid inclusion data on vein sphalerite, calcite and barite gave a mean Th of 309 ± 33, 1σ, °C (range 260-350°C) and a (mean salinity of 3.5 ± 0.4, 1σ, eq% NaCl (range 2.9-4.2 eq% NaCl) approaching that of seawater.

The alteration characteristics, i.e., silicification, carbonitization, sericitization, etc., of the intrusive subvolcanic rocks, mainly reflected by a relative increase of the authigenic mineral precipitation, such as chert, ankerite, sulfides, in the sedimentary rocks underlyng the stratiform deposit and the apparent sulfide mineral zonation suggest that these saline fluids circulated and interacted, within the footwall rocks, as well as the basement rocks, prior and during their introduction into the sedimentary basin.

The salient features of ore depositional environment referred to above suggest that ore formation was the result of hydrothermal activity imposed by subvolcanic intrusion during basin development. The ore-deposition mechanism was most likely mixing between an ascending hot metalliferous brine and ambient sea-water in spaces provided by fracture and rock porosity. This process has taken place in a sub-sea floor environment. (From the authors' abstract)

ASHMYAN, K.D., SHRIPKA, V.G. and NAMIOT, A.Yu., 1984, The solubilities of methane and nitrogen in water at high temperatures and pressures: Geokhimiya, 1984, no. 4, p. 580-581 (in Russian; translated in Geochem. Int'l., v. 21, no. 4, p. 138-139, 1984 (pub. 1985)).
Gas Research Inst., Moscow, USSR.

The solubility of CH_4, and of N_2, in water at 350°C and 98 MPa was determined by means of a constant-volume piezometer. (E.R.)

ASKHABOV, A.M., 1985, Regeneration inclusions in crystals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 5-6 (in Russian). Author at Geol. Inst. Komi Div. of Acad. Sci. USSR, Syktyvkar, USSR.

Artificial growth of crystals with use of crystal seeds leads to stage of regeneration. Regeneration of crystals, unlike growth itself, is characterized by a series of specific peculiarities (Askhabov 1979). From the point of view of crystallogenesis of inclusions, the regeneration inclusions are especially interesting and they have great morphological variations (Kalyuzhnyi 1972). The present paper shows studies on the genesis of regeneration inclusions in synthetic quartz, beryl and many water-soluble compounds. The essential results are as follows:

1. Regeneration inclusions are distinguished as a specific class of P authigenic inclusions with their own features, giving important technologic and genetic information.

2. Formation of regeneration inclusions is the consequence of change of unstable morphology and polynuclear growth of the crystal.

3. Trapping and sealing of regeneration inclusions depend on crystallization regime, conditions of mass transport and hydrodynamic conditions in the boundary layer crystal-solution. Probability of formation of inclusions increased with increase in diffusion resistance for growth, and with decreases in kinetic regime, and practically stops when solution is under turbulent conditions.

4. Regeneration inclusions are the source of defect formation (mostly dislocations) in crystals. However, regeneration inclusions also inhibit the continuing of dislocations in the overgrowing layer of crystal. This results in forming sufficiently perfect crystals on extremely imperfect seed plates.

5. Regeneration inclusions provide information about the most important moments of mineral development, especially about stages of dissolution and regeneration. (Author's abstract translated by A.K.)

AULSTEAD, K.L. and SPENCER, R.J., 1985, Diagenesis of the Keg River Formation, northwestern Alberta: Fluid inclusion evidence: Bull. Canadian Petroleum Geol., v. 33, no. 2, p. 167-183. First author at Inst. Sed. & Petroleum Geol., 3303 - 33 St. NW, Calgary, Alberta T2L 2A7, Canada.

Fluid inclusions studies on dolomite, fluorite and anhydrite cements in the Middle Devonian Keg River Formation of northwestern Alberta imply the presence of a thermal anomaly and hydrothermal system at the time the cements were formed. The timing of cement formation (before the end of the Frasnian) was deduced on the basis of a number of criteria, including the possibility of boiling during the formation of anhydrite cements, intersection of aqueous and hydrocarbon isochores (lines of constant density on a pressure-temperature diagram) and fluid composition of the inclusions.

This information indicates that some hydrocarbons (contained in inclusions in fluorite and anhydrite cements) migrated into the formation before the end of the Paleozoic. From the results of mass balance calculations, it is postulated that the diagenetic fluids originated as residual evaporite brines, which were diluted by sea or fresh water. These waters subsequently interacted with an igneous heat source. Fluid composition was further altered as the heated fluids migrated through the reef, forming dolomite, fluorite and anhydrite cements. Mass balance calculations also imply that the resulting waters are present as the formation waters. (Authors' abstract)

AVEDISIAN, C.T., 1985, The homogeneous nucleation limits of liquids: J. Phys. Chem. Ref. Data, v. 14, no. 3, p. 695-729. Author at Sibley Sch. Mech. & Aerospace Engrg., Cornell Univ., Ithaca, NY 14853.

This work provides a critical compilation of the homogeneous nucleation limits of liquids. Data for 90 pure substances and 28 mixtures have been compiled over a range of pressures, nucleation rates, and compositions. Detailed descriptions of the experimental methods used to obtain the included data are given to assess the accuracy of measured values. Criteria used to select the measurements included in the final listing are discussed. (Author's abstract)

AYALON, Avner and LONGSTAFFE, F.J., 1985, Diagenesis and pore-water evolution of the basal Belly River sandstone, Alberta: Mineralogic, petrographic and stable isotope studies (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 516.

BABANSKIY, A.D., SOLOVOVA, I.P. and RYABCHIKOV, I.D., 1985, The role of crystallization differentiation in the generation of intermediate and acid magmas based on thermobarogeochemical, experimental, and computer data (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 104-106 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. Ore Deposits, Petrogr., Min., & Geochem. Acad. Sci. USSR (IGEM AN SSSR), Moscow, USSR.

One of the samples examined is an andesite of the calc-alkaline series from the present-day Malyy Semyachik Volcano (Eastern Kamchatka), belonging to the differentiated basalt-andesite-dacite association. The porphyritic segregations in it consist of plagioclase of two generations (An_{92} and An_{46}), pyroxene, titanomagnetite, and occasional olivine. Plagioclase I contains such micro-inclusions as: glass + gas, glass + crystals + gas, and glass + devitrified glass + gas. The crystalline phases consist of clinopyroxene and Ti-magnetite. The inclusions in the clinopyroxene contain glass, dms (silicate and Ti-magnetite), and gas. The inclusions in olivine consist of glass and gas. The inclusions examined are ≤ 20 µm. The results of studying this sample are shown in the Table. We stress that no water-bearing minerals are present in the rock or amongst the dms of the inclusions, and water has not been found in the inclusions. It is also important that Ti-magnetite has been encountered in the rock, both in the form of phenocrysts, and in the groundmass. Two of its generatinos have also been found amongst the dms in the inclusions. Taking account of this information, we have experimentally studied the subliquidus phase equilibria in an anhydrous melt of this andesite in the pressure range of $1\text{-}4000 \times 10^5$ Pa with varying oxygen fugacity. An analysis of all the data, including thermodynamic and balance calculations, has shown that the rock arose as a result of crystallization differentiation of an original high-alumina basalt melt with a low content of water (<1 wt %) under conditions of increased $f(O_2)$ (an order of magnitude greater than that for the Ni-NiO buffer). In this case, it has been established that such a process cannot lead to the generation of more silicic melts, still preserving the ratios of amounts of other petrogenic components typical of the acid rocks.

In order to clarify the possibility of obtaining silicic melts during the course of crystallization differentiation of an original andesite magma, we examined a sample of andesite from the Kuban' River basin, belonging to the basalt-andesite-trachyandesite association of Pliocene-Quaternary age. In this rock, primary micro-inclusions were most common in plagioclase I (An_{51}) and orthopyroxene ($En_{76}Fs_{21}Wo_3$). In the former, the inclusions contain 2 glasses + gas of anomalously large volume. In the orthopyroxene, the inclusions are more varied: glass + cpx-dm + spn-dm + gas (15-20 vol %), fluid inclusions of sulfide, and 'ghost' inclusions of sulfide + glass + gas. T of the phase-transformations that take place in these inclusions as they are heated are also presented in the Table. As in the previous rock, the Khudes andesite has no hydrous minerals, and the gas phase in the inclusions consists of volatiles, poorly soluble in the melt. A common feature of this rock is the absence of Ti-magnetite. Ilmenite is prominent as the ore phase in the groundmass, with spinel standing out amongst the inclusions in the orthopyroxene. The experimental results and thermodynamic calculations have confirmed that crystallization of the Caucasian andesite took place in an anhydrous reducing environment ($f(O_2)$ is below the equilibrium for the quartz-fayalite-magnetite buffer). It is particularly important that the compositions of the residual glasses in the inclusions with dms and in the experimental products (degree of crystallization 0.5-0.6) are similar and correspond to the composition of the young granitoids of the Great Caucasus. On this basis, it is evident that the most likely mechanism for the generation of these granitoid magmas has been crystallization differentiation of the contemporaneous andesitic melts.

Thus, the combination of the thermobarogeochemical results and the experimental and computer data has demonstrated the leading role of crystallization differentiation in the formation of certain andesitic and granitoid magmas. (Authors' abstract)

Table 1. Thermometry of the andesites Examined (°C)

Phenomenon observed	Andesite, Malyy Semyachik	Andesite, Great Caucasus
Th of inclusions in apatite		1320
Th of inclusions in plagioclase I	1240 ± 10	1210 ± 10
Tm interval for cpx-dm in plagioclase I	1100 - 1240	
Tm of Ti-magnetite in plagioclase I	1330	
Th of inclusions in olivine	1230	
Th of inclusions in pyroxene	1190	
Tm interval of cpx-dm in pyroxene	1160 - 1190	1030 - 1170
Resorption of sulfide during interaction with melt of 'ghost' inclusion in pyroxene		1190
Tm of Ti-mt-dm in pyroxene	1170	
Th of inclusions in plagioclase of groundmass		1090 ± 10
Interaction between plagioclase and pyroxene of groundmass and mesostasis		1095 ± 5
Hardening of residual melt in mesostasis		1010 ± 10

BABANSKIY, A.D., SOLOVOVA, I.P. and RYABCHIKOV, I.D., 1985, Micro-liquation heterogeneity in melt inclusions and the mesostasis of andesite (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 122-124 (in Russian; translation by D.A. Brown). Authors at Acad. Sci. USSR (IGEM AN SSSR), Moscow, USSR.

In an andesite from the volcanic-plutonic association of the Great Caucasus (mouth of the Khudes River), the authors have found immiscibility in glasses in the mesostasis and in inclusions in porphyritic first-generation plagioclase (An_{52}). In addition, the phenocrysts consist of orthopyroxene ($En_{76}Fs_{21}Wo_3$), and the groundmass is made up of more acid plagioclase, clinopyroxene, and ilmenite. An insignificant proportion of residual melt is uncrystallized and has solidified in the form of a brownish glass with signs of immiscibility, where globules of a dark and sometimes opaque glass are found in the light matrix. These globules are relatively large (≤30 μm) only near the plagioclase. In the remaining cases, micro-liquation alone has been noted. Th of the residual glass in the mesostasis is ~1120-1135°C. P inclusions of the liquation type in plagioclase I in the original state have irregular outlines and contain two glasses and a gas bubble, occupying ≤18 vol %. On heating, they acquire the shape of negative crystals. Here, the light-colored matrix also contained dark globules, 1-15 μm in size. Moreover, dms have sometimes crystallized in the matrix and the globules. As an analysis of the glasses without preliminary homogenization shows, the dms in the matrix are most probably K-Na feldspars, and in the globules, pyroxene and spinel. The heterogeneous glass in the inclusions becomes uniform at ~1160°C, whereas complete homogenization of the inclusions takes place at ~1210 ± 10°C.

The compositions of the matrix and the globules of liquated melts are shown in the Table. It will be seen that the differentiation of the petrogenic components in the liquates of the mesostasis shows up more sharply as compared with the immiscible liquids in inclusions in the plagioclase. This is associated with the higher temperature of formation of immiscibility in the inclusions and corresponds to the topology of the physicochemical diagrams of model systems with liquation. (Authors' abstract)

Table. Composition of Matrices and Globules (wt %, total iron in form of FeO)

SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	MnO	CaO	Na_2O	K_2O	Σ
1) 75.29	0.78	9.96	0.01	2.38	0.47	0.0	0.81	0.14	2.20	92.04
2) 40.95	6.85	3.49	0.03	25.49	11.26	0.51	8.99	0.70	0.26	98.53
3) 73.92	0.64	15.00	0.00	1.12	0.05	0.02	2.00	0.47	4.79	98.01
4) 41.80	11.33	4.18	0.04	28.66	3.78	0.61	9.58	0.08	0.60	100.6

1) Matrix in inclusion in plagioclase (average of 2);
2) Globules, as above (average of 2 analyses);
3) Matrix in mesostasis (average of 2 analyses);
4) Globules, as above.

BÄCKER, H., LANGE, J. and MARCHIG, V., 1985, Hydrothermal activity and sulphide formation in axial valleys of the East Pacific Rise crest between 18 and 22°S: Earth & Planet. Sci. Letters, v. 72, p. 9-22.

BAI, Jiafeng, WANG, Changhuai and NA, Rongxan, 1985, Geological characteristics of the Jinding lead-zinc deposit in Yunnan with a special discussion on its genesis: Mineral Deposits, v. 4, no. 1, (Ser. No.: 11), p. 1-10 (in Chinese; English abstract). Authors at Central Lab., Geol. Bureau of Yunnan Province.

The Jinding lead-zinc deposit lies in the northern part of the west

Yunnan Mesozoic-Cenozoic depression. The strata are composed of two systems, i.e., an autochthonous system and an allochthonous one; the former refers to sediments of Upper Cretaceous time and Paleocene Yunlong Formation and the latter sediments of Upper Triassic, Jurassic and Lower Cretaceous times. Structurally, the whole mining area comprises an arch with the long axis trending NNE.

From east to west, the deposit can be divided into three major ore-bearing members: Jayashan, Beichang and Fengzishan. Sandstone in Lower Cretaceous Jinxing Formation (K_1j) was mineralized throughout, making up a thick bedded lead-zinc ore body. This deposit has an apparent vertical zoning with the upper part enriched in lead and the lower part in zinc; horizontally, it also shows an indistinct zoning with the east part enriched in zinc and the west part in lead. The ores might be grouped into sandstone type and limestone type, the former type possessing sedimentary oolitic, cemented and strawberry-like structures, while the latter type assumes metasomatic, corroded, concentric, gel, stockwork and banded structures; the ore minerals are mainly sphalerite, galena, and pyrite; the vein [gangue] minerals are composed chiefly of quartz, calcite and secondarily of gypsum, celestite and some others.

Trace elements in the ores are characterized by Sr>Ba, Sr:Ba = 0.5-3, Zn:Cd = 25-30, Mn = 0.1-0.4% and C = 0.1-0.47%. Besides lead and zinc, the contents of such ore-forming elements as silver, cadmium and thallium in the country rocks are several times or even tens of times higher than the contents of these elements in the normal sedimentary rocks of the same types.

Temperatures of inclusions contained in ore and vein minerals as determined by homogenization and decrepitation methods are 160-334°C, and freezing determination shows that salinities of mineral inclusions are 7.4-14.6 wt% NaCl; microscopic studies have identified submineral facies [daughter crystals?] of NaCl; spectrographic analysis of trace gases shows that inclusions generally yield 0.01-0.78% CO_2 and 0.08-1.21% H_2O with celestite possessing the highest quantities of water.

Lead isotopic modal ages are 22-83 m.y., approximately corresponding to ages of the stata; δS^{34} values vary in the range -1.71 - -30.43‰, characterized by concentration of light sulfur.

These data have led the authors to believe that the Jinding lead-zinc deposit is the product of early sedimentary diagenesis and mineralization, subsequently acted upon by late ore-bearing hydrothermal fluids; hence it belongs to the sedimentary stratabound lead-zinc deposits plus the later transformation type. (Authors' abstract)

BAIMUKHAMEDOV, Kh.N. and RAZYKOV, O.T., 1985, Conditions of formation of skarns and ores of Ingichka and Kotash: Uzbek Geol. Zhurnal, no. 4, p. 3-6 (in Russian). Authors at Uzbek Acad. Sci., Earth Sci. Div., Tashkent, Uzbekistan, USSR.

Scheelite skarn ores of Ingichka and Koitash (W. Uzbekistan) occur in the contact of carbonate rocks with granodiorites of Upper Carboniferous-Lower Permian age. The obtained Th values of inclusions in minerals are as follows (°C; Td values in parentheses): deposit Koitash, pyroxene (580-520, 480-460), early garnet 500-470 (560-520), late garnet 460-430 (480-460), early scheelite 450-420 (500-420), intermediate scheelite 360-340 (400-360), late scheelite 300-240 (340-260), quartz 410-220 (280-240), calcite 200-180 (230-200); deposit Ingichka, pyroxene (600-420), early garnet 480-440 (520-460), late garnet 440-400 (460-410), early scheelite 410-380 (480-400), intermediate scheelite 380-360 (360-320), late scheelite 280-210 (300-240), quartz 420-260 (460-240), calcite 230-210 (260-210).

The authors quote also Th and Td for the scheelite-rare metal skarn deposit Takfon (Rakhmanov, Fluid Inclusion Research--Proceedings of COFFI, v. 11, p. 175), essentially in the same ranges as listed above. The pH values for water leachates of skarn minerals range from 9.3 (pyroxene) to 6.8-7.4 (scheelite), 5.8-6.9 (quartz) and 8.3 (calcite). Solutes (mg per 100g of sample) vary widely: CO_3 nil to 0.50, HCO_3 0.05 to 2.01, Cl 0.03 to 1.31, SO_4 0.04 to 2.22, F nil to 0.51, Ca 0.20 to 2.26, Mg 0.01 to 0.46, K 0.02 to 0.49, Na 0.09 to 0.86, NH_4 nil to 1.20. The authors suggest the following evolution of mineral-forming solutions: pyroxene formed from $Cl-SO_4-CO_3$ solutions, garnet from $Cl-SO_4-HCO_3$, early scheelite from $SO_4-F-Cl-HCO_3$, intermediate scheelite from $F-SO_4-Cl-HCO_3$ (sequence of increasing concentration), late scheelite formed from solutions without F; presence of high concentration of Ca and HCO_3 is typical for scheelite formation. (Abstract by A.K.)

BAIRD, R.A. and DENNEN, W.H., 1985, A geochemical survey of the top of the Knox dolomite: implications for brine movement and mineralization in central Kentucky: Econ. Geol., v. 80, p. 688-695.

BAKUMENKO, I.T., BAZAROVA, T.Yu., PANINA, L.I., SIMONOV, V.A. and KOSUKHIN, O.N., 1984, Peculiarities of equilibrium and disequilibrium crystallization of magmas from inclusion studies data: Geologiya i Geofizika, no. 8, p. 81-90 (in Russian; English abstract). Authors at Inst. Geol. and Geophysics of Siberian Br. Acad. Sci., Novosibirsk, USSR.

The paper is a review of a large number of Th of melt inclusions in minerals from wide selection of magmatic rocks and other magmatic inclusion data that were published earlier in papers of the above and other authors. The original data may be found in items abstracted in the appropriate volumes of "Fluid Inclusion Research--Proceedings of COFFI." The quoted authors are as follows: Naumov, V.B. et al. 1971, Sobolev and Kostyuk 1975 (translation section, "Magmatogenic crystallization ..."), Bakumenko and Dobretsov 1976, Sobolev et al. 1980, Bazarova 1981, Bakumenko and Kosukhin 1981, Bakumenko et al. 1981, Motorina and Yashchenko 1981, Bazarova et al. 1982, Bazarova 1983, Bakumenko 1983, Panina 1983. (A.K.)

BALASHOV, S.P., 1985, The effect of false three-phase inclusions in highly birefringent minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 62 (in Russian). Author at Inst. Geochem. & Anal. Chem., Moscow, USSR.

During investigation on a Fyodorov stage, inclusions in scheelite that looked to be three-phase revealed their true, two-phase nature. Second, false meniscus appears due to total internal reflection, when inclusion wall inclination to preparation surface exceeds a certain angle $X = \arcsin n/n(min) + \arcsin n(\ell)/n$, where n = refractive index (r.i.) of air, $n(\ell)$ = r.i. of liquid in inclusion, n(min) - r.i. of host mineral. Solution of this equation with respect to n(min) if $X = \pi/2$ gives the limit of values of n(min) when false three-phase effect is possible. Minerals, in which inclusions may show such effect, should have $n(min) \leq 1.66$.
The total darkening of inclusions in sphalerite, making false impression of G inclusions is of a similar nature. The above formula may be used for determination of $n(\ell)$ by Kalyuzhnyi's method; $n(\ell) = \sin X / n(min)^2 - 1 - \cos X$. (Author's abstract, translated and shortened by A.K.)

BALDERER, Werner, FONTES, J.-C. and MICHELOT, J.-L., 1985, Isotopic investigations of the water-rock system in the deep crystalline rock of northern Switzerland (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A2. First author at Physics Inst., Univ. Berne, Switzerland.

First results of isotopic studies on groundwater samples and rock minerals from the deep drilled boreholes in crystalline rocks of the Nagra Investigation Project (for the assessment of repositories for high-level radioactive waste in geological formation) are presented. Especially the results of isotope equilibrium calculations for ^{18}O and ^{13}C of the observed secondary calcites (in closed and on walls of open fissures) with respect to the water and CO_2, which are revealing different origins of these calcites will be discussed.

The range of $\delta^{34}S$ and $\delta^{18}O$ values of the dissolved sulfates in the groundwater can be explained by an origin as a product of oxidation of sulfides contained in the granitic rock itself and for some others by a sedimentary origin from Permian sulfates. As far as results are available, this hypothesis of the origin of the dissolved sulfates is checked against the $\delta^{34}S$ and $\delta^{18}O$ values of sulfates minerals and the $\delta^{34}S$ values of sulfide minerals. Carbon 14 contents of the Total Dissolved Inorganic Carbon (TDIC) are interpreted according to possible sources of carbon isotopes and within the system (soil CO_2, primary and secondary carbonates, deep production).

Chlorine 36 data are discussed in terms either of simple decay of cosmic chlorine or of intraformational production. (Authors' abstract)

BALITSKIY, V.S. and KOTOVA, N.P., 1985, Gas-liquid inclusions in crystals of synthetic quartz and problem of formation of "reticulate" quartz (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 9 (in Russian). Authors at Inst. of Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka near Moscow, USSR.

Quartz crystals were grown from strongly alkaline solutions at 580-640°C, 140-150 MPa. Two types of inclusions were found in these crystals: 1 - inclusions in [on the surface of?] crystal seed plates, formed due to trapping of parent solution in minute etching cavities when solution became saturated with SiO_2; 2 - inclusions in the newly grown crystal layer. G-L ratios in inclusions in crystals grown at the same T and P remain the same. In crystals numerous growth twins were found, morphologically close to Dauphine ones. During cooling at 82.75°C/hour the newly grown crystals and quartz chips supplying SiO_2 to the solution do not display any fractures. Only one small part of crystal was fractured, and fine Dauphine twins were formed in this part of crystal, overlapping the usual growth twins. Rapid cooling of autoclaves (600°C/hour) causes cracking of all quartz present in autoclave, both grown crystals and quartz chips. Numerous tiny fractures are oriented parallel to rhombohedron faces. Relatively coarse Dauphine twins were formed. However, these fractures are distinctly different than typical "reticulate" fracturing and twins are not similar to those accompanying "reticulate" fracturing.

The obtained results prove the complicated nature of formation of "reticulate" quartz and are not explicable from the point of view of the existing presently theories about formation conditions of such quartz. (Authors' abstract, translated by A.K.)

BALL, T.K., FORTEY, N.J. and SHEPHERD, T.J., 1985, Mineralization at the Carrock Fell tungsten mine, N. England: Paragenetic, fluid inclusion and geochemical study: Mineral. Deposita, v. 20, p. 57-65. First author at Inst. Geol. Sci., Nicker Hill, Keyworth, Nottingham, NG 125GG, England.

Tungsten ore at Carrock Fell Mine comprises wolframite and scheelite in polyminerallic quartz veins which traverse the Grainsgill Granite cupola and surrounding country rocks. In the veins, a wolframite-scheelite-apatite assemblage pre-dates a scheelite-arsenopyrite-pyrite (plus other sulphides) assemblages. Temperatures of mineralization declined from a peak near 350°C to 170°C, and the hydrothermal fluid contained about 6 weight % NaCl and 3 wt% $NaHCO_3$. Contemporaneous greisenization involved loss of Na, Cr, Ca and Ba from granite, but Si and K were retained while B, Be and Al increases slightly. Sn also increased but is always a trace constituent, and F appears to have decreased. Zones of intense alteration contain high concentrations of quartz-hosted fluid inclusions resulting from penetration of the granite by fluid chemically similar to that in the vein quartz. The W-rich, Sn-poor nature of the mineralization may relate to the weakly saline, F-deficient but CO_2-rich fluid chemistry. The alteration and mineralization processes took place during late cooling of the Lower-Devonian Skiddaw Granite. Cross-cutting quartz-ankerite veins and argillitic zones which may be considerably younger than those producing the tungsten ore, have a distinct mineral suite lacking W and As and including major Pb and Zn. Temperatures at this late stage were below 150°C, and the fluid is estimated to have contained approximately 12 wt% NaCl and 15 wt% $CaCl_2$. (Authors' abstract)

BALLANTYNE, J.M., MOORE, J.N. and ADAMS, M.C., 1985, Arsenic geochemistry in geothermal systems (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 518. First author at Dept. Geol., Utah State Univ., Logan, UT 84322.

Arsenic plays an important role in exploration of both active geothermal systems and the epithermal gold deposits which are their fossil analogs. Arsenic is also an environmentally hazardous byproduct of production from many of these systems. Our ongoing study of As geochemistry aims to refine existing exploration methodologies and mitigate environmental problems.

Arsenic concentrations in fluids from producing geothermal systems generally range from 1 to 10 ppm although concentrations as high as 50 ppm have been reported. Variation within individual fields is related to both chloride content and temperature of the fluids. Plots of As vs Cl/As show that As content is not controlled simply by dilution or evaporation. Similarities of regression line slopes for data from different systems suggest that As concentration in fluids is controlled by fluid-mineral equilibria. The decrease in aqueous As concentration with decreasing temperature is consistent with the observed enrichment of As in rocks in the upper, cooler portions of hydrothermal systems. Oxidation also plays a role in the precipitation of As. Arsenic in deep fluids is present mostly as As(III), oxidizing to As(V) at surface.

Chemical analyses of geothermally altered rocks indicate that As is incorporated primarily in pyrite or in iron oxides after pyrite. Available data indicate that upward enrichment of As in rock in venting systems correlates with both pyrite abundance and the concentration of As in pyrite. Arsenic content of pyrite from the highly saline Salton Sea system displays complex coupled associations with Zn and Ag, but no upward enrichment. (Authors' abstract)

BALLHAUS, C., 1985, Fluid inclusions in the Merensky reef: Significance for sulphide precipitation and platinum mineralization (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 15.

The discovery of fluid inclusions in the pegmatitic portion of the Merensky reef sheds new light on the origin of base metal sulphides and platinum mineralization in the Bushveld Complex.

The major compositional domains of fluid inclusions have been identified: Highly saline inclusions with salinities well over 90 wt% NaCl equivalent; gas-rich inclusions with CO_2 and CH_4; and very rare composite inclusions of the system H_2O-CO_2-NaCl.

None of these are regarded to represent primary compositions. They are the products of chemical diversification of a parent multicomponent fluid after unmixing from the intercumulus magma. Evidence will be presented for close genetic links with precipitation of the base metal sulphides. These unmixed in situ and are the products of reaction of the fluid with melt.

Condensation of the fluid upon cooling leads to the formation of NaCl crystals and effervescence of CO_2-dominated vapor phase, and causes metal discharge of [from?] the fluid phase. The precious metals precipitated preferably on the edges of the base metal sulphide grains.

The reason for fluid accumulation at specific elevations within the Upper Critical Zone is discussed on the basis of Sr-isotope data. Interfaces between two magma heaves in a density-stratified magma chamber are the most favorable places for undisturbed fluid accumulation, condensation, and mineralization. (Author's abstract)

BALLHAUS, C.G., 1985, Fluid-melt inclusions in the Merensky and Bastard Reef, western Bushveld Complex, South Africa, and their significance for platinum mineralization (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 6-7. Author at Inst. Mineral. and Petrol., Montanuniver. Leoben, 8700 Leoben, Austria.

The recent discovery of composite fluid-melt inclusions in the platiniferous Merensky Reef (MR) and the platinum-free Bastard Reef (BR) 9 m above casts new light on the origin of platinum mineralization in the MR, and its deficit in the mineralogically similar BR.

Both MR and BR are, over wide areas, coarse-grained pyroxenitic (to harzburgitic) pegmatites, composed of orthopyroxene, chromite, and rare olivine as cumulus phases. Plagioclase is the predominant intercumulus mineral. Accessory minerals which hitherto have been interpreted as intercumulus are referred to here as post-cumulus. These include base-metal sulphides plus platinum-group minerals (BMS and PGM, respectively), hydrous silicates (amphibole, phlogopite, and biotite), sodic plagioclase, and quartz. The extensive hydrous alteration of both the cumulus and intercumulus assemblage into serpentine minerals, chlorite, epidote-zoisite, talc, calcite, and muscovite is contemporaneous with or slightly later than the post-cumulus phase. The sequence of formation with decreasing temperature is relevant for the evolution of the fluid inclusions; 1) BMS with amphibole and traces of quartz, partly overlapping the crystallization of normal intercumulus plagioclase; 2) BMS (mainly chalcopyrite) plus PGM with biotite and quartz; 3) quartz in eutectic intergrowth with sodic plagioclase, accompanied by hydrous alteration of cumulus minerals. Age differences between these three generations of quartz are not considered significant; they contain the same sequence of fluid inclusions, which are, as a first approximation, divided into three groups:

1. Rare gas-rich 1- to 4-phase inclusions as negative crystals (CO_2, H_2O-NaCl, and NaCl dm). Occasionally, CO_2 and CH_4 are the only constituents. They occur isolated and, sometimes, aligned along trails parallel to growth zones. The degree of filling of the four-phase inclusions is highly variable with Th >>580°C.

2. Complex polyphase fluid-melt inclusions. These may contain an indefinite amount of unidentified dms, including several halides and other salts, silicates, and, rarely, chalcopyrite, with H_2O-NaCl and V. In general, the phase volume ratios are variable; e.g., some large halite crystals with only trace amounts of liquid are completely enclosed by the

host quartz. Likewise, isolated melt inclusions (now crystallized to hydrous silicates) may also occur. Their Th has not been determined.

3. Abundant secondary 2- to 3-phase H_2O-NaCl inclusions with a uniform degree of filling. They occur along secondary healed cracks, which can be traced into zones of hydrous alteration in neighboring plagioclase. Th is 245 to 150°C, dependent on the amount of electrolytes present.

The fluid inclusions are correlated with associated post-cumulus crystallization, linked to distinct stages of complex fluid-gas-melt immiscibilities witin the late-magmatic differentiates of the evolving MR (resurgent boiling). The gas inclusions probably represent the earliest eposide of incipient unmixing of gas phases (mainly CO_2). These inclusions are considered primary. This is accompanied and followed by unmixing of the remaining melt into SiO_2- and H_2O-NaCl dominated fractions, the latter being included into the former upon crystallization. The exceptionally high concentrations of electrolytes (i.e., halite inclusions without H_2O) remain an enigma. The low temperature H_2O-NaCl inclusions are secondary and contemporaneous with the main alteration of the cumulus and intercumulus associations.

The mineralogy of the BR is similar to that of the MR; however, there are differences. These include the lack of PGM and smaller amounts of BMS and chromite. Instead, graphite may be an important intercumulus and post-cumulus constituent. The fluid inclusion sequence in quartz is qualitatively similar, but the quantitative distribution is markedly different. Over 80% of the inclusions encountered are one-phase gas inclusions, which are, in accordance with thermodynamic evidence, dominated by CH_4 in the presence of intercumulus-graphite. Their intergrowth relationships are similar those in the MR. Composite fluid-melt inclusions are very rare and always of lower salinity, as are the secondary inclusions.

These differences in fluid inclusion population between the MR and BR are considered important in explaining why the otherwise similar BR does not contain high concentrations of PGE. Chloride complexes are inferred as transporting agents for the precious metals, the earlier-formed BMS and chromite acting as catalysts for the precipitation of PGE in the MR. At the time of BR formation (slightly later than the MR) the fluids may have evolved to more gas-rich compositions, H_2O-NaCl being concentrated (and used up) within the MR. Considerably lower concentrations of chlorides in the BR prevented extensive mineralization. (Author's abstract)

BALLHAUS, C.G. and STUMPFL, E.F., 1985, Graphite, platinum and the C-O-H-S system (abst.): Can. Mineralogist, v. 23, p. 293-294. Authors at Inst. Mineral. & Petrol., Mining Univ., A-8700 Leoben, Austria.

Microscopic studies have revealed the widespread occurrence of graphite, not only in the platiniferous dunite pipes of the Eastern Bushveld (Stumpfl & Rucklidge 1982), but also in pegmatites of the Merensky environment, and in the Merensky Reef. Several morphological types of graphite occur in close association with amphiboles, phyllosilicates, sulfides and PGE. Microprobe analysis shows significant chlorine contents in hydrous silicates and graphite; accommodation of Cl in the latter is as intercalation compounds. The $\delta^{13}C$ in the graphite ranges from -19‰ to -21‰, suggesting contamination by a crustal source, probably sediments of the Transvaal System in the footwall of the Bushveld Complex.

After incorporation into mafic magmas, carbon forms an integral constituent first of a volatile-rich magma, and, on incipient cooling and dissociation, of a supercritical C-O-H-S-(Cl) phase with associated melt. The former buffers the melt with respect to $f(O_2)$ over a considerable part of its evolutionary path; the concomitant formation of graphite and hydrated silicates (± sulfides + PGE) agrees well with physicochemical parameters in the C-O-H-S system. Stratified volatile concentration between partly (or completely) solidified layers of the Bushveld magma chamber is considered a key for the development of stratiform features in layered igneous complexes; it facilitates the understanding of both the large-scale adherence of the Merensky Reef to a stratigraphic horizon, and the small- to medium-scale disturbances such as potholes and other cross-cutting relationships.

The gradual evolution of such a melt-volatile system has been deduced on the basis of microscope and microprobe studies, and correlation with physicochemical data. The evolutionary trend receives strong support from fluid-inclusion studies, which are treated in a separate paper. The significance of the C-O-H-S system not only for Pt genesis, but for the evolution of layered igneous complexes in general, is underlined by Volborth & Housley (1984), who describe complex graphite - sulfide - silicate - PGE associations from the Stillwater Complex. (Authors' abstract)

BALLHAUS, C.G. and STUMPFL, E.F., 1985b, Fluid inclusions in Merensky and Bastard Reefs, western Bushveld Complex (abst.): Can. Mineralogist, v. 23, p. 294. Authors at Inst. Mineral. & Petrol., Mining Univ., A-8700 Leoben, Austria.

Fluid inclusions in accessory quartz from the Merensky and Bastard Reefs have been examined. In the Merensky Reef the fluid inclusions represent the complete evolutionary trend during cooling. At least four generations of fluid inclusions occur:

1. Rare primary gas inclusions filled with CO_2 and CH_4. Sometimes traces of hypersaline brines with a minute halite daughter-crystal are present. The homogenization temperature is above 580°C.

2. Complex polyphase fluid-melt inclusions. These may contain up to eight different daughter-crystals, including several chlorides (?), silicates and, very rarely, oxides and sulfides. The volume ratios between solid, liquid and vapor phases are highly variable; extremes are large halite crystals completely enveloped by the host quartz and numerous melt-inclusions of different composition.

3. Abundant secondary three-phase H_2O-NaCl inclusions with more than 25 vol. % NaCl equivalent. Here the degree of filling is uniform. The temperature of homogenization was determined to be 230 ± 15°C.

4. Secondary two-phase H_2O-NaCl inclusions with NaCl equivalent from less than 25 vol. % to nil. These occur along healed cracks that can be traced back into sericitized plagioclase, and represent the latest generation. They are contemporaneous with the deuteric alteration of pyroxene and plagioclase. The homogenization temperature is 180 ± 30°C.

In contrast to the Merensky Reef, the fluid-inclusion association in quartz from the Bastard Reef and associated graphitic pegmatites is very simple. Here, primary (?) supercritical one-phase CH_4 inclusions, apparently parallel to growth zones of quartz, are by far the most abundant. CO_2 does not occur if intercumulus graphite is present; this agrees well with thermodynamic evidence. Fluid-melt inclusions are completely lacking; secondary H_2O-NaCl inclusions are rare.

The fluid-inclusion sequence sheds light on the late-magmatic history of the Merensky Reef. A genetic connection exists with several stages of fluid-melt immiscibility during cooling. Fluid-inclusion evidence also contributes to an explanation of the differences between the Merensky Reef with its PGE mineralization, and the barren Bastard Reef. (Authors' abstract)

BALLHAUS, C.G. and STUMPFL, E.F., 1985, Occurrence and petrological significance of graphite in the Upper Critical Zone, western Bushveld Complex, South Africa: Earth & Planet. Sci. Letters, v. 74, p. 58-68. Authors at Inst. Mineral. & Petrol., Mining Univ., 8700 Leoben, Austria.

Graphite occurs as a major rock-forming constituent in pyroxenitic pegmatites near the platiniferous Merensky Reef in the western Bushveld. It is associated with amphibole, biotite, low-K phyllosilicates, chlorite, sulphides and platinum-group minerals (RhAsS-IrAsS). Locally, rocks with up to 80% graphite occur. Chlorine is a significant constituent in both, hydrous silicates (0.1-0.3% Cl) and graphite (0.2-1.9%). Magnetite and quartz also occur with the above association. This facilitates estimation of T (500-600°C) and $f(O_2)$ (10^{-21} to 10^{-23} bar) during graphite deposition, which took place from C-O-H-S fluids at an oxygen fugacity in the vicinity of QMF in equilibrium with maximum H_2O mole fraction. The latter accounts for the widespread association of graphite with hydrous silicates. There is evidence for buffering of $f(O_2)$ of the melt by fluid phase; this process may be more widespread than hitherto assumed. C-O-H-S fluids are considered instrumental not only in the formation of graphite-rich pegmatites and associated mineralization, but also in the genesis of pothole depressions, and in the general development of stratiform pegmatites (such as the Merensky Reef) in layered igneous complexes. (Authors' abstract)

BANNER, J., HANSON, G., MEYERS, W.J. and PROSKY, J., 1985, Geochemistry of regionally extensive dolomites, Burlington and Keokuk formations (Mississippian), Iowa and Illinois (abst.): AAPG Ann. Conv. with Divs. SEPM/EMD/DPA, New Orleans, LA, Mar. 24-27, 1985, AAPG Bull., v. 69, no. 2, p. 236. Authors at State Univ. NY at Stony Brook, Stony Brook, NY, USA.

A study of isotopes of O and C suggesting that temperatures were less than the 80-110°C ranges implied by the two-phase fluid inclusions. (E.R.)

BANNIKOVA, L.A. and BARSUKOV, V.L., 1985, Using of isotopic and chemical data for study of redox reactions in hydrothermal systems: Geokhimiya 1985, no. 3, p. 314-330 (in Russian; translated in Int'l. Geol. Review, v. 27, no. 7, p. 834-849, 1985).

BANNIKOVA, L.A., SUSHCHEVSKAYA, T.M., VOLKOV, V.V., MAKHOV, S.F. and BARSUKOV, V.L., 1984, The role of redox reactions involving organic matter in producing tin deposits: Geokhimiya, 1984, no. 2, p. 197-208 (in Russian; translated in Geochem. Int'l. v. 21, no. 2, p. 105-115, 1984). First author at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

It is shown that changes in redox state due to reactions involving organic matter determine the deposition in sulfide-cassiterite deposits in the Komsomol region in the Soviet Far East. The conclusion is based on CO_2/CH_4 ratios in inclusions in minerals, the isotope compositions of carbonate carbon, and the chemical compositions of organic matter extracted from the successively deposited mineral associations. The new data are used in combination with the characteristics of the mineral associations and the isotope compositions of the sulfide sulfur to show that the preproductive quartz-tourmaline association was deposited under the most reducing conditions for the given system. The rise in redox potential during deposition of the quartz-cassiterite association led to an increase in the ratio of Sn(IV) to Sn(II) in the solution, which produced conditions favorable to the deposition of cassiterite. The deposition of the sulfide assemblage was associated with increase in the sulfide sulfur content in the solution and reduction in the redox potential, which prevented the deposition of cassiterite, since the proportion of Sn(IV) in the solution decreased, while the increase in ΣS in the solution favored the replacement of cassiterite by stannite. (Authors' abstract)

BARGAR, K.E. and BEESON, M.H., 1985, Hydrothermal alteration in research drill hole Y-3, Lower Geyser Basin, Yellowstone National Park, Wyoming: U.S. Geol. Survey Prof. Paper 1054-C, 23 pp.

Th was measured on 48 S inclusions in quartz and fluorite; most plot above but very close (within 20-40°) to present-day depth vs. T curve. (E.R.)

BARGAR, K.E., FOURNIER, R.O. and THEODORE, T.G., 1985, Particles in fluid inclusions from Yellowstone National Park--bacteria?: Geology, v. 13, p. 483-486. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

Micrometer-sized particles resembling microorganisms have been found in liquid-rich fluid inclusions in hydrothermal quartz crystals from a research drill hole in Yellowstone National Park, Wyoming. The particles are moving, apparently in Brownian motion. The 1-2-mm-long quartz crystals were obtained from fractures in late Pleistocene rhyolite at depths of 59.5, 102.1, and 102.5 m. The measured temperature and pressure at 102.1 m, where about 99% of the moving particles were found, were about 190°C and 1.25 MPa, respectively. Homogenization temperatures (190-280°C) of fluid inclusions at this depth mostly exceed measured temperatures, which suggests that the fluid inclusions probably did not form under present-day conditions. Instead, the fluid inclusions probably formed ≥45,000-14,000 B.P. at a much higher pressure owing to the weight of at least 490 m of glacial ice. Only 3 of the more than 200 quartz crystals examined contain up to several hundred rodlike, threadlike, or irregular-shaped moving particles. Fluid inclusions in 17 other quartz crystals each contain one or two moving particles that were observed only because of their continuous Brownian motion. (Authors' abstract)

See also Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 18, 1984. (E.R.)

BARKER, C.E. and BARKER, J.M., 1985, A reevaluation of the origin and diagenesis of borate deposits, Death Valley region, California, in Borates: Economic Geology and Production, J.M. Barker and S.J. Lefond, eds.: Proc. of Symp. Fall Meeting of SME-AIME, Oct. 24, 1984, Denver, CO, p. 101-136.

Two-phase L/V inclusions in borate minerals are probably secondary and have leaked or necked down. Tm ice near 0°C. P may be destroyed during recrystallization on burial, but some P monophase (L) inclusions are present and suggest low T origin, as verified by vitrinite reflectance and clay mineralogy. The inclusions stretch on heating. (E.R.)

BARKER, C.E. and HALLEY, R.B., 1984, Fluid inclusion and stable isotope evidence for the burial history of the Bone Spring limestone, southern Patterson Hills, Texas (abst.): Abstracts, First Ann. Meeting, Soc. Econ. Paleontologist and Mineralogists, p. 10. Authors at USGS, Denver, CO 80225.

The Permian Bone Spring Limestone is considered to be a major hydrocarbon source rock in the Permian basin. Outcrops contain fractures filled with as many as six calcite cement zones. Th of hydrocarbon fluid inclusions and $\delta^{18}O$ data divide these cements primarily into two sets. Set 1 cements have $\delta^{18}O$ near 0‰ and contain fluorescent and non-fluorescent inclusions with Th mainly between 55° and 75°C. Set 2 cements occur in fractures that crosscut set 1 and appear white in outcrop. They have $\delta^{18}O$ near -8‰ and contain sparse inclusions similar to those in set 1 but with Th mainly between 90° and 120°C. Many inclusions in both sets are considered primary because they lie in bands parallel to luminescent growth zones.

Petrographic observations suggest overlap in T between sets is due to: (1) incorporation of fragments of set 1 cements into crosscutting set 2 cements, and (2) local neomorphism of set 1 calcite along margins of set 2 calcite.

Th and $\delta^{18}O$ data suggest that oil migrated relatively early, perhaps as soon 25 m.y. after deposition while this rock was near 60°C, which equals about 1 and 2 km burial depth using a geothermal gradient of 2°C/100 m. Migration continued to maximum burial depth of about 3 km and 120°C, which was approached near the end of the Permian. Maximum Th values are consistent with the observed mean vitrinite reflectance of 0.7% . Calculations from calcite/water fractionation relations and Th indicate that both calcite sets precipitated frpm water having $\delta^{18}O$ of +4 to +10‰. This range is typical of water enriched by evaporation and/or dissolution and precipitation of marine calcite during burial. (Authors' abstract)

BARKER, Colin and SMITH, M.P., 1985, A microcomputer-mass spectrometer system for analysis of individual fluid inclusions: application to deep cements (abst.): EOS, v. 66, no. 18, p. 354. Authors at Dept. Geosci., Univ. Tulsa, Tulsa, OK 74104.

We have developed a new technique for analyzing volatiles in individual fluid inclusions using microcomputer-controlled, rapid scanning quadrapole mass spectrometry. Fluid inclusions are opened in vacuum by thermally-induced decrepitation and the computer program recognizes the abrupt rise in partial pressures for any, or all, of six selected components. The mass spectrometer scans from mass 1 to 65 every 25 msec which is within the time constraints of a bursting inclusion. The peak height of each AMU in each mass spectra is determined in "real-time" using 6502 machine language programming. Use of a 16-channel signal conditioner allows us to analyze trace gases down to 1 part in 10,000 with similar precision to the major components. Appropriate peak-height and background data are stored in RAM, and are reduced after the run is complete. Using this technique we can analyze more than 200 individual fluid inclusions in a 10 mgram sample in one hour.

Data on cements from several ultra deep wells (20,000'+) drilled by the petroleum industry have already been collected. Many of the inclusions in these cements must be modelled in terms of mixing three fluid phases; one water rich, one rich in hydrocarbons, and the third hydrogen sulfide rich. To date, our studies have mainly concentrated on the stability of methane in the deep crust. However, a particular interesting result from the ultra-deep Russian well in the Kola peninsula is the great influence of water-rich volatiles on deep crustal structure. These fluids may be sampled as inclusions in deep cements. The analyses of these fluid inclusions using our apparatus will provide important information that would otherwise be unobtainable. (Authors' abstract)

BARKER, Colin, TAKACH, N.E. and SMITH, M.P., 1985, Composition of ultradeep gas - Theoretical and experimental study (abst.): Am. Assoc. Petrol. Geol. Bull., v. 69, no. 2, p. 236. Authors at Univ. Tulsa, Tulsa, OK.

Increasingly greater numbers of wells are being drilled below 25,000 ft, and considerations of methane stability in the deep subsurface are becoming more important. We have calculated equilibrium gas compositions corresponding to conditions down to 40,000 ft for low, average, and high geothermal gradients, for hydrostatic and lithostatic pressures, and with and without graphite. Calculations have been made for sandstone reservoirs with various amounts and combinations of feldspars, clays, carbonate cements, and iron oxides with and without graphite, and for limestone and dolomite reservoirs with various combinations of clays, iron minerals, anhydrite, and sulfur, again with and without graphite. Natural gas shows considerable stability in sandstone reservoirs under most conditions, but its concentration in deep carbonates is much more variable and tends to a H_2S-CO_2 mixture except when an appreciable concentration of iron is present.

The thermodynamic predictions can (in principle) be checked by direct analysis down to the depth limit of available gas samples. In practice, considerable problems exist due to partial gas loss during sample retrieval. The analysis of gases trapped in fluid inclusions in late-stage cements offers one solution to this problem. This gas is being analyzed by thermally rupturing inclusions in the inlet system of a fast-scanning, computer-controlled mass spectrometer. Each bursting inclusion is analyzed separately, and several hundred individual inclusions can be analyzed using only 10 mg of sample. A wide variety of compositions, including water-rich, methane-rich, and H_2S-rich, is found in samples from below 20,000 ft. (Authors' abstract)

BARNES, Ivan, 1985, Mineral-water reactions in metamorphism and volcanism: Chem. Geol., v. 49, p. 21-29. Author at U.S. Geol. Survey, Menlo Park, CA 94025, USA.

Low-temperature (120°C and less) metamorphism of graywacke, granite and andesite yields zeolites and precursor gels by reaction with fresh water but low-greenschist facies by reaction with salt (sea)water. (Author's abstract)

BARNES, R.O., 1985, Fluid and chemical fluxes between seawater and basement rocks during hydrothermal circulation in the oceanic crust (abst.): EOS, v. 66, no. 46, p. 921.

BARNES, S.J., 1985a, Solubility of chromium in a synthetic Bushveld/Stillwater parent liquid at 1 atm as a function of temperature and oxygen fugacity (abst.): Lunar and Planetary Sci. XVI, p. 27-28.

BARNES, S.J., 1985b, The experimental determination of partition coefficients for Cr between orthopyroxene and a synthetic Bushveld/Stillwater parent melt, as a function of oxygen fugacity and temperature: Implications for the distribution of chromite in layered intusions (abst.): Lunar and Planetary Sci. XVI, p. 29-30.

BARNES, S.J. and NALDRETT, A.J., 1985, Geochemistry of the J-M (Howland) reef of the Stillwater Complex, Minneapolis adit area. I. Sulfide chemistry and sulfide-olivine equlibrium: Econ. Geol., v. 80, p. 627-645. First author at CSIRO Inst. Energy & Earth Resources, Div. Min., Private Bag, P.O. Wembley, Western Australia 6014, Australia.

A pulse of replenishing magma enters the Stillwater chamber as a buoyant plume and subsequently spreads to form a layer of hybrid melt. Sulfide liquation and olivine crystallization occur within the plume and the hybrid layer in response to mixing and subsequent cooling. Sulfide liquid attains high platinum-group element concentrations during turbulent ascent and spreading of the plume. (From the authors' abstract)

BARNICOAT, A.C., 1985, Fluids in Alpine eclogite (abst.): NERC 3rd Deep Geology Workshop Programme and Absts., Univ. Durham, 3-4 Jan., 1985 (unpaginated). Author at Univ. Aberystwyth.

[Several] features, together with a petrogenetic analysis of the assemblages found, imply that a fluid phase was present throughout most of the high-pressure history of these rocks. Furthermore, the assemblages found in the sequence eclogitic pillow core - glaucophanic pillow rim - carbonate-bearing inter-pillow sediment imply that the activity of carbon dioxide increased from pillow core to sediment, rather than the activity of water increasing as has been previously suggested. Relatively late eclogite to blueschist reactions during early uplift appear to have used up the fluid phase, rendering the rock vapor free.

The retention of a vapor phase within rocks undergoing dehydration is due to the high density of water under eclogite-facies conditions. The implication is that fluids may remain trapped within subducting oceanic crust until the P/T ratio decrease sufficiently to cause a lowering in the density of the trapped fluid to allow fracturing and subsequently fluid escape. (From the author's abstract)

BARNICOAT, A.C., 1985, Carbonates in eclogitic and associated rocks of the Zermatt-Saas Fee ophiolite (abst.): Second Int'l. Eclogite Conf., Terra Cognita, v. 5, p. 443. Author at Dept. Geol., Univ. College of Wales, Aberystwyth, Dyfed SY 23 3DB, UK.

Dolomitic carbonate occurs in a number of settings in the eclogites and blueschists of the Zermatt-Saas Fee ophiolite. An analysis of the assemblages in the system NCMAS-H_2O-CO_2 suggests that the variation in assemblage is due to an increase in $A(CO_2)$ from pillow core to interpillow sediment. The amount of fluid that reacted with the rock also increased in that direction. This variation in fluid composition and availability may have been inherited from the original pillow lavas. Alternatively, it may be a result of the diffusion of a CO_2-rich fluid into the pillows from the interpillow sediments once the carbonate-bearing assemblages there started to break down. The retrogression of the eclogitic assemblages to these carbonate-bearing blueschists ceased when the fluid phase was used up, and further retrogression occurred only when additional fluid was made available either by introduction from external sources or occassionally by the breakdown of lawsonite. (From the author's abstract)

BARRACLOUGH, B.L. and MARTI, Kurt, 1985, In search of the Moon's indigenous volatiles: Noble gases and nitrogen in vesicular lunar glasses (abst.): Lunar and Planetary Sci. XVI, p. 31-32. First author at Inst. Geophysics & Planet. Physics, Univ. California, Los Angeles, CA 90024.

Gas bubbles in lunar green or orange spherules were studied as possible "bottles" for lunar volatiles. Precompaction and irradiation history differences caused large differences in gases between samples. Analyses were made of 10 samples for ^{36}Ar, ^{40}Ar, ^{4}He, ^{20}Ne, ^{22}Ne, N_2, Kr and Xe. Interpretation is still an open question. (E.R.)

BARROS, J.C. and KINNAIRD, J.A., 1985, Fluid inclusion studies of emeralds and green beryls from the Porangatu deposit, Goias State, Brazil (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 8-9. First author at Dept. Geosci., Univ. Brasilia, Brasilia DF 70 000, Brazil.

The fluid inclusions occurring in emerald from ferroan phlogopite and talc schist have been compared with fluid inclusions in green beryl from quartz and feldspar matrices from the same deposit.

The inclusions ($\leq 470 \mu m$) are more abundant and smaller in the outer zones compared with the core. Inclusions vary from negative-crystals and elongate tubular forms to irregular forms.

Five categories are recognized:

i) Type C (70% of the total) are CO_2-rich with CO_2 gas normally predominating over CO_2 liquid, plus an aqueous phase and up to six dms.

ii) Type L (20% of the total) are aqueous fluid ± a small vapor bubble.

iii) Type S (5% of the total) are saline with dms occupying ≤ 60 vol.%.

iv) Type V (4-5%) consist of >50 vol.% vapor phase plus low salinity aqueous fluid.

v) Type G (rare) contain trapped silicate melt, now as devitrified glass, plus one or more small vapor bubble(s).

Thermometric studies show a range from 0.9-37 wt% NaCl, with peaks at 2 and 29.5 wt%. Densities range from 0.3 to 1.27 g/cm^3. Te, Tn, and Tm dms indicate that the fluids are enriched in NaCl, KCl, $MgCl_2$, and CH_4 in addition to abundant CO_2. The carbonic inclusions have 7.20 mole % CO_2 (calc.), and a density of 0.75 gm/cm^3.

Th (total) shows a frequency distribution that is different for each of the four matrix types, and a wide range of Th attributed to different pulses of beryl-forming fluid. The shallow depth of formation has facilitated sudden pressure release resulting in rapid variations in P-T conditions. Highest Th values of 520-530°C are in emeralds from the phlogopite zone with a peak 410-420°C. Emeralds from talc schist have Th max. 410°C and a similar peak at 390-400°C. Other gems have no peak value and Th max. 460°C. The highest trapping temperatures however are not representative [represented?] due to increased decrepitation as temperature increases.

The high temperature inclusions indicate that the early fluids had a discontinuous line of descent due to immiscibility, effervescence and/or boiling. At a later stage i.e. at lower temperatures and pressures there is a roughly continuous line of descent. (From the authors' abstract)

BARTA, Leslie and BRADLEY, D.J., 1985, Extension of the specific interaction model to include gas solubilities in high temperature brines: Geochimica Cosmo. Acta, v. 49, p. 195-203. First author at Dept. Chem. & Geochem., Montana College of Min. Sci. & Tech., Butte, MT 59701, USA.

A semi-empirical model for gas solubilities in high temperature brines was developed by modification of the Pitzer interaction model (Pitzer, 1973) and evaluated by least-squares fitting to available P-T-X data for carbon dioxide, hydrogen sulfide, and methane in pure water and in aqueous sodium chloride solutions. Over the range of experimental data used (25°-350°C, NaCl concentration 0-6 m, PCO_2 1-150 atm, PH_2S 1-1700 atm), standard deviations of fit in the natural logarithm of the Henry's law ratio were 0.096 for CO_2, 0.093 for H_2S and 0.116 for CH_4.

The model has several advantages. First, it has a theoretical basis which can easily be extended for the inclusion of more than one salt or gas. Second, the equations simplify to the empirically derived equation of Setschenow, in the limit of infinte dilution. Finally, the model is easily integrated into a framework of equations which can yield all of the thermodynamic properties of the system.

An example in which values of the model parameters for interaction of gas with salt may be used to estimate the effect of dissolved gas or salt solubility is given. (Authors' abstract)

BARTHEL, J. and GORES, H.-J., 1985, Data on transport properties of electrolyte solutions for applied research and technology: Pure & Appl. Chem., v. 57, p. 1071-1082. Authors at Inst. Phys. & Theoret. Chem. Univ. Regensburg, FRG.

Transport properties, conductance of electrolyte solutions and viscosity of their solvents, as well as dielectric properties are discussed in the framework of applications in modern technology. Electrolyte solutions in high energy batteries with lithium anodes are chosen for exemplifying both the role of the solvent and the fulfilment of supplementary conditions imposed by technical applications. The generation of electrolyte property profiles by means of a data base is used and the data and method base for electrolyte solutions, ELDAR, is presented. (Authors' abstract)

BATH, A.H., 1985, Deep source gases and hydrocarbons within the UK crust (abst.): NERC 3rd Deep Geology Workshop Programme and Absts., Univ. Durham, 3-4 Jan., 1985 (unpaginated).

BAUR, M.E., HAYES, J.M., STUDLEY, S.A. and WALTER, M.R., 1985, Millimeter-scale variations of stable isotope abundances in carbonates from banded iron-formations in the Hamersley Group of Western Australia: Econ. Geol., v. 80, p. 270-282.

BAZAROVA, T.Yu., KOSTYUK, V.D., KRASOV, N.F. and VAVILOV, M.A., 1985, The role of compositional studies of melt inclusions in genetic petrology (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 106-108 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. & Geophys. Sib. Div. Acad. Sci. USSR, Novosibirsk, USSR.

Analyses of syngenetic melt inclusions crystallized in varying degree during an early crystallization phase provide an ideal picture of differentiation of the orignal magma in a closed system. Tracing the compositional changes in a crystallizing medium under the conditions of an actual magma is possible only with successive analyses of homogenized inclusions in phenocrysts from all phases of crystallization.

The chemical compositions of the residual glasses (final differentiates) of inclusions in pyroxene phenocrysts from basalts of similar composition from four volcanic provinces (Bol'shoy Anyuy, South Armenia, Central Aldan, and East Pamir) have shown that differentiation of alkaline basaltic melts has proceeded in all cases according in a single pattern: substantial enrichment SiO_2, Al_2O_3, and K_2O and depletion of FeO, MgO, and CaO, with Na_2O remaining stable (Tables 1 and 2).

Thus, closed system differentiation of alkaline basaltoid magmas may lead to unique synnyrite rocks, and andesite-basaltic melts may become essentially silicic rocks. (Authors' abstract)

Table 1. Bol'shoy Anyuy (a tributary of the Kolyma Riser)

	Alkali-basalt, bulk composition*	Glass inclusion, Phase 1 (natural chilled product)	Glass inclusion, Phase 2, of initial interval of crystallization	Residual glass
SiO_2	46.66	49.22	52.45	56.02
TiO_2	0.77	0.94	0.76	0.33
Al_2O_3	14.63	19.52	20.15	22.75
FeO	9.45	8.13	7.06	2.83
MgO	8.58	2.30	1.80	0.28
CaO	10.68	4.66	4.30	1.99
Na_2O	4.00	4.69	4.63	4.70
K_2O	1.20	5.12	6.12	8.66
Total	100.33	94.58	97.27	96.56

*P_2O_5 - 0.54, H_2O - 3.81

Table 2. Western Kamchatka (Khayryuzovsk massif)

	Alkali-basalt, bulk composition*	Residual glass of inclusions in orthopyroxene	Residual glass of inclusions in clinopyroxene
SiO_2	53.59	70.36	73.42
TiO_2	0.78	0.68	0.24
Al_2O_3	15.91	10.27	16.84
FeO	6.97	---	0.65
MgO	7.27	---	0.04
CaO	7.70	2.61	1.33
Na_2O	3.32	4.33	3.28
K_2O	0.85	3.83	2.58
Total	99.31	101.09	98.38

*Cr_2O_3 - 0.06, MnO - 0.11, P_2O_5 - 0.26, H_2O - 2.49

BEANE, R.E., WILKINS, Joe, Jr. and HEIDRICK, T.L., 1985, Conditions of gold mineralization in the detachment fault environment (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 520. First author at Amax Explor., Inc., 10 E. Broadway, Ste. 400, Tucson, AZ 85701.

Mineral exploration in the detachment fault environment of southwestern North America was originally oriented toward base metals, but is currently focused on gold. Two different hydrothermal mineral assemblages are structurally localized in the detachment environment: I) chlorite + specularite + pyrite + chalcopyrite form replacements in the immediate vicinity of the detachment fault and tangentially-intersecting listric faults, and II) hematite + sericite + chrysocolla ± gold, barite, and calcite occur at structurally higher positions in tear faults and the listric faults which they transect. Fluid inclusion homogenization temperatures indicate hotter conditions of formation for assemblage I (225-300°C) than the assemblage II minerals (150-225°C). Inclusion salinities for both groups are in the approximate range 12-20 weight percent NaCl equivalent. The two mineral assemblages reflect chemically distinct environments in terms of the parameters $a(S_2)$ and $a(O_2)$; assemblage I lies at higher S_2 activities and more reducing conditions than assemblage II. Mineral stability calculations indicate transport of metals for both environments was by chloride complexes in moderately acidic solutions which can be shown to contain comparable concentrations of total dissolved sulfur. It is likely that the fluids depositing both assemblages were derived from the same source, probably graben-related basins formed by the same extensional tectonics as were the detachment faults. The presence of gold with the assemblage II mineralization results from the increased transport capacity of more oxidized fluids circulating at generally higher levels in the upper detachment plate, and deposition as a result of reduction by earlier-formed chlorite. (Authors' abstract)

BEATY, D.W., THOMPSON, T.B. and SOLOMON, G.C., 1985, The Leadville, Colo. district: Oxygen isotopic evidence for a magmatic-hydrothermal origin (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 521. First author at Noranda Explor., Inc., P.O. Box 15638, Denver, CO 80215.

A magmatic-hydrothermal origin for much of the manto and vein complex at Leadville, Colorado, is indicated by 60 $^{18}O/^{16}O$ and D/H analyses of rocks and minerals. The ore-related samples around Breece Hill all interacted with a high-^{18}O, high-D fluid. Phyllically altered Tertiary porphyries (Breece Hill, Black Cloud Mine, Yak Tunnel) equilibrated with fluids of $\delta^{18}O$ = +4.5 to +7.5 and δD = -53 to -70 permil (SMOW). Metal-rich quartz veins above, and vug quartz within manto ore, were deposited by fluids with $\delta^{18}O$ = +3.4 to +11.3. The host Leadville Dolomite shows high-^{18}O alteration adjacent to ore. Finally, silica-dolomite tubes surrounding mantos, possible conduits for spent ore fluids, transmitted fluids of $\delta^{18}O$ = +6.4 to +8.7. By contrast, early jasperiod ($\delta^{18}O$ fluid = -5 to -18) and late golden barite ($\delta^{18}O$ fluid = -18) formed from meteoric waters. Early white barite ($\delta^{18}O$ fluid = 0 to +2) formed from a fluid of indeterminate origin.

These data clearly show that a local meteoric-hydrothermal system was interrupted by a massive flux of high-^{18}O high-D fluid with the isotopic character of magmatic water. Two facts imply that the ore deposits were deposited from this magmatic-hydrothermal system: 1) The ore deposits and high-^{18}O effects are regionally coincident; 2) on a local scale the high-^{18}O effects and ores are intimately related (silica-dolomite tubes, metalliferous high-^{18}O veins, disseminated Au in high-^{18}O porphyry). (Authors' abstract)

BECKER, P. and BILAL, B.A., 1985, Ion products of water in 1 m NaCl under hydrothermal conditions: J. Solution Chem., v. 14, no. 5, p. 367-373. First author at Geochem. Group, Nuclear Chem. Div., Hahn-Meitner-Inst. Kernforschung Berlin, FRG.

The apparent ion product of water Q_W' has been determined potentiometrically at pressure up to 96.7 MPa and temperatures up to 246°C in solutions of ionic strength 1.019 m (NaCl). A concentration cell employing hydrogen electrodes was used. It was found that $-\log Q_W$ varies from 13.64 at 4.1 MPa and 20°C to 9.98 at 96.7 MPa and 230°C. (Authors' abstract)

BEHR, H.-J., 1985, Studies of deep crustal fluids - one target of the German deep drilling project (KTB) (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 10-11. Author at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

After a 5-year preparatory phase the Continental Deep Drilling Program of the Federal Republic of Germany was approved by the Ministry for Research and Technology.

Studies on crustal fluids in this program should contribute to, among others, the following problems:

1. The role of fluid phases during metamorphism and deformation associated with progressive metamorphism, uplift and decompression anatexis, and uplift and retrograde hydrothermal alteration. Upper and lower crustal rocks as well as possible mantle material (granulites, eclogites, garnet-pyroxenite, etc.) are expected. Three tectonometamorphic events have successively imprinted the basement: MP metamorphism with HP shear bodies, mylonitization and shearing resulting from intracrustal thrust and napped tectonics, and HT/LP metamorphism with anatexis and regional sillimanitization.

2. The role of internal fluid phases in the metamorphic crust and in intrusions concerning the transport and concentration of U, Sn-W, Au and Cu.

3. The role of highly saline external fluid phases from Permian-Mesozoic sediments in post-Variscan vein mineralizations of Pb-Zn, fluorite

and barite, and redeposition processes in older mineralizations. Formation of fluid convection and advection, leaching, transport and deposition of minerals are due to displacement of crustal permeability at depth through brittle deformation in conjunction with post-Variscan shear and fracture tectonics.

4. The role of fluid phases in heat and mass transfer.

It is expected that the bore profile will uncover zones below the hydrothermal low-grade alteration and below the convection of external saline fluids. The primary fluids and permeability structures in metamorphic rocks will be studied, measured and composed [analyzed?] to draw conclusions on the importance of fluid systems for the evolution of the Central European crustal structures. There is a particular demand for physical and chemical analyses of fluid inclusions, grain boundary fluids and fluids migrating in open structures. (From the author's abstract)

BEHR, H.-J., HORN, E.E., FRENTZEL-BEYME, K., GERLER, J. and REUTEL, C., 1985, Preliminary investigation of crustal fluids for the Continental Deep Drilling Project (KTB) of the Federal Republic of Germany (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 12-13. Authors at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

In the course of the current preliminary investigations for the KTB, samples have been taken from a large network of outcrops, ore deposits and drillings and studied using microthermometry.

The following clearly defined main types of inclusion generations are obtained from the available microthermometric data for the Oberpfalz [deep drilling] locality: N_2-CH_4-CO_2; CO_2-H_2O; H_2O, low salinity/high T (>220°C); H_2O, low salinity/medium T (150°-220°C); H_2O-$CaCl_2$-NaCl, high salinity/low T (<150°C); and H_2O, low salinity/low T.

The first three types are connected with metamorphism in the crust. The other generations were presumably influenced by postmetamorphic formation water. The wealth of pure gas inclusions in [some samples] is lithologically controlled.

The studies on fluid inclusions from the Black Forest have yielded three main types sofar: 1) H_2O, low salinity (near 0°C), high Th (usually between 280° and 380°C). This type is widespread in rocks of the pre-Variscan basement (gneisses, anatexites) and in Variscan granites; 2) H_2O, low salinity, low to medium Th; and 3) H_2O-NaCl-$CaCl_2$, high salinity (Te -58°C, Tm ice -25° to -23°C), low Th (usually between 100° and 140°C). This type is widespread in hydrothermal vein deposits in various parts of the Black Forest. The mineralization at the Clara mine near Oberwolfach has been extensively investigated [see Gerler, this volume]. It can be shown that these fluids are analogous to highly saline formation water.

Almost no CO_2 has been observed in the inclusions from the Black Forest, contrary to those from the Oberpfalz. The cause for this may be lithological differences. (From the authors' abstract)

BEHR, H.J., HORN, E.E. and GERLER, J., 1985, $CaCl_2$-rich fluids, a source of post-Variscan hydrothermal vein deposits in central Europe (Harz Mountains, Rhenish massif, Black Forest, Bavarian Forest (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 14. Authors at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

Regional investigations of fluid inclusions in hydrothermal, polymetallic vein deposits of Central European basement and supracrustal rocks allow the recognition of two different fluid systems. Mineralizations which are clearly related geologically and structurally to Paleozoic metamorphism and granitic intrusions are characterized by high-T, low-saline solution systems and ore solutions (e.g., the deposits at Ramsbeck and Siegerland in the Rhenish Massif). Typical microthermometric data from these types are: Te -20° to -24°C, Tm ice 0° to -6°C, Th 200° to 350°C.

On the other hand, nearly all significant vein mineralization with Pb-Zn-Cu and fluorite and barite in the Harz Mountains, Black Forest, Rhenish Massif and on the western margin of the Bohemian Massif are characterized by $CaCl_2$-NaCl solutions of average to very high concentration and by low to middle T (Te <-50°C, Tm ice -22° to -26°C, Th <200°C).

Neutron activation analyses of [leachates from] several quartz samples of this type yielded Cl 120,000-158,000 ppm; Na 45,000-81,000 ppm; Ca 13,000-44,000 ppm. The Cl/Br ratios lie between 54 and 220 and thus are at least lower than those of the low-saline, high-T saline inclusions of the first type.

Hydrothermal alteration of the basement rocks and formation waters of the Permian-Mesozoic supracrustal rocks are discussed as the origin of the Ca component. In view of the geological setting and mass balances it is assumed that formation water comes into consideration as the source. Hence, the conclusion is drawn that Ca-specialized mineralization in Central Europe is of post-Variscan age, between the Upper Permian and Cretaceous. (Authors' abstract)

BEHR, H.J., HORN, E.E. and LUDERS, V., 1985, The genesis of zoned quartz crystals in post-Variscan mineralizations in central Europe excluding the Alps (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 16-17. Authors at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

In Permian to Cretaceous vein mineralization seated on the post-Varisan fracture and shear systems, e.g., Harz Mountains, Rheinisches Schiefergebrige, Odenwald, Spessart, Frankenwald, Bavarian Forest and parts of the Black Forest, a strong zonation of quartz is characteristic.

After extensive low-T barite (Th <70°C), the solution temperatures rise clearly above 100°C, with the pseudomorphic zoned quartz (barite replacing quartz)[sic]. Studies on fluid inclusions of zoned quartz prove that this zonation results from the mixture of two fluid systems. Sudden SiO_2 oversaturation results in fast quartz growth, indicated by large numbers of inclusions (ore particles, etc.) in zones of milky quartz. At the same time a change of composition, salinity, redox potential, and O_2-fugacity is often observed which could be proven with measurements of Tm ice and Th[sic].

The saline low-T systems partly indicated by Ca and sulfate result from convecting, uprising meteoric water from the sedimentary cover with T >250°C. The mixture of solutions and thus the zonation can be traced back to seismic pumping, which was injected by tectonic shear from Upper Palaeozoic to Mesozoic. The zonation is thus a palaeoseismic record as well [and permits] calculations of the seismic activity and the transport of solutions. (From the authors' abstract)

BEHR, H.-J., HORN, E.E., LUDERS, V. and REUTEL, C., 1985, On the age of the vein mineralizations of the Harz Mountains - criteria from fluid inclusion studies (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 18-19. Authors at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

In the course of the exploration of the vein mineralizations of the Harz Mountains there are not yet any clear differentiation criteria. Some vein-forming solutions are related to late-Variscan granite intrusions (on the basis of mineral and T zoning) and others are indicative of independent post-Variscan solution systems of unknown origin. Vein tectonic analysis and individual mineralization up to the Mesozoic lead to the assumption of a younger age. Fluid inclusion studies on minerals of the ore districts of the Harz Mountains show the following results: 1) Formation T <+200°C with a max. $\sim$+150°C; 2) P and PS Te $\sim$-67°C and Tm ice $\sim$-26°C. (Analyses also prove that the solutions contain abundant $CaCl_2$.); and 3) Fluid inclusions of the Brocken granite by Homann have shown that NaCl systems are dominate in the granite.

A T zoning around the Brocken granite cannot be confirmed by data from fluid inclusions, but studies strongly indicate a post-Variscan age of the mineralization.

$CaCl_2$ and NaCl in fluid inclusions may result from mixing of Permian formation waters and hot hydrothermal alteration solutions rising from the basement during the uplift of the Harz Mountain block.

For this study samples from all mining regions of the Harz Mountains were examined (Pb- and Zn-sulfide veins with quartz and carbonate as well as barite and fluorite veins). The barite is younger than the Pb-Zn and lower T (Th <70°C). In the younger fluorite and partially appearing quartz pseudomorphs the formation T increases clearly >+100°C.

The source of heat for the post-Variscan mineralizations is the forced permeability of the crust resulting from the fracture tectonics and the descent of convecting cells of the fluid systems into deeper, higher T regions. No traces of CO_2 and CH_4 were found in any of the Harz Mountains mineralization. (From the authors' abstract)

BEHR, H.-J., HORN, E.E. and SCHMIDT-MUMM, A., 1985, Fluid systems in Metaplaya sequences (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 20-21. Authors at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

Includes further details not given in earlier abstract (Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 15-16). Te -80 to -35°C with peaks at -45, -55 to -65, and -70 to -80°; Tm ice -45 to -18°; Tm hydrate +9 to +15°; Th V-L(L) +100 to +260°; Th V-L(V) +220 to +450°; Tm dm +60 to +350°; Tm dm in sulfur-bearing inclusions mean 220°C. (E.R.)

BEHR, H.-J., PETERS, M., REUTEL, C. and WEBER, K., 1985, Hydrothermal alteration and secondary mineralization in continental-rift basalts of Vestfjella, western New Schwabenland (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 22-23. Authors at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

Hydrothermal mineralizations (pumpellyite, epidote, prehnite, quartz, calcite and chlorite) fill 1-2-m druses as large crystals (up to 10 cm). Microthermometric data from measurements of quartz, calcite and prehnite indicate:

1) CO_2-H_2O (+NaCl); salinities correspond to 10.5-13.9 wt. % NaCl; Th at least 270°C.

2) H_2O (+NaCl+$CaCl_2$-$MgCl_2$), very high[sic] Te (<-70°). Tm ice averaged -23°C; Th 120-145°C.

3) H_2O, Tm ice $\sim$0°C, Th 150°-200°C.

4) CH_4

5) H_2O (+NaCl ± $MgCl_2$), Tm ice -2° to +1°C, Th 140°-200°C.

There is a correlation between the hydrothermal alteration and the water content of the basalts: with no hydrothermal mineralization (excluding epidote and chlorite) but intensive alteration of the primary magmatic minerals: 1.25 wt. % H_2O; with intensive alteration and weak hydrothermal mineralization of pumpellyite, epidote, prehnite, chlorite, calcite and quartz: 2-4 wt. % H_2O; and with intensive alteration and hydrothermal mineralization: >4 wt. % H_2O.

The strong alteration was caused by meteoric water circulating for a long time in the basalt sequence and the nearby coal-bearing Permian sediments, from which CO_2 and CH_4 were derived. These data suggest the basalts are of post-Permian age, and not Precambrian. (From the authors' abstract)

BELKIN, H.E., De VIVO, B., Di GIROLAMO, P., LIMA, A., and ROEDDER, E, 1985, Ejected nodules from the 79 A.D. and 472 A.D. Plinian eruptions, Mt. Vesuvius: a fluid inclusion and petrographic study: IAVCEI 1985 Scientific Assembly--Potassic volcanism--Mt. Etna volcano. Abstracts & time schedule (unpaginated). First author at 959 National Center, U.S. Geological Survey, Reston, VA 22092 (USA).

The Mt. Somma-Vesuvius volcano has erupted silica-undersaturated, potassium-rich lava and tephra during at least seven Plinian and numerous smaller-scale, mainly effusive episodes. Ejected nodules, usually related to explosive activity, have been subdivided into four varieties: cumulate, "skarn" (magmatic hybrid?), hornfels, and hypabyssal equivalents of lavas. Thirty cumulate, skarn and hypabyssal nodules were collected from the pyroclastic airfall and surge deposits of the 79 A.D. "Pompeii" and 472 A.D. "Pollena" Plinian eruptions. We have made systematic microthermometric studies of the fluid inclusions and petrographic and chemical (microprobe) studies of their host phases.

Cumulate nodules are composed mainly of subhedral to euhedral, usually zoned, clinopyroxenes ("FeO" ≅ 2 to 5 wt.%, Al_2O_3 ≅ 1 to 7 wt.%), with subordinate biotite, Mg-rich olivine, apatite, and interstitial glass. Skarn nodules are composed mainly of interlocking unzoned fassaitic clinopyroxene ("FeO" ≅ 2 to 9 wt.%, Al_2O_3 ≅ 6 to 9 wt.%), phlogopite, and low Cr and Ni hercynitic spinel but lack interstitial glass. Vugs are common in these nodules. Hypabyssal nodules contain zoned clinopyroxene ("FeO" ≅ 4 to 9 wt.%, Al_2O_3 ≅ 2 to 8 wt.%), biotite, apatite, olivine, hornblende, plagioclase, leucite, and interstitial glass. Mineral reaction phenomena were not observed in any nodule. Three types of primary fluid inclusions, formed by trapping of various ratios of silicate melt plus an immiscible CO_2 or CO_2+H_2O phase, are present: (1) silicate melt, now glass, in part crystallized to various daughter minerals plus a shrinkage bubble, (2) (CO_2 + H_2O) inclusions, now consisting of CO_2 L+V + H_2O L (± glass), and (3) CO_2 L+V (± glass). Silicate-melt inclusions are present in all mineral phases in all three nodule types studied. (CO_2 + H_2O) inclusions are found in the clinopyroxene (zoned and unzoned), micas (now empty from decrepitation), and hercynitic spinel of the cumulate and skarn nodules. CO_2 inclusions are much less common and occur only in the clinopyroxene of cumulate nodules. Secondary silicate melt and (CO_2 + H_2O) inclusions are common in certain cumulate and skarn nodules.

The homogenization temperatures of the two-phase CO_2 and the (H_2O+CO_2) (CO_2 = 60 to 80 mole %) inclusions were determined with a CHAIXMECA stage and used to derive the trapping density. The melting point of CO_2(s) and CO_2 clathrate was also determined. Homogenization temperatures of silicate-melt inclusions determined by using a LEITZ 1350 stage average ~1200°C for the cumulate and hypabyssal nodules and ~1000°C for the skarn nodules. Differences in their quenching behavior suggest that melts of different compositions have been trapped. $(CO_2 + H_2O)$ and CO_2 densities, plus calculated P-V-T data on CO_2 and $(CO_2 + H_2O)$ at 1200° and 1000°C, provide estimates, with certain limitations, of the pressures during inclusion trapping. These estimates range from ~1.0 to ~2.5 kb in both the cumulate and skarn nodules, corresponding to ~4 to ~10 km trapping depth, assuming a density of 2.7 g/cm^3 for the magma column.

Nodules from non-Plinian eruptions, in contrast to the studied nodules from the 79 A.D. Pompeii and 472 A.D. Pollena Plinian eruptions, have very rare $(CO_2 + H_2O)$ fluid inclusions, although their temperatures and pressures of formation are similar. This observation suggests that the magmas that produce Plinian eruptions have a different and perhaps higher initial volatile content than those supplying non-Plinian eruptions. (Authors' abstract)

BELKIN, H., DE VIVO, B., GIANELLI, G. and LATTANZI, P., 1985, Fluid inclusions in minerals from the geothermal fields of Tuscany, Italy: Geothermics, v. 14, no. 1, p. 59-72. First author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092, USA.

A reconnaissance study on fluid inclusions from the geothermal fields of Tuscany indicates that the hydrothermal minerals were formed by fluids which were, at least in part, boiling. Four types of aqueous inclusions were recognized: (A) two-phase (liquid + vapor) liquid rich, (B) two-phase (vapor + liquid) vapor rich, (C) polyphase hypersaline liquid rich and (D) three-phase - H_2O liquid + CO_2 liquid + CO_2-rich vapor. Freezing and heating microthermometric determinations are reported for 230 inclusions from samples from six wells. It is suggested that boiling of an originally homogeneous, moderately saline CO_2-bearing liquid phase produced a residual hypersaline brine and a CO_2-rich vapor phase. There are indications of a temperature decrease in the geothermal field of Larderello, especially in its peripheral zones. (Authors' abstract)

BELKIN, H.E., DE VIVO, Benedetto, ROEDDER, Edwin and CORTINI, Massimo, 1985, Fluid inclusion geobarometry from ejected Mt. Somma-Vesuvius nodules: Am. Mineralogist, v. 70, p. 288-303. First author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

The Mt. Somma-Vesuvius volcano (Naples, Italy), part of the Italian-Tyrrhenian volcanic province, has erupted lavas and tephra that are silica-undersaturated and usually potassium-rich. Ejected nodules, usually related to explosive activity, have been subdivided into four varieties: cumulate, "skarn," hornfels, and hypabyssal lava equivalents. The results of a microthermometric study of fluid inclusions from seven cumulate and three "skarn" nodules collected from the pyroclastics of three non-Plinian eruptive episodes are presented in this paper. Two primary inclusion types, formed by trapping of immiscible fluids, are commonly present: silicate melt (now glass in part crystallized to various daughter mineral(s) plus a shrinkage bubble) and essentially pure CO_2 (now liquid and vapor) ± glass. Three inclusions in one nodule (N81) contain water in addition to CO_2 and glass. The homogenization temperature (Th) of two-phase CO_2 inclusions was determined with a Chaixmeca stage and used to derive the trapping density. In the seven cumulate nodules the CO_2 inclusion density ranged from 0.32 to 0.60 g/cm^3; those in the three "skarn" nodules ranged from 0.31 to 0.72 g/cm^3. Th of silicate melt inclusions, determined using a Leitz 1350 stage, averaged ~1200°C in cumulate and ~1000°C in "skarn" nodules. CO_2 inclusion densities plus calculated P-V-T data on CO_2 at

1200° or 1000°C provide an estimate, with certain limitations, of the pressure during silicate melt and CO_2 inclusion trapping. These estimates range from ~1200 to ~3050 bars for seven cumulate nodules and from ~925 to ~3550 bars for the three "skarn" nodules. Assuming a density of 2.7 g/cm^3 for the magma column, the depth of trapping of both CO_2 and silicate melt inclusions was ~4.5 to ~11.0 km for the seven cumulate and ~3.5 to ~13.0 km for the three "skarn" nodules. Based on the presence of primary silicate-melt inclusions, both the cumulate and "skarn" nodules appear to have crystallized from a silicate melt. Two types of silicate-melt inclusions can be distinguished in the "skarn" nodules based on quenching behavior after homogenization; one quenches to glass, and the other readily crystallizes on quench. These two types suggest that melts of different composition were present in the "skarn" nodule environment. Cumulate and "skarn" nodules appear to be crystallization products from a silicate melt containing an emulsion of supercritical CO_2 globules. Most nodules contain CO_2 inclusions with a narrow density range but three nodules (N30, N13, N45) contain CO_2 inclusions that have an inexplicable bimodal distribution and wide density range. (Authors' abstract)

BELKIN, H.E. and LIBELO, E.L., 1985, Whiskers of cryptomelane-hollandite in bedded salt, Palo Duro Basin, Texas; a natural example of solid-state diffusion growth (abst.): EOS, v. 66, no. 18, p. 398.

These whiskers are closely associated with fluid inclusions in the salt, but do not appear to be daughter minerals. (E.R.)

BELLANCA, A., DE VIVO, B., LATTANZI, P., MAIORANI, A. and NERI, R., 1985, Fluid inclusions in fluorite mineralization of N-W Sicily (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 24. First author at Ist. Mineral. Petrogr. Geochim., Univ. Palermo, Italy.

Fluorite mineralization, mainly controlled by post-Pliocene disjunctive faults, occurs in Mesozoic limestones in the area of Termini Imerese (NW Sicily). The host limestones are widely silicified and altered. Fluorite of several colors associated with late-stage barite and calcite, was examined from Rocca Grande and Poggio Balate.

Fluid inclusions are quite abundant in all varieties of fluorite. They are mostly two-phase liquid-rich. Less common types include: 1) monophase (liquid) inclusions; 2) two-phase gas-rich; 3) three-phase (liquid + gas + an accidentally trapped solid); 4) three-phase (gas + 2 liquids, most often recognizable as an aqueous and an oily liquid). Crushing tests shows the almost ubiquitous presence of gas under pressure (most probably methane).

During heating runs, a large number of inclusions leaked, decrepitated or stretched, and Th spread over a large range (60° to >300°C); average ~200°C at Rocca Grande and ~150°C at Poggio Balate. Pressure corrections should be minimal. However, the occurrence of stretching phenomena, the presence of gas under pressure (suggesting the possibility of heterogeneous trapping) and of organic compounds (which may release gases by thermal decomposition) make Th values most probably too high with respect to trapping temperatures. Tentatively, the lowest Th values may be taken as indicative of trapping conditions (~100°C at Poggio Balate, and 150°C at Rocca Grande).

With few exceptions, Tm ice was higher than -2°C, with several values higher than 0°C, indicating metastable persistence of superheated ice, in agreement with the geological setting and previous geochemical studies suggesting heated meteoric waters. On the other hand, reconnaissance δD determinations on bulk sample inclusions (about -20 per mil vs. SMOW) may reflect minor contributions of seawater to the hydrothermal fluids. The presence of abundant oil and methane is ascribed to interaction with organic matter in the local stratigraphic sequence. (Authors' abstract)

BENNANI, M. and WEISBROD, A., 1985, Fluid chemistry and Sn-W mineralization in the Tarmilet-Zgit sector, Walmes District, Central Morocco (abst.): Journes Geologiques et Minieres du Maroc, March 20-22, 1985, Rabat, Morocco (in French).

Fluids trapped in micro-inclusions in quartz and in vein-cassiterite from the Tarmilet sector of the Walmes District were studied by microthermometry and Raman spectroscopy. Many types of fluids were distinguished.

The earliest-stage fluids observed in quartz are low-density vapor phase fluids, essentially dominated by CO_2, with only a small amount of water (type Vl). This type passes continuously through liquids progressively richer in water, with variable (but significant) amounts of CO_2, CH_4 and N_2 (type L1).

In cassiterite, one observes fluids (type L2), similar to L1, with H_2O dominant, minor amounts of CH_4 and N_2, but without CO_2 (indicating a reduction of the system). In late-stage quartz, one finds two types of late-stage fluids: Type V2, rich in CO_2 and H_2O, with a relatively high density, and Type S, rich in complex brines, of high density and very high salinity. Types V2 and S were trapped at much lower T and P than were Types Vl, L1, and L2. These late-stage fluids are found in great abundance in veinlets at Zgit, outside the zones of wolframite mineralization.

It appears that the cassiterite precipitated as a result of mixing of a CO_2-rich fluid with an essentially aqueous fluid, perhaps accompanied by a reduction of the system. The relationship of wolframite to this scheme is not clear, and it is possible that the deposition of this mineral could be due to the circulation of a fluid that was distinct from that responsible for the cassiterite mineralization. A third and final, cooler and very superficial, hydrothermal event (represented by the late-stage fluids), irregularly affected the assemblage near the southern end of the Walmes District. These effects were either non-existent or very weak farther to the north (Al Qrit). (Authors' abstract, translated by M. Logsdon)

BERDNIKOV, N.V., KARSAKOV, L.P. and KOSYGIN, Yu.A., 1985, Evolution and tectonic controls of gas release from deep Earth zones (thermobarogeochemical data): Dokl. Akad. Nauk SSSR, v. 285, no. 3, p. 675-677 (in Russian). Authors at Inst. Tectonics & Geophysics of Far-East Sci. Center of Acad. Sci. USSR.

Studies of inclusions in Precambrian metamorphic rocks of the Soviet Far East and other regions of the Earth indicate that gases flowing out from the Earth's interior had essentially a CO_2 composition, with very little CH_4, N_2, rare and noble gases, and water. Only in minerals of Upper Archean gray gneisses of Stanovoy Ridge (location Tukuringa) besides of prevailing CO_2 inclusions, were there relic inclusions of dense N_2. Most probably water, accompanying CO_2 and CH_4, was used up in anatexis processes; CO_2 and CH_4, being poorly soluble in silicate melts, were essentially trapped in inclusions. Presence of N_2 inclusions indicates pre-metamorphic processes that developed locally in Precambrian and had the nitrogen-type specialization[sic]. The authors indicate the importance of gas migration for metallogenic processes. (Abstract by A.K.)

BERGER, B.R. and BETHKE, P.M., eds., 1985, Geology and geochemistry of epithermal systems, Reviews in Econ. Geol., v. 2, 298 pp.

Continued next page.

Contains 12 individually-authored chapters dealing with many aspects of epithermal deposits that are pertinent to the interpretation of fluid inclusion data, as well as one on the inclusions themselves. Included are relationships to geothermal fluids, behavior of silica and carbonates, light stable isotope systematics, boiling, cooling, and oxidation of fluids, and pertinence to exploration. (E.R.)

BERGER, G., LOUBET, M. and SCHOTT, J., 1985, Basalt-seawater interaction at high temperature. Behavior of trace elements (abst.): Bull. Minéral., v. 108, p. 88 (in French).

BERGER, V.I., SHUMSKAYA, N.I. and SHLEIKIN, P.D., 1984, Contact metamorphism of the Markovskoe antimony show of mineralization, East Yakutia: Geol. Rudn. Mest., v. 26, no. 6, p. 62-72 (in Russian). Authors at VSEGEI, Leningrad, USSR.

New-formed ore associations: pyrrhotite-berthierite, native Sb-mackinawite in the Markovskoe mineralization of the Yano-Kolyma belt are products of thermal decomposition of early pyrite and antimonite at about 400°C (Td of quartz). (A.K.)

BERNARD, A., SHINOHARA, H. and LeGUERN, F., 1985, Transport and condensation of volatile metals in high temperature volcanic gases (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

BERNARDINI, G.P., CORSINI, F., LATTANZI, P.F., MAZZETTI, G. and PARRINI, P., 1985, The possible application of lattice constants of stibnite for geothermometry in ore deposits: A discussion: N. Jb. Miner. Mh., 1985, no. 11, p. 521-527.

Temperature estimates based on lattice constants of stibnites from Southern Tuscany, Italy, show poor agreement with fluid inclusion Th in associated transparent minerals. It is concluded that a geothermometry based on the lattice constants of stibnite has not been established. (From the authors' abstract)

Table 2 gives average Th for fluorite from San Martino (116°) and for quartz from Montauto, Pereta, and Poggio Fuoco (220; 165-232, and 125, respectively). (E.R.)

BERNATOWICZ, T.J., KENNEDY, B.M. and PODOSEK, F.A., 1985, Xe in glacial ice and the atmospheric inventory of noble gases: Geochimica Cosmo. Acta, v. 49, p. 2561-2564. First author at McDonnell Center for the Space Sci., Washington Univ., St. Louis, MO 63130, USA.

We report noble gas abundance data for four Antarctic glacial ice samples which were selected to test the hypothesis that the apparent Xe deficiency in the earth's atmosphere relative to meteoritic abundance is due to incorporation of Xe in glacial ice. Our measurements indicate that the concentrations of Xe in glacial ice fall far short ($\sim 10^4$) of what the hypothesis requires. The present results complete the survey of all significant atmospheric reservoirs and show that the "missing Xe" is not contained in any of them. It must either be in the solid earth in yet unsampled reservoirs, or else it simply does not exist and the noble gas abundance pattern of the earth is dissimilar to that in meteorites. (Authors' abstract)

BERNDT, M.E., SEYFRIED, W.E., Jr. and JENECKY, D.R., 1985, Behavior of Cl during hydrothermal alteration of basalt in the low pressure supercritical region (abst.): EOS, v. 66, no. 46, p. 921. First author at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN 55455.

Fluids issuing from hot spring vents on the East Pacific Rise are often depleted in Cl with respect to seawater. In an attempt to quantitatively assess the relative mobility of Cl during basalt-seawater interaction, a Na-K-Ca-Cl fluid of seawater ionic strength was reacted with diabase at 400 and 425°C, 400 bars and fluid/rock mass ratio of 0.5.

The resultant fluids were initially depleted in Na and Cl by as much as 20% but the concentrations of these elements slowly rebounded as the experiments progressed. There was a nearly equimolal depletion of Na and Cl throughout the 425°C experiment suggesting a coupled process for Na and Cl removal from solution. The major element chemistry of the experimental fluids bracketed the major element chemistry of the most metal rich and Cl depleted EPR 21°N hot springs. Smectite-chlorite, clinozoisite, pyrite and magnetite were the dominant alteration phases. Although these minerals play an active role in controlling the pH and the dissolved Ca and Fe concentrations, reactions involving these minerals cannot produce the observed 1:1 correspondence between the Na and Cl concentrations. In addition, the conditions are far above the point at which a phase separation can occur. Thus, a third possible mechanism is proposed, that being adsorption of $NaCl^\circ$ onto the surfaces of solid particulates.

Speciation calculations indicate that such a process depends critically on the pressure of the system as well as the temperature. Lowering the pressure has the same effect as increasing the temperature in that it results in a lowering of the fluid density and a reduction in the dielectric constant which in turn produces an increase in complexation and adsorption of neutral chloride molecules. (Authors' abstract)

BETHKE, P.M., 1985, Geothermal systems and epithermal ores: Lessons from Creede, Colorado (abst.): Geol. Ass. Canada, Cord. Sec., Symp. Silver '85, Vanc., B.C., p. 4-5. Author at U.S. Geol. Survey, MS 959, Reston, VA 22092.

Analogies between geothermal systems and hydrothermal ore deposits are increasingly popular, but documentation of that conclusion is rarely presented. Observations on the chemical, thermal and hydrologic structure of active geothermal systems and the processes operating within them provide an understanding of the anatomy and physiology of the systems against which observations on hydrothermal ore deposits may be compared. Detailed and comprehensive observations of the volcanic-hosted epithermal Ag-Pb-Zn-Cu ore deposits of the Creede district in the San Juan Mountains of Colorado, together with a comparison with other epithermal districts and with geothermal systems in silicic volcanic terranes, permit the construction of a well documented "geothermal model" for the Creede system.

Studies of thermal springs and boreholes in active geothermal systems have led to the construction of a model of a hydrothermal systems characterized by an upwelling plume of heated, near-neutral, reduced, chloride waters of meteoric origin driven by a deep magmatic heat source. Mixing with cooler, less saline ground waters occurs along the margins and top of the upwelling plume. Phase separation occurs in the upper part of the plume, and volatiles such as CO_2 and H_2S are preferrentially partitioned into the vapor phase. Condensation of these volatiles in the overlying waters transfers heat to them to produce "steam heated" waters and acidifies them through hydrolysis reactions and, in the very shallow parts of the system, through oxidation of H_2S. These lower pH waters produce sericitic (or illitic) alteration overlying a feldspar-stable zone at depth and, often, a near surface zone of advanced argillic alteration.

By comparison, the Creede ores have been interpreted as having been deposited along the top of a fracture-controlled hydrothermal system near the interface between a deeply circulating brine and overlying ground waters. Lead-isotope studies seemed to require a significant addition of 1.4-1.7 b.y. lead to the systems, implying deep circulation to the pre-Cambrian rocks underlyng the San Juan volcanic pile. Stable-isotope studies indicate recharge from pore waters in the sediments that accumulated in the evaporative lake filling the moat of the Creede caldera. Fluid inclusion studies record the high salinities expected from such waters and show systematic relations between trapping temperature and salinity interpreted to result from mixing of the hot brines with cooler fresh waters in the ore zone. Boiling near the top of the system is also suggested by fluid inclusion observations. The intense illite-smectite mixed layer clay alteration that forms a discontinuous cap to the orebodies is interpreted to have resulted from the acidification of the overlying ground waters by condensation of acid volatiles distilled off the brine plume. The ore and gangue mineral assemblage indicates that the deep brine was near neutral and relatively reduced but that ore deposition took place following mixing of the deep, metal-bearing brine with more oxidized ground waters. The maintenance of the position of this interface at a nearly constant elevation throughout the duration of ore deposition is considered an important ore control.

This model is consistent with both concept and detailed observation with our understanding of geothermal systems, and is applicable to the broad class of epithermal ore deposits of which Creede is an important representative. The model is far from complete, however, and the conditions and processes that operated in the roots of the system must be known before it can be tested quantitatively. Gathering this knowledge forms the primary objective of a proposed program of deep drilling in the Creede district. (Author's abstract)

BETHKE, P.M. and J.J. Eidel, 1985, Research drilling opportunities in ore deposits and active hydrothermal systems (abst.): EOS, v. 66, no. 18, p. 371. First author at USGS, Reston, VA 22092.

Exploring the roots of active and fossil hydrothermal systems presents exceptional research opportunities to which drilling can make a critical and unique contribution. Such drilling would have practical as well as scientific importance because hydrothermal systems have: concentrated metals into exploitable deposits, been exploited for geothermal energy, altered large volumes of the Earth's crust, been known to cause violent volcanic eruptions and to be associated with earthquake activity, and have provided natural analogs on which the design of nuclear waste isolation repositories can be based. Drilling in active systems allows the direct measurement of the variations in fluid composition, temperature, pressure, porosity and state of stress within the system. Conversely, the evolution of these parameters with time can be traced in fossil systems, such as hydrothermal ore deposits. The Panel on Mineral Resources and the Panel on Thermal Regimes of the Continental Scientific Drilling Committee have identified hydrothermal systems in silicic volcanic terranes as the highest priority targets for research drilling. The overall goal of such a drilling program is a predictive, quantitative model of the morphology, dynamics, evolution, and transport properties of a hydrothermal system driven by a silicic epizonal intrusion. Emphasis to date has been on deep drilling to the roots of such hydrothermal systems. However, many significant problems can be addressed by shallow drilling in both ore deposits and active geothermal systems, and also by intensive study of existing core - particulary from well-studied ore deposits for which a physico-chemical framework already exists. The preservation of such existing core is a critical and immediate need. Opportunities for scientific studies using holes drilled for exploration or production purposes also exist, but require a mechanism for coordination. (Authors' abstract)

BIKUN, J.V. and BUSCHE, F.D., 1985, A manganese rich epithermal silver system, Chinati Mountains, Presidio County, Texas (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 151-152. Authors at Shell Mining Co., P.O. Box 2906, Houston, TX 77252.

The prospect consists of a vein system steeply dipping to the NW and striking N9°E with a total length of 1190 m. The vein is hosted by the Ojo Bonito bio-hbl-mag granitoid, which has been recognized by Henry and McDowell (1982) as a resurgent pluton within the Infiernito caldera. The Wood vein system is a series of en echelon segments varying in width from a few cm to 27 m, and in length from a few m to 186 m. Gangue minerals include crustiform and brecciated chalcedonic silica, Fe oxides, Mn oxides, amethyst, sericite, and rare fluorite. The ore minerals within the vein segments include gal, sph, py, acanthite (Ag_2S), and undifferentiated silver bromides and iodides. Alteration around the vein segments varies from a thin zone of siliceous to intermediate argillic to propylitic. Maximum precious metal intercepts are 3.0 m of 690 gm/tonne Ag and 1 gm/tonne Au. The Ag to base metal ratio decreases with depth. Reconnaissance fluid inclusion studies indicate that homogenization temp. range from 140°C to 315°C with corresponding salinities averaging 4%. As a result of our evaluation of the Wood vein system, we have concluded that the vein morphology, mineralogy, fabric, geochemistry, and fluid inclusions are kindred to those characteristics described for typical epithermal systems by Buchanan (1981). (From the authors' abstract)

BINDE, Gisela, 1984, Contribution to the mineralogy, geochemistry and genesis of cassiterite: Dissertation A, Bergakademie Freiberg/Sa., GDR (in German). Author at Bergakademie Freiberg, 9200 Freiberg/Sa., Schliessfach 47, GDR.

A large number of different mineral inclusions in cassiterite from Ehrenfriedersdorf and other deposits of the Erzgebirge were analyzed by electron microprobe methods, and their genetic significance is discussed.

This paper contains also some $\delta^{18}O$-values of cassiterite (0.4 to 6.8‰) and some results of thermometric studies on fluid inclusions in cassiterite from Ehrenfriedersdorf (Th from 377 to 425°C). (From an English abstract by R. Thomas)

BISCHOFF, J.L. and PITZER, K.S., 1985, Phase relations and adiabats in boiling seafloor geothermal systems: Earth & Planet. Sci. Letters, v. 75, p. 327-338. First author at U.S. Geol. Survey, Menlo Park, CA 94025, USA.

Observations of large salinity variations and vent temperatures in the range of 380-400°C suggest that boiling or two-phase separation may be occurring in some seafloor geothermal systems. Consideration of flow rates and the relatively small differences in density between vapors and liquids at the supercritical pressures at depth in these systems suggests that boiling is occurring under closed-system conditions. Salinity and temperature of boiling vents can be used to estimate the pressure-temperature point in the subsurface at which liquid seawater first reached the two-phase boundary. Data are reviewed to construct phase diagrams of coexisting brines and vapors in the two-phase region at pressures corresponding to those of the seafloor geothermal systems. A method is developed for calculating the enthalpy and entropy of the coexisting mixture, and results are used to construct adiabats from the seafloor to the P-T two-phase boundary. Results for seafloor vents discharging at 2300 m below sea level indicate that a 385°C vent is composed of a brine (7% NaCl equivlent) in equilibrium with a vapor (0.1% NaCl). Brine constitutes 45% by weight of the mixture, and the fluid first boiled at approximately 1 km below the seafloor at 415°C, 330 bar. A 400°C vent is primarily vapor (88 wt.%, 0.044% NaCl) with a small amount of brine (25% NaCl) and first boiled at 2.9 km below the seafloor at 500°, 520 bar. These results show that adiabatic decompression in the two-phase region results in dramatic cooling of the fluid mixture when there is a large fraction of vapor. (Authors' abstract)

BISCHOFF, J.L. and ROSENBAUER, R.J., 1985, An empirical equation of state for hydrothermal seawater (3.2 percent NaCl): Am. J. Sci., v. 285, p. 725-763. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

The pressure dependence of the specific volume of seawater (3.2 percent NaCl) was determined by isothermal decompression experiments from 650 bars down to the two-phase boundary. Temperatures of the isotherms ranged from 200° to 470°C.

Properties of seawater at subcritical temperatures and pressures do not greatly differ from those of pure water but become markedly different at supercritical conditions. Specific-volume calculations allow prediction of quartz solubility and construction of depth-versus-pressure profiles for seafloor geothermal systems. Results indicate that the depth below the seafloor to any given pressure is very much greater than previously visualized and that seawater may be circulating in its critical region while harvesting heat at the top of mid-ocean ridge magma chambers. (From the authors' abstract)

BISCHOFF, J.L. and ROSENBAUER, R.J., 1984, The critical point and two-phase boundary of seawater, 200° to 500°C: Earth Planet. Sci. Letters, v. 68, p. 172-180, 1984. Authors at U.S. Geol. Survey, Menlo Park, CA.

The two-phase boundary of seawater was determined by isothermal decompression of fully condensed seawater in the range of 200° to 500°C. The pressure at which phase-separation occurred for each isotherm was determined by a comparison of the refractive index of fluid removed from the top and bottom of the reaction vessel. The critical point was determined to be in the range of 403°C to 406°C, 285 to 302 bars and was located by the inflection in the two-phase boundary and by the relative volume of fluid and vapor as a function of T. The two-phase boundary of 3.2% NaCl solution was found to coincide exactly with that of seawater over the range tested in the present study. The boundary for both is described by a single seventh-order polynomial equation. The two-phase boundary defines the maximum T of seawater circulating at depth in the oceanic crust. Thus the boundary puts a limit of about 390°C for seawater circulating near the seafloor at active ocean ridges, (2.5 km water depth) and about 465°C at the top of a magma chamber occurring at 2 km below the seafloor. (Authors' abstract)

See also Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 32, 1984. (E.R.)

BLAGA, L., BLAGA, L.M. and BINDEA, C., 1984, Deuterium concentrations in the Oradea-Felix-1 May hydrothermal system in Rumania: Geokhimiya, 1984, no. 3, p. 430-435 (in Russian; translated in Geoch. Int'l., v. 21, no. 4, p. 1-6, 1984, pub. 1985).

BLANC, G., DE KERSABIEC, A.M. and BOULEGUE, J., 1985, Pore water chemistry of hydrothermal sediments from Atlantis II Deep (Red Sea) (abst.): Terra Cognita, v. 5, p. 192. Authors at Lab. Géoch. & Métallog., CNRS, UPMC, 4 place Jussieu, 75200 Paris Cedex 05, France.

More than 50 pore waters of hydrothermal sediments from Atlantis II Deep have been investigated for major elements and metals (MN, Fe, Cu, Zn, Cd, Ni, Co, ...). The chemistry of the major elements show that the compositions of the pore waters are similar to the composition of the lower brine of Atlantis II Deep. The metal contents are very high and show large local variations which are related to the diagenesis of hydrothermal minerals, mostly sulfides.

These results [permit us] to present a geochemical model involving a possible input of hot water in Atlantis II Deep as well as quantitative aspects of the inputs of metals. (Authors' abstract)

BLASCH, S.R., RAGAN, V.M. and COVENEY, R.M., Jr., 1985, Oil and brine inclusions at the Jumbo and Prescott mines, Linn County, Kansas (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 525. Authors at Dept. Geosci., Univ. Missouri-Kansas City, Kansas City, MO 64110-2499.

Well north of the Tri-State district, small deposits containing Pb, Zn, and Ba associated with organic matter occur in M. Pennsylvanian beds. One of these, the Jumbo Pb mine lies 2.5 km SE of Pleasanton, KS, and takes the form of a mineralized pipe or circle deposit. Similar mineralization occurs at the Prescott Zn deposit located approximately 12 km SSE of the Jumbo in an abandoned coal mine. Several minerals at both mines contain amber petroleum inclusions, fluorescent in UV light.

Primary oil inclusions in sphalerite from the Jumbo and Prescott mines homogenize at 83-93°C. Homogenization temperatures of oil inclusions in calcite are as low as 61°C. Aqueous inclusions in sphalerite fill at 82-110°C, generally 10-20°C higher than adjacent petroleum inclusions. Similar differences in homogenization temperatures for inclusions in Illinois fluorite and elsewhere have been attributed to higher rates of thermal expansion and compressibility for oil than water (Freas, 1961; Roedder, 1963).

Freezing data for aqueous inclusions in sphalerite imply salinities of 21-23 wt% NaCl equivalent. Some primary inclusions in calcite contain translucent reddish crystals, which may be a daughter mineral, possibly ferroan dolomite.

It is not clear whether organics have played an active chemical role in either transporting or precipitating the sulfides of the Jumbo and Prescott mines. Nevertheless, data from both mines are consistent with the basinal brine theory of origin postulated for Mississippi Valley-type deposits and suggest the possibility that these small deposits formed at or near a local oil-water interface or that local formational waters were exceptionally rich in oil droplets. (Authors' abstract)

BLATTNER, Peter, 1985, Isotope shift data and the natural evolution of geothermal systems: Chem. Geol., v. 49, p. 187-203. Author at New Zealand Geol. Survey, DSIR, & Inst. Nuclear Sci., DSIR, Lower Hutt, New Zealand.

Oxygen is a major component of rocks and of hydrous solutions, and interacting rock and water of initially arbitrary compositions always set up a potential for isotope exchange that in time leads to mutual isotope shifts. Regardless of kinetic factors exchanged rocks may be viewed as exhausted isotope shifting capacities that correspond to equivalent quantities of exchanged fluid. Since most of the actual isotope exchange in geothermal systems takes place in reaction zones with a relatively narrow temperature range, a zeroeth-order "mixed model" is considered, which consists of batches of water passing through a fixed rock reservoir. The model provides an estimate of the cumulative water throughput, or hydrological maturity, of geothermal systems in terms of the measurable isotope shifts of present-day throughput and the overall isotope shifting potential. The assumption of discrete batches of throughput partially simulates the inefficiency of natural water-rock interaction, while the continuous process (with vanishing batch size) sets a lower limit for the required fluid throughput. Hydrogen and strontium isotopes, respectively, could provide better sensitivity at very early and very late stages of evolution. Several examples of geothermal systems are discussed and placed into a tentative order of maturity. (Author's abstract)

BLATTNER, Peter, 1985, Progressive ^{18}O depletion during CO_2 separation from a carbon dioxide-rich hydrothermal fluid: Evidence from the Grey River tungsten deposit, Newfoundland: Discussion: Canadian J. Earth Sci., v. 22, p. 1380-1381. Author at New Zealand Geol. Survey & Inst. Nuclear Sci., DSIR, Lower Hutt, New Zealand.

A discussion of item by Higgins and Kerrich, 1985a (this volume). (E.R.)

BLAZHKO, V.I., 1985, Contribution to the method of determination of gases in rocks and minerals by gas chromatography (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 64 (in Russian). Author at Inst. Geochem. & Physics of Minerals, Kiev, Ukraine, USSR.

Gases released from sample are trapped in loop tube of volume 0.5-1 ml filled by sorbent (Polisorb-1 or Polichrom-1) and placed in LN_2. This procedure concentrates all gases except of H_2, Ne and He (the eluent gas). Next the tube is joined with gas chromatograph and heated to +120°C for desorption. Such procedure significantly decreases the detection limit of gases. (A.K.)

BLOCH, J.D., 1985, Fluid inclusion analyses of detrital quartz grains - New provenance tool (abst.): AAPG Bull., v. 69, no. 2, p. 239. Author at Washington Univ., St. Louis, MO.

Preliminary analyses by microthermometry of [inherited] fluid inclusions in detrital quartz of the Upper Cambrian Lamotte Sandstone reveal the occurrence of 2 distinct groups of aqueous fluid inclusions. Specific salinity signatures and Th may be used to distinguish specific granite types of the source rock terrain. The inclusions chosen for analysis occur in isolated clusters or are randomly distributed within a grain, commonly in association with mineral inclusions of zircon, sphene, rutile, and/or tourmaline. Secondary inclusions are present in the Lamotte but are not included in this study.

The first group of inclusions is characterized by low salinities (<1.0-8.0 wt. % eq. NaCl), the second by high salinities (12.1-29.6 wt. % eq. NaCl). Final melting temperatures as low as -30.6°C indicate the presence of divalent ions in these inclusions. Both groups yield Th between 150°C and 220°C. The low-salinity inclusions occur predominantly in subrounded to well-rounded sand less than 1.0 mm in size that is derived from a distal source. The brine inclusions occur exclusively in subangular to angular gravel 2.0-3.0 mm in size, implying a more proximal source area.

A comparison of these inclusions with inclusions found in the granites of the apparent source terrain indicates that a medium-silica amphibole-orthoclase granite (Slabtown type) or a low-silica amphibole-plagioclase granite (Silvermines type) or both are the primary source rocks for this quartz. These granite types have limited areal distribution in the present-day St. Francois mountains and the identification of these granite types as the source rock for the locally derived quartz has broad implications for reconstructing Cambrian depositional environments and paleostructure of the ancient St. Francois mountains. (Author's abstract)

BOBYLEV, I.B., ANFILOGOV, V.N., ZYUZEVA, N.A. and BEREZIKOVA, O.A., 1985, Effect of cations on immiscibility of silicate-salt melts: Geokhimiya, no. 6, 1985, p. 802-807 (in Russian).

BOCTOR, N.Z., 1985, Rhodonite solubility and thermodynamic properties of aqueous $MnCl_2$ in the system $MnO-SiO_2-HCl-H_2O$: Geochimica Cosmo. Acta, v. 49, p. 565-575.

BODNAR, R.J., 1985, Pressure-volume-temperature-composition (PVTX) properties of the system $H_2O-NaCl$ at elevated temperatures and pressures: Doctoral dissertation, The Pennsylvania State Univ.

Phase equilibria in the system $H_2O-NaCl$ have been determined from 550° to 1000°C and from 500-1300 bars using synthetic fluid inclusions formed by healing fractures in inclusion-free Brazilian quartz in the presence of two coexisting, immiscible $H_2O-NaCl$ fluids. Petrogaphic and microthermometric analyses indicate that the inclusions trapped either one or the other of the two fluids present, or mixtures of the two. Salinities of the two coexisting phases were obtained from microthermometric analyses of those inclusions which trapped only a single, homogeneous fluid phase.

Results of this study, combined with previously published data on the $H_2O-NaCl$ system at lower temperatures and pressures, indicate that the two-fluid-phase field extends well into the P-T range of most shallow magmatic-hydrothermal activity. As a consequence, chloride brines exsolved from many epizonal plutons during the process of "second-boiling" should immediately separate into a high-salinity liquid phase and a lower-salinity vapor phase and produce coexisting halite-bearing and vapor-rich fluid inclusions. This observation is consistent with results of numerous fluid inclusion studies of ore deposits associated with shallow intrusions, particularly the porphyry copper deposits, in which halite-bearing and coexisting vapor-rich inclusions are commonly associated with earliest stages of magmatic-hydrothermal activity.

PVT properties of $H_2O-NaCl$ mixtures having compositions of 30, 50 and 70 weight percent NaCl were determined from 100° to 900°C and from 1000 to 5000 bars using an internally heated pressure vessel equipped with a bellows-type volumometer system. These data were combined with other available volumetric data for $H_2O-NaCl$ mixtures and regressed to generate a single empirical equation relating the mean molar volume of the $H_2O-NaCl$ mixture to composition, T and P. The resulting equation predicts the volumetric properties of $H_2O-NaCl$ mixtures with an accuracy of a few percent over the range 100°-900°C, 1000-5000 bars and 0-100 wt.% NaCl.

Partial molar volumes of Nacl calculated from the experimental data display large variations as a function of T, P and composition. At low salinities, high T, and low P, partial molar volumes are large and negative, reaching values of ~-1000 to -3000 $cm^3 \cdot mole^{-1}$ at ~1000 bars and 700°-900°C and infinite dilution. These large negative values reflect the ability of dissolved NaCl to significantly collapse the water structure at these conditions. With increasing salinity, partial molar volumes become less negative and finally, at mole fractions of NaCl of 0.2-0.4, reach a constant value close to the molar volume of metastable, supercooled liquid NaCl, indicating saturation of the water structure with NaCl. (Author's abstract)

BODNAR, R.J., BURNHAM, C.W. and BLENCOE, J.G., 1985, PVT properties of H_2O-NaCl mixtures at high temperatures and pressures (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 526. First author at Chevron Oil Field Res. Co., P.O. Box 446, La Habra, CA 90631.

PVT properties of H_2O-NaCl mixtures having compositions of 30, 50, and 70 wt.% NaCl were determined from 100-900°C and 1000-5000 bars using an internally-heated pressure vessel equipped with a bellows-type volumometer system. These data were combined with other available PVT data for the H_2O-NaCl system and regressed to generate a single empirical equation relating the mean molar volume of the H_2O-NaCl mixture to composition, temperature, and pressure. The resulting equation predicts the volumetric properties of H_2O-NaCl mixtures with an accuracy of a few percent or better over the range 100-900°C, 1000-5000 bars, and 0-100 wt.% NaCl, and is valid both in the single-fluid-phase region as well as in the two-phase fields liquid plus vapor and saturated-liquid plus halite.

Partial molar volumes of NaCl calculated from the experimental data display large variations as a function of temperature, pressure, and composition. At low salinities, high temperatures, and low pressures, partial molar volumes are large and negative, reaching values of ~-1000 to -3000 cm^3/mole at approximately 1000 bars, 700-900°C, and infinite dilution, and reflect the ability of dissolved NaCl to significantly collapse the water structure at these conditions. With increasing salinity, partial molar volumes become less negative and approach a constant, positive value close to the molar volume of metastable, supercooled liquid NaCl. (Authors' abstract)

BODNAR, R.J., BURNHAM, C.W. and STERNER, S.M., 1985, Synthetic fluid inclusions in natural quartz. III. Determination of phase equilibrium properties in the system H_2O-NaCl to 1000°C and 1500 bars: Geochimica Cosmo. Acta, v. 49, p. 1861-1873. First author at Dept. Geol. Sci., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Phase equilibria in the system H_2O-NaCl have been determined to 1000°C and 1500 bars using synthetic fluid inclusions formed by healing fractures in inclusion-free Brazilian quartz in the presence of the two coexisting, immiscible H_2O-NaCl fluids at various temperatures and pressures. Petrographic and microthermometric analyses indicate that the inclusions trapped one or the other of the two fluids present, or mixtures of the two. Salinities of the two coexisting phases were obtained from heating and freezing studies on those inclusions which trapped only a single, homogeneous fluid phase.

Results of the present study are consistent with previously published data on the H_2O-NaCl system at lower temperatures and pressures, and indicate that the two-phase field extends well into the P-T range of most shallow magmatic-hydrothermal activity. As a consequence, chloride brines exsolved from many epizonal plutons during the process of "second-boiling" should immediately separate into a high-salinity liquid phase and a lower salinity vapor phase and produce coexisting halite-bearing and vapor-rich fluid inclusions. This observation is consistent with results of numerous fluid inclusion studies of ore deposits associated with shallow intrusions, particularly the porphyry copper deposits, in which halite-bearing and coexisting vapor-rich inclusions are commonly associated with the earliest stages of magmatic-hydrothermal activity. (Authors' abstract)

BODNAR, R.J., CHOU, I.-M. and ROEDDER, E., 1985, Chemistry of ore-forming fluids (abst.): U.S. Geol. Survey Circular 949, p. 1-3. First author at Chevron Oil Field Research Co., P.O. Box 446, La Habra, CA 90631.

Highly saline brines of various compositions have been involved in the formation of many types of ore deposit and have been trapped in fluid inclusions in the minerals of these deposits. Study of the phase relations of such fluid inclusions, which may contain many daughter crystals formed during cooling, can provide semiquantitative and in part quantitative data on their composition. Knowledge of the chemistry of such fluids is essential to understanding the processes involved in ore transport and deposition. However, the interpretation of fluid-inclusion data is hindered by the lack of data on salt solubilities and on volumetric properties of brines at elevated P and T.

Phase equilibria in the H_2O-NaCl system have been determined experimentally to 1000°C and 1500 bars by studying synthetic fluid inclusions in natural quartz. The results indicate a much larger immiscibility field for H_2O-NaCl than had been previously proposed. Solubility relations in the system NaCl-KCl-H_2O have been determined by differential thermal analysis for compositions having more than 53 weight percent total salt, at pressures and temperatures up to 2 kbar and 820°C.

Volumetric (PVTX) properties of H_2O-NaCl compositions of 30, 50, and 70 weight percent NaCl have been determined experimentally over the range 20-900°C and 0.5-5 kbar. These results have been combined with other available volumetric data for H_2O-NaCl to generate a single equation for specific volume as a function of temperature, pressure, and composition. This equation provides a reasonable approximation of specific volumes of H_2O-NaCl mixtures over the range 100-900°C, 0.5-5 kbar, and 0-100 weight percent NaCl and is valid in both the one-phase (fluid) and two-phase (fluid + solid) fields. Using a similar equation, with metastable liquid NaCl as the standard state, we have calculated partial molar volumes of both the H_2O and NaCl components in H_2O-NaCl solutions over the same PTX range.

Careful petrography permits recognition of some inclusions as samples of pre-ore or post-ore fluids responsible for wallrock alteration, whereas others can be shown to be samples of the actual ore-forming fluid. Studies now in progress include identifying and validating the criteria for determining inclusion origin and examining various procedures for obtaining compositional data on inclusions. A study of the brines present during the formation and later diagenesis of salt beds provides a low-temperature example. Compositional data on these brine inclusions have been obtained by two main procedures: (1) microscopy plus microthermometry of daughter crystal dissolution and (2) extraction and chemical analysis of single 1-mm inclusions for Na, K, Ca, Mg, Cl, SO_4, and Br. Although the purpose is to evaluate the salt beds for possible nuclear waste repository sites, the work has helped in the study of similar highly saline brine inclusions from metallic ore deposits and has provided a possible tool for the search for potash ore deposits. (Authors' abstract)

BODNAR, R.J. and KUEHN, C.A., 1985, Identification and significance of CO_2 in fluid inclusions from epithermal ore deposits (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 526. First author at Chevron Oil Field Res. Co., P.O. Box 446, La Habra, CA 90631.

Fluids associated with contemporary land-based geothermal systems and their fossil analogs, epithermal mineral deposits, generally contain on the order of a few tenths of a mole percent dissolved gas, most of which is CO_2. Using the system H_2O-CO_2 as a model, the densities of gas-bearing fluids at epithermal PTX conditions have been calculated, and these data have been combined with available PVT and phase equilibrium data for the H_2O-CO_2 system at low temperatures to predict the room temperature characteristics of fluid inclusions trapped in the epithermal environment. Based on these calculations, fluid inclusions containing three phases at room temperature - liquid H_2O and liquid and vapor CO_2 - cannot be produced at epithermal PTX trapping conditions. Rather, the inclusions will contain only two phases - liquid H_2O and CO_2 vapor - and the liquid to vapor ratio of these inclusions will be similar to that of simple H_2O-NaCl inclusions trapped at the same P-T conditions. Thus, the presence of CO_2 will not be revealed during normal low-temperature petrographic examination. However, the internal pressure of these inclusions at room temperature will almost always be greater than one bar, and may reach several tens of bars, allowing the presence of CO_2 to be easily recognized during normal crushing tests.

In addition to controlling the fluid chemistry, the presence of CO_2 in inclusions from epithermal deposits may significantly increase the pressure, and corresponding depth, at which boiling can occur. As a result, the portion of the earth's crust that may be considered as a favorable environment in which to explore for epithermal deposits is expanded considerably. (Authors' abstract)

BODNAR, R.J. and STERNER, S.M., 1985, Synthetic fluid inclusions in natural quartz. II. Application to PVT studies: Geochimica Cosmo. Acta, v. 49, p. 1855-1859. First author at Dept. Geol. Sci., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Synthetic fluid inclusions have been used to determine volumetric properties of H_2O and a 20 wt.% KCl solution from 300-700°C and 1-3 kb. Comparison of results obtained for H_2O with previously published data indicates that the synthetic fluid inclusion technique provides PVT data that are within a few percent of those obtained from conventional PVT studies. This technique thus provides a fast, relatively simple means of determining PVT properties of many fluids of geologic interest. (Authors' abstract)

BOGDANOV, N.A., ed., 1984, Geochemistry and Cosmochemistry, Proceedings of the 27th International Geological Congress, v. 11, Moscow 4-14 August 1984, VNU Sci. Press.

Includes numerous papers on deep seated volatiles, such as in diamonds, peridotite nodules, etc. (E.R.)

BOGOLEPOV, V.G., NAIDENOV, B.M. and POLYVYANNI, E.Ya., 1983, Genetic features of the formation of chambered pegmatites in the Upper Paleozoic granitic intrusives Bektauata and Akchatau determined from the study of argon isotopy from relics of solutions: Geokhim. Pegmatitov Metody Ikh Poiskov 1983, p. 120-123 (in Russian). Authors at Kaz. Nauchno-Issled. Inst. Miner. Syr'ya, Alma-Ata, USSR.

A necessary condition for the formation of chambered pegmatites is a closed system. To determine if this prerequisite was met and also to study the nature of the solutions involved in pegmatite formation, the Ar isotopic composition was determined of fluid inclusions in quartz from pegmatites of Kazakhstan. The determinations were made separate for high- and low-temperature inclusions. In all of the pegmatite bodies, the Ar was mainly (70-90%) of atm. origin. This suggests that the granitic magma giving rise to intrusives ascended from the region of origin to an upper, dry (anhyd.) structural stage and was dewatered by loss of volatiles after the emplacement and initial crystallization of the magma. A constant ratio of atm. to radiogenic Ar in the high- and low-temperature inclusions indicates that the solutions did not change composition with time, i.e., that they were in a closed system. (C.A. 99: 125944m)

BOKONBAYEV, K.Dzh. and ADYSHEV, M.M., 1984, Geologic aspects of the sinking bubble paradox: Dokl. Akad. Nauk SSSR, v. 274, no. 6, p. 1438-1440 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 274, no. 6, p. 99-101, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 37-38. (E.R.)

BONI, M., 1985, Fluid inclusion data from the Lower Cambrian ores in SW Sardinia (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 30.

The Iglesiente-Sulcis district in SW Sardinia is very well known for its Mississippi Valley-type ore deposits (Boni, Chron. rech. min., n. 479, in press), which have been exploited for at least 2500 years. The orebodies are of different types: the more abundant are stratabound concentrations of sphalerite, galena and barite in Cambrian shallow water carbonate rocks (Gonnesa Fm.). Minor amounts of sulphides, barite and iron oxides are also present along the Lower-Middle Ordovician unconformity and in a Permo-Triassic vein and paleokarst network, with sporadic amounts of fluorite and copper minerals.

The Cambrian ores have been subjected at least to two main tectonic phases (Caledonian and Hercynian): therefore they are thought to have shared with their host rocks most of the stress phenomena and subsequent deformation of these lithotypes.

Studies on the fluid inclusions of the Cambrian ores revealed in sphalerite and fluorite Th ranging from 80° to 150°C, with mean values of 115°C, while the quartz crystals from some chert lenses in the carbonates show values between 130° and 170°C. Particularly interesting are the analyses of calcite crystals from sparry limestone and from sparry calcite cements in some late diagenetic breccias hosting sulphide mineralization. These show Th ranging between 90° and 180°C with two maxima: the first around 115°C and the second around 155°C. The fluid inclusion generations with higher Th are thought to have been formed during the stress resulting from the main Hercynian tectonic phase. Moreover, the scattered values higher than 180°C, which have been found in calcite, quartz and in small occurrences of stratiform fluorite could be the product of leakage, mainly due to the same stress under which some of the primary inclusions were formed. Therefore, the original(?) diagenetic temperature (if recognizable) should be considered not higher than 80-140°C (mean value 115°C) as shown in the interval common both to the stratiform sphalerite and fluorite and also to the first generation of inclusions in the sparry calcite crystals from the host limestone. Salinity measurements are in the range of 0-15% NaCl eqv. for both sphalerite and calcite, but, also in this case, a positive dispersion of the salinity data could be related to the Hercynian deformation. (Author's abstract)

BONI, Maria, 1985, Mississippi Valley-type ore deposits in southwest Sardinia (Italy): A synthesis: Chron. rech. min., no. 479, p. 7-34 (in French; English abstract). Author at Dipart. Sci. della Terra dell'Univ. Napoli, largo S. Marcellino 10, 80138 Napoli, Italy.

This is a systematic review of the Pb-Zn-Ba (-Fe-F-Cu) ore deposits in southwest Sardinia, in the context of the geologic history of the

Iglesiente - Sulcis region, from the Early Cambrian to the present. The interpretation both of already existing data and of the results of recent research using a variety of analytical techniques such as isotope geochemistry, fluid inclusions and facies analysis has led to the conclusion that most of the orebodies belong to the Mississippi Valley-type. There are essentially four different kinds of mineralization:

1) stratiform and stratabound bodies in Early Cambrian limestones and dolomites;

2) stratabound bodies in karstic cavities and vein fillings related to the Ordovician and Permo-Triassic erosion surfaces;

3) quartz and/or carbonate veins with sulfides, fluorite and barite of late Hercynian age;

4) metamorphic orebodies in skarn and wide metamorphic aureoles around the Hercynian granites.

The southwest Sardinian orebodies range from syn-digenetic to epigenetic. The most feasible hypothesis for their origin is that the mineralizing solutions were normal diagenetic fluids of the Cambrian and Ordovician host rocks in the case of the stratabound and stratiform orebodies, with a contribution from magmatic fluids for the Hercynian mineralization. A common source in the Precambrian lower crust is very likely, however, for all the metal ions now forming the orebodies at the various stratigraphic levels. Several suggestions have therefore been made for recirculation of the same metal stock. The major bodies are unevenly distributed through the mining district and only the Pb-Zn stratabound Cambrian orebodies and the Ba-F-Pb (-Ag) vein deposits are of economic importance. (Author's abstract)

BORDIN, D., 1985, Carbon isotopic measurements from fluid inclusions in quartz veins of the Faymar gold property, Deloro Township, northwestern Ontario: Bachelor's thesis, McMaster Univ., Hamilton, ON, Canada, 55 pp.

BORISOV, M.V., RYZHENKO, B.N. and KRAYNOV, S.R., 1984, Influence of the acid base properties of rocks on the composition of equilibrated aqueous solutions: Geokhimiya, no. 5, p. 705-713 (in Russian, English abstract; translated in Geochem. Int'l., v. 21, no. 5, p. 87-94, 1985). Authors at Vernadsky Inst. of Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

The influence of rock chemistry, water-rock ratio, and temperature on the composition of solutions equilibrated with rock was studied. It is shown that the rock type, and not simply its chemical composition, determines the composition of equilibrated aqueous fluid and its acid-base characteristics. Alkali ion concentrations computed from a model are compared with actual concentrations observed in natural waters. (Authors' abstract)

BORODENKO, Yu.A., KATRICH, N.P. and TIMAN, B.L., 1985, Dependence of critical formation rate of gaseous inclusions in crystals of leucosapphire on melt layer thickness in horizontal zone melting and directed crystallization: Sov. Phys. Crystallogr., v. 30, no. 2, p. 235 (in Russian; English abstract).

BORODIN, V.A., STERIOPOLO, T.A., TATARCHENKO, V.A. and YALOVETS, T.N., 1985, Distribution of gaseous inclusions in shaped sapphire crystals: Izv. Akad. Nauk SSSR, Neogan. Mater. [Inorganic Materials], v. 21, no. 5, p. 798-801 (in Russian).

BORSELLI, Giovanni and LATTANZI, Pierfranco, 1985, Fluid inclusions in quartz from the Pollone deposit, Apuane Alps (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 26. Authors at Dipartimento di Sci. della Terr, Univ. di Firenze, Italy.

Pollone is a Ba-Fe-pyrite (± Pb, Zn, Ag) deposit, occurring as conformable lenses and stratiform bodies, or as discordant veins in a Middle Triassic silico-clastic complex, ± carbonates, which was metamorphosed in the greenschist facies during the Tertiary Apenninic orogeny.

Fluid inclusions of at least two generations in associated quartz pods are quite abundant. The first generation inclusions are mostly two-phase liquid-rich. At least one moderately birefringent, equant or elongate daughter mineral is sometimes present. In some inclusions, liquid CO_2 was also observed. The inclusions ($\leqslant 100$ μm) are often surrounded by haloes of much smaller inclusions.

During heating experiments, all the largest inclusions stretched or decrepitated before or just above Th, ~200°C. Smaller inclusions apparently yielded reproducible Th, mostly 190°-240°C. The dm generally dissolves before final Th at T 70°-200°C, but some of the largest inclusions decrepitated before the daughter mineral dissolved.

Freezing data are quite similar for all inclusions. Tm ice shows salinities of ~8-10% wt. NaCl equiv., and Te -32° to -27°C suggests that additional components (Mg, Ca?) may be present beside Na(K)-Cl.

The largest fluid inclusions show the typical features of naturally decrepitated inclusions. They are interpreted as early metamorphic inclusions which were deformed and decrepitated at later metamorphic stages (e.g., during uplift). The smaller inclusions probably represent coeval early metamorphic inclusions, which were not deformed because of their smaller size. (Authors' abstract)

BOTRYAKOV, G.V., 1985, Petrological appendices to the thermometry of melt inclusions in the phenocrysts of volcanic rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 142-144 (in Russian; translation by D.A. Brown). Author at Amur Interdiscip. Res. Inst. of Far Eastern Sci. Center Acad. Sci. USSR (AmurKNII DVNTs AN SSSR), Blagoveshchensk, USSR.

During a study of melt inclusions in quartz from Upper Cretaceous-lower Paleogene ignimbrites and rhyolites, widely distributed within the East Sikhote-Alin' volcanic belt (ESAVB), two kinds of rocks, markedly differing in the Th of their inclusions have been observed: with relatively high Th (= 1240-1260°C) and with lower Th (= 1040-1150°C) quartz. The former is in paragenesis with alkali-feldspar (orthoclase or sanidine) and pl phenocrysts, noted in minor amounts. The dark-colored minerals in the rocks with 'high-T' quartz are rare. The 'low-T' quartz is associated with pl, bi, hnb, and py. Alkali-feldspar (usually sanidine) in such provisionally named 'plagioclase' volcanics, although virtually always present, is significantly subordinate to pl in amount. The 'K-feldspar' rocks (with high-T quartz) have been recorded in all three Late Cretaceous-early Paleogene volcanic-extrusive complexes: Primor'ye (Senonian), Siyanovsk (Senonian-Danian), and Bogopol'sk (Danian-Paleocene), whereas the 'plagioclase' rocks occur only in the Bogopol'sk Complex (in the littoral part of ESAVB).

The peculiarities in the mineralogical composition of the volcanics of varying kind have been reflected in their chemistry: the 'plagioclase' volcanics are relatively enriched in Na (K_2O/Na_2O in them does not exceed 1.1), Ca, Mg, T, Sn, V, and F. Fluorine is here fixed partially in biotite (<2.5 wt %) and in the groundmass.

An analysis of the compositions of the glassy inclusions in quartz from both kinds of rocks (Table) has shown, first, that they are similar, and second, that there is a large concentration of magmatic volatiles in the glass of the 'low-T' inclusions (total oxides in them are lower than in the 'high-T' varieties). A comparison between the compositions of the inclusions and the bulk compositions of the rocks, allowing for the early crystallization of quartz, suggests increase in the amounts of Ca, Mg, Na, and Ti during evolution of the melts, producing the 'plagioclase' volcanics, which may satisfactorily explain the introduction of these elements by F-rich fluids. The capacity of the fluoride fluid to concentrate (at T = 1050°C) these very elements has been demonstrated experimentally (Botryakov, 1981) and has been controlled by their fluorophile nature (Marakushev, 1979).

The increase in the role of fluorine through time in the magmas that formed the belt has controlled the changes in the phenocryst parageneses, the appearance of a significant amount of fluorine-bearing silicates and fluorite, and lowering of Tf of quartz in the relatively young 'plagioclase' volcanics. The presence of rocks of two kinds in the Bogopol'sk Complex has been explained by varying fluid-permeability in areas of development of particular volcanics, depending on the crustal thickness, which increases from SW to NE from 28 to 33-36 km (the role of the 'K-feldspar' volcanics increases in this direction). The source of the deep-seated fluids has preferably been large subcrustal asthenoliths, indirect evidence of which is the presence of linear gravity anomalies of increased and high intensity, the trend of which coincides with the area of the ESAVB.

Thus, this study of the melt inclusions, along with other petrographic studies of the rocks, points to the fluid regime in the evolution of the volcanic complexes. (From the author's abstract)

Table. Composition of Melt Inclusions (with letter 'a') in Quartz from Volcanics of Different Kinds, and Bulk Compositions of Rocks

	SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	Σ
16/5a	73.60	0.06	13.90	1.03	0.03	0.43	3.45	5.88	98.30
16/5	75.28	0.04	13.59	1.93	0.36	0.35	2.90	5.00	99.45
K-1a	74.00	0.04	12.70	0.98	0.05	0.45	2.72	5.63	96.60
K-1	70.40	0.48	14.09	2.89	1.02	3.12	3.59	2.93	98.51

Note: 16/5) 'K-feldspar' ignimbrite, Bogopol'sk Complex, Mysovskaya structure; K-1) 'plagioclase' ignimbrite, Kristallinskaya structure. Microprobe analyses carried out by I.M. Romanenko.

BOTTINGA, Y., 1985, On the isothermal compressibility of silicate liquids at high pressure: Earth & Planet. Sci. Letters, v. 74, p. 350-360. Author at Univ. Nice, Parc Valrose, 06034 Nice, France.

From the fusion curves of six silicate/aluminosilicate minerals (Mg_2SiO_4, $MgSiO_3$, $CaMgSi_2O_6$, $Mg_3Al_2Si_3O_{12}$, $NaAlSi_2O_6$, $NaAlSi_3O_8$) and available thermodynamic data, isothermal compressibilities were calculated for pressures ranging from 0.001 to 150 kbar. In all cases the compressibility decreases with increasing pressure, but for liquid pyrope and jadeite this decrease is quite important at $40<P<60$ and $29<P<43$ kbar, respectively. The density of the liquid phase is always smaller than that of the solid phase when the two phases are in equilibrium. The composition dependence is appreciable, the two major factors seem to be the degree of polymerization and the presence of aluminum. (Author's abstract)

BOUDREAU, A.E. and McCALLUM, I.S., 1985, Composition of apatite and biotite from the Stillwater Complex, Montana: Evidence for hydrothermal transport of PGE and REE in Cl-bearing solutions (abst.): Lunar and Planetary Sci. XVI, p. 85-86. Authors at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195.

Includes a study of the OH-F-Cl contents of apatites and of Cl in biotites. Platinum-group-element ore-zone apatites are unusually rich in Cl. (E.R.)

BOULEGUE, Jacques and JEDWAB, Jacques, 1985, Deep conditions of hydrothermalism of dorsal East Pacific at 13°N: C.R. Acad. Sci. Paris, v. 300, Ser. II, no. 7, 1985, p. 273-276 (in French; English abstract).

Taking advantage of the formation of carbon graphite and Fe-Zn spinels one can compute the conditions of sea water-basalt interaction in deep conditions at 13°N E.P.R. One finds: $p = 260\text{-}500$ bar, $T = 440\text{-}480°C$, $fO_2 = 10^{-27}\text{-}10^{-24.5}$ bar, $pH_2O/pH_2 \cong 100$, $fCO_2/fCO \cong 600$. These conditions lead to a discussion of the possibilities of vaporization of the hydrothermal fluid and to a discussion of the geochemical behavior of U and Fe. (Authors' abstract)

BOULEGUE, J. and JEDWAB, J., 1985, Deep conditions of hydrothermal waters at 13°N E.P.R. (abst.): Terra Cognita, v. 5, p. 191. First author at Lab. Géoch. & Métallog., CNRS, UPMC, 4 place Jussieu, 75200 Paris Cedex 05, France.

We have collected particles transported by the hydrothermal fluid at 13°N EPR. We show that the presence of graphite and elemental iron is due to serpentinization processes. Iron-zinc spinels are also related to these processes. Owing to the presence of graphite, CO_2 and CO and of magnetite and silica, we can compute possible deep conditions of water-basalt interaction at this site. The results are in the following ranges:

$P = 260\text{-}500$ bars;
$T = 440\text{-}480°C$;
$\log (fO_2) = -27 - -24.5$ (bars);
$pH_2O/pH_2 = 100$;
$pCO_2/pCO = 600$;
$\log (fS_2) = -5.5 - -6.3$ (bars).

These conditions [permit discussion of] the possibility of vapor phase formation during sea water-basalt interactions in active hydrothermal areas. Vapor formation yields various salinity conditions for the hydrothermal fluids. We also discuss the behavior of uranium during these hydrothermal processes. (Authors' abstract)

BOULLIER, A.M., MICHOT, G. and PÊCHER, A., 1985, Diffusion and/or plastic deformation around fluid inclusions in synthetic quartz (abst.): [Abstracts of] Int'l. Conf. on Tectonic & Structural Processes, April 10-12, 1985, Utrecht, Netherlands (in French).

Synthetic quartz containing fluid inclusions (H_2O + NaOH, 0.5N) was submitted to high temperatures (438°C) and high confining pressures (Pc = 200 to 350 Mpa). The experiments led to variations in the shapes of inclusions and in the densities of the fluid assemblage depending on the internal pressure as a function of the confining pressure. The internal pressure tends to reequilibrate with the confining pressure. X-ray tomography at ambient temperature on biphase fluid inclusions after the experiments shows contrasts around the modified inclusions that were not observed before the experiments.

These experimental results show that the changes in form are a result of dissolution-recrystallization processes that are sensitive to the internal pressure. Variations in density are independent of the changes in form. They may be due to diffusion (positive or negative exchange of water with the quartz) and/or to plastic deformation in the vicinity of the inclusions. The force responsible may be the energy released due to the pressure difference between the fluid inclusion and the mineral. (Authors' abstract, translated by M. Logsdon)

BOUROT-DENISE, M., FABRIÈS, J., FIÉNI, C., SMITH, D.C., TOURET, J., BOYER, H. and PELLAS, P., 1985, Discovery of α-quartz-rich inclusions in ordinary chondrites (abst.): Lunar & Planet. Sci., v. 16, p. 89-90. First author at CNRS & Min. Museum, Paris, France.

We have recently observed that in some feldspar-enriched separates from St. Séverin (LL6) and Peetz (L6), α-quartz grains are present in variable abundances. It was the presence of fluid inclusions in many crystals that led us to finally find that all these peculiar grains were indeed quartz crystals.

At this preliminary stage, a major question should be answered: could these quartz grains be due to a terrestrial contamination? Although we cannot absolutely exclude such a possibility in the cases of the feldspar separates, this eventuality must be evidently discarded for the inclusion found in situ in the St. Séverin core. Furthermore, we are very reluctant to believe in a terrestrial contamination of the feldspar separates because of the very large abundance (~40%) of quartz in the feldspar fraction of St. Séverin. This would indeed imply a contamination level of at least 4% of pure (terrestrial) quartz, assuming a feldspar abundance of ~10% in the LL6 stone. Such a high level of contamination appears to us quite impossible. Finally, the D/H isotopic pattern of the aqueous fluid inclusions strongly supports a non-terrestrial origin. (From the authors' abstract)

See also Fiéni et al., 1985a,b, this volume. (E.R.)

BOWDEN, Peter and KINNAIRD, J.A., 1984, Geology and mineralization of the Nigerian anorogenic ring complexes: Geol. Jahrbuch, v. B56, p. 3-65. Authors at Dept. Geol., Univ. St. Andrews, Fife, Scotland.

A small amount of fluid inclusion data are reported on p. 36. (E.R.)

BOWERS, T.S. and HELGESON, H.C., 1985, Fortran programs for generating fluid inclusion isochores and fugacity coefficients for the system H_2O-CO_2-NaCl at high pressures and temperatures: Computers & Geosci., v. 11, no. 2, p. 203-213. First author at Dept. Earth, Atmos. & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139, USA.

Program DENFIND permits calculation of pressures and temperatures corresponding to isochores for H_2O-CO_2-NaCl fluids which can be used to generate pressure corrections of fluid inclusion homogenization temperatures. Program FUGCO facilitates calculation of fugacity coefficients in the system H_2O-CO_2-NaCl as a function of pressure, temperature and fluid composition. Both programs employ a modified Redlich-Kwong equation of state for the ternary system (Bowers and Helgeson, 1983a) which is applicable to fluids containing up to 35 wt. % NaCl (relative to H_2O + NaCl) at pressures above 500 bars and temperature from 350 to 600°C. (Authors' abstract)

BOWERS, T.S., VON DAMM, K.L. and EDMOND, J.M., 1985, Chemical evolution of mid-ocean ridge hot springs: Geochimica Cosmo. Acta, v. 49, p. 2239-2252.

BOWMAN, J.R., CONNELLY, M.P., COOK, S.J., COVERT, J.J., GERSTNER, M.R., KEMP, W.M. and TURNER, D.R., 1985, Changes in temperature, fluid sources and fluid pressure relative to total pressure during contact skarn development (abst.): EOS, v. 66, p. 1143. Authors at Univ. Utah, Dept. Geol. & Geophys., Salt Lake City, UT 84112.

Integrated phase equilibria, fluid inclusion, stable isotope, and geologic studies have defined limits to T, fluid (water) pressure relative to total pressure (P(T)), salinities, and fluid sources for six multistage contact skarn systems in the Western Cordillera of the United States and Canada. The initial development of anhydrous skarn (Stage I) in the Alta and Milford, Utah (Cu) skarns began at T >550°C, with subsequent development of later hydrous skarn (Stage II) at significantly lower temperature (<400°C). For both skarns, fluid inclusion data indicate an abrupt decrease in salinity, and stable isotope data document a change in the source of skarn fluids from dominantly magmatic (Stage I) to dominantly meteoric (Stage II). All stages of skarn development in the Hanover, New Mexico (Zn) skarns took place at T <400°C. During evolution of all three skarns, fluid pressure dropped from conditions near lithostatic ($P(H_2O) = P(T)$) during Stage I to conditions approximating hydrostatic ($P(H_2O) = 0.3 P(T)$) during the later, lower T, stage (II) of hydrous skarn development and accompanying ore deposition. This drop in fluid pressure was accompanied by boiling and/or entrapment at variable fluid pressure in one or more stages of skarn development. In contrast, temperatures for the formation of initial (I) and later (II) stages are similar or significantly overlap in the Elkhorn, Montana, and Can Tung and Mac Tung, NWT, Canada skarns. In these three skarn systems, fluid pressure persists near P(T) or lithostatic conditions, salinities do not abruptly or significantly decrease, and stable isotope evidence indicates absence of significant influxes of meteoric water during development of both anhydrous and hydrous skarn. Evidence for boiling is lacking in these latter three skarns. These data suggest a general connection during skarn development between the transition from lithostatic to hydrostatic fluid pressure conditions and a significant influx of meteoric water, accompanied by significant drops in T and salinity. Our data emphasize the need to evaluate T, P(T), and fluid pressure in each skarn studied before modeling skarn development, fluid-rock interaction, and ore deposition mechanisms. (Authors' abstract)

BOWMAN, J.R., COVERT, J.J., CLARK, A.H. and MATHIESON, G.A., 1985, The CanTung E zone scheelite skarn orebody, Tungsten, Northwest Territories: Oxygen, hydrogen, and carbon isotope studies: Econ. Geol., v. 80, p. 1872-1895. First author at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

Contact skarn formation at the CanTung scheelite deposit (Tungsten, Northwest Territories, Canada) involved replacement of calcitic marbles by garnet-pyroxene, pyroxene-pyrrhotite, amphibole-pyrrhotite, and biotite-pyrrhotite skarns, adjacent to a peraluminous biotite monzogranite pluton. Fluid inclusion studies presented in Mathieson and Clark (1984) and oxygen isotope thermometry data presented here are consistent with the initial development, essentially simultaneously, of a zoned array of both anhydrous and hydrous skarns at 450° to 500°C, as proposed by Dick and Hodgson (1982). Development of hydrous skarn continued to lower temperatures, as indicated by the fluid inclusion studies of Mathieson and Clark (1984) and suggested by the calcite-pyroxene isotopic data presented here.

The isotope data also do not support a model of skarn petrogenesis for CanTung which invokes an early high-temperature, exclusively anhydrous skarn stage formed dominantly from magmatic water, followed by a later, distinctly lower temperature (retrograde) hydrous stage formed from fluids dominated by meteoric water. (From the authors' abstract)

BOWMAN, J.R., O'NEIL, J.R. and ESSENE, E.J., 1985, Contact skarn formation at Elkhorn, Montana. II: Origin and evolution of C-O-H skarn fluids: Am. J. Sci., v. 285, p. 621-660. First author at Dept. Geol. Sci., Univ. Utah, Salt Lake City, UT 84112.

Zoned contact skarns have replaced dolomitic marbles on the upper sides and top of the Black Butte quartz diorite near Elkhorn, Mont. Mass-balance calculations indicate that the $\delta^{13}C$ and $\delta^{18}O$ values of skarn calcites cannot result from simple decarbonation of preexisting marble. The carbon and oxygen isotopic data suggest that the skarn calcites formed from fluids that were intially in exchange equilibrium with the Black Butte stock but that became progressively enriched in ^{18}O by exchange with the carbonate wallrock. The calculated hydrogen and oxygen isotope compositions of early, high-temperature (stages I and II) skarn fluids indicate that they contained little or no meteoric water. Replacement of the early, dominantly anhydrous assemblages of stage I by hydrous silicates during stage II was not accompanied by significant influxes of meteoric water. Meteoric water became abundant ($\leq$45 mol percent in stage III) and then predominant (>70-85 mol percent in stage IV) in later, lower temperature stages of skarn evolution. The close similarity in both hydrogen and oxygen isotope composition between early skarn (stages I and II) and igneous fluids in the Black Butte aureole is consistent with derivation of the skarn fluids from fluids that were equilibrated with isotopically normal igneous rock. The most obvious origin of such fluids is magmatic water that was exsolved during crystallization of the quartz diorite. However, derivation of skarn fluids from certain types of formation water cannot be ruled out. The available geologic, petrologic, and oxygen isotope evidence does suggest that, whatever the initial origin of the skarn fluids, these fluids last equilibrated with the Black Butte stock.

Systematic increases in the values of $\delta^{18}O$ and in $X(CO_2)$ of the skarn fluid away from the intrusive contact suggest progressive interaction with high-^{18}O carbonate wallrock. Mass-balance calculations suggest that these variations are the result of progressive mixing of water-rich skarn fluids ($\delta^{18}O = 7.5$) with CO_2 ($\delta^{18}O = 30$) evolved during reaction of the fluids with marble. The calculated limits to $X(CO_2)$ agree well with those defined by mineral zonation within the skarns. These calculations provide support for progressive H_2O-CO_2 mixing as a reasonable mechanism for producing the isotopic and mineralogic zonation documented in the Elkhorn skarns. (From the authors' abstract)

BOYARSKAYA, R.V. and GORSHKOV, A.I., 1985, Present-day electron microscopy and solution of thermobarogeochemical problems (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 76-77 (in Russian). Authors at IGEM, Moscow, USSR.

The authors give general outline of electron microscopy of fluid inclusions in minerals, listing the identification of dms or trapped minerals in inclusions: lanthanites[sic, A.K.] in gold-bearing quartz, zincite in native zinc, gold amalgam in native gold, graphite, quartz, calcite, hematite, sylvite, halite, garnets and sulfides in fluorite, magnetite, oldhaunite, silicates in volcanic glass, etc. They mention also determination of composition of precipitates in opened inclusions. (A.K.)

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, p. 387-389. First author at Geophysical Lab., Carnegie Inst. Washington, Washington, DC 20008, USA.

Involves solid inclusions only. (E.R.)

BOYD, S.R., CARR, L.P., SEAL, M., MILLEDGE, H.J., MENDELSSOHN, M., WOOD, P.J., MATTEY, D.P. and PILLINGER, C.T., 1985, Carbon and nitrogen isotopic zoning within diamonds (abst.): Terra Cognita, v. 5, p. 146-147.

BRACE, W.F., 1985, To what depth is the crust permeable? (abst.): NERC 3rd Deep Geology Workshop Programme and Absts., Univ. Durham, 3-4 Jan., 1985 (unpaginated). Author at Massachusetts Inst. of Technology.

Drill-hole measurements, together with reservoir-induced earthquakes, certain heat flow anomalies, and other large-scale phenomena suggest that the crust has a permeability as high as 10 md ($10^{-14}m^2$) to depths of 8, and possibly 10 kilometers, for all common crystalline and most sedimentary rocks. The only common exception is shale, where observed permeabilities are three to five orders of magnitude lower. Permeability of a millidarcy implies that pore pressure to these depths will seldom differ greatly from hydrostatic. This has important bearing on many tectonic, seismological and geochemical phenomena. A critical question is to what depths does this high permeability extend. (From the author's abstract)

BRADBURY, M.H. and GREEN, A., 1985, Measurement of important parameters determining aqueous phase diffusion rates through crystalline rock matrices: J. Hydrology, v. 82, p. 39-55.

BRATUS', M.D. and ZINCHUK, I.N., 1985, Composition, concentration, and pH of aqueous-hydrocarbon fluids in mineral inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 183-184 (in Russian; translation by D.A. Brown). Authors at IGGGI AN Ukrainian SSR, L'vov, USSR.

High concentrations of HC compounds have recently been found both in the gas phase of inclusions in hydrothermal minerals of ore and petroliferous regions, and also in the form of independent HC inclusions, which indicates the heterogeneous state of the H_2O-HC fluids.

The authors have attempted to study some peculiarities in the composition and other parameters of H_2O-HC fluids in mineral inclusions from vein formations in petroliferous regions with Alpine-type folding (Carpathians and Western Turkmenia) and prospective gas areas in the Donbass. The vein formations are mainly confined to tectonic disturbances. As a rule, they consist of quartz-calcite veins, containing well-defined [small], crystals of quartz among the calcite and in the cavities, and less commonly, granular aggregates and large crystals of quartz (≤3-10 cm).

Previous studies have shown that the HC component of heterogeneous fluid systems consists of high-density CH_4 with a trace of its first homologs. The Carpathian region is also marked by the presence of inclusions of liquid HCs of the light oil type, light-yellow in color.

The authors have examined the composition and concentration of the aqueous phases of H_2O-HC inclusions. Cryometric studies have shown that the composition of the salt components is specific for each region. All the Donbass samples have essentially NaCl. Inclusions in quartz from Western Turkmenia contain significant $NaHCO_3$, besides NaCl. At the same time, the solutions in quartz crystals ('Marmarosh diamonds') from the Carpathians have an extremely variable composition, from NaCl to Na bicarbonate-sulfate. This may be a reflection of a variety of geological environments in which the crystals were formed, or of the different origin of the hydrothermal waters. The concentration of aqueous phase is always low (0.5-5.0 wt.%). No clear relationship has been found between the compositions and concentrations of the solutions and the composition of the equilibrium HC phase (gas and petroleum).

Micro-colorimetric measurements of the pH of the aqueous solutions in individual inclusions in quartz have given a value of pH = 8-9. A tendency towards increase in alkalinity in the solutions has been noted during the final stages of formation of the quartz crystals.

These heterogeneous H_2O-HC fluids may have some relationship to the processes of HC migration in petroliferous regions and the role of HCs in redox processes during ore-deposition. (Authors' abstract)

BRAUD, C. and RIOU, R., 1985, Fluid inclusions in kaersutite-bearing xenoliths (Lower Tafna, Algeria): Evidence for reaction between fluid and host mineral (abst.): Terra Cognita, v. 5, p. 317. Authors at Centre Géol. & Géophys., USTL, Montpellier, France.

Zoned clinopyroxenes in kaersutite-bearing cumulate-textured clinopyroxenite xenoliths from quaternary alkali basalts of djebel Kerkour (Lower Tafna, Algeria) contain two distinct generations of fluid inclusions.

- I: CO_2(L) inclusions characterized by halite, sulfate and carbonate crystals lining walls of the cavities. They have globular or elongated negative crystal shape and occur together with sulphide globules in clusters or along trails restricted within diopsidic core of clinopyroxenes. Abundance of small blebs of amphibole inside inclusions I rich sectors of diopside is noteworthy.

- II: CO_2(L+G or G)-glass mixed inclusions ranging from ovoid to tubular or vermicular in shape with variable proportions of fluid and glass. Daughter minerals include amphibole + spinel ± sulfides ± oxides? and exceptionally carbonates. Inclusions II are trapped on growing faces of the salitic border of clinopyroxenes (primary) or arranged in planar arrays starting from this border (pseudosecondary).

In inclusions I, Th CO_2 show a well-defined maximum near +3°C (d: 0.9 g/cm^3; T: 1000-1200°C, P: 6-7 kbar) corresponding to a minimum depth of 30 km for crystallization of xenoliths.

In inclusions II, Th CO_2 range from +8 to +31°C (d: 0.85-.50 g/cm^3; T: 1000-1200°C; P: 2-6 kbar) corresponding to ascent of xenoliths to the surface after incorporation in the host basalt.

Despite the presence of NaCl crystals, no aqueous phase has been detected in inclusions I implying that part of the fluid has been lost during or after entrapment. Thus, preferential development of amphibole ± spinel ± plagioclase close to inclusions I, together with coherent variations of Ti, Si, Al, and Mg in nearby clinopyroxene suggest the following reaction: Ti-Al diopside + (H_2O, Na, K) fluid → kaersutite + diopside ± spinel ± plagioclase. (Authors' abstract).

BRAULT, Martine, SIMONEIT, B.R.T., MARTY, J.-C. and SALIOT, Alain, 1985, Geochemistry. - Hydrocarbons from the hydrothermal system at 13°N, East-Pacific rise: C.R. Acad. Sc. Paris, v. 301, Ser. II, no. 11, p. 807-812 (in French; English abstract).

Non-aromatic hydrocarbons have been analyzed in a hydrothermal metalliferous sediment sampled at the bottom of an inactive chimney, close to active sources, in the content of a sediment trap deployed at 50 m above the active zone and in water collected in the maximum of the hydrothermal plume, from the East-Pacific rise, near 13°N. Hydrocarbons from the hydrothermal sediment present characteristics of immature organic matter, freshly biosynthesized and microbiologically degraded, as indicated by the importance of low molecular weight n-alkanes and phytane, and a contribution of ubiquitous higher continental plant inputs shown by the predominance of odd carbon atom number high molecular weight n-alkanes. The immature character of organic matter is also shown by the presence of coprostane and cholestane, and the predominance of 17 β(H), 21 β(H)-hopanes over 17 α(H)-hopanes. The sediment trap content is characterized by the same type of biologically-derived material and also by the presence of compounds such as 17 α(H)-hopanes and intermediates of thermal alteration, sterenes, triterpenoid and isoprenoid ketones, which confirm the importance of thermal degradation of the organic matter near hydrothermal systems. Mature substances and intermediates from the thermal alteration process are also present in the water collected in the maximum of the hydrothermal plume. (Authors' abstract)

BRAZHNIK, A.V., 1985, Thermometric studies of hydrocarbon inclusions in the ores of the Tambatney mercury-tungsten deposit (Koryak Highlands) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 187-189 (in Russian; translation by D.A. Brown). Author at Permanent Br. Koryak Geol. Exped. Northeastern Interdiscip. Res. Inst. Far Eastern Sci. Center Acad. Sci. USSR, Anadyr', USSR.

The main lode of the Tambatney Hg-W deposit is a plate-like body of metasomatically-altered serpentinites, extending along the northern contact of the Tambatney ultramafic massif in a deep-seated fault. The Hg-W mineralization is mineralogically complex and genetically polyphase. Three stages are recognized: pre-ore (serpentinite, listwänite) and sulfide-argillisite ore (W) and quartz-chalcedony ore (Hg). The latter stage is marked by the widespread distribution of HCs both in the rocks and also in the ores. Petroleum, naphthoid maltha [soft asphalt], and naphthoid asphalt have been identified in various sectors of the deposit. Large amounts of CH_4 have been determined in the gas component of the inclusions, and there are three generations of HCs:

1) CH_4, in inclusions in a late cinnabar. Th of the GLIs in cinnabar is 110-115°C (PS 75-80°C), and in quartz, 95-125°C.

2) Naphthoid malthas in veinlets of chalcedonic quartz, cutting similar veinlets with a late cinnabar. The bitumen is red-brown in color, viscous, completely soluble in inorganic solvents, and luminesces pale-blue and yellowish-brown. It becomes liquid at 50-60°C. At 230°C, it partially vaporizes, leaving films of a yellowish-brown color, disintegrating at 390°C. The fluid inclusions in quartz have Th = 71-80°C. Inclusions with a liquid phase (Tuv > Zh)[sic]. Homogenization does not ensue on heating, but two immiscible liquids coexist until decrepitation.

3) Rounded masses of naphthoid asphalt entirely or partially fill the geodes [cavities?] of chalcedony plus central quartz druses in veins cutting the others. The geodes range from a few mm up to several cm. The bitumens are brittle, dark-brown, and sometimes almost black. The extract luminesces in yellow-orange shades. The material melts at 60-90°C, forming a viscous liquid. Volatile evolution begins at 220°C, and decomposition at 300-375°C. The inclusions in quartz from the geodes are solid-phase, for the most part in cavities, bounded by the facets of the adjacent crystals. Within the asphaltite there are inclusions of hair-like crystals of curtisite of pale-yellow color that luminesce bright yellow; sublimation T = 225-230°C.

These data indicate the evolution of the HC-bearing fluids in the Tambatney deposit. (From the author's abstract)

BRECKE, E.A., 1985, The chemical and thermal evolution of the fluids in the Cave-in-Rock fluorspar district, Illinois: Mineralogy, paragenesis, and fluid inclusions - A discussion: Econ. Geol., v. 80, p. 2044-2045. Author at 5400 Maryland Avenue North, Minneapolis, MN 55428.

Although the reference is not so listed, this is a discussion of papers by Richardson and Pinckney (1981, in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 170, 1981, and 1984, in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 278-279, 1984). For reply, see Richardson and Pinckney, this volume. (E.R.)

BRETT, Robin, HEDENQUIST, J.W. and EVANS, H.T., Jr., 1985, Sulfide chimneys from S. Juan de Fuca Ridge: Mineralogy and fluid inclusions (abst.): EOS, v. 66, no. 46, p. 927. First author at U.S. Geol. Survey, 959, Reston, VA 22092.

Sulfide chimneys and encrustations obtained from USGS 1984 Alvin dives resemble those described by Koski et al. (Bull. G.S.A. 95, 930). Minerals in approximate descending order of abundance include sphalerite (sl) (Fe 21.0 to 0.4 wt.%); wurtzite; marcasite (ms); pyrite; amorphous silica; MgO-SiO_2 gel; pyrrhotite (po) (Fe 61.6-60.5); isocubanite (iss); chalcopyrite (cp); barite; and gel-like phases composed of major Fe, Si, Mg, S, O, and minor Cl, P, and Mn. Secondary phases include probable (Fe, Zn) and (Zn, Fe) hydroxychlorosulfate, and probable Fe hydroxysulfate. The MgO-SiO_2 gel contains about 38 wt.% MgO and SiO_2, with H_2O and minor Zn, S, and Mn. Paragenetic sequence is quite variable, alternating bands of sl, ms, and amorphous silica being common. Most assemblages are not in chemical equilibrium.

One side conduit from the largest chimney is lined with iss (f.c.c., a = 5.2978(3) A, which grades into po (4C monoclinic, Fe_7S_8) and into flames, lamellae, and veins of Fe-rich cp in Fe-rich iss. Phase equilibria data (iss-cp-po compositions) indicate a temperature of formation of about 300°C. The same sample contains fluid inclusions in anhydrite 2-4 mm from the inner surface. Homogenization data given temperatures (T) of trapping of fluid in two crystals of 268° and 285°C, respectively, at 2200 m depth. Ice melting T's for three fluid inclusions are -2.6°, -2.8° and -3.0°C (±0.2°), suggesting that the equivalent salinity is about 50% greater than that of seawater. (Authors' abstract)

BRIGHAM, R.H. and O'NEIL, J.R., 1985, Genesis and evolution of water in a two-mica pluton: A hydrogen isotope study: Chem. Geol., v. 49, p. 159-177. Authors at U.S. Geol. Survey, Br. Isotope Geol., MS No. 937, Menlo Park, CA 94025, USA.

Measurements were made of the hydrogen isotope composition of 74 samples of muscovite, biotite, vein quartz and whole rocks from the Papoose Flat pluton, eastern California, U.S.A., and adjacent metamorphic and sedimentary rocks in order to elucidate the genesis and evolution of water and hydrous minerals in a two-mica granodiorite. Electron microprobe analyses were made of all micas so that the Suzuoki-Epstein equation could be used in evaluating the data. Based on experimental, theoretical and textural evidence of mica paragenesis, a model of hydrogen isotope fractionation between an aqueous vapor and a magma during crystallization has been constructed. This model accounts for the observed hydrogen isotope relations and implies that primary hydrogen isotope compositions have been preserved in a large portion of the pluton.

The δD-values of biotites vary widely over the range -103 to -66‰ with most values lying between -90 and -70‰. Muscovites, on the other hand, are isotopically more uniform and have δD-values of -61 to -41‰ with most values lying between -50 and -46‰. These data are consistent with the interpretation that biotite formed over a long period of crystallization whereas muscovite formed in a narrow interval, presumably during the final stages of crystallization when alumina and water contents were at their highest. Only 8 of the 21 muscovite-biotite pairs analyzed are in hydrogen isotope equilibrium as calculated from the Suzuoki-Epstein equation.

Biotites in the western half of the pluton have relatively low δD-values of around -85‰, whereas those in the eastern half have higher values of up to -66‰. This pattern is a consequence of a loss of permeability associated with the syn-intrusive deformation of the western margin of the pluton. This loss of permeability enhanced the preservation of primary hydrogen isotope relations thereby diverting water evolved from the magma out through the eastern half of the pluton where some deuteric exchange is documented. A much larger metamorphic aureole with extensive retrograde textures around the eastern end of the pluton attests to the passage of this water. (Authors' abstract)

BRIOLE, P., 1985, Continuous monitoring of gas and particle emission of Mt. Etna (abst.): IAVCEI 1985 Scientific Assembly Abstracts, unpaginated (in French).

BROMAN, Curt, 1985, Fluid inclusions of the sulfide deposits in the Skelleftefield, Sweden (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 28. Author at Ore Reserach Group, Geol. Inst., Stockholm Univ., Stockholm, Sweden.

The Skelleftefield is a sulfide ore district of Precambrian age in northern Sweden. The country rock consists of volcanics and sediments of submarine origin which have been metamorphosed and folded in relation to the intrusion of two major generations of granitoids.

Most of the sulfide mineralizations are associated with the border zone between the upper parts of the volcanic and the overlying sedimentary rocks. The deposits can be divided into two principal ore types; stratiform massive and stockwork ores. The massive ores typically form lens- or slab-shaped bodies with the stockwork type in the stratigraphic footwall.

Preliminary results from the ongoing microthermometric investigation of fluid inclusions in sphalerite, quartz and calcite from the massive ore type indicate deposition T around 270°C from aqueous solutions with a total salt content of 4 eq. wt. % NaCl. (Author's abstract)

BROMLEY, K.S., BOWMAN, J.R. and PARRY, W.T., 1985, A stable isotope study of the Wasatch fault zone at Corner Creek, Utah (abst.): EOS, v. 66, p. 1138. Authors at Univ. Utah, Dept. Geol. & Geophys., Salt Lake City, UT 84112.

Hydrothermal alteration accompanies cataclasis and results in an early mineral assemblage of chlorite, epidote, sericite, magnetite, and a later assemblage of laumontite, prehnite, hematite. Fluid inclusion studies (Parry, in press) indicate that the chlorite-epidote alteration took place at approximately 400°C, and laumontite-prehnite alteration at approximately 200°C. (From the authors' abstract)

BROOKS, J.M., JEFFREY, A.W.A., McDONALD, T.J., PFLAUM, R.C. and KVENVOLDEN, K.A., 1985, Geochemistry of hydrate gas and water from Site 570, Deep Sea Drilling Project Leg 84, in Orlofsky, S., ed., Initial Reports of the Deep Sea Drilling Project, v. 84, U.S. Govt. Printing Office, p. 699-703. First author at Dept. Oceanography, Texas A&M Univ., College Station, TX 77843.

Molecular and isotopic measurements of gas and water obtained from a gas hydrate at Site 570, DSDP Leg 84, are reported. The hydrate appeared to be Structure I and was composed of a solid framework of water molecules enclosing methane and small amounts of ethane and carbon dioxide. Carbon isotopic values for the hydrate-bound methane, ethane, and carbon dioxide were -41 to about -44, -27, and -2.9‰, respectively. The $\delta^{13}C(C_1)$ values are consistent with void gas values that were determined to have a biogenic source. A significant thermogenic source was discounted because of high C_1/C_2 ratios and because the $\delta^{13}C(CO_2)$ values in these sections were also anomalously heavy (or more positive) isotopically, suggesting that the methane was formed biogenically by reduction of heavy CO_2. The isotopically heavy hydrate $\delta^{13}C(C_2)$ is also similar to void gas isotopic compositions and is either a result of low-temperature diagenesis producing heavy C_2 in these immature sediment sections or upward migration of deeper thermogenic gas. The salinity of the hydrate water was 2.6‰ with $\delta D(H_2O)$ and $\delta^{18}O(H_2O)$ values of +1 and +2.2‰, respectively. (Authors' abstract)

BROOMHALL, R.W. and ALLAN, J.R., 1985 Regional caprock-destroying dolomite on the Middle Jurassic to Early Cretaceous Arabian Shelf: Proc. Middle East Oil Conf., 11-14 March, 1985, Manama, Bahrain, Soc. Petrol. Eng. Trans., v. 60, no. 4, p. 157-163.

Fluid inclusion geothermometry reveals that baroque dolomite precipitated from brine with salinities of 223,000 to 249,000 ppm TDS at temperatures of 102 to 134°C onshore and 131 to 155°C offshore. Petroleum fluid inclusions within the baroque dolomite indicate hydrocarbon migration contemporaneous with dolomitization. Carbon and oxygen isotope data suggest that the brine which precipitated baroque dolomite was also responsible for the massive recrystallization of shelf limestone to form host dolomite. Chemical analyses of formation waters suggest that brine which migrated out of halite deposits during burial was the dolomitizing fluid.

The geological and geochemical attributes of Arabian Shelf dolomites strongly resemble those reported for dolomite associated with Alpine and Mississippi Valley-type carbonate-hosted lead-zinc deposits in Europe and North America. (From the authors' abstract)

BROWN, C.E. and AYUSO, R.A., 1985, Significance of tourmaline-rich rocks in the Grenville Complex of St. Lawrence county, New York: USGS Bull. 1626-C, 33 pp.

Ore bodies at the nearby Balmat-Edwards mining district are in marbles associated with rocks of evaporitic origin. The boron- and scapolite-rich rocks under consideration in this study possibly also are related to an evaporite-producing environment. Similar rocks that have an evaporite origin are associated with stratabound sulfide deposits at many places. (From the authors' abstract)

BROWN, Grahame, 1985, Aquamarine from Mt. Surprise, Queensland, Australia: J. Gemm., v. 19, no. 8, p. 707-722.

Liquid, vapor and solid (NaCl?) inclusions are illustrated. (E.R.)

BROWN, P.E., 1985, Au-only and Au-Ag-base metal ores of the Sioux Lookout-Sturgeon Lake area, NW Ontario - a comparison (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 533. Author at Dept. Geol., 1215 W. Dayiton, Univ. Wisconsin-Madison, Madison, WI 53706.

Contents of fluid inclusions in quartz from Au-vein ores in the Sioux Lookout-Sturgeon Lake area vary substantially. The ores are hosted by felsic and mafic metavolcanic rocks as well as felsic plutonic rocks. The host rocks are part of the Wabigoon Subprovince and are located south of the better known Pickle Lake area of the Uchi Greenstone belt.

Samples from the Moede Showing south of Savant Lake contain abundant sphalerite and chalcopyrite. The 10-30 micron inclusions have halite cubes and often a second daughter salt. Salt dissolution occurs near 200°C with liquid-vapor homogenization (L-VH) between 390 and 450°C. Inclusions often leak near 350°C and decrepitate above 450°C.

Most of the Au-only vein ores contain dominantly water-carbon dioxide fluids with either 2 or 3 phases at room temperature (22°C). CO_2 L-VH temperatures range from -7 to 31°C. Quartz from the the active Goldlund mine contains CO_2-rich, 2 and 3 phase inclusions. Samples from the past producing St. Anthony mine contain inclusions with 60% CO_2 which homogenize between 0 and 10°C, corresponding to CO_2 densities between 0.84 and 0.93 g/cc. Inclusions from the more base metal-rich Coveney Pit have much more variable H_2O-CO_2 ratios and generally CO_2 L-VH temperatures in the range 19-28°C. Samples from Burnt Hut Island in Minnitaki Lake have CO_2 contents from 10-100% and a sprawling histogram of CO_2 L-VH temperatures from -7 to 31°C. The data peaks near 13°C which corresponds to a density of 0.8 g/cc. CO_2 clathrates typically melt between 7 and 8°C, indicating 2-7% dissolved salts.

The majority of measured isochores extrapolate to between 1.1 and 2.9 kb at a temperature of 350°C and 1.5 and 3.6 kb at 450°C. These pressures, temperatures and salinities are consistent with the general lack of evidence for boiling in Archean gold deposits and support the late epigenetic origin for most of the greenstone-hosted gold ores. (Author's abstract)

BROWN, P.E., BOWMAN, J.R. and KELLY, W.C., 1985, Petrologic and stable isotope constraints on the source and evolution of skarn-forming fluids at Pine Creek, California: Econ. Geol., v. 80, p. 72-95. First author at Dept. Geol. & Geophys., Univ. Wisconsin-Madison, Madison, WI 53706.

A detailed geochemical analysis of the well-exposed, multistage, Pine Creek, California, tungsten deposit has constrained the roles of magmatic, metamorphic, and meteoric fluids in the development of the zoned scheelite ore and calc-silicate skarn.

Metamorphic conditions of $P < 2$ kb, $T < 600$°C, and $XCO_2 < 0.25$ are recorded in the metasedimentary rocks of the septum. Metamorphism yielded calcite + diopside + graphite and calcite + dolomite + periclase + brucite + forsterite assemblages in the variably dolomitic, siliceous, carbonate rocks of the Pine Creek septum. Following intrusion of the Morgan Creek quartz monzonite, metasomatism developed the zoned endoskarn-exoskarn at the contact. The massive garnet (andradite[20-50]) + pyroxene (hedenbergite[20-80]) ± quartz skarn assemblage carries most of the scheelite. Calculated T-XCO_2 equilibria, corrected for solid solution effects, restrict skarn formation to $XCO_2 < 0.2$ at $T = 500° \pm 50$°C. Calculated fO_2-fF_2-fS_2 diagrams indicate fO_2 values near quartz-fayalite-magnetite and fS_2 values well below pyrrhotite-pyrite during skarn formation. Slightly falling temperatures were accompanied by increased fS_2 and hydration of the skarn assemblage.

Stable isotope data for calcites show a mixing trend from unaltered marble ($\delta^{18}O = 24‰$, $\delta^{13}C = 3.5‰$) to values in equilibrium with magmatic fluids ($\delta^{18}O = 8‰$, $\delta^{13}C = -6‰$). Biotite-quartz thermometry for the quartz monzonite yields temperatures of 410° to 460°C, well below the solidus and suggesting later reequilibration. Pyroxene-quartz analyses suggest that these minerals equilibrated at temperatures of 460° to 560°C. The $\delta^{18}O$ values measured for garnets suggest disequilibrium for the garnet-quartz and garnet-pyroxene pairs. D/H results for epidote and biotite suggest that meteoric water influx became more important with time. Sulfur isotope data are consistent with a reduced magmatic source. (Authors' abstract)

BROWN, P.E. and ESSENE, E.J., 1985, Activity variations attending tungsten skarn formation, Pine Creek, California: Contrib. Mineral. Petrol., v. 89, p. 358-369.

BRYZGALIN, O.V., 1985, Some strong electrolytes in the supercritical field (estimation of dissociation constants based on the electrostatic model): Geokhimiya, 1985, no. 8, p. 1184-1195 (in Russian; English abstract).

BULANOVA, G.P. and ARGUNOV, K.P., 1985, K-feldspar inclusions in diamond crystal from the Mir kimberlite pipe: Dokl. Akad. Nauk SSSR, v. 284, p. 953-956 (in Russian).

BUNTIN, T.J., GRANDSTAFF, D.E., ULMER, G.C. and GOLD, D.P., 1985, A pilot study of geochemical and redox relationships between potholes and adjacent normal Merensky Reef of the Bushveld Complex: Econ. Geol., v. 80, p. 975-987. First author at State Dept. Environ. Resources (DER), Hydrology Office, Norristown, PA 19401.

Lateral and vertical variations of fO_2 and carbon in whole rock and fO_2, Fe, Cr, Mg, and Al variations in separated chromites are employed to elucidate the chemical relationships between the Merensky Reef and associated structures termed "potholes." A model of potholes acting as plutonic furmaroles releasing reducing fluid rich in carbon and/or sulfur is discussed as a possible mechanism for Merensky Reef petrogenesis. The model integrates our geochemical data with published research from the literature to present an integration of ideas for platinum-group element enrichment in the Merensky Reef. (From the authors' abstract)

BURCH, C.R., 1985, A reexamination of Slocum Stone - with particular emphasis on inclusions J. Gemmology, v. 29, no. 7, p. 586-596.

Includes discussion of the gas bubble inclusions in this imitation opal material. (E.R.)

BURKE, E.A.J. and LUSTENHOUWER, W.J., 1985, Possibilities and impossibilities of multichannel laser Raman microspectrometry of fluid and solid inclusions (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 30. First author at Inst. Earth Sci., Free Univ. Amsterdam, The Netherlands.

The MICRODIL-28 (S.A. Dilor - Lille, France) is a laser Raman microspectrometer with a multichannel (512 diodes) detector which records spectra with a width of about 400 cm^{-1} and a practical resolution better than 1 cm^{-1}. The multichannel detector provides in practice a lower detection limit than a monochannel detector but allows for a rapid accumulation of spectra, thus providing an average spectrum with a very good signal-to-noise ratio.

The small diameter of the laser beam (1 μm at a microscope magnification of 1000) enables in situ non-destructive (semi)-quantitative analysis of mixtures of gases and/or liquids in fluid inclusions as small as 2-3 μm diameter. Raman microspectrometry data in combination with microthermometry data yield a rapid quantitative result of e.g. mixtures of CO_2-N_2-CH_4 in single fluid inclusions. An impossibility of the method is the analysis of H_2O because of its extremely low effective Raman cross section.

The Raman microspectrometry of solids opens a field which is not accessible for X-ray diffraction. With the help of reference spectra it is possible to identify daughter minerals and solid inclusions, under favorable conditions down to a size of 1 μm. In this way very small primary inclusions of carbonates and retrograde inclusions of andalusite have been found in granulites. There are some impossibilities: Raman inactive compounds (e.g., NaCl and KCl) and the light-absorbing opaque minerals (which are burned by the laser beam). (Authors' abstract)

BURNHAM, C.W., 1985, Energy release in subvolcanic environments: Implications for breccia formation: Econ. Geol., v. 80, p. 1515-1522.

BURROWS, D.R. and SPOONER, E.T.C., 1985 Generation of an Archean H_2O-CO_2 fluid enriched in Au, W & Mo by fractional crystallization in the Mink Lake intrusion, NW Ontario (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 536. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

Fractional crystallization (FC) of the post-tectonic trondhjemitic Mink Lake intrusion in NW Ontario resulted in a residual H_2O-CO_2 low salinity fluid (5.6 equiv. wt % NaCl aqueous component) with an isotopic composition ($\delta^{13}C_{cc}$ $\bar{x} = -3.3‰ \pm 0.4‰$ (1s), $\delta^{18}O_{cc}$ + 10.7 to 15.9‰, δD_{FI} $-70 \pm 9‰$ (1s) and $\delta^{34}S_{py}$ + 0.4 to +2.9‰) compatible with magmatic derivation and extremely similar to that in vein quartz-carbonate-pyrite ± scheelite, ± tourmaline, ± MoS_2 ± telluride systems characteristic of major Archean lode gold deposits. Inward FC of the granodiorite magma (69-71% SiO_2, $Na_2O/K_2O = 1.6$-3.0), as indicated by trace and REE data, produced a sequence of microgranites and aplitic dikes (75-76% SiO_2) with mean values by INNA (n = 10) for Au of 2.3 ppb, Mo = 22 ppm and W = 7.3 ppm as compared to mean background values in the granodiorite of Au <1 ppb, Mo <1 ppm and W <3.7 ppm (n = 4). The latest aplites are observed to coexist with a H_2O-CO_2 mixture and are characterized by carbonate alteration selvages and minor MoS_2. Subsequent separation of the H_2O-CO_2 fluid and interaction with an otherwise fresh granodiorite within the already solidified southern margin, produced MoS_2 mineralized sub-horizontal quartz veins and larger tabular lenses of carbonate alteration without internal veining. Such zones are anomalously enriched (n = 10) in Au (x = 153 ppb, range 2-570 ppb) Mo (x = 660 ppm, range 1-2500 ppm and W (x = 61 ppm, range 23-95 ppm). (Authors' abstract)

BURRUSS, R.C., 1985, Paleo-temperatures from fluid inclusions - Advances in theory and technique (abst.): AAPG Bull. v. 69, no. 2, p. 241-242. Author at U.S. Geol. Survey, Denver, CO.

Recent studies of fluid inclusions in diagenetic cements have attempted to determine paleosubsurface temperatures. Three sets of observations are necessary to make accurate interpretations: (1) detailed petrography to establish the relative time of formation of the inclusions, (2) careful analysis of the burial and tectonic history of the host rocks to relate the diagenetic paragenesis to the geologic history of the basin, and finally, (3) analysis of individual inclusions for Th and final melting temperatures, and for chemical composition to define the PVT properties of the trapped fluids.

Once these observations are complete, 2 major limitations on the temperature interpretation remain. First is the assumption that the inclusions have not altered in composition or volume since entrapment. Recently published work shows that inclusions can reequilibrate, but the extent that this affects most observations in sediments is unknown. Second, we must independently determine a "paleopressure" during inclusion formation, and we must know whether this pressure was hydrostatic or approached lithostatic. Data from both hydrocarbon and aqueous fluid inclusions in core samples from the Mission Canyon formation, Williston basin, North Dakota, illustrate a method for independently determining both paleotemperature and paleopressure from a single set of fluid inclusion measurements. The technique requires petrographic evidence for simultaneous trapping of 2 immiscible fluids. Theoretical analysis of the PVT properties of coexisting immiscible fluids demonstrates that the isochores for the 2 different fluids must intersect at the temperature and pressure of entrapment of the inclusions. Calculations of the PVT properties of each fluid requires detailed chemical analysis of both fluids. Recent results from new analytical techniques, especially capillary column gas chromatography to analyze hydrocarbon inclusions and laser Raman spectroscopy to analyze gases in aqueous inclusions, demonstrate that this approach to paleotemperature studies can be widely applicable in sedimentary environments. (Author's abstract)

BURRUSS, R.C., CERCONE, K.R. and HARRIS, P.M., 1985, Timing of hydrocarbon migration: Evidenced from fluid inclusions in calcite cements, tectonics and burial history, in N. Schneidermann and P.M. Harris, eds., Carbonate Cements, Symp. Soc. Econ. Paleon. & Mineral., p. 277-289. First author at Gulf Res. & Dev. Co., P.O. Box 37048, Houston, TX 77236.

The timing of petroleum migration in samples of fractured Cretaceous reservoir limestones from Oman and the United Arab Emirates is determined from observations of hydrocarbon fluid inclusions in calcite cements. Petrography and geohistory analyses of four wells that were variably affected by formation of the Oman Foredeep reveal five stages of diagenesis, fracturing, and fluid migration. (1) Quiet shelf deposition: early cementation associated with regional unconformities; (2) pre-orogenic shelf emergence: fractures cutting Stage 1 cements are healed by very cloudy, cleaved, and twinned calcite containing microfractures with yellow-white fluorescent, hydrocarbon fluid inclusions; (3) initial foredeep downwarp: fractures cross cutting Stage 2 fractures are healed with cloudy, cleaved, and sometimes twinned calcite containing dull-blue fluorescent, hydrocarbon fluid inclusions; (4) rapid subsidence and filling of foredeep with sediments including flysch, exotic blocks, and thrust toes: burial and tectonic stylolites crosscut Stage 2 and 3 fractures; and (5) uplift of the Oman Mountains: fractures cross cutting all diagenetic features are filled with clear, untwinned and uncleaved calcite containing only non-fluoresent, aqueous fluid inclusions. By correlating stylolite formation with overburden of approximately 2500 ft. (750 m), the hydrocarbon inclusions in Stage 2 fractures must predate all of Stage 4 and most of Stage 3. In the deepest portions of the foredeep, close to the Oman Mountain front, this correlation limits the presence of oil in fracture porosity to late Turonian-early Campanian time. Farther to the west, in the shallower parts of the foredeep, the timing constraint relaxes, and oil migration occurred as late as early Tertiary. (Authors' abstract)

BURSILL, L.A. and GLAISHER, R.W., 1985, Aggregation and dissolution of small and extended defect structures in Type Ia diamond: Am. Mineral., v. 70, p. 608-618, p. 608-618. Authors at Sch. Physics, Univ. Melbourne, Parkville, 3052, Victoria, Australia.

Gem quality diamonds often have up to one atom of carbon out of about one thousand replaced by nitrogen. This article reviews the structures formed by the nitrogen in various states of aggregation, ranging from a few atomic diameters up to platelet shapes several microns in extent. The understanding of such defect structures now emerging gives new impetus to studies of the geological origin and evolution of various diamond species.

Our analysis of the small defect (traditionally called point defect) structures and their mechanisms of diffusion and aggregation to form extended defects leads to the identification of essentially three stages, involving: (1) an activation energy for creation of carbon vacancies (Schottky mechanism), responsible for the production of A-centers (N-N substitutional pairs) from isolated substitutional N; (2) an activation energy for creation of split-nitrogen-interstitial/vacancy pairs (essentially a modified Frenkel defect), responsible for the conversion of A-centers into {100} platelet defects plus B-centers (nitrogen-charge-compensated vacancies) and (3) an activation energy for production of split-carbon self-interstitials (Frenkel-defect mechanism), responsible for the eventual dissolution of platelet defects and conversion of all nitrogen to an equilibrium concentration of B-centers plus nitrogen gas in void-like defects. (Authors' abstract)

BURTON, J.C., LAWLER, J.P. and AYRES, D.E., 1985, Genesis of Carlin-type gold deposits (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 536. Authors at Geol. Res. Dept., Exxon Minerals Co., P.O. Box 2189, Houston, TX 77001.

Carlin-type deposits are large, disseminated, sediment-hosted gold ore bodies. They are of major economic interest to mining companies because they represent low-cost, bulk-mineable targets.

To develop a genetic model for the Carlin-type deposits, we have employed a multidisciplinary research program of ten Carlin-type deposits in Nevada and Utah. Studies included rock geochemistry, alteration mineralogy, fluid inclusions, oxygen isotopes, incremental Ar^{40}-Ar^{39} age dating, hydrothermal experiments on temperature-stability relationships of gold complexes, and physical properties of host rocks.

Our studies demonstrate that Carlin-type deposits are formed at initial temperatures of approximately 250°C by acidic (pH = 3.2 at ΣK = 0.5), reducing $aO_2 = 10^{-38}$), low salinity (1-3 equiv. wt.% NaCl), Tertiary, meteoric fluids. Gold is transported as a chloride complex and deposition occurs in response to destabilization of this complex with decreasing temperature. Temperature is the major parameter controlling ore deposition. Boiling or vapor separation is observed only in very late-stage minerals (post-Au mineralization) and is not the precipitating mechanism for gold.

The physical properties of the host environment place major constraints on ore formation in addition to temperature. Although many of the known Carlin-type deposits occur in carbonates, the chemistry of the host rock plays no major role in gold deposition. In the Carlin systems studied, high porosity host rocks are capped by structural or stratigraphic closures which trap the ore fluid. The deposits do not necessarily form near the surface, and models based solely on analogies to hot springs systems may be misleading. (Authors' abstract)

BUTLER, B.F., 1985, Tops of epithermal veins in the Axell district, Platoro Caldera, San Juan Mountains, southwestern Colorado (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 211. Author at Dept. Geol. Sci. (AJ-20), Univ. Washington, Seattle, WA 98195.

The Axell District lies on the southeastern margin of the Platoro Caldera, and is located two miles east of Platoro where modest production from Au- and Ag-bearing quartz veins occurred between 1889 and 1974.

District-wide fluid inclusion data indicate that mineralizing fluids were relatively cool (168°-254°C) and of low salinity. No cooling trend with elevation was observed along a single vein; however, fluid inclusion studies from outcrop samples show that temperatures decrease from west to east. Data support the interpretation that mineralization from Platoro eastward through the Axell District represents sequentially higher levels in similar epithermal systems. Thus, a precious metal ore zone may exist at depth. (From the author's abstract)

BYERS, C.D., GARCIA, M.O. and MUENOW, D.W., 1985, Volatiles in pillow rim glasses from Loihi and Kilauea volcanoes, Hawaii: Geochimica Cosmo. Acta, v. 49, p. 1887-1896. First author at Chem. Dept. & Hawaii Inst. of Geophys., Univ. Hawaii, Honolulu, HI 96822.

Volatiles and major elements in submarine glasses from Loihi seamount and Kilauea volcano, Hawaii, were analyzed by high temperature mass spectrometry and the electron microprobe. Loihi glasses are subdivided into three groups: tholeiitic, transitional and alkali basalts. The glasses are evolved: Mg numbers range from 48-58. The alkalic lavas are the most evolved.

Total volatiles range from 0.73 to 1.40 wt.%. H_2O shows a positive linear correlation with K_2O content [$H_2O = 0.83 (\pm .09) K_2O + 0.08 (\pm .06)$]. Concentrations of H_2O are higher in the alkalic lavas, but Cl and F abundances are highly variable. Variations in ratios of incompatible elements (K_2O, P_2O_5, H_2O) indicate that each group was derived from a distinct source. CO_2 contents range from 0.05 to 0.19 wt.% but show no systematic correlation with rock type or Mg #. A well-defined decrease in glass CO_2 content with increasing vesicularity is shown by the alkalic lavas. CO_2 may have been outgassed from the tholeiitic and transitional magmas prior to eruption during storage in a shallow magma chamber. Reduced carbon species (CO and CH_4) were found in small amounts in most of the alkalic samples. Although the redox histories of Hawaiian lavas are poorly known, these new data indicate the presence of a reduced source for Loihi magmas.

The Kilauea tholeiitic glasses are evolved (Mg # 48.3 to 55) and have higher H_2O contents (av. 0.54 wt.%) than Loihi tholeiites (av. 0.42 wt.%) at the same Mg # (~55). Cl is distinctly lower in Kilauea glasses (0.01 wt.%) compared to Loihi glasses (0.09 wt.%). The data indicate significant source differences for two volcanoes, consistent with results of other geochemical studies.

Loihi tholeiites have distinctly higher $^3He/^4He$ ratios than Kilauea tholeiites and are the highest measured in submarine basalts (Kurz et al., 1983). These high ratios have been used to invoke a primitive source of Loihi basalts. The high Cl content of these basalts, the highest we have ever measured in submarine basalts, may be a fingerprint of this primitive source, as previously noted for Icelandic basalts (Schilling et al., 1980). (Authors' abstract)

CANBY, V.McN. and EVATT, R.L., 1985, Geology, character, and controls of epithermal silver mineralization in the Carbonate Creek area, Kingston, New Mexico: New Mexico Bureau of Mines & Mineral Resources Cir. 199, p. 25-31. First author at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

The silver-gold deposits of the Carbonate Creek area are entirely within Paleozoic sedimentary rocks which have been extensively replaced by fine-grained silica (jasperoid) along a series of NW-tending faults prior to silver-gold mineralization. These faults are the major ore control in the area.

Silicification took place in three stages, with ore mineralization during the latest stage. In the first stage solutions flowed along the faults, jasperoidizing the wall rocks. The carbonate rocks which were in contact with the faults, were largely replaced, forming jasperoid bodies. In the second and third stages, reactivation of faults in the area brecciated the jasperoid zones. Solutions then flowed along the faults silicifying and mineralizing the breccia zones. The peculiar alteration that preceded, or coincided with, mineralization rendered limestone to a powdery, soft, calcite-clay mixture which, along with fault gouge, may have clogged faults where they traversed limestone, resulting in reduced permeability.

Ore minerals present are acanthite, ruby silver, and polybasite, with some native silver, native gold, chalcocite, and small amounts of azurite, malachite, and chlorargyrite. Gangue mineralization is mostly silica, with some calcite, limonite, hematite, and small amounts of manganese oxides, pyrite, fluorite, dickite, and adularia. (From the authors' abstract)

Thirty inclusions in second stage quartz had Th 220-231°C (mean 224°C), with salinity <1%. (E.R.)

CARLISLE, T.R. and HODGSON, G.W., 1985, The formation of natural-gas hydrates in sedimentary rock: Chem. Geol., v. 49, p. 371-383.

CARPENTER, A.B., 1985, Origin of Na-Ca-Cl brines in Jurassic and Cretaceous reservoirs of Gulf Coast (abst.): Am. Assoc. Petrol. Geol. Bull., v. 69, no. 2, p. 242. Author at Chevron Oil Field Res. Co., La Habra, CA.

Na-Ca-Cl brines in Jurassic and Cretaceous reservoirs in the Gulf Coast have been attributed to the diagenesis of concentrated Jurassic seawater related to Louann Salt deposition and alternatively to the diagenesis of brines produced by halite dissolution. These brines contain up to 35,000 mg/L Ca, up to 4,000 mg/L Mg, from 400 to 2,400 mg/L Br, and up to 13,000 mg/L K. Mutual relationships of Na, Cl, total divalent cations minus sulfate and bicarbonate, K, and Br are similar to those in seawater that has been evaporated past the initial stage of halite deposition, particularly when the K content of the brine exceeds 5,000 mg/L. The concentrations of divalent cations and K increase, and the mutual relationships of all the dissolved salts become increasingly similar to those in seawater with increasing proximity to bedded salt. The abundance of authigenic K-feldspar in rocks above the salt beds explains the relatively rapid decrease in the K content of the brines upsection. The Ca and K contents of Jurassic Gulf Coast brines are similar to those in Na-Ca-Cl brines in feldspar-poor carbonate sequences in other basins.

C.S. Land and D.R. Prezbindowski suggested in 1980 that the Na-Ca-Cl brines in the Edwards formation of Texas originated from halite dissolution and gained Br from halite recrystallization, Ca from the albitization of plagioclase, and K from the alteration of K-feldspar. Since the Br content of the brines is high and the Br content of halite is low (generally <100 ppm), Br would have to be stripped from an enormous volume of (impermeable) salt and transferred to a relatively small volume of fluid. Mass-balance calculations indicate that Br would have to be stripped from more than 7.5 km of salt to account for the bromide in the brines of the Mississippi salt basin. If Ca and K in Na-Ca-Cl brines are derived from feldspars, these elements should increase in concentration relative to chloride with increasing distance from the source of NaCl. This is the reverse of the field relations in Mississippi, where unaltered authigenic K-feldspar is present in rocks above the salt, and the K content of the brines decreases relative to Cl with increasing distance from the halite. Finally, it is now clear how 3 completely independent processes can operate to produce such an excellent match to the dissolved constituents of evaporated seawater over such a wide geographic area and in strata with varying amounts of feldspar. The simplest genetic model is that Gulf Coast Na-Ca-Cl brines formed from evaporated seawater and evolved to their present composition accompanying the processes of dolomitization and loss of sulfate. (Author's abstract)

CARPINTERO, L.S., 1985, The importance of inclusions in gemology: Bol. del Inst. Gemologico Español, v. 26, p. 41-49 (in Spanish).

A review. (E.R.)

CARROLL, M.R. and RUTHERFORD, M.J., 1985, Sulfide and sulfate saturation in hydrous silicate melts: Proc. of the 15th Lunar & Planet. Sci. Conf., Part 2: J. Geophys. Res., v. 90, Suppl., p. C601-612. Authors at Dept. Geol. Sci., Brown Univ.

Hydrothermal experiments have been conducted on a sulfur saturated dacitic melt over a range of pressure, temperature, oxygen fugacity, and melt FeO content in order to examine the effects of these variables on sulfur solubility in fractionated melts. Experiments done under both reducing (GCH, QFM buffers) and oxidizing (MNO, HM buffers) conditions indicate the solubility of sulfur increases with increasing total pressure (= fluid pressure) over the pressure range 100 to 300 MPa. GCH buffered experiments (1025°C) with 18 to 30 wt % FeO show sulfur solubilities at sulfide saturation ranging from 0.1 to 0.5 wt % S; increasing pressure from 100 to 200 MPa increases sulfur solubility by 500 to 1000 ppm, with the greatest increase observed in more FeO-rich melts. GCH buffered melts with <5 wt % FeO show no measurable change in sulfur solubility (300 ± 150 ppm S) between 100 and 200 MPa at 1025°C. QFM buffered experiments (1025°C) with 10.0 to 12.4 wt % FeO show sulfur solubility increasing from 600 to 1000 ppm between 100 and 200 MPa. QFM experiments with lower FeO contents (1 to 8 wt %) showed no measurable (± 200 ppm S) effect of temperature (912°C to 1025°C) or pressure (100 to 220 MPa) on sulfur solubility. Experiments done under oxidizing conditions of the HM and MNO buffers (1025°C) show sulfur solubilities in melts with 3 to 5 wt % FeO ranging from ~1400 ppm at 10 MPa to ~3000 ppm at 300 MPa. More importantly however, the change to more oxidizing conditions is accompanied by a change from sulfide (an FeS-rich melt) to sulfate (crystalline $CaSO_4$) saturated conditions. Stabilization of anhydrite as a magmatic phase (1025°C, 100 to 300 MPa) is also accompanied by a significant increase in sulfur solubility relative to saturation values for more reduced melts with similar FeO contents. The results of this study show that upper crustal oxidation-reduction and crystal fractionation processes may exert considerable influence on the amount of sulfur contained in magmas erupted at the surface. These results are of basic importance in understanding volatile transport and volcanic degassing processes on planets such as the Earth, Mars, and Venus. (Authors' abstract)

CARTER, J.S., 1985, The connection between gaseous hydrocarbons and lead-zinc mineralization: Ph.D. dissertation, Imperial College of Sci. & Tech., London.

CARUSO, Louis and SIMMONS, Gene, 1985, Uranium and microcracks in a 1,000-meter core, Redstone, New Hampshire: Contrib. Mineral. Petrol., v. 90, p. 1-17. Authors at Dept. Earth, Atmosp., & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

The spatial distribution and mineralogical association of uranium in a core were examined with fission track techniques, backscattered electron imaging, and energy dispersive X-ray spectrometry. From these observations, we conclude that an extensive set of fractures throughout a significant volume of the granites were the conduits through which hydrothermal fluids containing CO_2, uranium, and REs circulated. Microcracks facilitated fluid-rock interactions resulting in alteration and uranium redistribution. Certain primary uraniferous accessory minerals, i.e., allanite and ilmenorutile may have been the source for at least part of the uranium and REs that now occur in secondary minerals in these granites. (From the authors' abstract)

CARUSO, L.J. and SIMMONS, Gene, 1985, Uraniferous microcracks in granites (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 540. First author at Earth Atmospheric & Planet. Sci., MIT, Cambridge, MA 02139.

Uranium in a dozen granites occurs in two types of microcracks: Type I, transgranular and coincident grain boundary cracks, usually sealed with 1 or 2 minerals, width <15 μm, length <1 to several mm; Type II, multigrain cracks, sealed with 1 to several minerals, width >75 μm, length mm to several meters. Many Type IIs consist of networks of narrower subparallel microcracks.

The microcracks form a three dimensional network and are sealed with (1) uraniferous minerals (siderite, calcite, tengerite, bastneasite group, hematite, monazite, coffinite, manganite, autunite, zoisite) and (2) non-uraniferous minerals (quartz, clay, calcite, chlorite). Each granite has a distinct crack sealing mineral assemblage, probably a result of fluid and rock compositions, pressure, and temperature. The assemblages are relatively constant over distances of at least kilometers in individual granites.

We suggest that the processes that created open microcracks and subsequently sealed them were uniform for scales of kilometers. (Authors' abstract)

CATHELINEAU, M., 1985, Uranium veins in western France: Mineralogy and geochemistry of uranium deposition, in Applied Mineralogy, W.C. Park, et al., eds.: Proc. Second Int'l Congress on Applied Mineralogy, Los Angeles, CA, Feb. 1984, Metallurgical Society of AIME, p. 1083-1094. Author at Centre de Recherches sur la Geol. de l'Uranium, Vandoeuvre, 54500, France.

The hydrothermal uranium veins of the western part of France are spatially associated with syntectonic leucogranites of the variscan range, and their surrounding metamorphic rocks. The study of these deposits has been performed from the point of view of comparisons between solid phases, associated fluids, and ore forming processes, as a function of lithological and geochemical environment, and ages of the mineralizations.

The observed features of the mineralizations have not been produced by a single phenomenon but a very complicated polyphase genesis, which started with Devonian and Hercynian events (340 and 380 m.y.) and continue to the present, involving chemical and mechanical reworking of the primary ores to give new paragenesis.

Uranium dpeosition appears to be a result of complex reactions between fluids (temperature range of 150-400°C and a pressure of few hundred bars [from inclusion study]) and host rocks, which produce modifications of physical and chemical characteristics of the uraniferous solutions. (Author's abstract)

CATHELINEAU, Michel, CHAROY, Bernard, CUNEY, Michel, DUBESSY, Jean, LEROY, Jacques, NGUYEN-TRUNG, Chinh, POTY, Bernard, RAMBOZ, Claire and WEISBROD, Alain, 1985, Contrasting behavior at the hydrothermal stage of U and Sn-W in the west European and North African section of the Hercynian orogen: An interpretation using mineralogy and fluid inclusion chemistry, speciation and solubility data (abst.): Int'l. Meeting on Concentration Mechanisms of Uranium in Geological Environments, Nancy, France, 2-5 Oct., 1985, Program & Abst., p. 177-182. First author at Centre de Recherches Géol. de l'Uranium, BP 23, 54501 Vandoeuvre les Nancy, Cédex, France.

Involves inclusion data from the literature. (E.R.)

CATHELINEAU, M., CHAROY, B., CUNEY, M., DUBESSY, J., NGUYEN, C., POTY, B., RAMBOZ, C. and WEISBROD, A., 1985, Role of $f(O)_2$ and pH in the control of the spatial and temporal distribution of uranium, tin and tungsten mineralization associated with Hercynian leucogranites (abst.): Bull. Minéral., v. 108, p. 88 (in French).

U, Sn and W behave similarly under magnetic conditions, but are usually separated (as U or Sn+W) in hydrothermal deposits (e.g., in the Hercynides of Europe). The following chemical parameters distinguish U and Sn-W associations in systems between 300 and 500°C: 1. Oxidation state. In U deposits, Fe oxide and sulfide assemblages constrain $f(O_2)$ and $f(S_2)$ near the pyrite-hematite-magnetite triple point. In Sn-W deposits, CO_2-CH_4-N_2 fluid inclusions indicate $f(O_2)$ between Ni-NiO and QFM. 2. pH. In U deposits, feldspars are commonly stable, indicating neutral to moderately acid pH. In Sn-W deposits, feldspar is altered to muscovite (greisen) indicating acid pH. 3. Solubility. SnO_2, $CaWO_4$ and $FeWO_4$ have minimum solubilities at neutral pH, and solubility increases with T. The solubility of UO_2 decreases with increasing T and with decreasing $f(O_2)$ at acid-neutral pH.

Cooling around 400°C can deposit SnO_2 and tungstates but not UO_2. The low $f(O_2)$ of Sn-W fluids does not favor transport of U. U-complexes are unimportant at the low pH of Sn-W fluids. Below 350°C, U-complexes become more stable. U could be deposited from lower-T fluids from which most Sn and W had been deposited. (Abbreviated abstract by translator C. Eastoe)

CAVARRETTA, G., DE VIVO, B. and TECCE, F., 1985, Fluid inclusions in anhydrite from SH2 deep geothermal well, Sabatini volcanic complex, Latium, Italy (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 32-33. First author at C.N.R.-Centro di studio per la Geol. dell'Italia Centrale, Rome, Italy.

A fluid inclusion study has been carried out in newly formed minerals throughout the well in order to better understand the chemio-physical characteristics of the fluid at the time of trapping. (Bottom-hole depth was 2498.7 m with a temperature of 290°C and no evidence for exploitable hot fluids.) Among the several newly formed phases, only anhydrite and rare calcite crystals contained fluid inclusions; only anhydrite inclusions from eight different depth levels have been measured. Five different types of fluid inclusions have been recognized: A: mono-phase; B: two-phase L+V, L-rich; C: two-phase L+V V-rich; D: three-phase L+V+solid (either a solid inclusion or a dm or both); E: $CO_2(l)$+$CO_2(v)$+L(water). B and D are the most abundant. Inclusions occur mostly as isolated, single inclusions or in planar arrays usually parallel to crystal faces. S inclusions occur along healed fractures crossing the crystals. Most of them were too small for measurement.

360 inclusions have been run giving the following results: Te suggests the fluid is a Na-chloride solution with no evidence of other ions. Salinity from Tm-ice, ranged from 0-10.7 equiv. wt.% NaCl for P and from 0-6.3 for S. Most homogenized to liquid, and few cases of Th(vapor) could be measured. P Th(liquid) ranged from +135°-290°C (1300-2490 m depth) and showed a clear increase in T with depth. Values of Th for S inclusions Th(liquid) show a narrower range between +220°-260°C (1190-2410 m depth) with a small increase with depth. Evidences of coexisting L-rich and V-rich inclusions, with highly variable ratios, have been observed in samples from throughout the well, in both P and S inclusions, and no evidence for leakage or necking down processes, indicating boiling fluid at the time of trapping. The lowest Th can be then considered the T of trapping with no P correction needed. Th values for vapor-rich inclusions with Th(vapor) suggest that the V-rich inclusions trapped some liquid along with vapor.

Type D inclusions contain several varieties of crystals; most of them did not dissolve during the heating runs and they are believed to be solid inclusions.

CO_2-clathrate was recognized in samples from all the depths. Values of Tm-clathrate indicate that other gases (methane) must be present in the fluid in addition to CO_2. Evidence of heterogeneous trapping was also found through the use of the crushing technique.

The only evolution in the fluid seems to be the salinity. Comparing the in-hole T with Th, the first are somewhat higher than Th. In the interval between 2000 and 2300 m depth, Th seems to flatten, suggesting a possible convective fluid circulation at the time of trapping of the inclusions. No evidence of such circulation pattern seems to be present now. (From the authors' abstract)

CAVARRETTA, G., GIANELLI, G., SCANDIFFIO, G. and TECCE, F., 1985, Evolution of the Latera geothermal system II: Metamorphic, hydrothermal mineral assemblages and fluid chemistry: J. Volcanol. Geotherm. Res., v. 26, p. 337-364. First author at Centro di Studio per la Geol. dell'Italia Centrale, C.N.R., c/o Dipartimento di Sci. della Terra, Univ. degli Studi di Roma "La Sapienza," Rome, Italy.

Nine deep wells have been drilled within the Latera caldera and four of them have been productive. The geothermal reservoir is located within the fractured carbonatic rocks of the Tuscan nappe; the overlying volcanic units, sealed by hydrothermal minerals (mainly calcite and anhydrite), act as an impervious cover.

The fluid produced by the wells comes from a deep aquifer (about 1000-1500 m depth) which at present is not connected with the shallow aquifer in the volcanoclastic units. Fluid temperatures range between 200 and 230°C; in-hole temperatures as high as 343°C at 2775 m depth have been measured in dry wells.

The study of the newly formed mineral assemblages from both volcanic and sedimentary units as sampled from the geothermal wells can be used to reconstruct the thermal evolution of the geothermal field.

The newly formed mineral assemblages can be divided into three groups: (a) "contact-metasomatic:" calcite, anhydrite, diopsidic pyroxene, grossularitic garnet, phlogopite, wollastonite or monticellite; (b) "High-temperature hydrothermal:" calcite, anhydrite, K-feldspar, vesuvianite, melanitic garnet,tourmaline, amphibole, epidote, sulphides; (c) "low-temperature hydrothermal:" calcite, anhydrite, K-feldspar, clay minerals, sulphides. Group (a) minerals are now relics. Part of (b) and all of (c) group are still in equilibrium with the existing conditions in different parts of the geothermal system.

Thermodynamic calculations on the observed mineral assemblages permitted estimates on the P, T conditions and gas fugacities. (From the authors' abstract)

CHALOKWU, C.I., 1985, A geochemical, petrological, and compositional study of the Partridge River Intrusion, Duluth Complex, Minnesota: Doctoral dissertation, Miami Univ., Oxford, OH, 251 pp.

Indexed under fluid inclusions.

CHANG, Hailiang, 1985, A study on the melting inclusions in the porphyritic topaz phenocrysts of xianghualingite, Hunan Province: Bull. of Yichang Geol. Inst., no. 9, p. 30-39 (in Chinese; English abstract).

The xianghualingite is a new type of magmatic rock which is rich in rare elements, such as Nb, Ta, etc. Numerous melt inclusions have been found in the porphyritic topaz crystals. These have Th 860°C to 660°C and [formed] at a depth of at least 2.2 km, indicating that the topaz crystallized directly from magma. During this crystallization the melt may contain 3-6 wt.% water. The final crystallization temperature of xianghualingite ranges from 520°C to 480°C, at a depth of about 0.6 km.

There are many daughter minerals in the melt inclusions in topaz, including topaz, and some opaque ore minerals. It suggests that the xianghualingite melt is rich in ore-forming elements. Therefore, the Nb and Ta deposits in dikes must be of magmatic origin. (Author's abstract)

CHANGKAKOTI, A., GRAY, J. and MORTON, R.D., 1985, Stable isotope indicators of the hydrothermal fluid environments in the Great Bear Lake silver deposits, Northwest Territories, Canada: Neues Jahrb. Mineral., Monatsh., 1985, no. 9, p. 411-417.

Twenty samples of quartz and dolomite from the veins of the Great Bear Lake silver province in the Northwest Territories of Canada were analyzed for oxygen isotopes. Water extracted from fluid inclusions in five quartz and dolomite samples were analyzed for hydrogen isotopes. The $\delta^{18}O$ of the hydrothermal fluids, as calculated from the $\delta^{18}O$ values of quartz and dolomite and fluid inclusion temperature data, range from 5.6 to 10.0 per mil for depositional stages I, II and III, and from -1.5 to 4.2 per mil for stages IV and V. The results of the analyses suggest deposition of minerals from an initial magmatic fluid and the influence of a subsequent fluid which was probably a mixture of magmatic-, meteoric- or sea-water. (Authors' abstract)

CHAREF, Abdelkrim, 1985, The role of the diapir in the Pb-Zn deposit of Fej-el-Hadoum (Tunisia), as deduced from fluid inclusion studies (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 34. Author at Centre Rech. Pétrogr. & Géochim., B.P. 20, 54501 Vandoeuvre Cedex, France.

Fluid inclusions have been studied in calcite, quartz and celestine-barites from massive sulphide mineralzation and from one vein which is considered to be representative of stockwork mineralization.

Fluids in the celestine-barites from the contact zone with the diapir are the hottest (290° ⩾ T ⩾ 180°C) and most saline (⩾ 23 wt % equiv. NaCl). These fluids contain CO_2 and N_2. Fluid inclusions in calcites from the same massive sulphides are less hot (145° ⩾ T ⩾ 50°C) and less saline (23.5 to 13.5 wt % NaCl); they always contain at least one solid phase (probably dolomite) which does not dissolve at T ⩽ 350°C. These calcites also contain rare and very small CO_2-bearing inclusions ($Tm(CO_2) \sim -57$, $Th(CO_2) \sim +27°C$) and monophase aqueous inclusions with salinities between 13 and 5 wt % equiv. NaCl.

Fluid inclusions in vein calcites have Th 135°-50°C but the mode is lower than that for fluids in calcite from the massive sulphides. Salinities are between 18 and 13 wt % and a solid phase is rarely associated. S inclusions are aqueous monophase with salinities less than 13 wt %.

Bipyramidal quartz was found in all samples and was particularly abundant within sulphides from the massive sulphides, less abundant in the associated calcite and rare in the vein calcite. Inclusions in these quartz crystals are aqueous with 260° > Th > 120°C and the halite and sylvite dm dissolve at about 240°C. They are comparable to inclusions in Triassic minerals from certain diapirs in the region. The data as a whole show that the rise of the Fej-el-Hadoum diapir contributed to the formation of the surrounding mineralization. The mineralizing fluids could be of either deep or sedimentary basin origin mixed with another fluid which was probably cooler and less saline. The associated changes in the physicochemical conditions could have been responsible for the deposition of the sulphides. (Author's abstract)

CHAREF, Abdelkrim and SHEPPARD, S.M.F., 1985, The Malines (Gard) Zn-Pb deposit: Isotopic (D/H) evidence for a relationship between K(II) karstic and hydrothermal F mineralizations: C.R. Acad. Sc. Paris, v. 301, Ser. II, no. 1, 1985, p. 39-42 (in French; English abstract).

The mineralization K(II) fills geodes and fractures in the main karstic mineralization K(I). The hydrothermal F mineralization fills fractures in the Cambrian carbonates. The similarity of the D/H ratios of fluid inclusions in sphalerite and dolomite from the K(II) and F mineralization suggest that they were both formed from the same type of hot (~140°C) formation waters. These hydrothermal ores contribute about half of the total ore related to the Paleozoic unconformity. (Authors' abstract)

CHAYKIN, V.G., 1984, Endogene ore formations in the areas of activization of the East-European Platform: Sovetskaya Geologiya, no. 6, p. 79-92 (in Russian). Author at All-Union Sci.-Research Inst. of Geology of Non-Ore Deposits, Moscow, USSR.

In Donets mineralized zone, antimony-mercury formation, antimonite-cinnabar association, quartz yielded Th 200-150°C. (A.K.)

CHEILLETZ, A., GIULIANI, G. and MECHICHE, M., 1985, The stratiform banded tungsten lenses from Djebel Aouam (central Morocco): A skarn interpretation (abst.): Terra Cognita, v. 5, p. 294. Authors at CRPG, BP 20, 54501 Vandoeuvre-les-Nancy Cedex, France.

A new type of tungsten mineralization is described at the Djebel Aouam polymetallic (W-Pb-Zn-Ag) deposit. It consists of early stratiform banded lenses originated by metasomatic replacement of complex siluro devonian metapelitic sequences. The banded structure of the mineralized lenses comes from: 1) contact metamorphic recrystallization of schist-sandstone and sandstone-limestone sequences producing biotitic hornfelses and calc-silicate bands and 2) superimposed metasomatic recrystallization of the former assemblages due to fluid circulation producing Mg biotite-actinolite-scheelite lenses (average grade WO_3 : 4000 ppm) with zonal disposition. Phlogopite-scheelite-fluorite veins (average grade WO_3 : 1%) are spatially associated with the development of these lenses. Silicate-sulfides parageneses in the mineralized lenses and fluid inclusions measurement allow the determination of T (550-600°C), P (1.5-2 kb) and fO_2 (10^{-19}, 10^{-23} b) during the infiltration process. The small volume of the calc-silicate assemblages in the replaced metasedimentary sequences explains the dominant biotite-actinolite assemblage found in the metasomatic lenses. Their genesis and mineralization thus corresponds to the development of a Mg-rich and reduced skarn. (Authors' abstract)

CHEN, Anfu, 1985, Application of the MOLE Raman spectroscopy for analysis of individual phases in fluid inclusions of minerals: Yanshi Kuangwu Ji Ceshi, v. 4, no. 3, p. 231-237, 1 plate (in Chinese). Author at Beijing Inst. Uranium Ore Geol., Beijing, P.R.C.

The theoretical premises and method for determining the composition of fluid inclusions with MOLE Raman microprobe are described. Seven fluid inclusions are analyzed. The fluid inclusion in quartz from Danzhai Hg ore deposit has gaseous phase containing CO_2 42, N_2 37, and CH_4 21%. The liquid phase is mainly water, with a salinity 8 wt.%. The dms in the fluid inclusions are mainly calcite in fluorite from the mineralization stage of the U ore deposit in Guang-Dong province. The fluid inclusions in fluorite of the U ore deposit of Zhe-Jiang province contain CO_2 and H_2S. (C.A. 104: 71904z)

CHEN, Dianfen, LU, Jun, SUN, Shuqiong, LIN, Yuejing and CHEN, Keqiao, 1985, A preliminary study on berthierite, Chashan, Guangxi: Acta Mineral. Sinica, v. 5, no. 3, p. 208-215 (in Chinese; English abstract). Authors at Inst. Min. Deposits, Chinese Acad. Geol. Sci., Beijing, PRC.

Decrepitation temperatures for the deposit are 265-210, 203-187, 202-180 and 124-120°C. (From the authors' abstract)

CHEN, J.H. and WASSERBURG, G.J., 1985, U, Th and Pb isotopes in hydrothermal fluids from the Juan de Fuca Ridge (abst.): EOS, v. 66, no. 46, p. 929.

CHEN, Xianpei, GAO, Jiyuan, ZHANG, Guoxin and CHEN, Fu, 1985, Sedimentary geochemical characteristics of Devonian strata-bound polymetal deposits in South China: Scientia Sinica, Ser. B., v. 28, no. 1, p. 101-112. Authors at Guiyang Inst. Geochem., Acad. Sinica.

In the light of thermometric data on fluid inclusions from ores and gangue minerals and fossil thermometric data and organic matter, it indicated that most of the Devonian strata-bound deposits have undergone a thermal dynamic event at the temperatures over 200°-250°C. (From the authors' text)

CHERNOV, V.I., KAYZER, S.A., IVANCHUK, A.V., RAKHIMOV, A.T., LEVENKO, N.G., TYUGAY, O.M. and BURTUBAEV, A.T., 1984, Formational classification of near-ore metasomatites of the Verkhne-Kayrakta deposit: Sovetskaya Geologiya, no. 4, p.   (in Russian). First author at Kazakh Inst. Mineral Raw Materials.

Hornfelses of the scheelite-bearing stockwork formed between 450-550 and 600-700°C, P 10^8 Pa. Ores of Mo-W type formed at 340-260°C, pH 6.7-7.8, P 4 x 10^7 to 12 x 10^7 Pa. Wall-rock greisenization develops at 350-450°C, berezitization - below 350°C, quartz-feldspar metasomatism - above 450°C. (A.K.)

CHEYNET, B., 1985, Thermodynamic study of multicomponent solid-gas equilibria in magmatic systems (abst.): IAVCEI 1985 Scientific Assembly Abstracts, unpaginated (in French).

CHIBA, Hitoshi and SAKAI, Hitoshi, 1985, Oxygen isotope exchange rate between dissolved sulfate and water at hydrothermal temperatures: Geochimica Cosmo. Acta, v. 49, p. 993-1000. First author at Inst. Thermal Spring Reseach, Okayama Univ., Misasa, Tottori-ken, 682-02, Japan.

Oxygen isotope exchange rate between dissolved sulfate and water was experimentally determined at 100, 200, and 300°C. The isotope exchange rate is strongly dependent on temperature and pH of the solution. Combining the temperature and pH dependence of the reaction rate, the exchange reaction was estimated to be first-order with respect to sulfate. The logarithm of apparent rate constant of exchange reaction at a given temperature is a function of the pH calculated at the experimental temperatures. From the pH dependence of the apparent rate constant, it was deduced that the isotope exchange reaction between dissolved sulfate and water proceeds through collision between $H_2SO_4^0$ and H_2O at low H, and between HSO_4^- and H_2O at intermediate pH. The isotope exchange rate obtained indicates that oxygen isotope geothermometry utilizing the studied isotope exchange is suitable for temperature estimation of geothermal reservoirs. The extrapolated half-life of this reaction to oceanic temperature is about 10^9 years, implying that exchange between oceanic sulfate and water cannot control the oxygen isotope ratio of oceanic sulfates. (Authors' abstract)

CHICHUA, I.B., YAROSHEVICH, V.Z. and AREVADZE, D.V., 1985, Hydrocarbon inclusions in minerals and problems of oil and ore geology (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 176-177 (in Russian; translation by D.A. Brown). Authors at Caucasian Inst. Mineral Raw-Materials, Tbilisi, USSR.

Difficult problems in petroleum and ore geology especially include: the presence of hydrocarbon deposits in volcanogenic sequences and the existence of a medium-low-T reduction of sulfur-bearing complexes in hydrothermal mineral-forming systems.

These problems are discussed with reference to the Tbilisi region, where oil deposits are known in the middle Eocene volanogenic-sedimentary sequence, along with thermal H_2S waters, and hydrothermal veins of quartz-calcite-zeolite-anthracolite composition. The following kinds of inclusions have been found in quartz and calcite crystals (in order of frequency of occurrence): 1. Two-phase (liquid hydrocarbon + gas, with Th 100-70°C); 2. Three-phase (a) liquid hydrocarbons + gas + solid bitumens, and (b) liquid hydrocarbons + gas + aqueous solution; 3. Two-phase (aqueous solution + gas with Th 220-120°C); 4. Single-phase (a) liquid hydrocarbons, (b) aqueous solution. The fluid is primarily heterogeneous, as is indicated by the different ratios of hydrocarbon and aqueous phases in the inclusions, which do not homogenize during heating. Cryometric studies indicate a sulfate type of aqueous solution. Judging by the absence of $CaSO_4$ in the veins, the mineral content of the aqueous fluid was low. Thermal H_2S waters of similar composition, with free hydrocarbons, are widely distributed in the area. It is possible that the hydrocarbons serve as a reducing agent of HSO_4^- to H_2S.

The following model for the formation of such heterogeneous fluids is proposed: in percolating through potentially petroleum-bearing rocks and altering them hydrothermally, the fluid has opened up pores holding liquid hydrocarbons. In view of the low solubility of the latter, the fluid has remained heterogeneous. Once mineral deposition occurs, the drops of hydrocarbons have been absorbed on the mineral surfaces and have been captured in the form of inclusions. These same fluids, under favorable geotectonic conditions, could have contributed to the formation of the well-known oil deposits in the area.

Such a model will also help to explain the high buffering capacity of the hydrothermal, mineral-depositing systems with respect to their redox potential. (Authors' abstract)

CHINESE ACADEMY OF GEOLOGICAL SCIENCES, 1983, Annual report, Beijing, Geological Publ. House, 458 pp. (in Chinese and English).

Pages 175-458 consist of summaries of the work of the Academy, including that on inclusions. (E.R.)

CHOU, I.-M. and PHAN, L.D., 1985, Solubility relations in the system sodium chloride-ferrous chloride-water between 25 and 70°C at 1 atm: J. Chem. & Engrg. Data, p. 216-218. First author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

Solubility relations in the ternary system $NaCl-FeCl_2-H_2O$ have been determined by the visual polythermal method at 1 atm from 20 to 85°C along six composition lines. These six composition lines are defined by mixing $FeCl_2 \cdot 4H_2O$ with six aqueous NaCl solutions containing 5, 10, 11, 15, 20, and 25 wt % of NaCl, respectively. The solid phases encountered in these experiments were NaCl and $FeCl_2 \cdot 4H_2O$. The maximum uncertainties in these measurements are ±0.02 wt % NaCl and ±0.15°C. The data along each composition line were regressed to a smooth curve when only one solid phase was stable. When two solids were stable along a composition line, the data were regressed to two smooth curves, the intersection of which indicated the point where the two solids coexisted. The maximum deviation of the measured solubilities from the smoothed curves is 0.14 wt % $FeCl_2$. Isothermal solubilities of halite and $FeCl_2 \cdot 4H_2O$ were calculated from these smoothed curves at 25, 50, and 70°C. (Authors' abstract)

CHUPIN, V.P., 1985, Primary solidified and fluid inclusions in minerals of granitoids and pegmatites: diagnostics, peculiarities of investigations and results (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 50-51 (in Russian). Author at Inst. Geol. & Geophysics of Siberian Br. Acad. Sci. of USSR, Novosibirsk, USSR.

Quartz is the most suitable mineral in granitoids and their pegmatites for studies of inclusions. The inclusions are completely crystallized (quartz + feldspars ± micas + H_2O ± CO_2, volatiles usually of high density), their size ranges from sub-micrometer to 10-20 μm. Presence of "anomalous" inclusions and S ones causes serious troubles in diagnostics of normal P melt inclusions. Melt inclusions were found also in leucosomes of migmatites, rapakivi granites, rhythmically banded granitoids and outer zones of pegmatites. Th of melt inclusions varies from >1000° to 560°C, depending mostly on H_2O content in melt (up to 8-10 wt.%). Also melts formed during anatexis have various T depending on H_2O and CO_2 content and their ratio. Remnant granitoid melts rich in volatiles either form pegmatites or separate intrusive phases in polyphase intrusions; appropriate melt inclusions have Th from 700 to 560°C. Low-T inclusions in quartz from rapakivi of the Vyborg massif (Th ~600°C) bear K-spar (prevailing), quartz, muscovite and almost pure albite (analysis by ion microprobe). This confirms the possibility of crystallization of muscovite and albite from low-T melts. (A.K.)

CHURNET, H.G., 1985, Fluid inclusion evidence for fluid mixing, Mascot-Jefferson City zinc district, Tennessee - a discussion: Econ. Geol., v. 80, p. 1440-1442. Author at Univ. Tennessee at Chattanooga, Chattanooga, TN 37403.

A discussion of Taylor et al., 1983 (Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 262). See reply by Taylor et al. (this volume). (E.R.)

CIRLIN, E.-H., TAYLOR, L.A. and LOFGREN, G.E., 1985, Fe/Mg K_D for olivine/liquid in chondrules: Effects of cooling rate (abst.): Lunar & Planet. Sci., v. 16, p. 133-134.

CLAYPOOL, G.E. and THRELKELD, C.N., 1985, Methane hydrate in slope sediments on west coast of Central America (abst.): AAPG Bull., v. 69, no. 2, p. 245.

Includes determinations of $\delta^{13}C$ of methane and associated HCO_3 (-40 vs +35 per mil, respectively) suggesting bacterial reduction of CO_2 to CH_4. (E.R.)

CLAYPOOL, G.E., THRELKELD, C.N., MANKIEWICZ, P.N., ARTHUR, M.A. and ANDERSON, T.F., 1985, Isotopic composition of interstitial fluids and origin of methane in slope sediments of the Middle America Trench, Deep Sea Drilling Project Leg 84, in Orlofsky, S., ed., Initial Reports of the Deep Sea Drilling Project, v. 84, U.S. Govt. Printing Office, p. 683-691. First author at U.S. Geol. Survey, Denver, CO.

CH_4 and CO_2 species in pore fluids from slope sediments off Guatemala show extreme ^{13}C-enrichment (δ^{13}C of -41 and +38‰, respectively) compared with the typical degree of ^{13}C-enrichment in pore fluids of DSDP sediments (δ^{13}C of -60 and +10‰). These unusual isotopic compositions are believed to result from microbial decomposition of organic matter, and possibly from additional isotopic fractionation associated with the formation of gas hydrates. In addition to the isotopic fractionation displayed by CH_4 and CO_2, the pore water exhibits a systematic increase in δ^{18}O with decrease in chlorinity. As against seawater δ^{18}O values of 0 and chlorinity of 19‰, the water collected from decomposed gas hydrate from Hole 570 had a δ^{18}O of +3.0‰ and chlorinity of 9.5‰. The isotopic compositions of pore-fluid constituents change gradually with depth in Hole 568 and discontinuously with depth in Hole 570. (Authors' abstract)

CLEMMEY, H., 1985, Sedimentary ore deposits, in Sedimentology; Recent developments and applied aspects, P.J. Brenchley and B.P.J. Williams, eds.: Blackwell Sci. Publications, p. 229-247.

A review of current concepts of the processes involved, including much on the nature and movements of interstratal fluids. (E.R.)

CLEVER, H.L., JOHNSON, S.A. and DERRICK, M.E., 1985, The solubility of mercury and some sparingly soluble mercury salts in water and aqueous electrolyte solutions: J. Phys. Chem. Ref. Data, v. 14, no. 3, p. 631-680.

CLIFFORD, Tom and KLATT, Ekkehard, 1985, The fluid content in the O'okiep copper deposits, Namaqualand, South Africa: Abstracts of oral presentations, 13th Colloquium of African Geology held at the Univ. of St. Andrews, Sept. 1985 (unpaginated).

The O'okiep copper district consists of over 1500 bodies of intrusive rock (Koperberg Suite) that are probably a result of progressive partial melting of a heterogeneous source of overall tholeiitic composition at a depth >25 km in the Earth's crust 1.1 b.y. ago.

First results on the characteristics of H_2O^-, CO_2-N_2-, H_2O-CO_2-, and N_2-inclusions in quartz and garnet of the Koperberg Suite and the surrounding country rocks are as follows:

The country rocks have many, up to ~20 µm, with salinity between 0 and 5 mol % NaCl equiv. They also have CO_2-N_2-inclusions with high- to medium density (0.90 to 0.73 g/cm^3).

The Koperberg Suite rocks have only few S inclusions (1-6 µm), with high salinity (14-23 mol % NaCl equiv.) and up to 3 salt crystals per inclusion. The CO_2-N_2-inclusions rearranged at cracks have a low degree of filling (0.6 to 0.2 g/cm^3). Ore dms occur in inclusions. Some quartz crystals contain oriented rutile needles.

There is a general trend of decreasing CO_2 densities with depth from surface outcrop: 0.90 g/cm^3 to 0.73 g/cm^3 at 1470' level (country rocks), and surface outcrop: 0.6 g/cm^3 to 0.2 g/cm^3 at 2640' level in the Koperberg Suite. Laser-Raman-microspectroscopy showed the presence of almost pure N_2 inclusions and CO_2-N_2 inclusions with 0 to 7 mol % N_2. (Authors' abstract)

CLOCCHIATTI, R. and MASSARE, D., 1985, Experimental crystal growth in glass inclusions: the possibilities and limits of the method: Contrib. Mineral. Petrol., v. 89, p. 193-204. Authors at Groupe des Sci. de la Terre, Lab. Pierre Süe, C.E.N. Saclay, 91191 Gif-sur-Yvette Cedex, France.

Glass inclusions trapped in bytownite phenocrysts (from the Ardoukoba eruption, Djibouti Republic, 7 November 1978) are used as an experimental environment to follow the evolution of crystallization and residual liquids in a magma with tholeiitic affinities. The results are compared with those obtained from abyssal tholeiites by Walker et al. (1979). In near equilibrium crystallization conditions, simultaneous crystallization of olivine and pyroxene is obtained in the enclosed silicate liquid as well as plagioclase as overgrowths on the cavity walls. Oxides only appear at lower temperatures. The olivine is homogeneous and rather rare (⩽ 5% in weight). It forms at a temperature between 1,186°C ± 3(Fo85) and 1,126°C(Fo66). The distribution coefficient of Mg between the liquid and the olivine varies regularly with the temperature until titanomagnetite appears. The augite is much more abundant (>20% in weight of the original trapped melt) and is characterized by a composition that varies from the center to the edges of the crystals Wo 43.5-36.2, En 43.8-41.7, Fs 12.7-22.1. Composition shows an unsatisfactory correlation with temperature and, at most, an Fs enrichment may be noted with temperature decrease. The composition of the plagioclase deposited on the cavity walls varies linearly with temperature from An 73.3 at 1,186°C to An 56.5 at 1,135°C in the case of contemporaneous crystallization of Pl, Cpx, Ol and Ox. If experiments are carried out by undercooling (as much as 150°C) in relation to crystallization of the ferromagnesian minerals, the composition of the plagioclase changes from An 78.8 at 1,160°C to An 52.8 at 1,025°C. In the case of the Pl, Ol, Cpx and +Ox crystallization, the included liquids evolve from tholeiitic basalts to ferrobasalts in the same way as the lavas studied in the Asal rift (Demange et al. 1980). The advantages and limitations of the method are discussed. (Authors' abstract)

CLOCCHIATTI, R. and METRICH, N., 1985, Reinjection and mineralogical disequilibrium in magmas from Mt. Etna: The Monte Frumento delle Concazze eruption (abst.): IAVCEI 1985 Scientific Assembly Abstracts, unpaginated (in French). Authors at Lab. Pierre Sue, CEN Saclay, 91191 Gif-sur-Yvette, France.

Mt. Frumento, situated on the NE side of the Etna, is a scoria cone (2150 m) ascribed to volcanic activity before the Roman period. The scoriae have been interpreted as the equivalents of basic aphyric lavas (1974 flow, Mt. Leporello, Nespole, Mezza Luna, Maletto) characteristic of eccentric eruptions, which (at least at superficial levels) are independent of the central feeder system. The Mt. Frumento products have a basaltic composition (MgO ⩾ 8%, K_2O/Na_2O = 0.48, Cr = 400 ppm, Ni ⩾ 100 ppm). Textural and mineralogical study of the volcanic bombs show - at the scale of a thin section - intimate mixing of two liquids characterized by two distinct mineral assemblages. The first assemblage consists of augite phenocrysts (Wo44.2-45.4 Fs15.7-11.4), olivine (Fo72-78), plagioclase and iron-titanium oxides which all show reversed zoning and partial resorption. Glass inclusions in millimeter-sized crystals from the same deposit show evidence of superheating and sometimes decrepitation. Superheating has led to enrichment of the liquids, trapped in the augites, in Ca and Mg (dissolution of the pyroxene host), and in Fe and Ti (partial fusion of titanomagnetites), and to major fluctuation in the K_2O/Na_2O ratios (0.6 to 1.7) which cannot be explained by the sole crystallization of plagioclase. Following this period of thermal disequilibrium, olivine (Fo88) and Mg-rich pyroxene (Wo45 Fs7) crystallized. The second assemblage consists of spinel-bearing olivine and diopside (Wo44.2 Fs6.4-7.6), and belongs to the intruding basaltic magma. Glass inclusions in these minerals are the most Mg-rich (5.6% MgO) and show no evidence of superheating. The K_2O/Na_2O ratios of these inclusions remain low (0.36-0.40) and constant, which excludes the crystallization of plagioclase. The assemblage olivine (Fo82)-diopside is interpreted as the result of early-stage fractionation in the case of the Mt. Silvestri and Mt. Rossi pyroclastics, as well as in the case of the present-day lavas of the Etna. In these formations they occur in very small amounts and mostly as relicts in the cores of more evolved crystals. Differentiation of the present-day magmas of the Etna is discussed in a geodynamic context. (Authors' abstract; translated by R. Kreulen)

CLOKE, P.L, QUAN, R., KESLER, S.E. AND DUNAWAY, J.H., 1985, Effect of $CaCl_2$ and $FeCl_2$ on phase relations for the halite trend (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 549. First author at ONWI, Batelle Mem. Inst., 505 King Ave., Columbus OH 43201.

To evaluate the possibility that highly saline (halite trend) fluid inclusions in porphyry Cu and skarn deposits were not formed by halite subtraction, we have measured the bulk compositions of halite trend inclusions at the Granisle, B.C., porphyry copper desposit and have determined preliminary phase relations in the $NaCl-KCl-CaCl_2-H_2O$ & $NaCl-KCl-FeCl_2-H_2O$ systems. Bulk compositions for the Granisle inclusions were determined by SEM analyses of opened inclusions and of residues of decrepitated inclusions, supplemented by phase volume, gas chromatographic and leachate analyses.

Identifications of nick points on p-t and $p-x(H_2O)$ plots, reversed, have indicated the general position of the halite-sylvite cotectic in the $NaCl-KCl-CaCl_2-H_2O$ system at t>100C. Synthetic fluid inclusions provided preliminary data on the halite-sylvite cotectic in the $NaCl-KCl-FeCl_2-H_2O$ system. At t>ca. 200C hematite or magnetite formed suggesting: a) generation of H_2 and HCl in expts., and b) presence of "free" HCl in natural inclusions high in Fe. These data show that $CaCl_2$ and $FeCl_2$ affect phase relations in the same way, as has been demonstrated previously. Using this parallelism we estimate from halite and sylvite disappearance temperatures and multidimensional regressional analyses from the analytical data that, as projected to zero H_2O, the trend projects within the uncertainty to nearly pure NaCl and no $CaCl_2$ or $FeCl_2$. These results are entirely compatible with the previously proposed subtraction of halite mechanism. (Authors' abstract)

COHEN-ADAD, Roger, 1985, The choice of fitting equations in critical evaluation of solubility data in binary mixtures $MCl-H_2O$: Pure & Appl. Chem., v. 57, no. 2, p. 255-262. Author at Univ. Lyon I, Lab. Physico-chimie Min. 2, L.A. CNRS No. 116, 69622 Villeurbanne, France.

A methodical approach to the critical evaluation of solubility, vapor pressure and density data of saturated solutions is proposed. If appropriate fitting equations are chosen, this approach allows the extrapolation of solubility, vapor pressure and density curves and the deduction of such missing data as phase change enthalpies, heat capacities, metastable equilibria, double saturation points, etc. The choice is difficult, since fitting equations must obey several conditions, and assumptions must be made concerning the interactions between solvent and solute and their variation with concentration and temperature. Some examples of critical evaluations are examined for binary systems $MCl-H_2O$. (Author's abstract)

COLBECK, S.C., 1985, Temperature dependence of the equilibrium form of ice: J. Crys. Growth, v. 72, p. 726-732. Author at U.S. Army Cold Regions Res. & Engrg. Lab., Hanover, NH 03755, USA.

Individual crystals are grown [from vapor] under controlled conditions at temperatures between -0.6 and -20°C at rates as low as 10^{-4} g/year and supersaturations as low as 6.5×10^{-7}. The transition between the kinetic growth form and the equilibrium form is clearly distinguished at temperatures between -2 and -10°C where the equilibrium form is a well-rounded plate with an aspect ratio of about 2.5. At temperatures below -11°C the equilibrium form is a hexagonal prism of about the same aspect ratio. This transition coincides with the rapid increase in surface roughening on the prism faces at temperatures above -10°C. The equilibrium form is a fully rounded particle just below 0°C although we had expected the fully rounded particle to pervail down to at least -5°C. Furthermore, there are unresolved differences between these experimental results and observations of crystals from the seasonal snow cover where particles are fully rounded at slow growth rates and low temperatures. (Author's abstract)

COLLIER, J.D., 1985, Geology and uranium mineralization of the Florida Mountain area, Needle Mountains, southwestern Colorado: U.S. Geol. Survey Open File Rpt. 84-336, 88 pp. Author at Dept. Geol., Ft. Lewis College, Durango, CO 81301.

[From fluid inclusion studies it is concluded that] pitchblende was deposited from oxidizing, paragenetically early fluids at approximately 300°C. Later fluids were more reducing; a sulfide-dominant stage precipitated at about 250°C. Pitchblende-depositing fluids were rich in CO_2 and either boiled or effervesced CO_2. Uranium was precipitated as a result of increase in pH and/or reduction produced by boiling or effervescence. Uranium is believed to have been transported as the complex $UO_2F_3^-$. (From the author's abstract)

COLLIN, E., CLARKE, W. and GLEW, D.N., 1985, Evaluation of the thermodynamic functions for aqueous sodium chloride from equilibrium and calorimetric measurements below 154°C: J. Phys. Chem. Ref. Data, v. 14, no. 2, p. 489-610. Authors at Corp. Res. & Dev., Dow Chem. Canada Inc., Sarnia, Ontario, Canada N7T 7K7.

Tables are given for freezing point, solubility, boiling point, osmotic and activity coefficients, vapor pressure, apparent molal relative enthalpy, partial molal relative enthalpies, integral heat of solution, specific heat, apparent molal heat capacity, partial molal heat capacities, apparent molal relative heat capacity, partial molal relative heat capacities, standard thermodynamic functions, and their changes for dissolution. (From the authors' abstract)

COLLINS, C.J. and STRONG, D.F., 1985, The behavior of fluorine in magmatic systems: A case study of Canada's largest fluorspar deposit (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 66-71. Authors at Dept. Earth Sci., Memorial Univ. of Newfoundland, St. John's, Newfoundland, A1B 3X5.

Fluid inclusions in fluorite from veins in the St. Lawrence area, Newfoundland, showed 5-15 wt.% NaCl equiv. and Th 80-500°C, with boiling between 223 and 450°C. TE geochemistry of zoned fluorites was compared with Th and Tm values. (E.R.)

COLUCCI, M.T., FERGUSON, K.M., HARMON, R.S. and DUNGAN, M.A., 1985, Hydrogen isotope relationships in oceanic basaltic glasses (abst): Geol. Soc. Am. Abst. with Programs, v. 17, p. 349. Authors at Dept. Geol. Sci., Southern Methodist Univ., Dallas, TX 75275.

A step-heating procedure has been developed which permits the indigenous water in oceanic basaltic glasses to be distinguished from that introduced by secondary alteration. Most, if not all, apparently 'fresh' glasses contain small amounts of seawater-derived hydrogen that has diffused into the glass. This water is not totally removed by standard pretreatment (outgassing) techniques and the failure to do so may result in δD (SMOW) values which are erroneous by up to ±10‰ .

This technique has been applied to several apparently 'fresh' basaltic glasses each from the Mid-Atlantic Ridge, the Mid-Cayman Rise, the Juan de Fuca Ridge, and the East Pacific Rise. D/H ratios and water contents were observed to vary from -75 to -41‰ and 0.13 to 0.622 wt.% respectively. Our results combined with existing data in the literature substantiate the conclusions of Kyser et al. (GCA, 48: 2123-2133, 1984) that the outgassing of volatile phases and high-temperature contamination by seawater have affected the parent magmas (δD = -80 ± 5‰; wt.% H_2O ≈ 0.12 - 0.3) from which the submarine lavas were derived. We observe a significant positive correlation between ridge spreading rate and both D/H ratio and H_2O content and their variations which is attributed to the contamination of magma chambers beneath fast-spreading ridges by the stoping of roof rocks whose H-isotope composition and water contents have been modified by seawater hydrothermal alteration. (Authors' abstract)

COMBREDET, Nicole, 1985, Fluid inclusions and geothermal systems: Relations between ebullition and production of dry steam: C.R. Acad. Sci. Paris, v. 301, Ser. II, no. 9, p. 593-598 (in French; English abstract).

Two distinct wells (A1 and A17) of the geothermal field of Los Azufres (Mexico) have been selected to test different thermometric techniques. The description of the hydrothermal mineral paragenesis allows us to conclude that the geothermal conditions are situated here at the limit of the albite-zeolite facies and of the greenschist facies. The precision brought by the thermometric study of the fluid inclusions (Th and Tm) are very well corroborated by the data furnished by the chemical couples and by the oxygen isotopes. The characteristics of the fluid inclusions observed under microscope with heating plate let us recognize a well supplied by hot waters and cooling (A1) from a well supplied by dry steam and thus highly productive (A17). The technique of microthermometry, easily transportable on the field, seems to be quite suitable to the following of geothermal drilling. (Author's abstract)

CONSTANTOPOULOS, J.T., 1985, Fluid inclusions and geochemistry of fluorite from the Challis quadrangle, Idaho (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 214. Author at Dept. Geol., Univ. Idaho, Moscow, ID 83843.

Epigenetic fluorite mineralization associated with Tertiary igneous activity occurs in a northeast-trending belt within the Challis quadrangle. Microthermometric measurements on 372 two-phase, water-rich inclusions with low vapor:water ratios indicate homogenization temperatures of 160°C for Meyers Cove samples, 150°C for the Stanley district, and 130°C for the Bayhorse and Yankee Fork districts. The presence of metastable superheated ice and the failure of the vapor phase to renucleate were common problems, especially with fluid inclusions from the Bayhorse and Yankee Fork districts. Salinities are very low for all districts with a maximum of 1.4 weight percent NaCl equivalent. Deposition occurred by fluid mixing and a change in pH. (From the author's abstract)

CONWAY, B.E., 1985, Local changes of solubility induced by electrolytes: salting-out and ionic hydration: Pure & Appl. Chem., v. 57, no. 2, p. 263-272.

COOL, C.A., 1985, Effects of boiling and CO_2 volatilization on the chemical composition of hydrothermal aquifers and hot springs of the Idaho batholith, central Idaho (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 214.

CORTECCI, G., LATTANZI, P. and TANELLI, G., 1985, C- and O-isotope and fluid inclusion studies of carbonates from pyrite and polymetallic ore deposits and associated country rocks (southern Tuscany, Italy): Chem. Geol. (Isotope Geosci. Sec.), v. 58, p. 121-128. First author at Dipt. di Sci. della Terra, Univ. di Pisa, I-56100 Pisa, Italy.

A total of 42 C- and O-isotopic analyses on 35 samples of carbonates from pyrite and polymetallic deposits of southern Tuscany and associated country rocks are presented. Hydrothermal calcites and dolomites in the ore deposits show a wide range of isotopic compositions, which probably accounts for multiple sources of carbon and oxygen. Calculated isotopic compositions for C-O-H species in equilibrium with calcites are similar to those measured in present-day geothermal fluids of the nearby Larderello-Travale field, suggesting a common link for all late- to post-Apenninic hydrothermal manifestations in the area. The isotopic compositions of country rocks range from typical marine values to lower values, the isotopic depletion likely accounting for metamorphic and hydrothermal effects related to the Mio-Pliocene Appenninic event. In contrast, 10 samples of similar rocks from non-mineralized areas of northern Tuscany show no isotopic evidence of metamorphic and hydrothermal alteration. Data from fluid inclusions [see Cortecci et al., 1983, Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 53-54] indicate important relationships between calcite-forming fluids and sphalerite-forming fluids in the ore deposits here studied. (Authors' abstract)

CORTECCI, Gianni, LATTANZI, Pierfranco and TANELLI, Giuseppe, 1985, Barite-iron oxide-pyrite deposits from Apuane Alps (northern Tuscany, Italy): Geologica Carpathica, v. 36, no. 3, p. 347-357. First author at Dipart. Sci. della Terra, Univ. Pisa, I-56 100 Pisa, Italy.

Reconnaissance S-isotopic and fluid inclusion data are: $\delta^{34}S$ (sulphides) = -29.9 to +18.9 per mil; $\delta^{34}S$ (barite) = +6.5 to +30.8 per mille; Th of fluid inclusions in quartz and barite = 190° to 250°C, with salinities of about 10% wt. NaCl equivalent.

The deposits, as many others in the Apuane Alps, were previously considered to be formed from hydrothermal fluids related to hypothetical early- to synkinematic granitic intrusions during the Tertiary Apenninic orogeny. We suggest, on the contrary, that they had a Middle Triassic sedimentary-diagenetic origin, followed by tectonization, metamorphism and partial remobilization during the Apenninic orogeny. (From the authors' abstract)

CORTINI, Massimo, LIMA, Annamaria and DE VIVO, Benedetto, 1985, Trapping temperatures of melt inclusions from ejected Vesuvian mafic xenoliths: J. Volcanol. Geotherm. Res., v. 26, p. 167-172. First author at Dipartimento Sci. della Terra, Largo S. Marcellino 10, 80138 Naples, Italy.

Th for melt inclusions in clinopyroxene, olivine, spinel and mica ranges from 850 to 1240°C. CO_2 inclusions in pyroxene, olivine, spinel, and apatite show a bimodal range of densities of ~0.35 and 0.6, with a very few near critical and a group at 0.7. Authors suggest that these ejecta underwent multistage crystallization at depths of ~4 and 9 km. (E.R.)

COVENEY, R.M., Jr. and GOEBEL, E.D., 1985, Fluid inclusions in Midcontinent country rocks (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 154-154. Authors at Dept. Geosci., Univ. Missouri, Kansas City, MO 64110.

Within and outside of Midcontinent mining districts, sphalerite, calcite and dolomite contain inclusions of aqueous brines (≥15 wt% equiv. NaCl) and hydrocarbon fluids. Most inclusions homogenize at 80-110°C, recording the presence of warm fluids in the U.S. craton at some time in the past. Most likely, only a thin layer of sediments (≤1/2 km) ever covered most of the strata containing the inclusions. Hence the measured temperatures are too hot to be explained solely on the basis of burial depths--at least not with normal geothermal gradients.

There are indications that some inclusions may contain brines expelled from nearby basins such as the Arkoma-Ouachita Trough (Rowan, et al., 1984, GSA Abs). However, because the ages of most inclusions are unknown, it may be premature to conclude that all stem from a single event. Other feasible explanations exist for the measured temperatures: for example, passage of the Midcontinent over a mantle hot spot during or subsequent to the L. Paleozoic. In addition, Hanor (1980, Econ. Geol.) suggests that generation of gases from organic matter trapped in fluid inclusions may lead to anomalously high filling temperatures and consequently to erroneous conclusions about thermal histories. From crushing stage runs we have found compressed gases in some inclusions. If these gases were generated after the entrapment of the fluids, estimated temperatures of formation may have to be adjusted downward in some cases. Regardless of these ambiguities, fluid inclusions are useful to petroleum geologists as well as the students of ore deposits, although clearly they provide no panacea and must be examined critically. (Authors' abstract)

COX, D.P., 1985, Geology of the Tanamá and Helecho porphyry copper deposits and vicinity, Puerto Rico: USGS Prof. Paper 1327, 59 pp.

Th of vapor bubbles and dissolution of crystalline phases in fluid inclusions within quartz veins from Tanamá mainly range from 200 to 500°C; some mineral- and vapor-rich inclusions in the interior of the deposit have Th >500°C. Crystalline phases in inclusions are, in order of abundance: NaCl, Fe chloride, KCl, complex Na-K-Fe-Ca chlorides, hematite, and chalcopyrite. Oxygen-deuterium analyses of amphibole, chlorite, and white micas suggest equilibrium with meteoric or ocean water. The Helecho copper deposit is similar to the Tanamá deposit [and both] were probably formed by introduction of volatile minerals - mainly H_2O and H_2S - and metal-chloride complexes from some deep source into a fractured porphyry intrusion. Potassium was also introduced from depth, as indicated by the low initial K_2O content of intrusive rocks and wallrocks. This K_2O was fixed as biotite in an early-formed potassic-alteration zone surrounding a core zone in which hydrothermal amphiboles were dominant. Within this potassic-alteration zone, the copper-gold ore bodies were deposited from chloride solutions. Meteoric or marine water entered the system through fractures and caused widespread nearly complete replacement of amphiboles and biotite by chlorite. This replacement released K^+ and H^+ and caused extensive plagioclase destruction and sericitization in the upper parts of the system. Also in these upper levels, pyrite replaced magnetite as the temperature and oxygen activity decreased. The copper-gold ore body was not affected by these changes, but Pb, Zn, and Mn were expelled from the upper levels of the deposits during the sericite-pyrite-alteration stage. (From the author's abstract)

COX, K.R. and MOORE, M.A., 1985, Effects of temperature and pressure on multiphase equilibria containing aqueous electrolytes: Fluid Phase

Equilibria, v. 24, p. 151-164. Authors at Shell Dev. Co., Westhollow Res. Center, P.O. Box 1380, Houston, TX, USA.

For applications involving dense CO_2 in equilibrium with aqueous salt solutions, a unified description of multiphase equilibria including precipitation of solid phases is often required. The model described uses a reference substance approach to provide a compact representation of the effects of temperature, pressure, and ionic strength. (Authors' abstract)

COZAR, J.S., 1984, Enstatite "Ojo de Gato" in the olivine of Lanzarote island: Bol. Del Inst. Gemologico Español, v. 24, p. 30-50 (in Spanish; English abstract).

Studies were made of the composition of gem quality olivines from Lanzarote, as well as of inclusions in this material, making use of chemical analysis techniques, X-ray diffraction and optical microscopy.

One of these inclusions, of macro size, has been identified as enstatite. [It also has] the peculiarity of showing a marked "cat's eye" effect, so it has a certain gemological interest. (From the author's abstract)

CRAMPIN, S., 1985, Stress-aligned liquid-filled microcracks throughout the Earth's crust (abst.): NERC 3rd Deep Geology Workshop Programme and Absts., Univ. Durham, 3-4 Jan., 1985 (unpaginated).

CRAMPIN, Stuart and ATKINSON, B.K., 1985, Microcracks in the Earth's crust: First Break, v. 3, no. 3, p. 16-20.

CRERAR, David, WOOD, Scott, BRANTLEY, Susan and BOCARSLY, Andrew, 1985, Chemical controls on solubility of ore-forming minerals in hydrothermal solutions: The Can. Mineralogist, v. 23, p. 333-352. First author at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544, USA.

The transport, deposition and zoning of hydrothermal ores are controlled by three main factors: the crystal chemistry and stability of the mineral phase, the physicochemical properties of aqueous electrolyte solutions at high T and P, and the thermodynamic and molecular properties of aqueous species of metals. Recent solubility and spectroscopic data permit the following generalizations on the chemistry of transition-metal complexes at elevated temperatures. Bonding changes from primarily ionic to covalent from left to right across each transition row. The d^{10} transition-metals behave more as Pearson soft acids, preferentially complexing with soft bases (electron donors) such as HS^-, whereas metals to the left show increasing "hardness," bonding to moderately soft electron-donors such as Cl^-. The Pearson rule successfully describes speciation to about 250°C, but breaks down at higher T as all metals become harder, and electrostatic interaction increases. Recently recognized relativistic effects predict increased tendency toward covalent bonding down each vertical group of elements; this in part explains the preference of Au and Hg for HS^- complexes and may also explain the apparent differences in speciation between Sb and Bi. Ligation numbers decrease with temperature, and neutral complexes like $FeCl_2^0$ predominate above roughly 300°C. This can be attributed to some or all of the following changes at higher temperatures: decreasing dielectric constant of water, descent from octahedral to tetrahedral complex coordination, pronounced decrease in activity coefficients of anionic ligands, and increasing importance of hydrolysis. Increased solubility of ore minerals at higher temperatures can be attributed to some of the above effects; an equally important explanation is the temperature dependence of oxygen and sulfur fugacities and of pH buffering capacity. The buffer capacity also depends on solute composition and may help explain the rapid precipitation of minerals in porphyry-type ores and the more gradual precipitation in Mississippi-Valley type deposits. (Authors' abstract)

CRISS, R.E., FLECK, R.J. and TAYLOR, H.P., Jr., 1985, Oxygen isotope studies of fossil meteoric- and metamorphic-hydrothermal systems in central Idaho (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 215. First author at U.S. Geol. Survey, Reston, VA 22092.

$\delta^{18}O$ values of igneous and metamorphic rocks in a 50,000-km^2 region in central Idaho reveal several of the largest fossil hydrothermal systems yet identified. The primary igneous $\delta^{18}O$ values of the plutonic (+8 to +12) and volcanic (+6 to +10) wallrocks were lowered in large zones surrounding a series of epizonal Eocene batholiths and stocks (locally to $\delta^{18}O = -9$). These altered zones formed as a result of exchange with fluids derived from low-^{18}O meteoric waters ($\delta^{18}O = -16$) that were circulating around the Eocene plutons. Widespread propylitization accompanied the ^{18}O exchange. The two largest meteoric-hydrothermal systems, the 4,500-km^2 Casto Ring Zone and the 2,400-km^2 Sawtooth Ring Zone, closely coincide with major cauldron complexes. Several smaller systems appear to be confined to the contact zones of known or inferred plutons. The hydrothermal systems are generally characterized by large water/rock ratios of order unity and by rather sharp lateral and vertical boundaries, regardless of circulation scale. Au-Ag ore deposits are localized along the steep ^{18}O gradients near system boundaries. In contrast, Belt Supergroup (Wallace Formation) metasediments around the northern Idaho batholith show a progressive decrease from $\delta^{18}O = +15 \pm 1$ in low-grade zones >60 km from mapped pluton contacts to $\delta^{18}O = +11 \pm 1$ in the highest grade zones (sillimanite ± kyanite) adjacent to the batholith. These data reflect large-scale and deep circulation of high-^{18}O metamorphic-hydrothermal fluids during Late Cretaceous-early Tertiary time. Deep circulation of these metamorphic fluids may have played a significant role in batholith formation. (Authors' abstract)

CROCETTI, C.A. and HOLLAND, H.D., 1985, A model for the origin of the lead ores of southeastern Missouri (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 556.

CUNNINGHAM, C.G., 1985, Characteristics of boiling-water-table and carbon dioxide models for epithermal gold deposition, in Geologic characteristics of sediment- and volcanic-hosted disseminated gold deposits--Search for an occurrence model, E.W. Tooker, ed.: U.S. Geol Survey Bull. 1646, p. 43-46.

Two models are proposed to explain two ways in which boiling can cause deposition of gold and to suggest fluid-inclusion and mineral-paragenetic criteria that may be useful in precious-metal exploration. (From the author's abstract)

CURRIE, K.L. and ZALESKI, Eva, 1985, The relative stability of elpidite and vlasovite: A P-T indiator for peralkaline rocks: Can. Mineral., v. 23, p. 577-582. Authors at Geol. Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada.

The more common occurrence of elpidite, relative to vlasovite, suggests that an aqueous phase separates from peralkaline granitic magma only when crystallization is virtually complete. (From the authors' abstract)

CYGAN, R.T., 1985, Soret diffusion processes in aqueous sodium chloride solutions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p.

555. Author at Geochem. Div. 1543, Sandia Nat'l. Lab., Albuquerque, NM 87185.

The mass transport of chemical species induced by a temperature gradient, commonly known as Soret diffusion, has been examined for the case of the sodium chloride and water system. The occurrence of significant thermal gradients in geological media, especially those associated with radioactive waste disposal sites, can produce a measurable flux of sodium chloride and therefore enrich the local solutions. Soret coefficients, or the ratio of thermal to isothermal mass transport factors, describe this rate of mass transfer and are necessary for evaluating certain nonequilibrium processes, such as the migration of fluid inclusions in rocksalt.

Experimental Soret coefficients for the $NaCl-H_2O$ system were obtained by the use of a conductimetric thermal diffusion cell. This approach relies on monitoring the electrical conductivity change of two separate isothermal reservoirs which are maintained at different temperatures. The Soret cell is situated between the reservoirs and is comprised of an inert matrix of glass beads in order to minimize any solution convection. The utilization of this porous medium requires correlations for porosity and tortuosity. Measurements were made for 0.1 and 1.0 N NaCl solutions at mean temperatures of 40°C and 50°C with the mass transport induced by a thermal gradient of 2.6°C/cm. The preliminary results indicate a Soret separation (concentration difference between reservoirs) on the order of 1 to 2 percent with the attainment of a steady state in approximately 15 hours. (Author's abstract)

DAHM, K.-P. and THOMAS, Rainer, 1985, A new model of the origin of tin deposits in the Erzgebirge (quartz-cassiterite-formation): Freiberger Forschungshefte, v. C390, p. 254-274 (in German). First author at ZIPE (Zentralinstitut für Physik der Erde), 1500 Potsdam, Telegrafenberg A 51, GDR.

According to trace element data and thermobarometric studies on fluid and melt inclusions in minerals of the quartz-cassiterite formation and quartz from the granitic rocks this paper summarizes a new model for the formation processes of tin deposits in the Erzgebirge.

This model is characterized by progressive, rhythmic, marginal crystallization of the granitic melt coupled with repeated cycles of roofward enrichment of volatile components H_2O, CO_2, Cl, F and B together with Li, Na, Rb, Cs, Sn, W, Mo, Bi and Be toward the cooling surface and episodic, sometimes explosive losses of these elements produced by fluctuations between lithostatic and hydrostatic pressure conditions from $\geq$2.3 kbar to $\leq$240 bar. (Abstract by R. Thomas)

D'AMORE, F. and PANICHI, C., 1985, Geochemistry in geothermal exploration: Energy Research, v. 9, p. 277-298.

DANYUSHEVSKIY, L.V., SOBOLEV, A.V., ZLOBIN, S.K., KONONKOVA, N.N. and SHCHERBOVSKIY, Ye.Ya., 1985, Petrology of the boninites of the Tonga Trench based on a study of magmatic inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 135-137 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

A study of samples of boninites (products of crystallization of primitive water-rich, high-magnesian mantle melts) dredged from the island slope on the northern end of the Tonga Trench (16th cruise of the SRV

'Callisto'), has provided the following conclusions:

1. Petrographic and microprobe methods of analysis have established the order of separation of the crystalline phases: ol + Cr-spn, ol + opx + Cr-spn, opx + cpx + Cr-spn + ol, and opx + pl + tmt.

2. The crystalline phases contain P melt, solid-phase, fluid, and combined magmatic inclusions, clearly marking the growth zones of the minerals, as well as PS melt and fluid inclusions. The P fluid inclusions indicate saturation of the magma in fluids at the time of crystallization.

3. Th of the P melt inclusions is related to the composition of the host-mineral and ranges from 1350°C for the most magnesian olivines (Fo_{93}) to 1150°C for Fo_{87}, and from 1300°C for the most magnesian opx (En_{90}) to 1080°C for En_{63}. These relationships indicate fractional crystallization of the magma.

4. A rise in Th for P melt inclusions when maintained at high T (>1100°C) and their autoxidation, as seen in the formation of magnetite during the experiments, indicate significant amounts of water in the melt [and its loss during the experiment]. The presence of amphibole in the crystallized P melt inclusions in opx supports this view.

5. Some of the P melt inclusions bear signs of natural autoxidation (a trace of magnetite throughout the inclusion); this also indicates a signficiant amount of water in the melt.

6. Fluid inclusions with a clearly-defined liquid-gas phase boundary at room T are present in the chilled glasses. Th of the inclusions, in the gas phase, ranges from 340°C for the less-differentiated material (No. 26) to 325°C for the most differentiated (No. 28). The liquid phase is water with ≤0.5 wt.% NaCl equiv. (Tm ice = -0.2 to -0.5°C) for No. 26, and ≤1.4 wt.% (Tm = -0.7 to -0.9°C) for No. 28. The small amount of salt and the inclusion morphology indicate the magmatic nature of the water. This has enabled the authors, using the fluid density (0.0928 g/cm^3 for No. 26, and 0.0710 g/cm^3 for No. 28), the softening point for the glass (640°C for No. 26, and 590°C for No. 28), the Tm of the glass (1160°C for No. 26, and 1080°C for No. 28), the composition of the glass (Table), and experimental data, to calculate the minimum amount of H_2O in the residual boninitic melt, which comprised 2.7% for No. 26, and 4.1% for No. 28. Correcting for the ratio of glass to microlites (dms) in it, these values, at Te, are 2.3% for No. 26, and 3.8% for No. 28, before degassing. (Authors' abstract)

Composition of Melt at Moment of Fluid Capture (wt%)

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
No. 26	55.78	0.29	13.69	7.95	0.12	6.45	11.03	1.4	0.4
No. 28	64.59	0.60	12.80	7.79	0.18	1.45	5.51	2.5	1.1

DARIMONT, A., 1985, Fluid inclusion study (abst.): Annales de la Soc. Géol. de Belgique, v. 108, p. 411-3419. Author at Univ. Liege, Géol. Appliquée, av. des Tileuis, 45, B-4000 Liège, Belgium.

The fluid inclusion technique permits determination of the composition, salinity and density of the mineralizing fluid. It can, sometimes, provide an estimate of the P-T conditions of formation.

Two problems are considered: the Pb-Zn-Ba-F ore deposits from Belgium: Meuse-Vesdre (North district) and Sud Dinant (South district), and the relations between quartz veins and metamorphism or magmatism in the Ardenne (Rocroi-Serpont-Stavelot massives and metamorphic area of Bastongne). (Author's abstract)

DARIMONT, Anne and DHAMELINCOURT, Paul, 1985, Detection of CO_2, N_2 and

CH_4 fluid inclusions in quartz from Ardennes by microthermometry and Raman microprobe: Annales de la Soc. Géol. de Belgique, v. 108, p. 361-364 (in French; English abstract). First author at Chercheur IRSIA - Lab. Géol. Appliquée, 45, avenue des Tilleuls, B-4000 Liège, Belgium.

Optical and analytical studies were performed on liquid-gas inclusions in vein quartz from Ardennes. Due to the technical limits of the freezing stage (minimum temperature: -100°C), the Raman microprobe has been used to determine the volatile component responsible of the lowered CO_2 melting temperature, and to test the composition of fluid inclusions recognized as "aqueous" by microthermometry.

The lowered CO_2 melting temperature is due to the presence of nitrogen. CH_4 is rarely present, and in relatively negligible quantity. Nitrogen was detected with a high mole ratio (>0.7) in "aqueous" fluid inclusions. The 62 analyzed fluid inclusions are divided into three classes: aqueous (42), $CO_2 > N_2$ (11), and $N_2 > CO_2$ (9). (Authors' abstract)

DARIMONT, A. and HEYEN, G., 1985, Simulation of phase equilibria in the system CO_2-N_2 (abst.): Symp., European Current Res. on Fluid Inclusions, April 10-12, 1985, Göttingen, FRG, Program, p. 36 (in French). First author at Lab. de Géologie Appliquée, 45 avenue des Tilleuls, B-4000 Liege, Belgium.

The equation of state for the system CO_2-N_2 below +20°C and 90 bar permits prediction of the P-V-T-X conditions of phase equilibria in this system. Based on the P-V-T-X data thus obtained, a $Z(N_2)$ (mole fraction of nitrogen) - d (density of CO_2-N_2 mixture) diagram is constructed. The following parameters are shown in this diagram:

1) Tf = melting temperature of CO_2
2) Th = temperature of gas-liquid homogenization
3) L/L+G = degree of filling with liquid at the CO_2 melting temperature.

The diagram permits interpretation of heating/freezing data on CO_2-N_2 inclusions in terms of composition and density. (Authors' abstract, translated by R. Kreulen)

DAVIS, T.M., DUCKETT, L.M., OWEN, J.F., PATTERSON, C.S. and SALEEBY, Robert, 1985, Osmotic coefficients of aqueous LiCl and KCl from their isopiestic ratios to NaCl at 45°C: J. Chem. Eng. Data, v. 30, p. 432-434.

DAVIS, W.J. and WILLIAMS-JONES, A.E., 1985, A fluid inclusion study of the porphyry-greisen, tungsten-molybdenum deposit at Mount Pleasant, New Brunswick, Canada: Mineral. Deposita, v. 20, p. 94-101. First author at Dept. Geol., Univ. Auckland, Auckland, New Zealand.

Th and salinity data are presented for fluid inclusions from hydrothermal gangue minerals (quartz and fluorite) associated with porphyry wolframite-molybdenite-arsenopyrite-sphalerite-bismuth-chalcopyrite-cassiterite mineralization within the Fire Tower ore zone, Mt. Pleasant, New Brunswick. The data indicate that ore mineral precipitation occurred within a temperature range of 260° to 490°C from moderate to high salinity (10-42 wt% NaCl equivalent) aqueous fluids. Two stages of hydrothermal activity characterized by high (>30 wt% NaCl equivalent) salinity fluids are recognized; one which occurred at relatively high temperature (350°-490°C); and one which took place at lower temperature (180°-250°C). The high salinity, high temperature stage is interpreted to be the result of resurgent boiling. Dilution of these early fluids by convecting meteoric water resulted in low to moderate salinity fluids, which dominate the inclusion population. The low temperature, high salinity fluid inclusions are interpreted to represent late residual fluids derived from boiling which occurred as a result of a change in the pressure regime from dominantly lithostatic to hydrostatic conditions. (Authors' abstract)

DEC, S.F. and GILL, S.J., 1985, Heats of solution of gaseous hydrocarbons in water at 15, 25 and 35°C: J. Solution Chem., v. 14, no. 12, p. 827-836.

DE GROOT, P.A., BAKER, J.H. and JASINSKI, A.W., 1985, The behavior of major and trace elements in a fossil hydrothermal system, Hjulsjö, Bergslagen, C. Sweden (abst.): Terra Cognita, v. 5, p. 153. First author at Geol. Inst., Univ. Amsterdam, Amsterdam, The Netherlands.

Mg-rich schist zones in the Hjulsjö area are developed in felsic volcanics altered by seawater, which consisted originally of submarine pyroclastic flows and associated rhyolites (Baker and De Groot, 1983, CMP 82, 119). Major and trace element variations through sections across the concentric alteration zones have implications for the behavior of these elements.

SiO_2 contents in and outside the alteration zones are generally high for rocks of originally rhyolitic composition, and show no consistent patterns.

Fe(tot), Mn, Ca, and nearly all trace elements are leached from the rock with strongest depletion towards the center of the alteration zones. Exceptions are Cr, Zr, Nb, Hf, and Ta which are weakly enriched, while Rb is stable.

The enrichment of Mg, derived from seawater, in the rock is dependent on T and w/r ratio, starting at low T (10°C) and increasing as T rises. At w/r ratio of ±50 and elevated T Mg removal from the fluid is maximal. K and Na show a negative correlation, with K enrichment in the rock at T below 150°C and Na enrichment at T above 150°C.

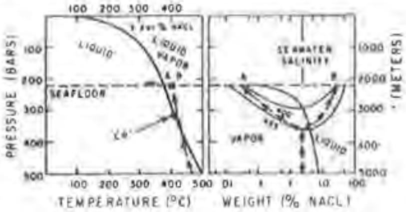
A model of hydrothermal circulation with increasing w/r ratio and T towards the heat source (a funnel shaped system), and ascending hot fluid is presented. Alteration of Na- and K-feldspar into sericite, Mg-rich chlorite and phlogopite with increasing T and a(Mg) is supported by thermodynamic calculations.

Exhalation of a hot brine onto the seafloor is thought to be the source for iron-ores and associated carbonate and chert horizons. (Authors' abstract)

DEINES, Peter, 1985, Identification of ^{13}C depleted mantle carbon in diamonds from the Roberts Victor kimberlite, South Africa (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 561.

DELANEY, J.R., McDUFF, Russ and LUPTON, J.E., 1985, Evidence for supercritical two-phase separation in submarine hydrothermal systems (abst.): EOS, v. 66, no. 18, p. 402. First author at School Oceanog., Univ. Washingotn, Seattle, WA 98195.

Independent lines of evidence require 2-phase separation in sub-seafloor hydrothermal systems at temperatures and pressures greater than 407°C and 315 bars. A. The presence of salinities greater than 3 x seawater in quartz-hosted aqueous fluid inclusions from the axis of the Mid-Atlantic Ridge cannot be explained in terms of subcritical phase separation. Phase separation in the supercritical region readily produces brines of adequate salinity. B. Direct measurement of actively venting hydrothermal fluid temperatures in excess of 405°C requires that the effluent have passed directly through the 'critical point' if it decompressed isothermally; alternatively, it passed the 2-phase boundary at a temperature and pressure in excess of the 'critical point' if the solution were cooling upon decompression. The sketch below indicates a probable path along which the initial seawater-like fluid must have moved. In the vicinity of 425°C, the fluid encountered the two-phase surface at a salinity slightly less than that of the critical curve for the NaCl-H_2O system. If conditions did not favor phase segregation, continued decompression, equilibrium phase separation, and cooling would produce, at vent level, two co-existing phases with salinities A and B. (Authors' abstract)



DERGACHEV, V.B., 1985, Temperature of heating of samples in the analysis of the gas composition of fluid inclusions (preliminary data on the results of mass spectrometric analysis): Morfol., Genezis Zakonomern. Razmeshcheniya Miner. Obraz. Altae-Sayan. Skaladchatoi Obl. Sib. Platformy 1985, p. 112-118 (in Russian).

The final temperature of heating in the analysis of geol. fluid inclusions should in general not exceed 550°. (C.A. 104: 28078w)

DERNOV-PEGAREV, V.F. and MALININ, S.D., 1985, Experimental study of solubility of apatite in aqueous solutions of carbonates of alkaline metals at 300, 400 and 500°C: Geokhimiya, 1985, no. 8, p. 1196-1205 (in Russian; English abstract).

de RONDE, C.E.J., 1985, Studies on a fossil hydrothermal system at Golden Cross, Waihi, New Zealand: MS degree, Univ. Auckland.

The Golden Cross fossil hydrothermal system (probable age Pliocene to Pleistocene) is located 8 km northwest of Waihi, N.Z., within calc-alkaline volcanics of the Coromandel Peninsula.

Intense country rock alteration within a volume of 3 km x 1.5 km x 0.5-0.8 km is characterized by the assemblage: quartz-adularia-smectite-interstratified illite/smectite-illite-chlorite-calcite-pyrite. Gravity models (2-D and 3-D) and magnetics are consistent with the alteration zone observed in drill core.

Fluid inclusion studies suggest that initially, early, hot brine (Th >350°C, 12-14 wt% NaCl equiv.) permeated country rock along joints under predominantly lithostatic conditions. Unusual inclusions of high apparent salinity (26-29 wt% NaCl equiv., Th 270°C) containing at least two immiscible liquids of unknown composition are restricted to the upflow portion of the system.

Alkali-chloride fluid of probable meteoric origin (pH ~7 at 200°C) precipitated main-stage quartz (Th 200-250°C, predominantly 200°C, 0.8-2.7 wt% NaCl equiv.) under predominantly hydrostatic conditions. Permeability was enhanced by faulting, and subsequent hydraulic fracturing. Precious metals are confined to the main-stage quartz zone, and were precipitated as a result of changes in fluid temperature.

Temperature variations at the time of main-stage quartz deposition are reflected in the distribution of clay types. The sequence smectite-interstratified illite/smectite-illite-chlorite is observed with increasing depth and temperature.

Lateral fluid flow is evidenced by $\delta^{18}O$ contours and the distribution of quartz and adularia.

Late calcite was deposited from near-neutral pH alkali-chloride fluid (Th 150-200°C, 0.8-1.0 wt% NaCl equiv.) and is located beneath the main-stage quartz zone.

As the system waned, near-surface acid-sulphate water was drawn down permeable channels within the system to a minimum depth of 500 m below surface level, overprinting earlier mineral assemblages with kaolinite ± hematite ± limonite ± jarosite.

Water/rock ratios indicate the system was hydrologically mature. (Author's abstract)

DeTITTA, G.T., 1985, ABSORB: an absorption correction program for crystals enclosed in capillaries with trapped mother liquor: J. Appl. Cryst., v. 18, p. 75-79. Author at Medical Foundation of Buffalo, Inc. 73 High St., Buffalo, NY 14203-1196, USA.

A computer program to calculate the contributions of crystal, capillary and a simple model of mother liquor to the overall absorption of X-rays has been written. It is based on the Gaussian quadrature method of integration; the crystal is described by the polyhedral faces bounding it, the capillary by its diameter, thickness and orientation with respect to the diffractometer axes and the mother liquor by the crystal faces that trap it between crystal and inner capillary wall. The program is written in Fortran for a VAX 11/780 computer and incorporates tables of mass absorption coefficients for silver, molybdenum and copper radiations for easy calculation of linear absorption coefficients. (Author's abstract)

Of pertinence in X-ray identification of extracted daughter crystals. (E.R.)

DICKENSON, M.P., 1985, Fluid flow in metamorphism: results from shear zones in amphibolite grade calc-silicate shists (abst.): EOS, v. 66, no. 18, p. 389.

DICKSON, J.A.D., 1985, Diagenesis of shallow-marine carbonates, in P.J. Brechley and B.P.J. Williams, Sedimentology: Recent developments and applied aspects: Blackwell Sci. Pubs., Oxford, 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 illustrated by Sr^{2+}, was oversimplified in the 1970s; kinetic factors and recrystallization complicate the use of the distribution coefficient. $\delta^{13}C$ 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. (From the author's summary)

DIDENKO, A.V., 1985, Carbonaceous substances and minerals as indicative signs of mercury mineralization (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 186-187 (in Russian; translation by D.A. Brown). Author at IGGGI, L'vov, USSR.

The association between various HCs and sulfides has long been known, e.g., the Hg deposits of Transcarpathia (Didenko, 1981), Donbass, and Chukotka, and also in present-day hydrothermal deposits.

The confinement of HC inclusions to definite genetic kinds of quartz has been noted. Thus, in a gangue quartz of elongate-prismatic aspect with trigonal cross-section (Th of syngenetic inclusions of aqueous solutions = 255-260°C, pH of solutions = 6.5-6.7), no HCs have been found in the inclusions; the main gaseous component is CO_2. At the same time, in an ore quartz of prismatic aspect and hexagonal cross-section, there are liquid and solid HCs; the gas phase consists of CO_2, N_2, H_2, and CH_4 and its homologs. In this instance, the CH_4 content varies from 1.12 to 28.7%, and C_2H_6 from 0.01 to 1.81% (by mass-spectrometry). In the P inclusions in quartz from the Vyshkov ore field, the liquid HCs cover a gas bubble or are found in the form of droplets, immiscible in the aqueous solution. The luminescence of these droplets in UV light places them in the heavy 'oil' category. A large amount of inclusions of such kind (Th = 50-60°C) has been found in the inner zones of post-ore calcites. The liquid phase luminesces in shades of blue, which places them amongst the light 'oils.'

Submicroscopic inclusions of solid HCs with spheroidal outlines, luminescing in bright brown shades, have frequently been observed in the near-surface zone of prismatic quartz crystals. Chloroform extraction produced an oily-resinous bitumoid, 0.02-0.06% in amount, which emphasizes the presence of HCs in the hydrothermal solutions.

The content of HCs in the primary inclusions, and also the formation of carbon compounds of varying consistency depending on T, from hydrothermal solutions, suggest the joint transport of Hg and HCs, evidently in the steam-gas phase. Proofs of such a form of transport may be: first, the deep-seated nature of Hg and the carbonaceous matter; the nature of the filling of the honeycombed cavities in quartz diorite-porphyries by cinnabar and solid asphaltic matter; and second, the transport of Hg in present-day hydrothermal solutions. N.A. Ozerova (1974) has expressed the view that transport of Hg in the present-day Sb-Hg-As hydrothermal in the Uzon Caldera is also taking place in a steam-gas phase. It is generally concluded that carbanceous substances and minerals are index features that may be used in prospecting-assessment of Hg occurrences. (Author's abstract)

DIMITROV, Stojan and KRĂSTEVA, Margarita, 1984, Mineral-thermometric studies on quartz from the Elacite porphyry copper-molybdenum deposit: Rudoobraz. Procesi i Miner. Nahodista, no. 21, 1984, p. 25-29 (in Russian).

The ore mineralization is confined to the contact of the Vezen granodioritic pluton with metamorphic rocks of the diabase-phyllitoid complex. Seven stages are distinguished in the mineral-forming process: potash-feldspar, quartz-magnetite, molybdenite, pyrite-specularite, chalcopyrite-pyrite, quartz-pyrite and manganocalcite-manganankerite stages. The results of the mineral-thermometric studies (by Th fluid inclusions in quartz from various stages) establish a temperature range of mineral formation between 400 and 80°C. The first two stages are characterized by >300°C, the molybdenite stage took place between 290 and 250°C, the pyrite-specularite stage - 240-180°C, the chalcopyrite-pyrite stage - 180-80°C, and the quartz-pyrite stage - 260-140°C. The formation of carbonates during the final stage took place probably between 140 and 80°C. (Abstract by R. Arnaudova)

DINGWELL, D.B., 1985, The structure and properties of fluorine-rich silicate melts: Implications for granite petrogenesis (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 72-81.

DMITRIEV, L.V., SOBOLEV, A.V., SUSCHEVSKAYA, N.M. and ZAPUNNY, S.A., 1985, Abyssal glasses, petrologic mapping of the oceanic floor and "geochemical leg" 82, in Bougault, H., Cande, S.C. et al., eds., Initial Reports of the Deep Sea Drilling Project, v. 82, Washington, U.S. Govt. Printing Office, p. 509-518. Authors at Vernadsky Inst. Geochem., USSR Acad. Sci., Moscow, USSR.

Includes analysis of experimentally homogenized melt inclusions in olivine from two compositional groups of lavas. (E.R.)

DOBSON, D.C., 1985, Petrologic and geochemical evolution of the Lost River, Alaska, tin deposit (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 82-86. Author at P.O. Box 60433, Palo Alto, CA 94306, USA.

Fluid inclusion studies show early skarns formed at ~400°C and 500-600 bars, followed by pressure decline and active boiling during deposition of topaz and sulfides. Salinities ranged between 21 and 9%. (E.R.)

DOBSON, P.F. and O'NEIL, J.R., 1985, Stable isotope systematics of a boninite volcanic suite, Bonin Islands, Japan (abst.): EOS, v. 66, no. 18, p. 413. First author at Geol. Dept., Stanford Univ., Stanford, CA 94305.

Comagmatic Eocene volcanic rocks on the island of Chichi-jima in the Izu-Bonin arc of Japan range in composition from boninite to low-K rhyolite. Values of $\delta^{18}O$, δD, and H_2O+ were determined on separates of glass, phenocrysts, and whole rocks from all members of the suite.

δD values of boninite series lavas are inversely correlated with both $\delta^{18}O$ values and H_2O+. All silicic rocks have undergone low-temperature alteration resulting in increases in $\delta^{18}O$ and H_2O+ to values of +17.0 permil and 5.3 weight percent, respectively, and decreases in δD to a value of -76 permil. Phenocryst data indicate that $\delta^{18}O$ values of the magmas increase systematically with differentiation from +5.8 to +7.0 permil. Unaltered primitive to intermediate boninite glasses have δD values of -58 to -53 permil and primary water contents of 2.2 to 3.0 weight percent.

An important feature in models of boninite petrogenesis is the introduction of a water-rich fluid into a highly-depleted mantle source region. The fresh primitive boninites have $\delta^{18}O$ values that are characteristic of but δD values that are substantially higher than those of most mantle-derived melts. A possible source of fluids is subducted oceanic crust, with the dehydration of minerals such as serpentine and amphibole generating fluids of the appropriate isotopic composition. (Authors' abstract)

DOLGOV, Yu.A., 1985, Essential features of thermobarogeochemical models of mineral formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 21-23 (in Russian). Author at Inst. Geol. & Geophysics of Acad. Sci. USSR, Novosibirsk-90, USSR.

A general characterization of zones of migration of fluids and magmas in tectonic zones is given. (A.K.)

DOLGOV, Yu.A, TOMILENKO, A.A. and CHUPIN, V.P., 1984, Conditions of anatexis and metamorphism (from inclusions in minerals): Geologiya i Geofizika, no. 8, p. 91-98 (in Russian; English abstract). Authors at Inst. Geol. and Geophysics of Siberian Br. Acad. Sci., Novosibirsk, USSR.

Inclusions in quartz from leucosomes of anatektites (Aldan River, Timpton River, Olekma River, Ungra River, Mynchukur in Dzhungarian Alatau, South Chuy Ridge, Mama River and Chupa in Karelia) are silicate melts of granitoid type, with 2-3 to 5 wt.% (to 8 wt.% for pegmatites) H_2O and up to 0.6 wt.% CO_2; P H_2O reaches $3 \cdot 10^8$-$4 \cdot 10^8$ Pa. For granulite facies Th are in ranges 800-900°C, for amphibolite facies 640-840°C (migmatites, granites and pegmatites). Palingenic-anatectic melts produced during heating of granites, gneisses, etc., by intruding basic magmas have low T of final crystallization 600-620°C and water content up to 7 wt.%. The paper presents also results of studies of inclusions of CO_2, N_2 and CH_4-rich dense fluids in minerals of eclogites, amphibolites, granulites and migmatites, mostly taken from the book of Tomilenko and Chupin, 1983 (see Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 267). (Abstract by A.K.)

DOMENICO, P.A. and ROBBINS, G.A., 1985, The displacement of connate water from aquifers: Geol. Soc. Am. Bull., v. 96, no. 3, p. 328-335.

DONG, Jihe, 1984, Mineralogical chemistry of halite in modern salt lakes of China: Acta Mineral. Sinica, 1984, no. 1, p. 29-34 (in Chinese; English abstract). Author at Qinghai Inst. of Salt Lakes, Acad. Sinica.

Twenty-two pure halite samples collected from surfacial sediments of fourteen salt lakes and twelve halite samples precipitated by solar evaporation were analyzed, revealing the existence of some trace components such as K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, HCO_3^-, Br^-, etc., in the samples of naturally deposited halite. Evidence shows that these ions present in halite are mainly due to the existence of parent liquid inclusions. The content of K^+, Mg^{2+}, B^{3+}, Li^+ and Br^- in halite is in direct proportion to their concentration in the water in lakes. During the stage of potassium deposition, the content of potassium is more than 0.09% in halite in the salt lake water, and sylvite and carnallite may be precipitated in this kind of salt lakes. (Author's abstract)

DORNSIEPEN, U.F., HEIN, U.F. and WOLFF, C., 1985, Fluid inclusions associated with different types of metamorphism in the phyllite-quartzite-series of Crete and Peleponnesos (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 38-39. Authors at Inst. Angewandte Geol. der FUB, Wichernstr. 16, D-1000 Berlin 33, FRG.

The phyllite-quartzite-series of Crete is built up by Permotriassic sediments which underwent intensive and multiphase deformation and a high-pressure-low-temperature metamorphism during the Oligocene/Miocene orogeny.

During maximum burial joints containing quartz and ferrocarpholite formed. Fluid inclusions in this quartz are characterized by high internal pressures not allowing the development of a vapor bubble at room temperature, low to medium salinity, and mostly contain liquid CO_2.

During and after nappe-thrusting the rocks were folded and deformed again. Veins of mm- to cm-size filled with quartz, albite, and hematite crosscut these late structures. Fluid inclusions in this quartz are characterized by extreme salt content (predominantly NaCl dxls); liquid CO_2 is not visible at room temperature.

According to petrological data the ferrocarpholite crystallization in E-Crete should have happened at 200-300°C and more than 5 kbar. The metamorphic conditions during the later events after nappe-thrusting are up to now estimated to 200-250°C and less than 2 kbar. (From the authors' abstract)

DRESEL, P.E., ROSE, A.W. and GAMMONS, C.H., 1985, Geochemistry and origin of brines from western Pennsylvania (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 567. Authors at Dept. Geosci., Pennsylvania State Univ., University Park, PA 16802.

Brines from 26 gas and 14 oil wells from Devonian and Silurian reservoirs in western Pennsylvania are Na-Ca-Cl brines (molar Na/Ca near 3) with dissolved solids from 10 to 340 g/L (median 200). Other medians (mg/L) are Mg 2100, K 190, Sr 1000 (to 13000), Ba 170 (to 4400), Li 47, Cu 0.02, Zn 0.06, Pb 0.01, Br 1000, I 20 and F <1. Most oil wells and Medina Fm. brines have 200-400 mg/L SO_4; most gas wells have <5 mg/L SO_4; sulfide is very low in all. Reservoir rocks commonly contain pyrite and ankeritic or sideritic carbonate, which, given the observed CH_4-CO_2 ratios and assuming equilibrium allows calculation of very low dissolved Fe (15 mg/L) and H_2S (10^{-7} M). Most Fe (to 500 mg/L) was probably derived by corrosion.

On plots of Br vs. Cl and MCl_2 (Carpenter, 1978) highest-salinity samples fall close to halite-saturated evaporated seawater. Other samples fall along dilution trends, slightly offset for different stratigraphic reservoirs. δD for 12 samples is -40 ± 10‰ (SMOW), and $\delta^{18}O$ (-5.5 to +2‰) generally correlates with TDS; both trend toward local meteoric water at low salinity. Ca/Mg ratios are explainable by dolomite-calcite equilibrium at varying temperatures. The brines are tentatively interpreted as residual brines from Silurian evaporites that migrated out of the evaporites, experienced sulfate reduction to form pyrite and extensive Ca/Mg exchange to form dolomite, and then were diluted with meteoric water. The δD of the high-salinity end member is consistent with δD expected for evaporite brines. The lack of change in δD and Na/Ca with TDS and the wide variation in TDS between nearby samples from the same stratigraphic unit argues against membrane filtration. (Authors' abstract)

DROMGOOLE, E.L. and PASTERIS, J.D., 1985, Interpretation of the sulfide assemblages in a suite of xenoliths from Kilbourne Hole, New Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 157. Authors at Dept. Earth & Planet. Sci., Washington Univ., St. Louis, MO 63130.

Electron microprobe and petrographic analysis were done on sulfide assemblages in a xenolith suite of spinel lherzolites, clinopyroxenites, megacrysts, mafic granulites, and sillimanite-quartz granulite. The xenoliths occur in a Ne-normative alkali olivine basalt in Kilbourne Hole, NM. Sulfide abundances usually are <<0.1 vol.%. Minute sulfide blebs containing Po ± Pn ± Cb occur fully enclosed in silicates and spinels or interstitial to the major phases. They commonly are associated with arrays of fluid and glass inclusions, and may be concentrated in partial melt zones. There is a general relationship between specific sulfide assemblage and xenolith lithology: 1) Po only (mafic gran., sill-quartz gran., 1 megacryst), 2) Po ± Cb (Ol-poor clinopx., 1 mega.), 3) Po ± Pn ± Cb: "Po" has -10-30 wt.% Ni (spinel lherz., 1 clinopx., 1 mega.). Composite xenoliths of spinel lherz. veined by clinopx. generally contain Po + Cb(± Pn). The largest sulfide blebs and highest sulfide contents occur in these clinopx. veins. Formation of sulfide seems lithology dependent: An immiscible sulfide liquid developed in mantle melts that precipitated mega. and clinopx. A similar situation accounts for mafic granulites that probably came from a subcrustal magma chamber. Sulfides in spinel lherz. apparently came from an immiscible sulfide liquid that formed during partial melting of mantle material. The spinel lherz. (residuum) later was infiltrated by this sulfide + melt + fluid. Kilbourne Hole (KH) samples bear similarities and differences to xenolith sulfides described by others, e.g., DeWaal and Calk 1974; Lourande and Conquere 1983. Bulk sulfide compositions in Kh spinel lherz. are very similar to those reported by L & C. Unlike in the samples of D & C and L & C, there is no appreciable compositional difference between enclosed and interstitial sulfides. (Authors' abstract)

DROOP, G.T.R., 1985, Alpine metamorphism in the south-east Tauern Window, Austria: 1. P-T variations in space and time: J. Metamorphic Geol., v. 3, p. 371-402. Author at Dept. Geol., Univ. Manchster, Oxford Road, Manchester, M13 9PL, UK

Combined oxygen-isotope and fluid-inclusion studies on late-stage veins, thought to have been at lithostatic pressure and in thermal equilibrium with their host rocks during formation, suggest that they crystallized from aqueous fluids at 1.1 ± 0.4 kbar and 420 ± 20°C. (From the author's abstract)

DROOP, G.T.R. and CHARNLEY, N.R., 1985, Comparative geobarometry of pelitic hornfelses associated with the Newer Gabbros: A preliminary study: J. Geol. Soc. London, v. 142, p. 53-62. First author at Dept. Geol., Univ. Manchester, Oxford Road, Manchester M13 9PL, England.

Based on mineral thermometers and barometers. (E.R.)

DRUMMOND, S.E. and PALMER, D.A., 1985, Formation constants for aqueous ferrous acetate complexes from magnetite solubility measurements from 100° to 250°C and 250 to 1250 bars (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 567. Authors at Chem. Div., Oak Ridge Nat'l. Lab., P.O. Box X, Oak Ridge, TN 37831.

Our previous results on the kinetics of acetate decarboxylation demonstrated that acetate is sufficiently stable below 300° to be effective in transporting metals in hydrothermal solutions by enhancing the solubility of minerals through complexation. The overall reaction studied to evaluate metal-acetate formation constants is expressed by the general equation: Fe_3O_4 (magnetite) + $2CH_3COOH \rightleftharpoons Fe(CH_3COOO)_n^{2-n} + (2-n)CH_3COO^-$ + H_2O + Fe_2O_3 (hematite) [1]. The experiments, which cover a compositional range from .03-.70 m acetate and .01-.20 m acetic acid, indicate that $FeCH_3COO^+$ (n = 1) predominates up to 150° but is subordinate to $Fe(CH_3COO)_2$ (n = 2) at higher temperatures. The data have a precision of ±10%. ΔV for reaction 1 is about -34 cc/mol when n = 1 (150°) and ranges from -45 cc/mol (200°) to -51 cc/mol (250°) when n = 2. Elimination of the redox and hydrolysis equilibria from reaction [1] allows the complex formation to be expressed simply: $Fe^{2+} + nCH_3COO^- \rightleftharpoons Fe(CH_3OO)_n^{2-n}$ [2]. At pressures along the liquid-vapor boundary for water the $\log_{10}$ of the equilibrium constants for reaction [2] range from 2.5 at 100° to 3.5 at 150° for n = 1 and from 4.5 at 200° to 5.6 at 250° for n = 2. This corresponds to values of ΔH_1 = 13 kcal/mol and ΔH_2 = 24 kcal/mol. Inasmuch as these formation constants are 2-3 orders of magnitude greater than current estimates for the corresponding ferrous-chloride complexes, it is quite likely that acetate complexing accounts for the majority of iron and perhaps other metals in many hydrothermal solutions below 300°. This concept is particularly attractive in environments where other ligands are insufficient to account for the metals in solution and where there is a source for acetate. Oil and gas field waters, Mississippi-Valley and Carlin-Gold ore solutions are among the likely candidates. (Authors' abstract)

DRUMMOND, S.E. and OHMOTO, H., 1985, Chemical evolution and mineral deposition in boiling hydrothermal systems: Econ. Geol., v. 80, p. 126-147. First author at Chem. Div., Oak Ridge Nat'l. Lab., Oak Ridge, TN 37831.

A thermodynamic model of boiling hydrothermal solutions is developed and applied over a wide range of physical and chemical conditions. Within the range of conditions observed in natural boiling hydrothermal systems the processes of liquid-vapor partitioning and the resultant effects on mineral solubilities are highly varied and complex. Metals that are complexed by chloride are deposited largely as a result of the decreasing proton concentration associated with CO_2 exsolution during boiling. Metal bisulfide complexes are destabilized most when the decrease in proton concentration is sluggish relative to the loss of H_2S.

Vaporization of only a few percent of a solution can decrease the proton concentration by several orders of magnitude when the CO_2/H^+ and $CO_2/\Sigma SO_4$ concentration ratios are initially high. The relationship between the proton, CO_2 and ΣSO_4 concentrations prior to boiling to the proton concentration after boiling is defined explicitly by a few simple equations. These equations along with the solubilities of calcite and anhydrite constitute the chemical boundary conditions for significant mineral deposition by boiling. Typical hydrothermal fluids lose most of their volatile components to the vapor phase and most of their metals to mineral phases by the time boiling has proceeded to the point where the volumes of the vapor and liquid phases are equal.

Physical variables such as the heat budget and the restrictions on the partitioning of mass between liquid and vapor, although significant, are subordinate to the compositional variables in determining the chemical evolution of a boiling hydrothermal solution. Mineral deposition is most vigorous when the volatile components partition from the solution to the vapor phase in a manner resembling perfect fractional (Rayleigh) distillation. As temperature decreases, the efficiency of boiling for depositing metals from solution increases, and the amount of metals in solution typically decreases such that the net effect of boiling is most favorable for ore formation at temperatures around 300°C. Mineral and metal complex stoichiometries in combination with the relative volatilities of CO_2 and H_2S determine the general sequence of mineral deposition during boiling. These major variables, many other minor variables, and the multiple interactions thereof are accounted for rigorously. The amount and paragenesis of ore and gangue minerals deposited by boiling are presented for numerous hypothetical hydrothermal systems. Analysis of these results suggests that boiling is perhaps the most generally effective ore depositional mechanism at the conditions operative in many boiling hydrothermal systems. (Authors' abstract)

DUBESSY, J., 1985, Contribution to the study of the interactions between paleo-fluids and minerals based on Raman-spectrometric analysis of fluid inclusions - Metallogenic consequences: Thesis - Doctorat d'Etat, Inst. Polytechnique de Lorraine (in French).

Coupled with microthermometry, Raman spectroscopy allows a major, qualitative step in the characterization of the major constituents of fluid inclusions, including: 1) identification and determination of the concentration of sulfate >~200 ppm; 2) characterization of the major mono-atomic cations by identification of their salt hydrates; and 3) determination of gaseous species (CO_2, CO, CH_2, N_2, H_2S, H_2, O_2) and their molar fractions. This step is essential to interpreting, in terms of molar volumes, the phase changes that are observed in microthermometry.

Modifications to the distribution of molecular species of fluids in the system C-O-H-N were calculated for the following conditions: 1) lowering of temperature at constant volume to understand the evolution of V-X properties of an inclusion during freezing; 2) increasing volume to simulate a partial decrepitation without selective loss of a species; and 3) loss of molecular hydrogen to study the effects of post-entrapment diffusion of hydrogen. These calculations indicate that fluids in the system C-O-H-N have a significant buffering capacity, considerably limiting the variations in composition and molar volume of each case.

By using appropriate chemical equilibria ($CO_2 = CO + 1/2\ O_2$ in the system C-O; $CH_4 + 2O_2 = CO_2 + H_2O$ in the system C-O-H-N), V-X properties of fluid inclusions allow the calculation of oxygen fugacity, if one knows the temperature of entrapment. At the scale of a single crystal, fluid inclusions represent markers of the time-varying evolution of this parameter, which controls the transport and deposition of numerous metals.

While molecular nitrogen may be in equilibrium with ammonia ($N_2 + 3H_2 = 2NH_3$), it typically remains dominantly as the molecular species for systems in which the ratio N/(C+O+H+N) is high. The release of ammonium from silicate lattices at temperatures of 500-600°C, leads to a strong reduction of the fluid phase. Thus, molecular nitrogen must be considered not solely as an inert phase, but also as the potential final product of redox reactions.

The absence of genetic relationships between uranium and tin-tungsten mineralizations associated with Iberian and French Hercynian leucogranites is a result of the very low oxidation state of the fluids responsible for tin-tungsten, near the Ni-NiO and Q-F-M buffers. At moderately acid pH, these fluids cannot carry uranium and therefore cannot deposit it.

Uranium mineralization superposes the effects of ionizing radiation on the classical chemical interactions between mineralizing fluids and the host rocks. Studies with M. Pagel in the Rabbitt Lake and Cluff Lake (Sakatchewan, Canada) uranium deposits have shown fluid inclusions containing H_2 and O_2 resulted from alpha radiation of water that was in contact with the mineralization prior to being entrapped: the concentration of uranium in the of the transporting fluid is too low to lead to an identifiable decomposition of water after trapping. Finally, H_2-dominant fluids discovered in a fission-reaction zone at Oklo (Gabon) resulted from the radiolysis of both organic material and water by the fission products of the nuclear reactions.

The study conducted in collaboration with J. Mullis on fluids from Alpine fissures has allowed the author to relate their P-V-T-X evolution to the tectono-metamorphic evolution of different portions of the Swiss Alpine chain along a traverse from Bale to Chiasso. (Author's abstract, translated by M. Logsdon)

DUBOIS, M., CHAROY, B. and OHNENSTETTER, M., 1985, The importance of fluid phases in the genesis and alteration of the ophiolitic "plagiogranites" of Cyprus and Oman (abst): Ofioliti, Bollettino del Gruppo di Lavoro Sulle Ofioliti Mediterranee, v. 9, no. 3, Spec. Issue: Ophiolites: Oceanic Tectonics and Metamorphism, G.B. Piccardo and V. Bortolotti, eds.: Bologna, Italy, Pitagora Editrice Bologna, p. 688-689. First author at CRPG, B.P. 20, Vandoeuvre, France.

A petrographic and mineralogic study has been made on plagiogranites of the ophiolitic suites of Cyprus and Oman. They represent late acid differentiates of a complex sequence comprising, from the bottom upwards, quartz gabbronorite and ferrogabbros with cumulate textures (orthocumulates), leucodiorites and quartz leucoferrodiorites in which the graphic texture between quartz and plagioclases are well represented. The cumulate textures disappear in favor of more coarse-grained intersertal and ophitic textures. The same primary minerals occur in different proportions and constitute the essential aspect of these rocks. All these rocks are always pervaded by a hydrothermal metamorphism: lower amphibolite facies for the less evolved quartz leucogabbronorite and ferrogabbros, greenschist facies for the upper acid differentiates. Pyroxene in such cases is generally transformed into magnesium-hornblende with rims of magnesium-actinolite which in turn may be rimmed by chlorite.

Generally in the less evolved rocks, plagioclases are not very altered but in the acid differentiates they are transformed into a fine cryptocrystalline association of albite-chlorite-phengite or into an albite-epidote assemblage. In the plagiogranites, exsolved intergrowth of ilmenite + magnetite are sometimes rimmed by sphene + rutile. Prehnite-pumpellyite association postdates the hydothermal metamorphism and occurs in fractures or patches in plagioclase.

Two groups of fluid inclusions within quartz in samples of Cyprus have been identified. One homogenizes at high temperature (350°<Th>550°C)[sic] and is highly saline (35 to 55% wt. equiv. NaCl). Several solid phases and anomalous Tf ice suggests a complex composition. This fluid sometimes shows critical homogenization. These inclusions occur scattered through quartz. The other, more abundant group with lower Th (110°<Th<250°C) is found in secondary planes. The salinity is low (~5% wt. equiv. NaCl). (From the authors' abstract)

DUFRESNE, M.B., NESBITT, B.E., LONGSTAFFE, F.J. and MORISON, S.R., 1985, A Plio-Pleistocene, epithermal origin for Au mineralization in the White Channel sediments of the Klondike region, Yukon (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 569. First author at Dept. Geol., Univ. Alberta, Edmonton, AB T6G 2E3, Canada.

To date, exploration of mesothermal quartz veins in Klondike Schist has failed to locate a source for the 10+ million oz of Au recovered from the Plio-Pleistocene White Channel sediments and modern day placers. As first suggested by Templeman-Kluit (1982) and supported by this study, Au mineralization in the unconsolidated White Channel sediments and underlying bedrock is now believed to have formed directly from Plio-Pleistocene epithermal processes, and through subsequent erosion, supplied most of the Au incorporated into the modern day placers. The White Channel sediments are massively disorganized to poorly stratified gravels and sands situated on elevated bedrock benches. Post-depositional hydrothermal alteration zones in the White Channel sediments cross-cut sedimentary structures and facies, and are frequently isolated from the surficial weathering zone. The upper regions of the alteration zones have a bleached appearance and contain abundant, well-crystallized secondary kaolinite. Alteration at the bedrock contact is characterized by a 2-3 metre zone of iron-stained gravels composed of secondary iron-hydroxides + kaolinite + adularia ± smectite ± mica in the clay size fraction (<2 μm). Altered bedrock is characterized by smectite + kaolinite alteration in the clay fraction. The iron-stained gravels contain up to 25% Fe, 0.5% S, 6750 ppm Ba, 4230 ppm Mn and 250 As. Veins in the altered bedrock show a similar chemical enrichment and consist of quartz ± siderite ± goethite with botryoidal and comb textures. Fluid inclusion results indicate a Th of 100°C to 150°C and low salinities. Au appears to be disseminated in low grades and large tonnages throughout hydrothermally altered gravels and bedrock. (Authors' abstract)

DUJON, S.C. and LAGACHE, M., 1985, Experimental study of equilibria in aqueous NaCl-CaCl$_2$ solutions, and their effect on exchange between solution and plagioclase between 600 and 800°C and 1 and 2 kbar. Geological applications (abst.): Bull. Minéral., v. 108, p. 89 (in French, translated by C. Eastoe).

The reaction 2NaAlSi$_3$O$_8$(albite) + CaCl$_2$(aq) $\rightleftarrows$ CaAl$_2$Si$_2$O$_8$(anorthite)

+ $2NaCl(aq)$ + $4SiO_2$(quartz) was studied experimentally using gels for the solid phases. (...)

Consistent with the law of mass action, $K_D = (X_{An} \cdot X^2_{NaCl})/(X^2_{Ab} \cdot X_{CaCl_2})$ does not depend on the solution composition when the fluid is homogeneous. In experiments at <1 kbar, 600°C; 1 kbar, 700°C; 2 kbar, 800°C, K_D varies with concentration. This is interpreted as due to boiling. The measured K_D thus has no true physical significance, and corresponds to a weighted mean of K_D's for the liquid and the vapor. Apparent variations of K_D correspond to variations in relative proportions of liquid and vapor. The results agree well with direct measurements of boiling in $NaCl-H_2O$ fluids (Sourirajan and Kennedy, 1962), and allow the boundaries of the 2-phase field to be extended into the ternary system $NaCl-CaCl_2-H_2O$. A geological consequence is the possibility of metasomatism through boiling, which is an effective metasomatizing process in $KCl-NaCl-H_2O$ fluids. In $NaCl-CaCl_2-H_2O$ fluids, it is shown that boiling is less effective than dilution.

One-phase, dilute aqueous solutions can be considered ideal, and are used as a reference to determine the departure of plagioclases from ideality (Orville, 1972; Dujon and Lagache, 1984). Where there is boiling, the process is more complicated, and it is necessary to apply a correction to the calculations (Kotel'nikov et al., 1981). (From the authors abstract)

DUNHAM, A.C. and WILKINSON, F.C.F., 1985, Sulphide droplets and the Unit 11/12 chromite band, Rhum: A mineralogical study: Geol. Mag., v. 122, no. 5, p. 539-548. Authors at Dept. Geol., Univ. Hull, HU6 7RX, UK.

A microscopic and electron microprobe investigation has been made of six samples of the allivalite-chromitite-peridotite band at the junction of Units 11 and 12, Eastern Layered Series, Rhum. Analyses are presented of olivine, plagioclase and pyroxene, the plagioclase showing reverse zoning in the chromitite. Sulphide droplets occur within and above the chromitite, and contain pyrrhotite, pentlandite, cubanite, bornite, digenite, chalcocite, native copper and electrum, as well as chromite zoned to magnetite, spinel and ilmenite. The variation from aluminous chromite to chromite in the chromitite is confirmed by analyses of five new traverses. The rocks formed during and just after the time when new magma entered the magma chamber. The variation in the chromite compositions is ascribed mainly to magmatic variation in composition due to the mixing process. (Authors' abstract)

DUNNING, J.D., 1985, The effect of pH on subcritical cracking in quartz and calcite (abst.): EOS, v. 66, no. 18, p. 373.

DURASOVA, N.A., BARSUKOV, V.L., RYABCHIKOV, I.D., KRAVTSOVA, R.P. and EFIMOV, A.S., 1985, Peculiarities of tin behavior during crystallization of alumosilicate melts: Geokhimiya, no. 3, p. 412-416 (in Russian). First author at Inst. Geochem. & Anl. Chem., Moscow, USSR.

Experiments with melts of 1) hawaiite and 2) magnetite-silicate melt ($K_2O-Al_2O_3-SiO_2-$"FeO") were performed at 1150 ± 10°C for 46 hours (1) and 1200 ± 10°C for 22 hours (2) in evacuated silica ampoules, using buffers of magnetite/hematite and magnetite/wüstite, with Sn added as metal or SnO_2. Low fO_2 causes crystallization of Sn-poor plagioclase and the hawaiite melt concentrates Sn; higher fO_2 yields crystallization of Sn-rich magnetite and ilmenite. Composition (2) gives magnetite and melt with a Sn partition coefficient of 0.8-1.0. (A.K.)

ĎURIŠOVÁ, J., 1983, Physico-chemical conditions of origin of tin-tungsten ores in the Krušné hory Mts. (Czechoslovakia): Thesis, Geol. Survey Czechoslovakia, 101 pp., 14 plates (in Czech; abstract translated by the author). Available from the Geol. Survey, and from Geofond, part of GEOINFORM, ČSSR).

Tin and tungsten deposits in the Krušné hory Mts. (NW margin of the Bohemian massif in Czechoslovakia) belong to the so-called cassiterite-quartz type. They are associated with postmagmatic processes in exo- and endocontact zones of a Variscan granitoid pluton. The deposits consist of quartz veins and greisens. The latter accompany either quartz veins or form lens-like bodies and/or stockworks. Quartz, zinnwaldite or muscovite, topaz and cassiterite or wolframite are the essential constituents of the ore bodies.

The fluid inclusions in quartz, topaz and cassiterite were studied mainly by optical methods of homogenization and cryometry, but also by gas chromatography and by the analysis of water extracts.

The main minerals of the greisens and of the quartz veins originated under very similar conditions. Quartz, topaz and cassiterite in the ore-bearing assemblages formed at 500° to 320°C. The solutions were a sodium-chloride type (Na/K = 3.8-16.6, atomic). Calcium (2-5 wt%), fluorine, and a small amount of CO_2 were also determined. In vein minerals the content of CO_2 is 9 wt% and in the minerals of greisen <4 wt%. The minerals crystallized from two types of solutions which differed in their concentrations: 1. low concentration solutions of low density, (total salinity <10 wt% NaCl equiv. (avg. 5 wt%)); 2. high concentration solutions of high density (35-40 wt% NaCl, plus other components). At certain stages of the postmagmatic process both solutions existed at the same time; the salts were concentrated in the liquid phase (high density inclusions with solid phases) whereas the gas phase (low density gas inclusions and inclusions with critical filling) contained CO_2 and low concentrations of NaCl equiv. The coexistence of these two types of solutions was probably caused by the heterogenization of a original homogeneous ore-forming solution, probably from pressure drop due to tectonic movements. Pressure during deposition was 50 to 12 MPa. The molar ratio CO_2/CO testifies to reducing conditions.

The studies of inclusions in cassiterite indicated that it formed from solutions close to critical P-T conditions. Cassiterite crystallized at 420° to 380°C and at 29 MPa to 22 MPa. The solutions were very low density and their concentration did not exceed 5 wt% NaCl equiv., plus several mol. % of CO_2. (Author's abstract)

Ed. note: See also Ďurišová, 1984a, Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 85.

DYAR, M.D., BIRNIE, D.P., III and NANEY, M.T., 1985, The theoretical determination and experimental effects of cooling history on silicate glasses (abst.): Lunar and Planetary Sci. XVI, p. 200-201. First author at Dept. Earth, Atmos. & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

Possibly of pertinence to understanding the cooling history of melt inclusions. (E.R.)

DZHERBASHYAN, D.S., 1985, Some inconsistencies in crystallization trends in the magma chamber and melt inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 117 (in Russian; translation by D.A. Brown). Author at Inst. Geol. Sci. Acad. Sci. Armenian SSR, Tbilisi, USSR.

Differences between Tm dms and Tt of solid crystalline inclusions may be due to the difference in P within the inclusion and outside the host phase in the magma chamber and must be considered in evaluating the determined order of crystallization in the inclusions. (Abbreviated by E.R. from the author's abstract)

DZHUN', V.S. and KUZNETSOV, A.G., 1985, Applicability of complex decrepitation-thermoluminescent analysis in mineralogical-petrographical studies of deposits of non-ore mineral raw materials (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 83-84 (in Russian). Authors at Simferopol' State Univ., Simferopol', USSR.

The authors used apparatus for joint recording of Td and thermoluminescence effect. Samples of calcite, quartz and feldspar from marbles and plagiogranites from Priazov'ye (grain class 0.25-0.50) had the weight 0.5 g. Hydrothermal calcite veins in the Crimea deposits cut the above rocks and, on approaching these veins, Td increases and thermoluminescence intensity decreases. In plagiogranites most intensive thermoluminescence is observed at 230°C, and in marbles - at 300-340°C. Authors recommend this method especially for prospecting. (A.K.)

DZYUBA, A.S. and ZU, Y.Y., 1985, Interaction of gas bubbles with melt crystallization front: Kristallografiya, v. 30, p. 1177-1180 (in Russian; translated in Sov. Phys. Crystallogr., v. 30, no. 6, p. 684-686). Authors at State Univ. Khar'kov, USSR.

Gas bubbles of small size are captured by the growth front, whereas large ones are repelled, and grow during repulsion owing to influx of gas dissolved in the melt, even moving from the front into the melt. The results of the experiment are compared with the theory. (Authors' abstract)

EADINGTON, P.J., 1985, The solubility of cassiterite in hydrothermal solutions in relation to some lithological and mineral associations in tin ores (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 110-115.

EASTOE, C.J., SOLOMON, M. and WALSHE, J.L., 1985, A sulfur-isotope study of Cambrian massive-sulfide and associated mineralization, western Tasmania (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 571.

EBERHART, J.G., 1985, The thermodynamic limit of superheat of water: J. Colloid & Interface Sci., v. 107, no. 2, p. 574-575. Author at Dept. Chem., Univ. Colorado, Colorado Springs, CO 80933.

Pertinent to the nucleation of vapor in homogenized aqueous inclusions. (E.R.)

ECKSTRAND, O.R. and WILLIAMSON, B.L., 1985, Vesicles in the Dundonald komatiites (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A16. Authors at Geol. Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A0E8, Canada.

Amygdules form a slightly altered, undeformed, ultramafic komatiite flow in Dundonald township, Ontario, appear to have formed from gas bubbles which existed in the molten lava. They occur in the spinifex zone, within 3m of the upper contact of a 40m thick flow, over a strike length of at least 100m. They form spherules 0.25-4.0mm in diameter, and show cavity-filling banded colloform texture. The amygdules generally contain serpentine, chlorite and tremolite (deposited by serpentinizing or other metamorphic fluids), sulphide, or matrix-like acicular pyroxene and glass (which represent segregation vesicles). They commonly are bounded by coarser skeletal olivine grains above and by later crystallizing interstitial matrix material below, suggesting a gas bubble rising through molten magma until trapped by flow-top crystals. In oriented samples the inferred direction of movement of the bubble is towards the stratigraphic top (as determined by grain size gradation of the spinifex zone). Some trapped amygdules have irregular proturberances on the top indicating attempted escape upwards between skeletal olivine crystals. Sulphide blebs or euhedral chromite grains are attached to the outside of some amygdules, usually on the bottom. The shapes suggest that gravitationally settling chromite and molten sulphide liquid were intercepted by the rising gas bubbles and carried upwards, similar to a metallurgical froth flotation cell. (Authors' abstract)

EDGAR, A.D. and ARIMA, Makoto, 1985a, Fluorine and chlorine contents of phlogopites crystallized from ultrapotassic rock compositions in high pressure experiments: Implication for halogen reservoirs in source regions: Am. Mineral., v. 70, p. 529-536, p. 608-618. Authors at Dept. Geol., Univ. Western Ontario, London, Ontario, Canada, N6A 5B7.

Phlogopite crystallized in suprasolidus high pressure experiments between 10 and 40 kbar from four ultrapotassic mafic-ultramafic rock compositions shows wide variations in F content (0.13 to 2.41 wt.%) and Cl below the detection limits (<0.03 wt.%). The rock compositions range from 0.02 to 1.59 wt.% F, with K/(K + Na) ratios of 0.41 to 0.94. For compositions in which phlogopite is the only F-bearing mineral, the F contents of phlogopite are higher than those of the rocks from which they crystallize and F in phlogopite increases with decreasing temperature and is not appreciably affectd by pressure. These data suggest that F is preferentially incorporated in the phlogopite rather than in the liquid and that increasing F contents in phlogopite with decreasing temperatures are primarily a result of increasing crystal/liquid ratios. In one rock composition with coexisting apatite and phlogopite, F in the phlogopite appears to decrease with decreasing temperature and is slightly lower than in the rock composition. This suggests that in the presence of both F-bearing minerals, F is partitioned between them. Average F content of phlogopite in this study is about twice that of F in "primary" phlogopite from garnet lherzolite nodules in kimberlites although the range of F values is similar.

A composition of F and K_2O contents in ultrapotassic rocks indicates higher K_2O and F and slightly greater F/K_2O ratios than in other basaltic rocks. A higher F/K_2O and greater abundance of phlogopite relative to apatite in the source regions for ultrapotassic magmas may account for this higher ratio. The higher ratio also implies that phlogopite rather than apatite may be the main reservoir for F in such regions. (Authors' abstract)

EDGAR, A.D. and ARIMA, M., 1985b, F & Cl contents of phlogopites in high pressure melting experiments on ultrapotassic rocks; implication for F and Cl reservoirs in mantle source regions (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A16. Authors at Dept. Geol., Univ. Western Ontario, London, Ontario, N6A 5B7, Canada.

See previous abstract. (E.R.)

EDMUNDS, W.M., KAY, R.L.F. and McCARTNEY, R.A., 1985, Origin of saline groundwaters in the Carnmenellis granite (Cornwall, England): Natural processes and reaction during hot dry rock reservoir circulation: Chem. Geol., v. 49, p. 287-301. First author at Hydrogeology, Res. Group, British Geol. Survey, Wallingford, Oxon X10 8BB, Great Britain.

Saline groundwaters (up to 19,100 $mg \cdot l^{-1}$ total mineralization) issue in tin mines in the Carnmenellis granite in Cornwall (U.K.) at depths up to 800 m. Their stable-isotope composition rules out seawater as a contributor to salinity. Circulation experiments carried out during Hot Dry Rock (HDR) reservoir development in the same granite also produce return fluids with enhanced salinities. Acid hydrolysis of plagioclase and biotite are proposed as the main sources of salinity in the groundwater. Experimental studies carried out on biotites from a borehole used for HDR evaluation demonstrate the reactivity of the biotite and confirm the hypotheses of the field studies.

Mg, Li, K and silica levels in reacted solutions reflect the stoichiometric composition of the biotite. Chloride, Na and Ca in solution, on the other hand, are enriched between 1 and 3 orders of magnitude over that of biotite, reflecting the strongly incongruent nature of the reaction. Quartz and chalcedony saturation of the groundwaters encourages silica (or silicate) deposition rather than dissolution of rock-forming quartz; this argues against fluid inclusions as the source of salinity and suggests that new inclusions might be formed. The proposed model for the genesis of saline water therefore links together, or explains, several processes - groundwater movement, convective heat transport, the chemistry of the water, water-rock interaction, secondary mineral (including kaolinite) formation and fluid inclusion formation and stability. (Authors' abstract)

EGGLESTON, T.L. and NORMAN, D.I., 1985, Geology and geochemistry of rhyolite-hosted tin deposits, northern Black Range and Sierra Cuchillo, southwestern New Mexico: New Mexico Bureau of Mines & Mineral Resources Cir. 199, p. 45-49. Authors at Geosci. Dept., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Tertiary (28 my) rhyolite lavas host a number of tin occurrences in southwestern New Mexico. These lavas are typically crystal-rich, white, flow-banded, high SiO_2, K_2O, F, Cl, and low CaO, Fe_2O_3, Sr, Ba "topaz" rhyolites. Vapor-phase recrystallization, due to magmatic fluids exolved during ascent and cooling of the lavas, bleached and crystallized the groundmass glass to a fine mosaic of quartz and feldspar. Tin was partitioned into this fluid from the melt and was deposited from it near the carapace of the rhyolite domes in response to the extreme thermal gradients there. Temperatures for tin mineralization range from >600 to <400°C, with salinities exceeding 50 eq. wt. % NaCl. Lower temperatures (400-130°C) and lower salinities (2-5 eq. wt % NaCl) suggest that meteoric water was important late in the cooling of the dome. (Authors' abstract)

ELLIOTT, J.E., 1985, The tin-bearing granite of Jibāl al Qārah in the southern Arabian Shield, Kingdom of Saudi Arabia: Prof. Papers - Kindgom of Saudi Arabia, Ministry of Petrol. & Min. Resources, v. 2, p. 1-17. Author at U.S. Geol. Survey, Denver, CO, USA.

A microcline-albite granite exposed at Jibāl al Qārah in the southwestern corner of the Wādī Wasaṭ, quadrangle contains an average of 66 ppm tin. Compared with normal granites, this granite is notably enriched in fluorine, lithium, and rubidium, in addition to tin, and depleted in titanium, magnesium, calcium, and strontium. Essential minerals are albite, quartz, microcline, and light-colored mica; accessory minerals include fluorite, topaz, and cassiterite. This granite is similar in chemistry and mineralogy to tin-bearing granites from other parts of the world. No tin deposits were found. Guides for prospecting for granites of this type include distinctive mineralogy, chemistry, textures, and fluid inclusions [vapor-rich and liquid CO_2-bearing]. (From the author's abstract)

ELOY, J.F., 1985, Contribution to fluid microinclusion analysis using the time-of-flight type laser probe mass spectrograph LPMS 2 (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 40. Author at IRDI/DERDCA/DCAEA/SEA/SEAPC - CEA/Cen-Grenoble 85 X - 38041 Grenoble Cedex, France.

From previous work on fluid inclusions, the absolute sensitivity of the LPMS has been improved by a sophisticated laser microprobe and a T.O.F. detector, both patented, to take advantage in real time of its analytical performance. New results have been obtained about the chemical composition of both the fluid and the walls of inclusions enclosed in halite and dolomite. In addition they show evidence of a redistribution in some elements at the fluid-wall interfaces. (Author's abstract)

ELOY, J.F., 1985, Geological applications of ionization LTE model in laser probe mass spectrometry: Scanning Electron Microscopy, 1985, v. 2, p. 563-576. Author at DCAEA/EAPC, Centre d'etudes Nucléaires, BP 85 X, 38041 Grenoble Cedex, France.

Recently, the laser plasma ionization process of the laser probe mass spectrograph permitted one to obtain quantitative information on the fluid inclusions and trace distributions in ores. Indeed laser ionization provides the physical conditions for a substantial application in the Local Thermodynamical Equilibrium (LTE) model. Other geological information in the case of micro-analysis on the quartz, fluorite, and zircon has also been obtained. (Author's abstract)

EMANUEL, K.M., SELKE, M.W. and PARKISON, G.A., 1985, Geology of the Red River mining district, Taos county, New Mexico (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 51. Authors at NICOR Min. Ventures, Inc., Albuquerque, NM.

The Red River mining district is centered on the town of Red River, nestled within the Sangre de Cristo Mountains of northen New Mexico. Past production from the district is minimal, with sporadic activity from 1890 to 1940.

Precambrian crystalline rocks are overlain by a variable thickness of andesitic to rhyodacitic volcanic rocks of the Latir volcanic field, dated at 26 to 35 m.y. The south and southeast ring-fracture zone of the recently recognized Questa caldera has localized the intrusion of three extremely altered and mineralized granitic plutons along Red River that date at 22 to 23 m.y.

Precious-metal mineralization of the Red River district forms an arcuate pattern a few miles outside the ring-fracture zone peripheral to the late mineralized intrusives of the Questa caldera. Most mineralization is associated with quartz-cemented breccia zones or finely banded, massive or vuggy quartz veins. Many veins have argillically altered and weakly silicified and mineralized envelopes. Vein trends are generally east-west or north-south, are steeply dipping, and may be related to concentric ring-fracture zones and radial faults associated with the Questa caldera. Silver to gold ratios are typically 80:1 in mineralized zones. Known ore minerals are native gold, pyrargyrite, and chalcopyrite.

Fluid-inclusion studies indicate that boiling occurred. These studies also suggest a positive correlation between inclusion temperature and associated precious-metal grades. Precious-metal mineralization in the district may be related to the molybdenum deposits at Questa. (Authors' abstract)

ENTING, I.G., 1985, A lattice statistics model for the age distribution of air bubbles in polar ice: Nature, v. 315, p. 654-655.

ETMINAN, Hashem, LAMBERT, I.B., BUCHHORN, Ian, CHAKU, Surender and MURPHY, G.C., 1984, Research into diagenetic and mineralizing processes, Lennard Shelf reef complexes, W.A., in The Canning Basin W.A., P.G. Purcell, ed.: Proc. GSA/PESA Canning Basin Symp., Perth Australia, 1984, p. 447-453. First author at Baas Becking Lab., Canberra, ACT 2601.

Wide-ranging research is being undertaken on the Devonian carbonate complexes of the Lennard Shelf, at the northern margin of the Canning Basin. This work is aimed at obtaining a detailed understanding of the processes involved in reef diagenesis and formation of Pb-Zn mineralization.

Preliminary results imply that the early diagenetic carbonate cements are largely of marine origin. Later diagenetic carbonates, including those intimately associated with Pb-Zn mineralization, formed at temperatures of 45°C to 110°C from fluids of widely varying salinities, some of which contained minor amounts of hydrocarbons. Stable isotopic data imply that there were different sources of sulfur for the different deposits, and that iron sulfides formed separately from galena and sphalerite. (Authors' abstract)

EUGSTER, H.P., 1985, Granites and hydrothermal ore deposits: A geochemical framework: Mineralogical Mag., v. 49, p. 7-23. Author at Dept. Earth & Planet. Sci., Johns Hopkins Univ., Baltimore, MD 21218, USA.

The geochemial evolution of tin-tungsten deposits and their associated sulphides [is] discussed in terms of four sequential processes: acquisition of the ore-forming elements (OFEs) by the granitic magma, emplacement of these elements in minerals and residual melt of the crystallizing granite, release of the OFEs to the circulating hydrothermal fluids and transport to the depositional sites, and finally, deposition of ore minerals through interaction of these fluids with the wall rock. (From the author's abstract)

EUGSTER, H.P., 1985, Oil shales, evaporites and ore deposits: Geochimica Cosmo. Acta, v. 49, p. 619-635.

FABRICIUS, J., 1985, Studies of fluid inclusions in halite and euhedral quartz crystals from salt domes in the Norwegian-Danish basin: Sixth Int'l. Symp. on Salt, 1983, v. 1, p. 247-255.

See Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 91, 1984. (E.R.)

FABRICIUS, J., 1985, The thermal stability of natural carnallite in cognate geological environments (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 42.

See previous abstract. (E.R.)

FAIZIEV, A.R. and ISKANDAROV, F.Sh., 1985, Physico-chemical parameters of fluorite-forming fluids in the deposits of Tadjikistan (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 44-45. Authors at Geol. Dept., Tadjik State Univ., Dushanbe, USSR.

Fluorite deposits of late-Hercynian, early- and late-Alpine mineralization epochs are known in northern and central Tadjikistan, as well as in the Pamirs. Here all genetic types of fluorite mineralization are found: magmatic, pegmatitic, pneumatolytic, hydrothermal. In northern Tadjikistan the fluorite mineralization was formed in the late-Hercynian epoch. In central Tadjikistan, along with the late-Hercynian deposits, the deposits formed in the Alpine epoch can also be found, while in the Pamirs all deposits are of Alpine age.

In northern Tadjikistan deposits mainly two-phase, gas-liquid and occasionally single-phase liquid inclusions are found. In the central Tadjikistan deposits, along with single-phase and two-phase inclusions, polyphase inclusions with 1-2 crystals of readily dissolved salts occur. In both areas, salinities range from ~5-40%. In the Pamirs fluorites polyphase inclusions with 3-7 crystal phases usually occur, some with liquid CO_2, and salinities of 4->75%.

The formation of fluorite mineralization in northern Tadjikistan occurred at 50-350°C and <100-400 atm from $Ca-HCO_3$ solutions, while in central Tadjikistan it was at 60-370°C and 8-450 atm, from $Ca-HCO_3-SO_4-Na-K-Cl$ solutions. The Pamirs deposits formed 85-700°C and 30-400 atm, from Ca-Cl solutions, ± Na, K, Mg, and Li, with insignificant HCO_3. A vertical temperature zoning with a paleotemperature gradient of 8-15° per 100 m depth was detected. (From the authors' abstract)

FALKUM, T., KONNERUP-MADSEN, J. and ROSE-HANSEN, J., 1985, A preliminary study of REE elements and fluid inclusions in the Homme granite, Flekkefjord, south Norway, in A.C. Tobi and J.L.R. Touret, eds., The deep Proterozoic crust in the North Atlantic provinces: D. Reidel Publ. Co., p. 579-583. First author at Geol. Inst., Aarhus Univ., 8000 Aarhus C, Denmark.

The results of a preliminary study of REE evolution and fluid inclusions [CO_2 and/or aqueous] in the Homme biotite granite are presented. Both sets of data are tentatively related to one of two mechanisms: (1) assimilation of felsic granulite facies gneisses, and/or (2) formation of the Homme granite by fractionation from a charnockitic source. The REE pattern does not appear to be controlled by mineral fractionation. (Authors' abstract)

FALLICK, A.E., JOCELYN, J., DONNELLY, T., GUY, M. and BEHAN, C., 1985, Origin of agates in volcanic rocks from Scotland: Nature, v. 313, p. 672-674. First author at Isotope Geol. Unit, Scottish Univ. Research & Reactor Center, East Kilbride, Glasgow G75 0QU, UK.

Isotopic data ($^{18}O/^{16}O$ and D/H) imply that bound waters associated with the agates have preserved their hydrogen isotope ratios since agate deposition, which supports arguments that the water content is of genetic significance, but does not support a model for agates as 'refused' chert xenoliths. We infer that agates of both ages were formed at low temperature (~50°C) from fluids having at least a component of present day meteoric origin. (From the authors' abstract)

FAM, T.S., 1984, Experimental studies of immiscibility phenomena in the system nepheline-kalsilite-quartz: Geologiya i Geofizika, no. 9, p. 139-143 (in Russian; English abstract). Author at Moscow State Univ., Moscow, USSR.

Experiments performed under P H_2O = 400 MPa revealed an immiscibility field at 825°C, nepheline 35-47%, kalsilite 31-38%, quartz 48-65%; the importance of this immiscibility for pegmatite formation is discussed. (A.K.)

FAN, Qihao, MO, Jinyou and LI, Yuzu, 1985, A preliminary study of the migration direction of ore fluids in special reference to fluid inclusion data from Banxi antimony mine, Hunan Province: Acta Mineral. Sinica, v. 5, no. 1, p. 10-14 (in Chinese; English abstract). Authors at Inst.

Metallurgical Geol., Hunan Province.

The Banxi antimony mine is located in the southwestern part of Taojiang County, Hunan Province. The rich ore deposit occurs in the Proterozoic Banxi Group metamorphic arkose and variegated slate.

According to geological, mineralogical, petrological and fluid inclusion data the process of mineralization can be divided into four stages: (1) the Si-W-Au stage, (2) the Si-Au-Sb stage, (3) the Si-As-Sb stage, and the carbonate-Sb stage. The isothermal map based on precipitation T data of stibnite in lode V_2 indicates a migration direction of ore fluids from SW to NE. In terms of the above data, in conjunction with the geological features of the deposit, ore prediction has been made, and high-grade blind lodes have been found by drilling to the depth of 300 m in the southwestern domain of V_2. (Authors' abstract)

FANG, Hua, YAO, Jiadong, HE, Dagui and JIANG, Qinsheng, 1985, The significance of deep-seated magmatic differentiation in the rock- and ore-forming processes of copper-nickel sulfide deposits--exemplified by the Limahe copper-nickel sulfide deposit of Sichuan Province: Acta. Geol. Sinica, v. 59, no. 2, p. 141-154 (in Chinese; English abstract).

Taking the Limahe copper-nickel sulfide deposit of Sichuan Province for example, this paper discusses deep-seated magmatic differentiation and its relation to the rock- and ore-forming processes. The authors consider that the magmatic differentiation--gravitational liquid differentiation and liquid immiscibility of sulfides occurring at great depth are very important geological phenomena in the history of magmatic evolution. The main role of the deep-seated magmatic differentiation in the rock- and ore-forming process of copper-nickel sulfide deposits is as follows: (1) In the abyssal magma chamber under stable tectonic environment the parent magma is often differentiated into two or more "daughter magmas," with the basic magma in the upper part and the ultrabasic magma in the lower part; meanwhile, ore-forming elements such as iron, nickel and cobalt are markedly enriched in the lower magma. The mechanism of this kind of differentiation may be explained in the light of the law of migration of ions or ion groups. (2) The liquid immiscibility of sulfides occurring in the abyssal magma chamber is accomplished on the basis of the gravitational liquid differentiation of magmas and along with differentiation into basic and ultrabasic magmas. As a result of liquid immiscibility, sulfides are concentrated in the ultrabasic magma in the lower part of the magma chamber and are further separated into sulfide-rich ultrabasic magma or ore melt (sulfides being rich in the lower part and poor in the upper part) and pure sulfide melt. (3) The above differentiated magmas or ore melts commonly move upwards successively through the same channel way under the effects of tectono-magmatism and, after consolidation, form the sulfide-barren diorite-gabbros, sulfide-rich peridotites and pure sulfide orebodies. The entire rock- and ore-forming process mainly proceeds at great depth. Therefore the authors propose that such a kind of deposit be termed a "deep-seated magmatic liquation-injection deposit." (Authors' abstract)

FELDMAN, V.I. and LETNIKOV, F.A., 1985, Behavior of fluid components in the process shock metamorphism (abst.): Lunar and Planetary Sci. XVI, p. 234-235. First author at Moscow State Univ., Moscow, USSR.

Total fluid contents was studied in 72 samples of impactites and target rocks from three astroblemes of USSR by chromatography of products of bulk thermodegassing. Nine analyses are presented for H_2O, CO_2, CO, CH_4, H_2 and N_2, and discussed particularly in terms of state of reduction, as determined by various gas ratios. (E.R.)

FENG, Zhongyan and ZHANG, Xingyu, 1985, Geologic characteristics and genesis of the stratiform sulfide ore deposits in the Xinglong region, eastern Hebei: Mineral Deposits, v. 4, no. 3, p. 1-9 (in Chinese; English abstract). Authors at Dept. Geol., Beijing Univ., PRC.

In addition to studies of S and Pb isotopes, the decrepitation temperatures are at 196-330°C for pyrite, 297-340°C for sphalerite with high content of F in mineral inclusions, and the salinity is over 20%. (From the authors' abstract)

FERRI, Diego, GRENTHE, Ingmar, HIETANEN, Sirkka, NEHER-NEUMANN, Erzsebet and SALVATORE, Francesco, 1985, Studies on metal carbonate equilibria. 12. Zinc(II) carbonate complexes in acid solutions: Acta. Chemica Scandinavica, v. 39, p. 347-353.

FIELD, C.W. and POWER, S.G., 1985, Metallization in the Western Cascades, Oregon and southern Washington (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 218. Authors at Dept. Geol., Oregon State Univ., Corvallis, OR 97331.

Polymetallic hydrothermal deposits of the Western Cascades are hosted in propylitically altered mid-Tertiary volcanics of calc-alkalic affinity and nearby compositionally similar intrusions 7 to 22 m.y. in age. Recent geologic and exploration efforts have documented systematic physical-chemical changes in the hydrothermal systems of this province. The evidence, regional from south to north and local from high to low altitudes, includes increasing salinities (1 to >30 wt % NaCl), homogenization temperatures (160° to >385°C), and amounts of daughter minerals in fluid inclusions of quartz. Minor variations of the sulfur isotope data (1 ± 3‰) suggest a continuum of "magmatic" values between vein, disseminated, and breccia pipe sulfides. Accordingly, hydrothermal deposits of the Western Cascades record a south to north progression from epithermal (Au-Ag), through mesothermal (Zn-Pb-Cu-Ag), to hypothermal (Cu-Mo) environments. (From the authors' abstract)

FIELD, M.E. and KVENVOLDEN, K.A., 1985, Gas hydrates on the northern California continental margin: Geology, v. 13, p. 517-520.

FIÉNI, C., BOUROT-DENISE, M., PELLAS, P., TOURET, J. and ROBERT, F., 1985, Fluid inclusions in quartz and phosphates of ordinary chondrites: More data (abst.): Lunar & Planet. Sci., v. 16, p. 236-237. First author at Lab. Min. Muséum, Paris, France.

Fluid inclusions (i.e., inclusions which contain a visible moving vapor bubble) have been observed by Fiéni et al. [1978] in separate grains of phosphates (apatite, merrillite) and feldspar from Peetz (L6), and in merrillites from St. Séverin (LL6) chondrites. From melting temperatures (very close to 0°C) and homogenization temperatures (converging between 180-220°C) it was concluded that the fluid was almost pure water. A recent report on the ubiquitous presence of fluid inclusions in a number of chondrites and achondrites [Warner et al., 1983] has since then been retracted: the fluid inclusions were attributed to artifacts resulting from thin section preparation [Rudnick et al., 1984]. As it is of some importance for a full understanding of chondrite accretionary processes and metamorphic histories to know whether fluid inclusions are really present - or not - in some minerals of chondrites, we decided to reverify all our previous observations and to obtain new data by other methods. We absolutely confirm - by new microthermometric data - the presence of fluid inclusions of almost pure water in mineral grains of Peetz and St. Séverin chondrites. These minerals are: phosphate (merrillite, apatite) and α-quartz. In a companion paper [Bourot-Denise et al., this volume] we describe the non-rare occurrence of quartz grains in some ordinary chondrites. Many of these quartz grains do contain aqueous fluid inclusions (<1 to ~10 µm in size) in variable abundances (up to 20 fluid inclusions per crystal of ~100 µm in dimensions); these grains also contain other very similar inclusions but devoid of moving bubble. Other quartz grains don't contain any perceptible fluid inclusions. On the other hand, we don't confirm the presence of fluid inclusions in feldspars from Peetz: the "feldspar" grains were in fact quartz grains. Fluid inclusions have also been detected in a few quartz grains from Nadiabondi (H5) chondrite [Aines and Rossman, 1984], but they have not yet been studied by means of microthermometry. Some important points should be emphasized: 1) the fluid inclusions were only found in quartz grains separated along with the feldspar fraction and in phosphate fractions; 2) they have never been observed in olivine and pyroxene crystals, contrary to observations reported in [Rudnick et al., 1984]; 3) they were only found in 3 ordinary chondrites (St. Séverin, Peetz, Nadiabondi) out of 19 studied with the same procedure (i.e., through mineral separates).

A sample of the St. Séverin "feldspar" fraction was analyzed for its D/H ratio. The minimum measured δD value (-340‰) is a maximum for the bulk δD-inclusion, provided the signal corresponds to the water released from the fluid inclusions. Such a low δD value seems difficult to attribute to terrestrial H_2 contamination. (From the authors' abstract)

See also Bourot-Denise et al., this volume. (E.R.)

FIFAREK, R.H., 1985, Alteration geochemistry, fluid inclusion, and stable isotope study on the Red Ledge volcanogenic massive sulfide deposit, Idaho: Doctoral dissertation, Oregon State Univ., Corvallis, OR, 200 pp.

Indexed under fluid inclusions.

FILIPPOV, V.N. and YUKHTANOV, P.P., 1985, Use of vacuum decrepitation for determination of gas-content of raw material for glass (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 93 (in Russian). Authors at Geol. Inst. Komi Div. Acad. Sci. USSR, Syktyvkar, USSR.

Use of vacuum decrepitometry gives good coincidence of results on amount of volatiles in raw quartz for glass production with traditional methods (visual, light transmission measurement, determination of mass loss on calcination), but also gives information about T of gas release, can be determined on a small sample (50 mg and less), and allows the distinguishing of gas release from inclusions and from opened micropores. (A.K.)

FINE, Gerald and STOLPER, Edward, 1985, The speciation of carbon dioxide in sodium aluminosilicate glasses: Contrib. Mineral. Petrol., v. 91, p. 105-121. Authors at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125.

Infrared spectroscopy has been used to study the speciation of CO_2 in glasses near the $NaAlO_2$-SiO_2 join quenched from melts held at high temperatures and pressures.

Infrared spectroscopic measurements of species concentrations in glasses provide insights into the molecular level processes accompanying CO_2 solution in melts and can be used to test and constrain thermodynamic models of CO_2-bearing melts. CO_2 speciation in silicate melts can be modelled by equilibria between molecular CO_2, CO_3^{2-}, and oxygen species in the melts. Consideration of the thermodynamics of such equilibria can account for the observed linear relationship between molecular CO_2 and carbonate concentrations in glasses, the proposed linear relationship between total dissolved CO_2 content and the activity of CO_2 in melts, and observed variations in CO_2 solubility in melts. (From the authors' abstract)

FINK, Jonathan, MANLEY, Curtis and KRINSLEY, David, 1985, Volatile migration, crystallization, and vesiculation during emplacement of Inyo obsidian dome (abst.): EOS, v. 66, no. 18, p. 387.

FIRSOV, A.P., 1985, Influence of thermal expansion of host mineral for determination of PT parameters from inclusions of mineral-forming media (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 32-33 (in Russian). Author at Geol. Inst. of Buryatian Div. Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

For thermobarometric estimations with use of fluid inclusions, the isochore for the appropriate physico-chemical system is frequently determined. However, fluid inclusions are isochoric only to the first approximation. Thermal expansion and pressure compressibility of the host mineral lead to the necessity of determination of the influence of small changes in inclusion volume, resulting in changes of inclusion filling density, because Th is very sensitive to density variations. During inclusion cooling from Tt to Th the inclusion point will move aside from the isochore along new dP/dT line to lower specific volumes of fluid in PT plot. The slope of this dP/dT line is smaller than slope of the isochore. The difference between the specific volume of inclusion fluid at Th and Tt may cause errors in P determinations from melt and LH_2O coeval inclusions from 14 up to 140 MPa, if the Th of the LH_2O inclusions are in the range 150-350°C, and the same for the Lemmlein-Klevtsov water-salt method - up to 100 MPa. Such errors may be removed by use of the following equation for calculation of specific volume of fluid at Tt (V_2) from specific volume at Th (V_1): $V_2 - V_1(1 + \alpha\Delta T)$, where $\Delta T = Tt - Th$, α - coefficient of thermal expansion of host mineral.

In the T interval between Th and Tt, during heating, the P in inclusions increases, sharply, leading to expansion of inclusion volume due to P compressibility of the mineral; at Tt pressure in inclusion is equal Pt. However, since specific volume of fluid is determined on the basis of Th, when P in inclusion is low, correction for specific volume value on P influence should not be applied. (A.K.)

FISHER, D.E., 1985, Radiogenic rare gases and the evolutionary history of the depleted mantle: J. Geophys. Res., v. 90, no. B2, p. 1801-1807. Author at Rosenstiel Sch. Marine & Atmosph. Sci., Univ. Miami, Miami, FL.

U, Th/He, K/Ar, and U/Xe ages of the depleted mantle source region of oceanic basalts are much less than the age of the earth, showing clearly that the midocean ridge basalt mantle source was not completely degassed and decoupled from the atmosphere early in earth history. Rather, extensive degassing has continued up to at least the last few hundred million years. A stable, layered mantle is not suggestd by these data. (Author's abstract)

FISHER, D.E., 1985, Rare gases in terrestrial rocks: Mantle heterogeneity or atmospheric contamination? (abst.): Lunar and Planetary Sci. XVI, p. 244-245. Author at Rosenstiel Sch. of Marine & Atmos. Sci., Univ. Miami, Miami, FL 33149.

Isotopic abundances of the rare gases measured in a variety of terrestrial samples which have trapped mantle gases show anomalies at He-3, He-4, Ne-21, Ne-22, Ar-40, Xe-129, Xe-134, and/or Xe-136. These nonradiogenic, nonnucleogenic isotopes may reflect atmospheric contamination.

Data are presented on a wide spectrum of oceanic rocks, from basaltic glasses which have effectively trapped mantle-ambient gases to altered metabasalts and gabbros which have not. The results exhibit a strong anticorrelation between trapping efficiency (as indicated by the radiogenic isotopes) and contents of Ar-36 and Xe-132. The conclusion is that these latter isotopes are not mantle components but are rather atmospheric contamination. These data suggest that Ar and Xe isotopic ratios from "undepleted" mantle samples do not reflect true mantle abundances and should not be used in mantle evolutionary studies. In particular, previous conclusions which state that the heavy rare gas isotopic record stipulates the existence of a stable, layered mantle are not valid. (From the author's abstract)

FISHER, R.S. and POSEY, H.H., 1985, Extent of water-rock interactions in Lower Permian Wolfcamp carbonates, Palo Duro Basin, Texas (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 583.

FONTEILLES, Michel and PASCAL, M.-L., 1985, Feldspathization as a sign of magmatic origin of hydrothermal fluid: C.R. Acad. Sc. Paris, v. 300, Ser. 2, no. 20, p. 1003-1006 (in French; English abstract).

Quartz-muscovite veins in W-Sn type ore deposits, as well as mineralized skarns, result from the percolation of acid fluids. They occur frequently in association with metasomatic rocks involving Al-transport (feldspathites, skarns with grossular-almandine garnet) which are produced by alkaline fluids. Such fluids, unsaturated with quartz, cannot have their source in the surrounding schists, but they may have been equilibrated with the granite at a higher pressure: such a pressure gradient can be expected because the fluid released by the crystallizing magma is likely to undergo an overpressure as it remains trapped at the top of the granite (presence of stocksheiders) before the opening of the vein system. This model implies that the magma cools down rather quickly, and therefore, intrudes relatively cold terranes. (Authors' abstract)

FORURIA, Jon, 1985, Geology and precious-metal occurrences of the San Jose district, Socorro county, New Mexico (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 52. Author at Colorado State Univ.

The San Jose district encompasses several silver-gold "fissure-type" vein occurrences hosted within the Oligocene Vicks Peak Tuff.

Hydrothermal-alteration effects contemporaneous with precious-metal mineralization consist of quartz-alunite-replacement alteration, pervasive intermediate argillic alteration, and pervasive and veinlet silicification related to a single hydrothermal episode.

Mineralization accompanies vein-related silicification consisting of pyrite, cerargyrite, native gold, and native silver. Cursory fluid-inclusion examinations document the presence of local boiling confined to structures which led to the development of argillic and advanced argillic assemblages. (From the author's abstract)

FOSTER, R.P., 1985, Major controls of Archaean gold mineralization in Zimbabwe: Trans. Geol. Soc. S. Afr., v. 88, p. 109-133.

An extensive review, including a discussion of the generation of high $f(O_2)$, high SO_2/H_2S fluids capable of efficient Au transport. (E.R.)

FOURNIER, R.O., 1985, Heat transfer and brine evolution in magma-hydrothermal systems (abst.): U.S. Geol. Survey Circular 949, p. 13.

There are many uncertainties in the mechanism (or mechanisms) by which heat is transferred from magma to a surrounding hydrothermal system. Mechanisms that have been proposed include (a) conduction, (b) transfer of heat by movement of water and volatiles out of the magma, and (c) circulation of meteoric water into a thin zone of thermal cracking that migrates inward towards the magma with time as the rocks cool. Several recent investigations have focussed upon the likely significance of this last mechanism, but major aspects are poorly understood. Among these are the thickness of the cracking zone, the temperature gradient across it, the temperatures at which it occurs (perhaps 350-450°C), and the chemical consequences of water-rock interaction in that zone. More than one convection cell may be present at a given time within an active hydrothermal system, with fluids of varying composition associated with different types of mineralization in the various cells. Convecting hydrothermal systems at hydrostatic pressure may partly surround hydrothermal systems in which fluid pressures are greater than hydrostatic but less than or equal to the least principal stress in the rock. Fluid pressures greater than hydrostatic are particularly likely to develop where the flow of fluid away from a heat source is impeded by a barrier of relatively impermeable rock, perhaps a layer of very ductile material such as shale in otherwise brittle rock, or a zone where mineral deposition has filled all or most of the pre-existing fractures and pore spaces.

Our present knowledge of hydrothermal mineral deposits and active geothermal systems demonstrates the importance of interaction between shallow dilute meteoric water and deeper brines. The highly concentrated brines thus far encountered in active hydrothermal systems are all in environments in which the waters may have interacted with evaporites. Experimental data, however, indicate that highly saline as well as moderately concentrated brines may evolve from a crystallizing magma, depending on the initial water and chloride contents and the depth of crystallization. Brines may also develop from dilute meteoric water as a result of boiling, which disproportionates the fluids into a more concentrated liquid (brine) and a gas. As a result of boiling or gas disproportionation, highly saline brines are likely to evolve in and around shallow magmatic intrusions, particularly at depths less than 6 to 8 km. Because of density contrasts, hot brines will remain below hot, dilute, hydrothermal waters or to the side of cold, dilute waters. These hot brines will scavenge metals from the surrounding rock, and the base metals in turn will react with much of the sulfur that is liberated from crystallizing magma. Thus, a base-metal ore deposit may form in the brine part of the hydrothermal system while the dilute part remains relatively unmineralized with respect to base metals. (Author's abstract)

FOURNIER, R.O. and PITT, A.M., 1985, The Yellowstone magmatic-hydrothermal system, U.S.A.: 1985 Int'l. Symp. on Geothermal Energy, International Vol., p. 319-327. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

At Yellowstone National Park, the deep permeability and fluid circulation are probably controlled and maintained by repeated brittle fracture of rocks in response to local and regional stress. Focal depths of earthquakes beneath the Yellowstone caldera suggest that the transition from brittle fracture to quasi-plastic flow takes place at about 3 to 4 km. The maximum temperature likely to be attained by the hydrothermal system is 350 to 450°C, the convective thermal output is about 5.5 x 10^9 watts, and the minimum average thermal flux is about 1800 mW/m^2 throughout 2,500 km^2. The average thermal gradient between the heat source and the convecting hydrothermal system must be at least 700 to 1000°C/km. Crystallization and partial cooling of about 0.082 km^3 of basalt of 0.10 km^3 of rhyolite annually could furnish the heat discharged in the hot-spring system. The Yellowstone magmatic-hydrothermal system as a whole appears to be cooling down, in spite of a relatively large rate of inflation of the Yellowstone caldera. (Authors' abstract)

FRANCE-LANORD, C.L.P., PÊCHER, A. and SHEPPARD, S.M.F., 1985, Fluids of the Himalayan M.C.T. from Central Nepal: Carbon and oxygen isotope study of some quartz pods and siliceous marbles: Himalayan Geol., in press.

In the M.C.T. zone of Central Nepal, the overthrusting was accompanied by important releases of fluids below the M.C.T. Microthermometric data on fluid inclusions in syn- to late-tectonic quartz exudation lenses show the fluids to be ternary mixtures of H_2O, CO_2 and salts. The isotopic compositions of structural oxygen in the quartz are uniform, suggesting that associated fluids were homogeneous on a regional scale. Isotopic compositions of carbon from the fluid inclusions are less homogeneous (+1 to -15‰). The carbon appears to have originated from crustal mixtures, including derivatives of organic material, though a mantle contribution cannot be excluded. The siliceous marbles probably underwent isotopic exchange with an external oxygen reservoir. (Authors' abstract, translated by M. Logsdon)

FRANCE-LANORD, C., SHEPPARD, S.M.F. and LE FORT, P., 1985, Hydrogen isotopic data of coexisting muscovite and biotite from the Manaslu leucogranite (Central Nepal Himalaya): Terra Cognita, v. 5, p. 228-229 (in French).

Hydrogen isotopic composition and concentrations of H_2O^+ were analyzed for biotites and muscovites in samples from both the principal massif of Manaslu and from the granitic Chhokang arm. In the principal massif the delta D values are relatively uniform over the entire 8-km-thickness of the granite. The muscovite values are: delta D = -75 to -82‰ and H_2O^+ 4.2‰(sic); the biotite values are: delta D = -92 to -110‰ and H_2O^+ 3.7‰ (sic). Samples from the Chhokang arm are more heterogeneous: delta D muscovite = -64 to -127‰; delta D biotite = -92 to -162‰. The biotite-muscovite fractionation ranges from 17 to 42‰. These values are slightly below the equilibrium values determined as function of the Fe, Mg and Al concentrations of the micas. There is no simple correlation between the delta D of the micas, H_2O^+, altitude and/or deformation.

The fluid which was in equilibrium with the principal massif had a delta D between -60 and -80‰, and is therefore comparable to magmatic fluids and close to the values for the Tibetan Slab, the probable source of the granite. The heterogeneous values observed in the Chhokang arm may have resulted either from local degassing of the magma or from interactions with meteoric waters. (Authors' abstract, translated by M. Logsdon)

FRANCHI, I.A., GIBSON, E.K., Jr., WRIGHT, I.P. and PILLINGER, C.T., 1985, Nitrogen isotopes by laser probe extraction (abst.): Lunar and Planetary Sci. XVI, p. 248-249.

FRANCK, E.U., 1985, Aqueous mixtures to supercritical temperatures and at high pressures: Pure & Appl. Chem., v. 57, p. 1065-1070. Author at Inst. Phys. Chem., Univ. Karlsruhe, Kaiserstraße 12, D-7500 Karlsruhe, FRG.

Thermophysical properties of dense supercritical water with special emphasis on dielectric permittivity are discussed. Phase diagrams and some critical curves of the binary systems H_2O-H_2, H_2O-N_2, H_2O-O_2, H_2O-

CH_4 and H_2O-He to 450°C and 200 MPa are shown. H_2O-He has a type I critical curve. A rational equation of state to calculate phase diagrams and critical curves for polar-non polar systems is described. Measurements with the ternary system H_2O-CH_4-NaCl are presented. 2 mol per cent of added NaCl shifts the phase separation H_2O-CH_4 by 100 degrees to higher temperatures. The excess Gibbs energy for homogeneous supercritical H_2O-N_2-mixtures to 200 MPa is shown. The static permittivity of supercritical H_2O-benzene mixtures is presented as an example of dielectric behavior of polar-non polar mixtures in general. (Author's abstract)

FRANKE, V.D., GLIKIN, A.E., GRUNSKIY, O.S. and VOLOSHINA, O.A., 1985, Modelling of trapping of gas-liquid inclusions by prismatic and tabular crystals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 12-13 (in Russian). Authors at Leningrad State Univ., USSR.

Most complete information about types of inclusions may be obtained by studying crystals with large anisotropy of growth velocity. The following compounds were selected: $K_2Cr_2O_7$, KH_2PO_4, $(NH_2)_2CO$ and $(NH_2)_2CS$. Potassium dichromate (space group P 1) has flattened habit parallel to monohedra {001} and {00$\bar{1}$} * with sharp growth anisotropy. KH_2PO_4 (I$\bar{4}$2d) forms prism {100} and dipyramid {101}, and changes its habit from prismatic to equant. $(NH_2)_2CO$ has strong elongation parallel to [001] up to acicular habit, consisting of prism {110} and tetrahedron {111}. $(NH_2)_2CS$ (Pnma) has faces of pinacoid {010} plus prism {110} and has habit close to equant.

Connection of inclusion type with crystal morphology was studied when composition of parent solution was controlled, including addition of admixtures and change of solvent. In $K_2Cr_2O_7$ in the growth pyramid of the face {001}, numerous flat inclusions form. The face becomes iridescent and apparently tension causes splitting of crystal and formation of small subindividuals along the whole face. Formation of inclusions is preceded by a change of growth layers to amoeboid and polygonal shape. KH_2PO_4, in addition to flat inclusions below {101}, traps tiny equant ("dotty") inclusions on faces {100} in alkaline solutions or when oversaturation is insignificant. Crystals of carbamide have unsealed channel inclusions along [001], sometimes of large width. Filling of channel is G/L, and G phase is connected with decomposition of solution and its amount increased with increase in T. Thiocarbamide typically contains a lot of inclusions causing mikly crystals; periodical zones of short, amoeboid channel-like inclusions are trapped parallel to {110}. Growth of {001} faces causes formation of unsealed craters. Change of growth conditions leads to a change of inclusion types.

Formation of the above described inclusions is connected with diffusion limit of growth material to the crystal (carbamide, thiocarbamide - faces {001}) or with poisoning of faces by admixtures ($K_2Cr_2O_7$, KH_2PO_4 - {100}, thiocarbamide - {010}, {110}); it may be also caused by peculiarities of dislocation growth of crystals (KH_2PO_4, faces {101}) (...). (Authors' abstract translated by A.K.)

*Original text gives here again {001}, but this is obviously a misprint. (A.K.)

FREGEAU, E.J. and EGGLER, D.H., 1985, Partitioning of minor elements between supercritical H_2O fluid and silicate melt at 15-20 kbar pressure: Implications to metasomatism (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 586. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Partitioning of major elements and minor elements (0.2-1.0 wt% in melt as oxides) was determined at 1250°C. About ten runs were made at each of two pressures, 15 and 20 kbar. Melts were andesitic in composition. Melt was contained in a crimped Ag-Pd capsule set within an outer capsule containing only fluid. Fluid of initially pure H_2O contained, after experiments, an estimated 18 wt% solute at 15 kbar and 22 wt% at 20 kbar. Solute contents can be estimated by weight of collected solute or by weight-loss of the inner capsule. After evaporation of H_2O from quenched runs, solute and partially-devitrified glass (containing some fraction of solute) were mixed with $LiBO_2$, fused, and analyzed by electron microprobe, with detectability limits of about 0.1 wt% oxide. Distribution coefficients (Table) represent melt with H_2O content calculated with Burnham's model and fluid with a best-estimate (above) solute content.

All minor elements are incompatible in fluid relative to melt, showing that melts will be considerably more efficient in material transport than fluids. General similarities of KD's for different elements, at any pressure, show that silicate melts and hydrous fluids will nevertheless have similar geochemical effects in metasomatic processes. (Authors' abstract)

KD (fluid-melt)

	K	Rb	Ba	Sr	Ce	Sm	Y	Tm	Cr	Ti	Nb	Zr	P
15	0.25	0.25	0.18	0.15	0.16	0.16	0.18	0.18	0.20	0.15	0.20	0.25	0.20
20	0.35	0.16	0.20	0.26	0.25	0.30	0.25	0.25	0.20	0.22	0.22	0.25	0.25

FRENTZEL-BEYME, K., 1985, Distribution of fluid systems in the Oberpfalz and Fichtelgebirge, NE-Bavaria, West-German (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 46. Author at Inst. Geol. und Dynamik der Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

Several types of fluid inclusions in quartz with great regional distribution and clear age sequence were determined as follows, from oldest (1) to youngest (10):

1) pure gas, CO_2, CO_2-CH_4, CH_4-N_2.
2) CO_2-CH_4-H_2O, with wide range in composition.
3) H_2O, low salinity, high T.
4) H_2O, low salinity, high T, NaCl, KCl, low $CaCl_2$-$MgCl_2$.
(hiatus)
5) H_2O, low salinity, high T, NaCl, KCl, low $CaCl_2$-$MgCl_2$.
6) H_2O, medium salinity, high T, NaCl, KCl, medium $CaCl_2$-$MgCl_2$.
7) H_2O, high salinity, medium T, NaCl, KCl, high $CaCl_2$-$MgCl_2$.
8) H_2O, medium salinity, high T, NaCl, KCl, medium $CaCl_2$-$MgCl_2$.
9) H_2O, low salinity, high T, NaCl, KCl, low $CaCl_2$-$MgCl_2$.
(hiatus)
10) H_2O, low salinity, low T.

Fluids 1 to 3 belong to the metamorphic rocks of Saxothuringikum, Moldanubikum and the Münchberg nappe-pile. Fluid 4 is derived from the granitic intrusions. Most significant are eutectic temperatures between -30 and -24°C. Fluids 5 to 9 belong to discordant hydrothermal mineralizations during isostatic uplift. Their high salinity in connection with high contents of $CaCl_2$ and $MgCl_2$ discriminates them as a relative short duration event. Fluid 10 is related to ground water. These inclusions were all destroyed by freezing studies. (Author's abstract)

FREUND, Friedemann, CHANG, Sherwood and DICKINSON, J.T., 1985, The emission of organic molecules and metal atoms by fracture of olivine (abst.): EOS, v. 66, p. 1118. First author at NASA Ames Res. Center, MS 239-4, Moffett

Field, CA 94035.

Olivine single crystals from San Carlos, AZ, which contain dissolved C and H due to the incorporation of traces of fluid phases, were fractured by impact at 300 K in ultrahigh vacuum of 5 x 10^{-8} mbar. The spontaneous emission of atoms and molecules were measured by mass spectroscopy with μs time resolution for ~1.6 s.

Upon fracture, a rise in the non-condensable components is initiated, reaching a maximum in ~100 ms, followed by a slow decay. Typical emission intensities were 2 x 10^{16} molecules/cm^2. Prominent are several singular mass peaks, equally spaced by 12 mass units, which suggest polyynes (cyanopolyacetylenes HC_nN with $n \leq 4$ and oxyacetylenes HC_nO with $n \leq 5$). Further pronounced peaks occur at the masses 85, 91, 105 plus still higher molecular weight species, when the crystals were heated to = 350 K. In addition to the emission of these "organic" molecules, Mg and Fe atoms were also released from the fracture surface, often in large quantities and for ≥ 1s.

The data indicate that, upon fracture, extremely rapid diffusive transport of C, N, and H occurs from the bulk to the surface. At the surface, lattice oxygen is consumed in the synthesis of O-bearing molecules and cations are reduced to metals. These experiments shed light on possible synthesis mechanisms of complex "organic" molecules and on the injection of metal vapor in interstellar dust clouds; i.e., by grain-grain collisions. (Authors' abstract)

FREYER, H.D. and WAGENER, K., 1975, Review on present results on fossil atmospheric gases trapped in evaporites: Pure & Applied Geophysics, v. 113, p. 403-418. Authors at Inst. Chem. 2 (Biophys. Chem.), Nuclear Res. Center (KFA), D-517 Juelich, FRG.

Evaporites contain atmospheric gases (oxygen, nitrogen, CO_2, atmospheric argon) in the order of 1 cm^3 s.t.p. gas/kg of evaporite rock and sometimes decay products of organic matter (CH_4, NH_3, H_2S) which is also present in the evaporite rock. The methods of investigation applied and results obtained are reviewed. The principal findings and conclusions are: 1) the atmospheric gases are trapped during the first formation of the evaporites; 2) the K/Ar ages of the Zechstein samples correspond with the results of other authors; 3) most probably the gases have been dissolved in the solid phase from the liquid phase which was in contact with the atmosphere; 4) there are significant variations in the O_2/N_2 ratio in different evaporite minerals. This ratio is correlated with the amount and degradation level of the organic matter in the evaporite, and is obviously the result of aerobic or anaerobic conditions, respectively, during the formation; 5) in general, highly delicate molecular species have been preserved: amino acids, proteins, fatty acids. (Authors' abstract)

FRICKE, A. and SCHREYER, W., 1985, Abundance of CO_2 fluid inclusions within an "in-situ pseudotachylite" crosscutting a leucogranofels of the Vredefort Ring, South Africa (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 48-49. Authors at Inst. Mineral., Ruhr-Univ., Postfach 102148, D-4630 Bochum, FRG.

The basement rocks of the Vredefort Ring are characterized by high-temperature metamorphism, in the course of which a violent shock event occurred (Schreyer, 1983). Quartz in these rocks contains numerous fluid inclusions that consist essentially of pure CO_2. Commonly such fluid inclusions are aligned along planar elements in quartz that were formed during the shock event. Therefore, the CO_2 gas must have been available immediately after the shock, and it might, in fact, be genetically related to the shock, whatever its cause may be. Extensive measurements of the homogenization temperatures of fluid inclusions in 23 samples from the Vredefort basement have not, however, indicated any appreciable differences between inclusions situated on planar elements versus others in older quartz grains or in newly formed quartz (Fricke et al., 1984).

The unusual relations to be described here of fluid inclusions occurring in a veinlet dissecting a leucogranofels (name after Stepto, 1979) may support the idea that there is a genetic link between the shock event and the availability of large amounts of CO_2. The sample is from a shallow drill hole in the geometric center of the ring structure. It consists essentially of coarse crystals of perthitic K feldspar (2.5 mm) and quartz forming a granular fabric and is crosscut by a ~1 cm wide veinlet carrying these same minerals, both with impressively smaller grain size (80 µm). The contacts of the veinlet are curved, forming embayments into the neighboring large grains, which are obviously older. Most importantly, however, there are places where the Q/Kf grain boundaries of the old, coarse fabric extend fully undisturbed into the veinlet where the grain size of both minerals drops immediately. Under crossed nicols it can be seen that there is coarse recrystallization of quartz (200 µm) outside, but very fine one inside the veinlet. Moreover, the fine quartz inside the veinlet contains a multitude of CO_2 fluid inclusions (up to 5 vol%?), which is most unusal in comparison to any previous experience. On the other hand, the coarsely recrystallized quartz outside the veinlet shows only relatively few CO_2 inclusions of the same Th (28-30°C) [as those] that are aligned along former planar elements of quartz prior to recrystallization (Schreyer and Medenback, 1983).

We try to interpret these observations by the assumption that the rock volume within the veinlet was transformed into a structureless, diaplectic state through the shock event. Since the grain boundaries of the earlier fabric, however, are largely preserved, not much movement or flow has occurred within the veinlet, and we coin the term "in-situ pseudotachylite" for this feature. Subsequent heating of the diaplectic matter led to the fine grained, independent fabrics of both quartz and K feldspar. The abundance of fluid inclusions inside the veinlet seems to be linked to the high magnitude of shock pressure which must have been focused on this particular portion of the rock. The occurrence of planar elements in quartz outside the veinlet shows that there quartz was able to retain its crystal structure, thus indicating lower shock pressures. The accumulation of CO_2 fluid exclusively in the quartz volumes of the veinlet might be caused by a preferential solution mecahnism of CO_2 in the transient, diaplectic, glassy SiO_2 formed by the shock. At any rate, the CO_2 must be linked closely both in time and space to the shock event.

A. Fricke et al., Fortschr.d.Min. 62, Beih. 1, 61-63, 1984
W. Schreyer, Journ. of Petrology 24, 26-47, 1983
W. Schreyer and O. Medenbach, Contrib.Mineral.Petrol. 77, 93-100, 1983
D. Stepto, Diss.Univ.Witwatersrand Johannesburg 3 Vol. (Authors' abstract)

FRITZ, B., CASSAN, J.P., CLAUER, N. and TARDY, Y., 1984, Interstitial fluid circulations and diagenetic mineral transformations in sedimentary basins: A geochemical modelling approach, in Thermal Phenomena in Sedimentary Basins, B. Durand, ed.: Int'l. Colloquium, Bordeau, June 7-10, 1983, Collection Colloques et Séminaries 41, Editions Technip, Paris, 1984, p. 293-300.

FRITZ, B., CLAUER, N. and KAM, M., 1985, Strontium isotopes and magnesium control as indicators of the origin of saline waters in crystalline rocks (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst.,

v. 10, p. A19. Authors at Centre Sédimen. & Géochimie de la Surface (CNRS), 1 rue Blessig, F-67084 Strasbourg, France.

The occurrence of saline waters in deep crystalline rocks has been documented recently by several authors, particularly for granitic rocks from the Canadian Shield and from Scandinavia.

Surprisingly, the origin of the salinity of most of these waters is not obvious today; the marine origin is almost always disproved by geochemical arguments and authors argue for long-term effect of rock-solution interaction and/or leaching of fluid inclusions.

Our approach of the problem combines an analytical approach using Sr isotope ratios ($^{87}Sr/^{86}Sr$) and a modelling approach for calculation of the evolution of Mg in solutions which would have altered granitic rocks for a very long time producing Mg-rich clays (smectites and/or chlorites). Analytical results show that the solution collected now in fractures and fissures from the granitic body at Stripa (Sweden) are saline (Na, Ca, Cl), poor in Mg compared to Ca, and contain Sr with a particularly high $^{87}Sr/^{86}Sr$ ratio. This ratio excludes a solely marine origin for this element and can only be due to the alteration of minerals of the granite, rich in radiogenic ^{87}Sr, such as micas. This conclusion connects to the modelling approach of a possible long alteration of a granite with a low fissure porosity and low water velocities; chlorite formation might have resulted from the alteration of rock-forming minerals, especially Mg-rich chlorites from micas, with a subsequent very low Mg/Ca ratio in the solution and a specific $^{87}Sr/^{86}Sr$ ratio. (Authors' abstract)

FRITZ, J.J., 1985, Thermodynamic properties of chloro-complexes of silver chloride in aqueous solution: J. Solution Chem., v. 14, no. 12, p. 865-879.

FRITZ, Peter, FRAPE, S.K. and MILES, Michael, 1985, Methane in the Canadian Shield (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A19. Authors at Dept. Earth Sci., Univ. Waterloo, Waterloo, Ontario, N2L 3G1, Canada.

Methane occurs in most deep mines in the crystalline rocks of the Canadian Shield. Most visible are discharges from exploration boreholes where the free gas phase has up to 80 vol % methane. Accompanying gases are helium (up to 20 vol %) and argon (up to 4 vol %) with the balance being dominated by nitrogen with very minor amounts of higher hydrocarbons. The high rare gas concentrations indicate that the gas "reservoirs" are relatively tight and possibly very old.

These gases occur in association with Ca-Na-Cl brines whose isotopic compositions indicate non-hydrothermal temperatures for their most recent geochemical history. This appears to contrast with the $\delta^{13}C$ values measured for the methane (-25 to -56‰ PDB) which are typical for thermocatalytic methanes. However, a high temperature origin for these methanes is not necessarily supported by the deuterium data where $\delta^{2}H$ values range from about -130 to -450‰ SMOW. Several interpretations are discussed. It also is important to notice that the isotopic compositions of the methane do not vary at random across the Canadian Shield but show ^{13}C variations of only a few permil at each locality. This excludes the production of this methane by man-introduced bacteria. (Authors' abstract)

FRONDEL, Clifford, 1985, Systematic compositional zoning in the quartz fibers of agates: Am. Mineralogist, v. 70, p. 975-979. Author at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

Of pertinence to the interpretation of "fluid inclusions" in agate nodules ("enhydros"). (E.R.)

FUJINO, Toshio and YAMASAKI, Tatsuo, 1985, Geologic and geothermal structure of the Hatchobaru field, central Kyushu, Japan: Geothermal Resources Council Bull. April 1985, p. 11-15. First author at WJEC-West Japan Engrg. Consultants, Inc., Fukuoka, Japan.

Recent investigations and exploration in the Hatchobaru geothermal field have confirmed the upflow of thermal fluids along the high-angle faults. The fluids seem to be flowing up from the basement in the footwall of the faults which form the main reservoirs in the Usa group and the Hohi volcanic rocks. The acid altered zones which extend near the surface act as the cap rock. The main reservoirs are chloride water-dominated and are found along the Kamatsuike sub-fault and Hatchobaru fault. The temperature is estimated to be 240-270°C on the basis of fluid inclusion thermometry and measured temperatures. Futhermore, there is a large possibility of finding high temperature reservoirs of 290-300°C in the basement. (Authors' abstract)

FUJINO, Toshio and YAMASAKI, Tatsuo, 1985, The use of fluid inclusion geothermometry as an indicator of reservoir temperature and thermal history in the Hatchobaru geothermal field, Japan: Geothermal Res. Council, Transactions, v. 9, Part I, p. 429-433. First author at WJEC-West Japan Engrg. Consultants, Inc., Fukuoka, Japan.

Fluid inclusions provide a fast and easy method for estimating underground temperatures, which in turn are very useful for defining the thermal history of a geothermal system. The lowest value of fluid inclusion temperature at each depth is quite close to the present temperature of fluid conduits and reservoirs. The distribution of fluid inclusion temperatures from producing zones has a relatively narrow range up to 40°C in the Hatchobaru geothermal field. Their minima give an estimate of 260-290°C for the reservoir temperature. On the other hand, the fluid inclusion temperatures from a reinjecting zone show a biomodal distribution. The minimum value (230°C) of the lower temperature peak agrees well with the present temperatures, whereas the value (273°) of the higher temperature peak seem to be equal to the original reservoir temperatures. (Authors' abstract)

FUZIKAWA, K., 1985, Fluid inclusions: Usual methods of study and applications, in Contribuições à Geologia e Petrologia, Boletim Especial do Núcleo de Minas Gerais - SBG, p. 29-44 (in Portuguese; English abstract). Author at the Nuclebrás, Av. Uruguai 531, Belo Horizonte, Minas Gerais, Brazil.

A review of fluid inclusion studies and their applications. (E.R.)

FYFE, W.S., 1985, Tectonic recycling of volatiles (abst.): NERC 3rd Deep Geology Workshop Programme and Absts., Univ. Durham, 3-4 Jan., 1985 (unpaginated). Author at Univ. Western Ontario.

As most common mantle magmas are denser than continental crust at Moho pressures, subduction induced mantle melting may lead to massive magma underplating and sinking and assimilation of dense crust components (e.g., greenstone belts). Degassing of such materials at very high temperatures may lead to gases rich in CO_2, CO, COS, which may be involved in the development of graphite veins often seen in granulites. We understand little about the chemical transport processes associated with major collision events and the more localized thickening associated with transform motions. (From the author's abstract)

FYFE, W.S. and KERRICH, R., 1985, Fluids and thrusting: Chem. Geol., v. 49, p. 353-362.

GAFFEY, S.J., 1984, Fluid inclusions in skeletal carbonates and their loss during diagenesis (abst.): Abstracts, First Ann. Meeting, Soc. Econ. Paleontologist and Mineralogists, p. 33. Author at Planetary Geosci., HIG, Univ. Hawaii at Manoa, Honolulu, HI 96822.

Reflectance spectra in the visible and near-infrared (0.35 to 2.55 µm) indicate that skeletal carbonates contain water in amounts ranging from a few tenths to 2 to 3 per cent by weight. Positions of absorption bands due to water are very sensitive to the environment in which the water molecule resides, making it possible to distinguish between liquid water, water bound in clays and in hydrated carbonate phases, and hydroxyl ions. Spectra indicate water in skeletal material is present principally as liquid water in the form of fluid inclusions, although some skeletal types may contain some hydrated carbonate phases as well.

Different calcareous organisms incorporate different quantities of fluid inclusions into their skeletons. Of the skeletal types studied so far, coralline red algae and Scleractinian corals appear to contain the most, coccoliths the least.

Recrystallization of skeletal material from aragonite or high Mg calcite to low Mg calcite is accompanied by partial loss of fluid inclusions, as are the solution-reprecipitation processes which cause the ooze-chalk-limestone transition in deep sea carbonate sediments. Fluid inclusion content is potentially a useful diagenetic parameter, and when sufficient data are available should permit primary skeletal material to be distinguished from that which has been altered. In addition, fluid inclusion content may be a factor affecting relative stabilities of skeletal material with the same mineralogy but different inclusion contents. (Author's abstract)

GAFFEY, S.J., 1985, Reflectance spectroscopy in the visible and near-infrared (0.35-2.55 µm): Applications in carbonate petrology: Geology, v. 13, p. 270-273. Author at Geol. Dept., Rensselaer Polytech. Inst., Troy, NY 12181.

Reflectance spectroscopy in the visible and near-infrared (0.35-2.55 µm) is also very sensitive to the presence of water and indicates that aqueous fluid inclusions are nearly ubiquitous in carbonate minerals and rocks. Spectra indicate that inclusions are lost during diagenesis of skeletal material. (From the author's abstract)

GALABURDA, Yu.A and KVASNITSA, V.N., 1985, Petroleum inclusions in hydrothermal quartz from the Donbass coal-bearing sequence (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 184-185 (in Russian; translation by D.A. Brown). Authors at Inst. Phys. & Geochem. Minerals of Acad. Sci. Ukrainian SSR, Kiev, USSR.

A study has been made of large (≤1.5-2.7 mm) inclusions in ≤1-1.5 cm quartz crystals of the 'diamond' type [i.e., "Marmarosh diamonds;" Ed.] from hydrothermal veins in deep horizons (900-1000 m) of shales and mudstones of Middle Carboniferous age in the Donets-Makeyevka region. The region lies at the intersection of two deep-seated faults, the Volnovakha-Kazan' and the Devladovo fractures, which are supposedly genetically connected with hydrothermal phenomena.

The inclusions were examined by cryometry, thermometry, and on the 'Lyumam-II' luminescence microscope and the MX-1303 mass-spectrometer. inclusions have irregular and well-facetted cavities, and contain gas-liquid (80-5% liquid) and essentially gas; S inclusions are essentially gaseous and irregular in shape and in the form of negative crystals.

At room T some inclusions contain small light yellow solid phases. In UV light, with a UFS 6-3 filter, the liquid fluoresces blue. At T = 16-6°C, new solid phases appear in the liquid or overgrow those already present. Complete solidification of the liquid, accompanied by intense darkening, takes place at ≤-60°C. The gas phase in the primary inclusions becomes heterogeneous during cooling, and two or three phases gradually precipitate from the separated liquid. The solid phases of different inclusions have Tms from -173°C to -74°C. Th into gas takes place at -78°C to -66°C.

As the S inclusions are cooled, they heterogenize with the appearance of a liquid, from which a solid phase later precipitates. Tm of the solid phase is ~-65 to -56°C, and Th into gas is ~-27 to -8°C.

Mass-spectrometry has identified the following composition of the gas component of the P inclusions: CH_4, 99.28-95.02%; ethane, 2.87-0.57%; propane, 1.11-0.07%; and CO_2, 1-0.08%.

No inclusions of aqueous solution have been identified; all liquid in the P inclusions consists of organic compounds of petroleum type. Heating of one such inclusion with maximum filling (~80%) was carried out. At +75°C, the liquid darkened, and at +80°C, the inclusion decrepitated.

The mineral-forming medium for the quartz crystals has evidently been an anhydrous heterogeneous fluid, the liquid phase of which consists of petroleum; in the gas phase, CH_4 predominated, with insignificant traces of other HCs and CO_2.

The discovery of quartzes with inclusions of the described composition in this area of the Donbass indicates the possibility of discovering oil and gas pools in the deep-seated horizons. (From the authors' abstract)

GALIMOV, E.M., 1985, Some evidences of reality of the cavitation synthesis of diamonds in nature: Geokhimiya, 1985, no. 4, p. 456-471 (in Russian; English abstract). Author at Inst. Geochem. & Anal. Chem., Vernadsky Inst., Acad. Sci. USSR, Moscow, USSR.

A detailed review (66 references) of the evidence the author believes is adequate to prove that diamonds form initially as a microcrystalline, partly ordered material on the cavitational collapse of methane gas bubbles in fast-moving kimberlite, followed by recrystallization. (E.R.)

GALIMOV, E.M. and SHABAEVA, I.Ju., 1985, Carbon isotope composition of CH_4 and CO_2 in sediments of the Middle American Trench, in Orlofsky, S., ed., Initial Reports of the Deep Sea Drilling Project, v. 84, U.S. Govt. Printing Office, p. 693-694.

GAMBLE, B.M., ASHLEY, R.P. and PICKTHORN, W.J., 1985, Preliminary study of lode gold deposits, Seward Peninsula: U.S. Geol. Survey Cir. 0967, p. 27-29. Authors at U.S. Geol. Survey.

Preliminary studies of one gold quartz vein show low salinities (2-5 wt.%) and significant CO_2 and some CH_4. These data and some $\delta^{18}O$ data on quartz suggest metamorphic fluids. (E.R.)

GAMMONS, C.H., ROSE, A.W., SNEE, L.W. and LUND, K., 1985, Paragenesis, fluid inclusions, and Ar-dating of the Big Creek Mining district, Valley County, central Idaho (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 588. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

The Big Creek District includes a number of small vein deposits hosted by Cretaceous granitic rocks of the Idaho batholith and metamorphic roof pendants of disputed age. Mineralization is confined to a NNE-trending fault zone occupied by a swarm of post-ore porphyritic dikes. Although past workers have assigned a Tertiary age to polymetallic vein deposits in central Idaho, samples of hydrothermal sericite and vein adularia from the Big Creek district yield dates of 76.1 to 78.0 m.y. ($^{40}Ar/^{39}Ar$ age spectrum technique), indicating a late Cretaceous age.

Petrographic studies suggest several episodes of mineralization. Stage I consists of widespread silicification and replacement of wallrock biotite by sericite and weakly auriferous Fe-As sulfides. Stage II includes smaller quartz (± fluorite, adularia) veins rich in base metal sulfides, sulfosalts, electrum and local huebnerite. Stage III includes discordant veins with complex mineralogy, including sulfides, Ag-tellurides, Ag-Sb-Pb sulfosalts, electrum, stibnite, cinnabar, barite, dolomite, quartz and Mn-rich gangue. Radiometric ages of Stage I sericite (78.0 m.y.), Stage II adularia (76.8 m.y.) and Stage III sericite (76.1 m.y.) suggest consanguinity in time, as well as space.

Fluid inclusions in Stage II and III veins show a wide range of Th (200 to 400°C), salinity (0.0 to 7.2 wt% NaCl eq) and CO_2-content (up to 1M). All veins with inclusions trapped above 300°C display evidence of "boiling," although acidic alteration typical of many boiling epithermal systems is absent. Depth of mineralization assuming hydrostatic pressure is estimated at 2.0 to 5.0 km, consistent with a "deep epithermal" origin for the deposits. Depositional mechanisms proposed to explain the complex paragenesis include fluid mixing, temperature decrease, and "boiling." (Authors' abstract)

GANEEV, I.G., 1985, Chemical composition of gas-liquid inclusions and form of migration of mineral substance (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 16-17 (in Russian).

Studies of G/L inclusions gave a certain recognition about relation between state of fluid and the form of migration of mineral-forming substance. Presence of low-density inclusions (<0.5 g/cm^3) suggested activity of low-density fluids in mineral formation. Experimental studies proved that low-density alkaline fluids are very reactive to quartz. However, experiments did not confirm quartz crystallization from such fluid. The abstract mentions salt hydrolysis in high-temperature solutions, and the importance of data on mineral solubility in parent solutions. (A.K.)

GANEYEV, I.G., 1984, A physicochemical model of the transport of mineral material by hydrothermal solutions: Izv. AN SSSR, Ser. Geologicheskaya, 1984, no. 6, p. 66-80 (in Russian; translated in Int'l. Geol. Review, v. 27, no. 2, p. 129-143, 1985).

The article advances a comprehensive physicochemical model of a hydrothermal system involving transport of both sulfide and gangue materials as complexes. (IGR abstract)

GARCIA IGLESIAS, Jesus and LOREDO PEREZ, Jorge, 1984, Estimation of the "pressure connection" to the temperature of homogenization of fluorite from the "Villabona-Arlos" district (Asturias): Revista de Minas, v. 4, p. 51-56 (in Spanish; English abstract). Authors at Dept. de Metalogenia, Escuela Tecnica Superior de Ingenieros de Minas, Univ. de Oviedo, Spain.

On the basis of the fluorite deposit from the "Villabona-Arlos" district (Asturias), a simple method is applied to the magnitude-rate calculation about the mineral pressure formation. It's about the use of supposed lithostatic and hydrostatic thickness above the mineral at the time of deposition to the pressure calculation.

The pressure-rate obtained is utilized to effect the "pressure correction" on the homogenization temperatures obtained from the primary fluid inclusions in fluorite[sic]. (Authors' abstract)

GARDNER, H.D. and HUTCHEON, Ian, 1985, Geochemistry, mineralogy, and geology of the Jason Pb-Zn deposits, Macmillan Pass, Yukon, Canada: Econ. Geol., v. 80, p. 1257-1276. First author at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

Three separate stratiform Pb-Zn deposits occur on the Jason property in the Macmillan Pass area of the Yukon, Canada. Fluid inclusions in quartz, siderite, and ankerite within veins indicate that the ore-forming fluids were NaCl brines (9 equiv. wt %) with temperatures of approximately 250°C. Sulfur isotope data indicate that the sulfides within the three separate deposits had a common sulfur source, probably reduced seawater sulfate. Barite has $\delta^{34}S$ values consistent with coeval Devonian seawater. The sulfide minerals are approximately 10 per mil lighter than coeval seawater.

A maximum water depth of 420 m for venting of hydrothermal fluids was determined by combining fluid inclusion data with boiling curves for H_2O-NaCl. Brine densities indicate the hydrothermal plume may have reached the seawater surface and dispersed laterally to form the barite. Accumulations, on unstable slopes, of thick deposits of sulfide slumped to cause thinning and soft sediment deformation. (From the authors' abstract)

GARVEN, Grant, 1985, The role of regional fluid flow in the genesis of the Pine Point deposit, western Canada sedimentary basin: Econ. Geol., v. 80, p. 307-324.

GARVIN, P.L., 1985, Hydrothermal mineralization of the Mississippi Valley type at the Martin-Marietta quarry, Linn County, Iowa: Proc. Iowa Acad. Sci., v. 91, no. 2, p. 70-75. Author at Dept. Geol., Cornell College, Mount Vernon, IA.

A hydrothermal sulfide mineral deposit is exposed at the Martin-Marietta Quarry (MMQ) near Cedar Rapids, Iowa. Mineralization occurs along solution-enlarged vertical joints in host rocks of the Silurian Scotch Grove and Gower formations. The hydrothermal minerals in general order of deposition are: marcasite, pyrite, sphalerite, calcite. Wall rock alteration is not extensive, and consists of solution enlargement of joints and dissemination of microscopic marcasite in the host rock. Fluid inclusion homogenization temperatures for sphalerite and calcite range from 69° to 99°C. The physical mineralogical similarities between the MMQ deposit and main-district Upper Mississippi Valley hydrothermal deposits evidence cogenesis. The origin of the MMQ deposit is considered in light of the East Central Iowa Basin model of Ludvigson, et al. (1983a). (Author's abstract)

GATTER, István, 1985, Fluid inclusion studies and the time-space relations of ore-forming fluids at Gyöngyösoroszi deposit (N-Hungary) (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 50-51. Author at Eötvös Loránd Univ., Faculty Sci., H-1099 Budapest, Muzeum krt. 4/a, Hungary.

The Gyöngyösoroszi Pb-Zn-Cu vein-like, polyascendent deposit is connected with Neogene intermediate volcanic-subvolcanic processes. The country rocks show endometamagmatic alterations like potassium metasomatism, argillitization, silicification, etc. Fluid inclusions were examined from quartz, barite, sphalerite, and calcite.

The following groups of inclusions can be identified: They are single phase gas, single phase liquid, two-phase liquid-gas; two-phase oil, and three-phase inclusions with trapped solid particles.

Th values show the deposit formed under epimesothermal conditions and a characteristic distribution profile. Cryoscopic data distinguish two types of fluids, in agreement with the results of water-leach analysis:

a) Na-Ca-Cl fluids, recognized in vein quartz and sphalerite and partly in calcite and barite. This was identified by the basis of the $NaCl \cdot 2H_2O$-ice eutectic.

b) Alkali-bicarbonate fluids, in the quartz of vein apophyses, and partly in barite and calcite. The fluids are accompanied by a small quantity of heterogeneously distributed CO_2. The salinity, density and pressure of the solutions are characteristic of young volcanic-subvolcanic vein-type deposits. The paleogeothermal gradient increases with the paragenetic sequences. The late stage calcite shows decreasing concentrations from mixing with groundwater. Maps contoured by Th, Te, and c[sic] can be used for the delineation of ore-bearing territory. The time control of the deposition can be drawn by the inclusion data on each paragenetic member. (From the authors' abstract)

GAUTIER, D.L., KHARAKA, Y.K. and SURDAM, R.C., 1985, Relationship of organic matter and mineral diagenesis: Tulsa, OK, Soc. Econ. Pal. & Min. Short Course 17, 279 pp.

GEGUZIN, Ya.E., KRUZHANOV, V.S. and STARUKHINA, L.V., 1985, How the velocity of an inclusion is influenced by a liquid layer between it and the crystal: Kristallografiya, v. 30, p. 1210-1212 (in Russian; translated in Sov. Phys. Crystallogr., v. 30, no. 6, p. 705-707). Authors at State Univ. Khar'kov, USSR.

The velocity is increased by the presence of a film. (E.R.)

GEGUZIN, Ya.E., KURZHANOV, V.S. and STARUKHINA, L.V., 1984, Motion of a liquid inclusion in a supersaturated solid solution in a temperature gradient field[sic]: Kristallografiya, v. 29, p. 819-821 (in Russian; translated in Sov. Phys. Crystallogr., v. 29, no. 4, p. 486-487). Authors at State Univ., Kharkov, USSR.

Actually deals with the movement of fluid inclusions away from solid materials originally part of the inclusion. (E.R.)

GEGUZIN, Ya.E., KRUZHANOV, V.S. and STARUKHINA, L.V., 1985, Liquid inclusions in a crystal with a phase boundary in a temperature gradient field: Kristallografiya, v. 30, p. 786-791 (in Russian; translated in Sov. Phys. Crystallogr., v. 30, no. 4, p. 457-460). Authors at Stae Univ., Khar'kov, USSR.

The authors describe the results of experiments on the motion of inclusions of saturated aqueous solution and of phase boundaries in a single crystal of ammonium nitrate NH_4NO_3 in the temperature regions of the $\delta \rightleftarrows \gamma$ and $\gamma \rightleftarrows \beta$ polymorphic transitions. They study the structural sensitivity of the coefficients determining the process of motion of inclusions. They find the influence of liquid inclusions on the motion of the phase transition boundary. (Authors' abstract)

GEGUZIN, Ya.E., KRUZHANOV, V.S. and STARUKHINA, L.V., 1985, Role of dislocations in motion of bounded liquid inclusions in single crystals: Fiz. Tverd. Tela [Leningrad] (Solid State Physics), v. 27, no. 8, p. 2367-2370 (in Russian; translated in Sov. Physics Solid State, v. 27, no. 8, p. 1420-1422, 1985). Authors at A.M. Gorki State Univ., Kharkov, USSR.

A study was made of the role of dislocations in the process of motion of liquid inclusions in crystals characterized by layer-by-layer growth and dissolution. An analysis was made of the results of experiments on the motion of aqueous solution inclusions in KCl crystals in a temperature gradient, characterized by different dislocation densities. It was found that inclusions could travel only when the frontal boundary of an inclusion was intersected by screw dislocations. The reasons were established for the existence of a threshold size below which the inclusions in a given force field were immobile even when intersected by dislocations. The threshold was due to the drag of a dissolution step by the shape of the frontal boundary when it lagged behind the points of emergence of dislocations by an amount smaller than the diameter of a critical nucleus. An analysis based on this hypothesis yielded a linear dependence of the threshold size on $(\nabla T)^{-1/2}$ which was confirmed experimentally. (Authors' abstract)

GEHLEN, Kurt, 1985, Halides and calcium sulfate in a pseudomorphous quartz vein, Odenwald, F.R. Germany: N. Jb. Miner. Mh., v. H. 11, p. 508-512.

First results of a SEM-EDAX study of pseudomorphous quartz from the Odenwald indicate that brines containing Ca, Fe, and K as cations and Cl, Br, and SO_4 as anions were present, probably contemporaneous with the formation of sulfate (barite/anhydrite?) and the quartz replacing it. The brines most probably descended at some time during the Tertiary. (Author's abstract)

GERLACH, T.M., 1985, Carbon isotope systematics of Kilauea Volcano (abst.): EOS, v. 66, no. 18, p. 417.

GERLACH, T.M. and GRAEBER, E.J., 1985, Volatile budget of Kilauea volcano: Nature, v. 313, p. 273-277. First author at Geochem. Div. 1543, Sandia Nat'l. Labs., Albuquerque, NM 87185, USA.

The volatile content of magma in the reservoirs of active volcanoes has an important bearing on problems of petrogenesis, magma degassing, eruption mechanisms, eruption forecasting and monitoring and the environmental impact of eruptions. Volcanic gas compositions and the S content of glasses are used to infer the volatile content and the degassing systematics of magma from the Kilauea volcano. Our results are combined with data for Kilauea's magma supply and distribution over the past 27 yr to calculate the volatile budget of the volcano. (Authors' abstract)

GERLER, Jürgen, 1985, Investigations on fluid inclusions of the Clara mine (Black Forest, FRG) (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 52. Author at Inst. Geol. und Dynamik der Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

The post-Variscan barite-fluorite vein deposit Clara is located near Wolfach in the central Black Forest. The deposit consists of three different veins (a fluorite, a barite and a quartz-barite-fluorite vein) which are hosted in pre-Variscan gneisses. The barite vein also cuts a Triassic sandstone. Mineralization took place in four main phases with various subphases: At the beginning an alteration and silicification of the surrounding crystalline and sedimentary rocks occurred, followed by the main fluorite, the main barite and a final quartz phase.

Fluid inclusion studies have shown that the temperature and salinity of the ore-forming fluids were remarkably constant over the entire mineralization cycle. All inclusions in fluorite and quartz had Th 60°C-160°C range (typically 110°C-130°C); all inclusions in barite at room T contained only a liquid phase and lacked a vapor phase. All inclusions in fluorite, barite and quartz had Te near -58°C and had Tm ice in the -22°C to -26°C range, indicating a high divalent-cation content.

A characteristic of the inclusions in fluorite was the melting of $NaCl \cdot 2H_2O$ as a last phase between -25°C and 0°C. The inclusions contained neither daughter crystals or CO_2.

The microthermometry and neutron activation analyses have shown that the inclusion fluids are analogous to the highly saline formation waters of the Ca-Na-Cl type. Hence, it is expected that the sedimentary cover rocks influenced the ore deposition. (Author's abstract)

GERLER, J., REUTEL, C. and RIEKEN, R., 1985, Experimental investigations on the system $CaCl_2$-$MgCl_2$-NaCl-KCl and their application on fluid inclusion microthermometry (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 54. Authors at Inst. Geol. und Dynamik der Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

During microthermal measurements it is observed that the eutectic temperatures of fluid inclusions often range below -60°C. It is not possible to explain these extreme temperatures with the previously published experimental phase diagrams. INAA data of quartz crystals yield high values of $CaCl_2$ and NaCl in these fluid inclusions. Using INAA analysis, synthetic solutions were produced with variable amounts of $CaCl_2$, $MgCl_2$, NaCl and KCl to study the cryometric phase changes. The melting properties do not change significantly if one replaces Ca components by Mg components. The obtained results are comparable with those of natural fluid inclusion studies. (Authors' abstract)

GERLER, J. and SCHNIER, C., 1985, Determination of elements in fluid inclusions by means of neutron activation analysis (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 56-57. First author at Univ. Göttingen, Inst. Geol., D-3400 Göttingen, FRG.

The chemical composition of fluid inclusions in hydrothermal quartz from various localities in West Germany and Africa has been determined by non-destructive neutron-activation analysis. Sample fractions of 400-600 mg with no visible contaminating minerals were handpicked using a binocular microscope and cleaned ultrasonically in acetone. The chosen specimens were then placed in hot concentrated HNO_3 for about 24 h, followed by thorough cleaning with H_2O of high purity. Experiments showed that surface contamination is negligible when using this cleaning procedure.

Samples were irradiated in the reactors of the GKSS research center, Geesthacht. In a first step elements with short half-life (Al, Cl, Ca, Ti, V, Mn, Dy) were determined by irradiating the samples in a pneumatic tube facility for 5 minutes at a neutron flux of 7×10^{12} $cm^{-2}sec^{-1}$ and counting the gamma-rays three times for 10, 16 and 30 minutes. After a 4 week wait the samples were irradiated a second time for 24 hours at a neutron flux of about 5×10^{13} $cm^{-2}sec^{-1}$. The gamma radiation from the activated specimen was measured three times after decay periods between 1 and 40 days. The Ge(Li) detectors used have efficiencies of 10% and 15% for the 1332 keV energy of Co-60 relative to a 3' x 3'[sic] NaJ(Tl) detector[sic; probably NaI(Tl)].

Elements that can easily be detected in quartz by this method are given in table 1. Additional elements which were determined in some samples are Ti, V, Ni, Cu, Se, In, J, La, Ce, Nd, Sm, Eu, Tb, Dy, Yb, Lu, Hf, Ta, W, Au, Hg, Th and U.

Three months later, after decay of the main activities, some of the quartz samples were irradiated again for 1 hour. The active specimens were comminuted in a steel mortar containing H_2O or a weak salt solution of NaCl and KCl. The slurry was thoroughly leached in a vacuum filtering apparatus, first with H_2O or a dilute salt solution and then with HNO_3 or aqua regia.

The gamma radiation from the filtrates and the leached quartz powder was measured with a Ge(Li) detector. The results are given in table 2. It can be seen that nearly all the chlorine and bromine is leachable and must therefore be associated with the fluid inclusions. The remaining concentrations of the elements in the quartz powder may be due to the inefficiency of the grinding process.

The relatively high sodium content of 40% in the leached quartz powder cannot be explained solely by inefficient grinding (grain size 3-15 μm). Since the sodium and the chlorine concentrations are positively intercorrelated in all samples (correlation coefficent $r = 0.85$, significance 99.9%), and since in samples of the same quartz crystal with variable amounts of fluid inclusions the Na/Cl ratios are reasonably constant, the sodium should also be present mainly in the fluid inclusions. We suppose that the sodium was incompletely leached out of the fluid inclusions due to adsorption on the highly reactive surfaces of newly formed quartz particles while comminuting the samples.

The potassium content of many samples is unrealistically high compared to the sodium concentration (i.e., K/Na about 1). Moreover, the potassium and chlorine concentrations show a positive correlation of only 0.45. Therefore, potassium cannot be present only in fluid inclusions but must occur in other modes elsewhere in the crystal.

The results of this investigation show that non-destructive neutron activation analysis is an excellent method for the determination of trace elements in quartz, and especially, for the Br/Cl and Na/Cl ratios in fluid inclusions. (Authors' abstract)

Element	Concentration range	Median	A	B
Na	0.94 - 296	30	67	67
Cl	< 1.2 - 656	30	67	65
K	< 0.42 - 285	13	67	63
Ca	<12 - 115	<12	28	8
Sc	$< 2.4 \times 10^{-5}$ - 0.034	6.3×10^{-4}	30	29
Cr	$< 8.5 \times 10^{-4}$ - 1.0	9.1×10^{-3}	30	24
Mn	$< 2.3 \times 10^{-3}$ - 7.8	0.14	67	64
Fe	< 0.27 - 51	1.9	30	27
Co	$< 1.7 \times 10^{-4}$ - 0.22	5.2×10^{-4}	30	22
Zn	$< 2.6 \times 10^{-3}$ - 7.1	0.021	30	19
Ga	$< 4.7 \times 10^{-3}$ - 18	0.020	67	42
As	$< 1.3 \times 10^{-3}$ - 21	0.056	67	56
Br	$< 2.2 \times 10^{-3}$ - 5.1	0.31	67	60
Rb	$< 2.1 \times 10^{-3}$ - 6.8	0.025	30	22
Sr	< 0.048 - 124	0.083	30	19
Ag	$< 1.8 \times 10^{-4}$ - 4.4	$< 1.8 \times 10^{-4}$	30	15
Sb	$< 1.2 \times 10^{-4}$ - 37	0.44	67	58
Cs	$< 1.9 \times 10^{-4}$ - 0.19	6.5×10^{-3}	30	28
Ba	< 0.059 - 110	0.27	30	21

Table 1: Concentration of elements in quartz (μ g/g). The median is based on all samples, including those in which the element concentration were below the detection limit. A = Number of analyzed samples. B = Number of samples in which the element could be detected.

Table 2: Leachable portions of elements in quartz. The concentration in the quartz before comminution corresponds to 100%.

Na	50 - 60%
Cl	79 - 90%
K	13 - 18%
Mn	32 - 70%
Ga	<1%
As	1 - 10%
Br	85 - 95%
Sb	<1%

GERRESTEN, J., PATERSON, M.S. and BITMEAD, J., 1985, Improved procedures for diffusing "water" into quartz at high temperature and pressure (abst.): EOS, v. 66, p. 1144.

GERWE, J.E. and NORMAN, D.I., 1985, Ag-Ni-Co-U mineralization in the Black Hawk mining district, Grant county, New Mexico (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 52. Authors at Dept. Geosci., NMIMT, Socorro, NM 87801.

The Black Hawk mining district in the Burro Mountains near Silver City, New Mexico, was studied by field mapping, petrography, whole-rock major- and minor-element geochemistry, fluid-inclusion microthermometry, and K-Ar dating methods.

The predominant lithologies in the district are a Precambrian monzodiorite gneiss and a Late Cretaceous monzonite-porphyry stock (72.5 ± 4.7 m.y.) which intrudes the gneiss. The gneiss contains 35 ppm Co and 23 ppm Ni, while the monzonite contains 20 ppm Co and 11 ppm Ni. Ag-Ni-Co-U mineralization occurs in NE-trending fissure veins, dominantly in the monzodiorite gneiss. The major ore minerals are native silver, argentite, skutterudite, rammelsbergite, and uraninite within a carbonate gangue. Pyrite, quartz, clay, and carbonate are the most commonly occurring alteration minerals along the vein. Away from the vein, the mafic minerals are altered to chlorite, feldspars to sericite, and disseminated pyrite occurs along fractures. A whole-rock sample of the vein alteration assemblage yielded a date of 65.3 ± 1.2 m.y. There is a bimodal distribution of Th from the Black Hawk mine, one population averages 357°C (299-404) and another averages 189°C (155-210). The salinities of the fluids were 0.0 to 2.6 eq. wt. % NaCl. Boiling occurred as evidenced by the coexistence of vapor- and liquid-filled inclusions.

The petrograpy, geochemistry, fluid-inclusion, and K-Ar-age data allow the following conclusions to be made. First, the source for the Ni and Co was probably the monzodiorite, since it has the largest areal distribution in the district and the highest Ni and Co concentrations of the predominant lithologies. Second, the low salinities of the fluids suggest that the water was meteoric in origin. Third, the high T and the relatively similar ages of the intrusion and alteration suggest that the monzonite-porphyry intrusion was the heat source for the hydrothermal system. Finally, boiling and cooling of the fluids along the northeastern fractures were responsible for the Ag-Ni-Co-U mineralization. (Authors' abstract)

GESINK, J.A. and KESLER, S.E., 1985, Confirmation of multiple fluid involvement in the Sweetwater MVT district, Tennessee (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 590-591. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Previously reported observations on fluid inclusions in fluorite from the Knox-hosted Sweetwater (SW) F-Ba-Zn MVT district in East Tennessee have shown an inverse correlation between homogenization and final melting temperatures, which was tentatively ascribed to mixing of two solutions. In an effort to determine whether this phenomenon was caused by salinity differences alone or variations of the Ca/Na ratio of the fluid, we have determined the Ca/Na ratio of the fluid inclusions using the temperature at which the cotectic phase $NaCl \cdot 2H_2O$ disappears in the ternary system H_2O-$NaCl$-$CaCl_2$. Data on 30 inclusions from both early and late stage fluorite show no correlation between $CaCl_2/CaCl_2 + NaCl$ ratios (range .35 to .53, mean = .45) and salinity over a total salinity range of 9 to 21 equivalent wt % NaCl, further suggesting that the inverse correlation represents mixing of a highly saline brine with a more dilute, but warmer brine of similar Ca/Na ratio. Similar observations of the cotectic disappearance in earlier widespread sphalerite in the SE district could not be made, but SEM energy dispersive analyses of individual inclusion decrepitates indicate that the sphalerite-forming solution was significantly lower in Ca ($CaCl_2/CaCl_2 + NaCl$ = .09 to .44, mean = .23) and significantly more saline (17 to 23 equivalent wt % NaCl). The observations can be explained by a model in which early Zn-depositing brine reacted with carbonate wallrock, thereby increasing the Ca/Na ratio sufficiently to cause precipitation of early fluorite, which apparently persisted during subsequent dilution of warmer, less saline fluids. Our data for SW sphalerite and fluorite are significantly different from fluid inclusion data reported for the Mascot-Jefferson City zinc district to the northeast, suggesting distinct brine source and evolution patterns in the two districts. (Authors' abstract)

GHENT, E.D., STOUT, M.Z. and KNITTER, C.C., 1985, Garnet-hornblende-plagioclase-clinopyroxene-calcite-quartz equilibria in metabasites from Mica Creek, British Columbia (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A21. Authors at Dept. Geol. & Geophys., Univ. Calgary, Calgary, Alberta T2N 1N4, Canada.

Metabasites from the sillimanite zone at Mica Creek, B.C., contain hornblende-plagioclase-garnet-clinopyroxene-calcite-quartz. Lower grade amphibolites do not contain coexisting garnet and clinopyroxene. Temperature and pressure estimates using garnet-clinopyroxene Fe-Mg thermometry and plagioclase-clinopyroxene-garnet-quartz barometry are consistent with pressures and temperatures estimated from mineral equilibria in nearby pelites. Garnet-hornblende Fe-Mg thermometry (calibration of Powell and Richardson) yields temperatures which are higher than those estimated from other thermometers for upper kyanite and sillimanite zone rocks. Fluid compositions estimated from hornblende-plagioclase-garnet-quartz-H_2O and hornblende-calcite-quartz-clinopyroxene-H_2O-CO_2 equilibria at 650°C and 6 kbar are broadly consistent. The estimates carry a large uncertainty because of the uncertainties in the hornblende crystalline solution model. Using an ideal coupled substitution solution model suggests $XH_2O \sim 0.7$ or greater and the lack of graphite in these rocks suggests the fluid was dominated by H_2O and CO_2. A comparison with recent fluid inclusion data on the empirical H_2O-CO_2 solvus suggests that these rocks could have equilibrated at hypersolvus conditions. Metamorphic fluids in metabasites and adjacent metapelites were H_2O-rich, but uncertainties in the estimation of fH_2O prevent us from making precise estimates of apparent gradients in μH_2O between metabasites and metapelites. (Authors' abstract)

GIBSON, E.K., Jr., CARR, L.P. and PILLINGER, C.T., 1985, Nitrogen isotopic composition of Archean samples: Evidence of the Earth's early atmosphere? (abst.): Lunar and Planetary Sci. XVI, p. 270-271. First author at Experimental Planetology Br., NASA Johnson Space Center, Houston, TX 77058, USA.

The stepped extraction technique demonstrates that nitrogen within Archean samples exists in at least three forms of different isotopic composition, ranging from -30 to +18‰. The results from the stepped extractions clearly indicate that bulk nitrogen isotopic measurements for Archean samples are of little value. (From the authors' abstract)

GIGASHVILI, G.M., GREBENCHIKOV, A.M., NARTIKOYEV, V.D. and TARKHANOV, G.V., 1985, The use of fluid inclusions in catagenic minerals, the reflectivity of vitrinite, and present-day temperatures in studying the evolution of the geothermal field in petroliferous basins (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 205-207 (in Russian; translation by D.A. Brown). Authors at All-Union Res. Inst. Nucl. Geophys. & Geochem. (VNIIYaGG), Moscow, USSR.

Until recently, the principal method for studying the paleogeothermal field in petroliferous basins was based on reflectivity of vitrinite. Lately, Td has been used, but because of significant indeterminancy, this has not been widely accepted. Th of fluid inclusions in catagenic minerals have turned out to be more informative and promising.

The authors have measured paleotemperatures by both methods, in order to investigate the evolution of the geothermal field in the Tersk-Caspian marginal trough.

The studies have shown that the magnitude and deviations of the paleotemperatures, determined from Th from the maximum paleotemperature, based on vitrinite (Tv), and from the present (drillhole) T of the rocks, (Tdh), are essential for estimating fluctuations in the geothermal field. The following have been established:

1) For structures undergoing slow steady downwarping with PT conditions, ensuring the equilibrium state of reactions of transformation of vitrinite, the geothermal field corresponds to the conditions: $\Delta t_1 = \Delta t_2$, where Δt_1 = Tv-Th, and Δt_2 = Th-Tdh.

2) Structures, within which the geothermal field was permanently lowered from the time of Tmax, correspond to the conditions $\Delta t_1 > 0$, and $\Delta t_2 > 0$. This is typical for structures which have undergone steady uplift.

3) Structures, within which the geothermal field has been developed in a progressive-recurrent manner, have been subdivided into: a) those within which the geothermal field initially diminished steadily, and then later steadily increased, are marked by the relationships $\Delta t_1 > 0$, and $\Delta t_2 < 0$. Such development of the geothermal field is typical of structures which have undergone uplift in the past and are subsiding at present; and b) those within which the T field is marked by relationships $\Delta t_1 < 0$, and $\Delta t_2 > 0$, apparently for a single group of GLIs. Such development of the geothermal field is defined by the influx of heated solutions into the structure.

4) Structures, within which the geothermal field corresponds to the condition $\Delta t_1 < 0$, and $\Delta t_2 \leq 0$. This applies to structures, within which T is increasing at a rate exceeding that of the equilibrium reactions altering vitrinite, for example in zones of present-day downwarping. (From the authors' abstract)

GILAT, A. and LANG, B., 1985, Fluid inclusions in barite megacrystals from Nahal Boqeq (southern Judean Desert) (abst.): Israel Geol. Soc. Annual Meeting 1985, [Abstracts], p. 29. Authors at Geol. Survey of Israel, Jerusalem.

Tabular, rhomb-shaped barite crystals, up to 7 cm long and 1.5 cm wide were discovered during the geological mapping (1:20,000) of the Nahal Boqeq area (Gilat and Arnon, 1981). The crystals occur within the previously dolomitized and argillitized Senonian chalk (Menuha Formation) and are associated with halite. Tectonically the mineralization is located at the intersection of two shear zones (strike-slip faults) where the NNW trending fault is displaced by a younger fault trending EW. The barite crystals usually show idiomorphic shapes and well-developed growth zones parallel to the rhomb face. The zones are represented by alterations of limpid, transparent areas with semitransparent to opaque, light-brown areas.

Fluid inclusions are frequent within the transparent zones of the crystals. Two types of primary inclusions can be separated:

a) two-phase, relatively small fluid inclusions (10-20 µm) of rounded to elongated shape, sometimes showing a negative crystal form. The gas bubble forms up to 10% of the total volume of the inclusions. This type shows Th 165-210°C and low melting temperatures indicating the participation of solutions rich in NaCl.

b) two-phase, very large tabular fluid inclusions (100-300 µm), of irregular form and refringence close to [that] of the crystal. Very large bubbles representing more than 50% of the total volume are present. In heating up to 400°C no significant changes in the liquid/vapor ratio are observed. The freezing measurements always show positive temperatures of last melting (usually between 3° to 6°C), thus indicating the presence of gases other than H_2O in the vapor phase (CO_2 and/or CH_4?), probably in a state of immiscibility with the liquid phase at the time of trapping.

The presence of two different types of fluid inclusions in different zones of the barite crystals may be interpreted as an indication of relatively quick changes in the chemical and/or physical character of the solution. This assumption, however, calls for further detailed study. (Authors' abstract)

GILETTI, B.J., 1985, The nature of oxygen transport within minerals in the presence of hydrothermal water and the role of diffusion: Chem. Geol., v. 53, p. 197-206. author at Dept. Geol. Sci., Brown Univ., Providence, RI 02912, USA.

Oxygen isotope exchange between minerals and hydrothermal waters can occur by means of solution-precipitation, chemical reaction, or diffusion. Further, minerals are known to exchange oxygen isotopes faster in the presence of water than when dry. Careful laboratory measurement of exchange rates by diffusion has been effected. The large differences in values of diffusion coefficients for different diffusing species in one mineral, the trivially small free-energy change for reaction involving only isotope exchange, and the excellent fit of ^{18}O concentration profiles to a diffusion relation, all combine to demonstrate the diffusion process. The same diffusion coefficients are obtained whether the natural mineral sample is in contact with +80‰ (SMOW) water, or with 40‰ ^{18}O water. Diffusion must happen if the mineral is above its closure temperature, although exchange will only occur if another phase is available with which it can exchange. The use of a "compensation law" to assess the validity of experimental data is, strictly speaking, limited to cases where the same diffusion mechanism is operating for the different diffusing species being compared in a given mineral. (Author's abstract)

GILL, J., WILLIAMS, R. and BRULAND, K., 1985, Eruption of basalt and andesite lava degasses ^{222}Rn and ^{210}Po: Geophys. Res. Letters, v. 12, no. 1, p. 17-20. Authors at Earth Sci. Board, Univ. California at Santa Cruz, Santa Cruz, CA.

Activities of ^{222}Rn and ^{210}Po were measured in a September 1983, basic andesite lava from Arenal and a November 1983, basalt from Kilauea, starting 3 and 1 days after eruption, respectively. In both cases, in-growth patterns show that all Rn volatilized during eruption. Po degassing also was complete at Kilauea but only 84 ± 10% at Arenal. (Authors' abstract)

GIORDANO, T.H., 1985, A preliminary evaluation of organic ligands and metal-organic complexing in Mississippi Valley-type ore solutions: Econ. Geol., v. 80, p. 96-106. Author at Dept. Earth Sci., New Mexico State Univ. Las Cruces, NM 88003.

The role of organic matter in mechanisms of base metal transport during Mississippi Valley-type mineralization is not well understood. Evidence from field, experimental, and theoretical studies suggest that ore metals may be transported as organic complexes in Mississippi Valley-type ore fluids. However, specific ligands capable of concentrating significant quantities of lead and zinc in these ore solutions have not been identified. As a preliminary evaluation of metal transport by metal-organic complexing, activities of lead and zinc complexes involving nine carboxylate ligands (acetate, propionate, n-butyrate, phthalate, oxalate, tartronate, malate, D-tartrate, and salicylate) have been calculated for PbS- and ZnS-saturated, average ore solutions (those proposed by Giordano and Barnes, 1981) at 100° and 200°C. Calculated concentrations of lead and zinc in all of the complexes considered are well below the 10 ppm (10^{-4} molal) minimum required to form an ore deposit.

To ascertain the nature of other organic ligands which may have contributed significantly to base metal transport during Mississippi Valley-type mineralization, speciations of acetate, phthalate, and salicylate were calculated for three different average ore fluids at, or near, 100°C. Results suggest that for weakly alkaline, sulfide-rich ore solutions, organic ligands should have stability constants for 1:1 and 1:2 base metal complexes of at least 10^{10} and 10^{20}, respectively. Such high stabilities would not be required if actual ore fluids were more acid or more oxidized, contained lower amounts of inorganic sulfide, or contained specific organic ligands at concentrations greater than 10^{-4} molal. In addition to carboxylate, or similar complexes, metal-organic sulfide complexes may have provided a mechanism to transport significant quantities of lead, zinc, and reduced sulfur in Mississippi Valley-type ore solutions. (Author's abstract)

GIRET, Philippe, TOURAY, J.-C., ILDEFONSE, J.-P. and JEBRAK, Michel, 1985, Fluid inclusions data for understanding the setting of Liassic monoclinal extrusions near Taourirt (Eastern Morocco): Bull. Soc. Géol. Fr., v. 5, no. 8, p. 787-790 (in French; English abstract). First author at École Supérieure l'Energie et des Matériaux, Univ. d'Orleans, 45046 Orléans Cedex, France.

Fluorite samples collected at Jbel Tirremi and Koudiat Titeft, near Taourirt, contain abundant secondary fluid inclusions that have recorded various T and P information during the burial and subsequent uplift of these extrusions. The oldest inclusions are grouped in heterogeneous families with CO_2-bearing inclusions and halite-bearing ones in the same healed cracks. The minimum Tt is 160°C. Two independent geobarometers indicate trapping pressures higher than 0.5 Kb, implying a minimum burial of 3 to 4 km. Later epirogenesis, possibly related to deep faulting and associated halokinesis put to outcrop these structures, probably from Miocene to Present. (Authors' abstract)

GISLASON, S.R. and EUGSTER, H.P., 1985, Interaction of basalt with meteoric water: a field and laboratory study (abst.): EOS, v. 66, no. 18, p. 401-402.

GITLIN, Ellen, 1985, Sulfide remobilization during low temperature alteration of seafloor basalt: Geochimica Cosmo. Acta, v. 49, p. 1567-1579.

GITLIN, E.C., 1985, Alteration and fluid flow around a sulfide-carbonate-quartz vein, Lucky Friday mine, northern Idaho (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 593. Author at Dept. Geol. Sci., AJ-20, Univ. Washington, Seattle, WA 98195.

Wall rocks at the Lucky Friday mine, Coeur d'Alene district, Idaho, contain a >500 m wide zone about a steeply dipping Pb-Zn-Ag vein. This zone has experienced local conditions distinct from the regional metamorphism of the quartzite + argillite host rock. Within the district, the host rock (Precambrian Revett Formation) has undergone low grade metamorphism and contains varying proportions of quartz, phengitic muscovite, detrital alkali feldspar, magnetite, hematite, ilmenite, rutile, zircon, tourmaline, ± calcite, ± ankeritic dolomite. In contrast, the Lucky Friday wall rocks lack feldspar and Fe-bearing oxides, and contain Fe-poor muscovite and up to 40% carbonate: siderite, ankerite, and/or calcite. The carbonates define concentric subzones about the vein. From the vein outward, the subzone sequence are variants on: sid → sid + ank ± cal → ank + cal. These mineral transitions may be traced on trajectories within the $CaCO_3$-$MgCO_3$-$FeCO_3$ phase diagram.

A comparison of district-wide Revett rocks with Lucky Friday wall rocks suggests that the wall rocks have undergone localized dephengitization with concomitant Fe-enrichment in the carbonates and Fe-depletion of the oxides. Pertinent metamorphic reactions consume CO_2 and liberate H_2O. Fluid inclusions from the vein and wall rock stringers have homogenization temperatures from ≈ 200° to >375°C, but they define no temperature gradient. With few exceptions, compositions of the carbonates are identical throughout the altered wall rock. These observations suggest that the carbonate subzone contacts are not isograds but "isofluxes:" the loci of equivalent fluid/reactant mineral ratio. The disposition of isofluxes around a dominant fluid channelway, i.e. the vein, affords an opportunity to interpret fluid flow pathways during low temperature metamorphism. (Author's abstract)

GLAZNER, A.F., 1985, Petrology of Miocene volcanic rocks from the Mojave Desert: Interaction of mafic magmas with old continental crust (abst): Geol. Soc. Am. Abst. with Programs, v. 17, p. 356. Author at Dept. Geol., Univ. North Carolina, Chapel Hill, NC 27514.

Miocene volcanic rocks in the central Mojave Desert are commonly assumed to be subduction-related because they are largely intermediate in composition and "calc-alkaline" in character. However, because they were erupted during the changeover from subduction to transform-fault tectonics off the coast of southern California, the tectonic setting under which they were erupted is unclear. Petrographic, chemical, and isotopic data indicate that intermediate rocks in the Mojave Desert formed largely by magma mixing and that recycling of old continental crust played a major role in their genesis.

Andesites and dacites in the Mojave Desert show abundant petrographic and chemical evidence for magma mixing. Andesites usually contain rounded quartz xenocrysts which are rimmed by augite. These quartz grains contain blebs of pale brown glass whose compositions resemble minimum-melt rhyolite but are considerably more siliceous (over 80 wt% SiO_2). The glass blebs are interpreted to be trapped rhyolite melt which dissolved some of its quartz host when it was mixed into hotter basaltic melt. Plagioclase phenocrysts in dacite show similar glass blebs. Plagioclase phenocrysts in the andesites are reversely zoned and exhibit resorption textures. $^{87}Sr/^{86}Sr$ shows a strong positive correlation with SiO_2, and major- and trace-element data fall along simple mixing lines. These data support generation of this suite by mixing of basaltic melt with anatectic melts of Mesozoic and Precambrian continental crust.

The strong evidence for generation of Mojave andesites and dacites by mixing demonstrates the futility of using these rock compositions to make inferences about depth to the subduction zone or dip of the subducted slab. (Author's abstract)

GLIKIN, A.E. and SINAY, M.Yu., 1985, Entering of inclusions in crystals during formation of monomineralic pseudomorphs (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 36-38 (in Russian). Authors at Leningrad State Univ., Leningrad, USSR.

Inclusions of a new genetic type, called introduced inclusions, were obtained experimentally. These inclusions form during and cause the continuation of the process of replacement of monocrystalline minerals by their isomorphic analogues. The process is as follows: the crystal to be replaced (protocrystal) dissolves, causing formation of a mixed solution and a coeval epitaxial overgrowth of appropriate isomorphic component on certain parts of the protocrystal surface. Substance exchange between solution and solid phase goes on continuously until equilibrium is achieved. The experiments were made with sulfates like $MgSO_4 \cdot 7H_2O \rightarrow (Mg,Ni)SO_4 \cdot 7H_2O$ (morenosite-epsomite group), $CoSO_4 \cdot 7H_2O \rightarrow (Co,Fe)SO_4 \cdot 7H_2O$ (biberite-melanterite group) and many others, at room T. Protocrystal plate was glued between two parallel glass plates; the gap between the glasses was filled by solution and covered by appropriate glue to prevent evaporation. Replacement started quickly by formation of a rough crystal surface, next changed to a number of re-entrants, up to 0.01-0.1 mm deep, without visible regularity. Re-entrants gradually enter crystal, altering into inclusions. The inclusions penetrate the crystal, and after a certain time they spread out through the whole crystal volume. The process duration is from few hours (e.g., for $(Mg,Ni)SO_4 \cdot 7H_2O$) to few months (e.g., for $(Ni,Co)(NH_4)_2(SO_4)_2 \cdot 6H_2O$), when protocrystals were a few mm on an edge. The introduced inclusions form a complicated system of channels representing the diffusion paths for exchange of substance between crystal and solution. Sometimes open channels are preserved. The inclusions continuously migrate, causing replacement of protocrystal by new substance. This mobility ceases when the system crystal + solution achieves equilibrium. Inclusions compensate for the volume change during replacement. The described inclusions would be included in new class of "metainclusions." (A.K.)

GODWIN, C.I., WATSON, P.H. and SHEN, Kun, 1985, Genesis of the Beaverdell silver vein, and the Carmi gold vein deposits, south-central British Columbia (abst.): Geol. Ass. Canada, Cord. Sec., Symp. Silver '85, Vanc., B.C., p. 6-8. First author at Univ. British Columbia, Vancouver, B.C.

The Beaverdell silver vein and the Carmi gold vein camps are in south-central British Columbia. The veins in the Beaverdell camp generally are hosted by the Westkettle granodiorite of Jurassic age, but mineralization is related to the Beaverdell quartz monzonite stock which is Late Paleocene in age based on a K-Ar biotite date of 48.8 + 2.0 Ma. Carmi type gold vein mineralization is in Westkettle granodiorite or in metamorphic pendants. Galena lead isotope characteristics of the nearby Carmi gold type are distinctively different from those of the Beaverdell silver type. Plots of $^{206}Pb/^{204}Pb$ galena lead isotopes, using the SHALE and MIXING LINE ISOCHRON models of Godwin, Andrew, and Sinclair, confirm that Carmi gold-rich type mineralization was generated by the earlier Westkettle batholith and that the Beaverdell silver-rich type mineralization is related to Tertiary stocks. Lead isotopes provided the easiest way of distinguishing between these two types of deposits, which, although generated in markedly different environments, are not easily distinguished by field observation.

Examination of metal zoning, mineralogy, fluid inclusions and sulfur isotopes in the Lass vein system allows it to be divided into two distinctly different parts, an upper western portion and a lower eastern one. The differences between the two can be related to the dominance of one of two events.

Event 1 is the earliest event and is represented by mineralization in the lower portion of the Lass vein system. Characteristics of the mineralization, compared to event 1, include: (1) relatively gold-, zinc- and lead-rich, but silver-poor, ore; (2) thicker veins; (3) sulfides with abundant pyrite, arsenopyrite and dark sphlerite with exsolved chalcopyrite; and (4) fluid inclusions with high salinities, local CO_2 phases, and high temperatures of homogenization with matching equilibrium temperatures indicated by sulfur isotope geothermometers for galena and sphalerite.

Event 2, the oldest one, 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: (1) is relatively silver-rich and gold-, zinc- and lead-poor; (2) has narrower veins; (3) has sulfides characterized by silver-sulfosalt bearing galena and pale sphalerite; and (4) is represented by fluid inclusions that are variable but lower on average in salinity, have lower temperatures of fluid homogenization, and do not contain CO_2.

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 pressure at temperatures near the boiling point, and if the latter formed at hydrostatic pressures at boiling temperatures. Sulfur isotope data indicate that event 1 was nearly boiling but no similar definition is available for event 2. The data indicates that gold will continue to depth if the veins can be followed.

We suggest that 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 are deposited in a confined system under lithostatic pressures, and high salinities where chloride complexing can be important in the transportation of gold. Fracturing of the vein system to the surface changes the pressure regime to hydrostatic. Consequently temperatures and salinities drop, presumably mainly in response to mixing with cooler, less saline ground water. Gold solubilities concomitantly decrease and silver deposition becomes more significant. (Authors' abstract)

GOFF, Fraser, GARDNER, Jamie, VIDALE, Rosemary and CHARLES, Robert, 1985, Geochemistry and isotopes of fluids from Sulphur Springs, Valles Caldera, New Mexico: J. Volcanol. Geotherm. Res., v. 23, p. 273-297.

GOFFE, B., MURPHY, W. and LAGACHE, M., 1985, Transport of Si, Al and Mg in hydrothermal solutions: Experimental study, and applications to metamorphic assemblages (abst.): Bull. Minéral., v. 108, p. 90 (in French).

GOLD, Thomas, 1985, The origin of natural gas and petroleum, and the prognosis for future supplies: Ann. Rev. Energy, v. 10, p. 53-77. Author at Center for Radiophysics & Space Res., Space Sci., Bldg., Cornell Univ., Ithaca, NY 14853.

A defense of Gold's theory of a mantle origin for natural gas and petroleum. (E.R.)

GOLDBERG, R.N. and STECKLER, D.K., 1985, A bibliography of sources of thermodynamic data for the sytems: $CO_2 + NH_3 + H_2O$, $CO_2 + H_2S + H_2O$, $H_2S + NH_3 + H_2O$, and $CO_2 + NH_3 + H_2S + H_2O$: National Bureau of Standards SP-699, 34 pp. First author at Natinal Bureau of Standards, Gathersburg, MD 20899.

Contained herein is a bibliography of sources of experimental and correlated thermodynamic data for the systems $CO_2 + NH_3 + H_2O$, $CO_2 + H_2S + H_2O$, $H_2S + NH_3 + H_2O$, and $CO_2 + NH_3 + H_2S + H_2O$. The types of data in this bibliography include all types of equilibrium data, including both equilibria in solution and vapor-liquid equilibrium data, enthalpies, heat capacities, and densities. There are 215 references cited. (Authors' abstract)

GOLDFARB, R.J., LEACH, D.L., HOFSTRA, A.H. and LANDIS, G.P., 1985, Geochemistry of gases from fluid inclusions within gold-quartz veins in the Chugach and Kenai Mountains, south-central Alaska (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 594. Authors at U.S. Geol. Survey, P.O. Box 25046, MS 973, Denver, CO 80225.

Gold-bearing quartz veins within the Valdez Group turbidite sequences of the Chugach and Kenai Mountains are largely restricted to areas of medium-grade greenschist facies. The veins postdate accretion, deformation, and peak regional metamorphism of the Valdez Group. Liquid dominant, low salinity (<5 wt.% NaCl equiv.) fluid inclusions in quartz from four mining districts show homogenization temperatures generally ranging from 210° to 280°C. Consistent liquid-vapor ratios are indicative of fluids trapped in the one-phase field. Estimated minimum trapping pressures of 1.5 kbar were obtained from quartz decrepitation data. Our observations tend to support the theory that ore-forming fluids were derived during regional metamorphism.

Microthermometry, Raman spectroscopy, and mass spectrometry were used to analyze the volatile components of fluid inclusions from the four districts. Inclusions adjacent to gold and sulfide grains from each district contained 7-10 mole % CO_2, 0-2 mole % CH_4, and 0-2 mole % N_2. Both a pure CO_2 volatile phase and CO_2-N_2-CH_4 mixtures were consistently observed within quartz embaying intergrown gold and sulfide grains. Gas solubility data and the observed inclusion homogenization temperatures support minimum trapping pressures in approximate agreement with the quartz decrepitation data. The estimated minimum pressures correspond to a minimum depth of vein development at 3.5-5 km under the condition that fluid pressure equals lithostatic pressure. The ubiquitous presence of appreciable and similar dissolved gases, along with the consistent salinities and homogenization temperatures, provide further support for a regional process of ore genesis. (Authors' abstract)

GOLDFARB, R.J., LEACH, D.L., PICKTHORN, W.J. and MILLER, M.L., 1985, Genesis of gold deposits in Chugach Terrace of south-central Alaska: Evidence from fluid inclusions (abst.): AAPF-SEPM-SEG Pacific Sections, Ann. Mtg., Alaskan & West Coast geol, energy, & mineral resources, Anchorage, AK, May 22-24, 1985, AAPG Bull., v. 69, no. 4, p. 665. Authors at U.S. Geol. Survey, Denver, CO.

Gold-bearing quartz veins occur in shear zones, faults, and joints within the Upper Cretaceous Valdez Group flysch in the Kenai and Chugach Mountains of south-central Alaska. The veins are regionally restricted to areas of medium greenschist-grade metamorphic rocks and are notably absent in lower and higher grade metamorphic rocks.

Fluid inclusion studies were conducted on samples of gold-bearing quartz from the Moose Pass, Hope-Sunrise, Port Wells, and Port Valdez districts. Tm ice and clathrate indicate that the ore-forming fluids had low salinities, ranging from 0 to 5-equivalent wt.% NaCl. These fluids contain appreciable amounts of dissolved gases, as shown by the nearly ubiquitous formation of clathrates during inclusion freezing and by the common presence of three-phase inclusions consisting of aqueous fluid, liquid CO_2, and vapor. Total gas content varies from essentially nondetectable to as much as 10 vol.%. Freezing measurements on the inclusion fluids show the gas composition to vary from nearly pure CO_2 to mixtures dominated by CH_4 and N_2. Inclusion data indicate minimum trapping pressures of 1.5 kbar corrected Th ranging from 260°C to 330°C.

We believe that the gold-bearing veins represent pathways for the escape of metamorphic fluids during rapid uplift of the Chugach and Kenai Mountains. The veins are believed to have formed along hydraulic fractures or along dilated preexisting fractures, created when fluid pressure exceeded load pressure. (Authors' abstract)

GOLDHABER, M.B. and VIETS, J.G., 1985, Isotope evidence for sulfur sources for the Viburnum Trend of lead-zinc mineralization, southeast Missouri (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 594. Authors at U.S. Geol. Survey, MS 916, Denver, CO 80225.

The ore minerals of the Pb-Zn deposits of the Viburnum Trend in southeast Missouri, hosted by the Cambrian Bonneterre Formation have a wide range of sulfur isotope delta values (0 to +25 permil). We report a similar range (-6 to +25 permil) for pyrite and marcasite in unmineralized samples of the Bonneterre from a core fence oriented perpendicular to the mineralized trend. The Bonneterre has been variably altered by warm, saline fluid. The portion considered least affected is the "brown rock," an early diagenetic alteration facies. This "brown rock" has systematically heavier sulfur isotopes (mean +8.8 permil, maximum +25 permil) than other rock facies. Petrographic examination suggests that FeS_2 minerals in the brown rock predate mineralization. The FeS_2 in the highly porous, vuggy "white rock" facies characteristically has lower isotope ratios (mean -1.3 permil) than brown rock. White rock FeS_2 formed during or after mineralization. Some cores show a progression from brown to white rock which coincides with decreasing sulfur and carbon-oxygen isotope ratios and with increasing vuggy porosity. Our data suggests that a source of isotopically heavy sulfur was available locally in the Bonneterre in the brown rock, and that this local sulfur was remobilized and combined with an extrinsic, isotopically light S component during mineralization to produce ore sulfide. (Authors' abstract)

GOLDMAN, Saul, 1985, Theories of solubilities of non-electrolytes: Pure & Appl. Chem., v. 57, no. 2, p. 273-282.

GONCHARENKO, O.P. and MOSKOVSKIY, G.A., 1985, Conditions of formation of salts during the concluding phases of halogenesis based on inclusions in minerals (western part of the Caspian Syneclise) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 199-200 (in Russian; translation by D.A. Brown). Authors at Saratov State Univ., Saratov, USSR.

In the western part of the Caspian Syneclise, there are deposits of salt in the Kungurian sediments of the concluding phases of halogenesis (sylvite,carnallite, and bischofite). These salts form several paragenetic associations: halite-sylvite, halite-sylvite-carnallite, halite-kieserite-carnallite, and halite-kieserite-bischofite. They have been studied in detail in the El'ton and Gremyachinsk deposits of potash salts. Drillholes have exposed these minerals over considerable areas of the Volga Homocline and the marginal zone of the basin.

These minerals are highly prone to recrystallization and, consequently, to the loss of sedimentational inclusions. Of these minerals ('eutonic'), only halite contains a primary texture, based on the regular arrangement of solid-liquid or multiphase inclusions in it.

P inclusions. Eutonic halite usually contains two-phase (L + S) and multiphase ($L + S_1 + S_2 + G$) inclusions, of highly-concentrated brines, formed at relatively high T, yielding dm sylvite, carnallite, and less commonly, bischofite. Sylvite lacks the zonal structure of halite, and contains solid and essentially gas inclusions. Occasional solitary solid-liquid inclusions with a halite dm are found. These inclusions evidently form during diagenesis. Carnallite and bischofite only contain solitary liquid inclusions or equant gas-liquid vacuoles, elongated in chains, which, like their enclosing mineral, are diagenetic. S inclusions in all the eutonic minerals are mainly gas-liquid, and less commonly, solid-liquid inclusions with a variable ratio of phases.

A study of the chemical composition of individual inclusions in eutonic halite and sylvite (>300 analyses) suggests that during evaporation of the brine in the Caspian saline basin, and prior to precipitation of the K-Mg salts, along with an increase in the [absolute] amounts of K, Mg, and SO_4, there was a relative increase in K and SO_4 ions to 28-32 and 35-45 g/L respectively. This suggests an ingress of slightly evaporated sea-waters into the basin.

During deposition of K and K-Mg salts, the content of K and Mg in inclusions in halite and sylvite was similar to that in present-day evaporated sea-water during the precipitation of sylvite, carnallite, and bischofite.

The maximum SO_4 in the brine of the Caspian saline basin, determined from inclusions in sylvite in the central part of the syneclise, was ~80 g/L. This possibly indicates the presence of K_2SO_4 minerals in the primary parageneses of K-Mg salts.

Th for the solid-liquid inclusions in halite from the potash rocks in the El'ton and Baskunchak regions and the Krasnokut sector of the marginal zone, and the Gremyachinsk deposit of potash salts, have shown that P sylvite and carnallite rocks formed at ~50-70°C; S sylvites in the Gremyachinsk deposit formed at <45°C. (From the authors' abstract)

GOODRICH, C.A. and BIRD, J.M., 1985, Formation of iron-carbon alloys in basaltic magma at Uivfaq, Disko Island: The role of carbon in mafic magmas: J. Geol., v. 93, p. 475-492. First author at Inst. Meteoritics, Dept. Geol., Univ. New Mexico, Albuquerque, NM 87131.

Discusses the conditions under which a separate immiscible metallic iron phase, ± various amounts of C, Ni, Co, P, etc., has formed. (E.R.)

GORMAN, Jonathan, 1985, Geochemical environment of mineralization and alteration in the southern OH vein, Creede, CO (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 595. Author at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109-1063.

Detailed mineralogical, paragenetic, and geochemical studies in the southern OH vein at Creede, CO, a Tertiary volcanic hosted Pb-Zn-Ag epithermal deposit, indicate that two hypogene vein fluids with distinct redox characteristics alternately precipitated oxidized and reduced assemblages. Oxidized assemblages are characterized by barite and hematite, whereas the reduced fluids appear responsible for the base and precious metal, as well as gangue deposition. The oxidizing fluid was generated either through shallow level boiling or volatile exsolution (CO_2, H_2S) of an initially reduced primary hydrothermal fluid or through mixing with an oxidized groundwater. Observed alternating episodes of barite precipitation (oxidizing) and dissolution (reducing) are best explained by vertical displacement of the redox front during periods of fluctuating fluid flow. This also accounts for the widespread occurrence of hematite "dust" punctuating periods of carbonate, sulfide, and gangue growth and perhaps oscillating chalcedony-quartz precipitation.

Hypogene events in the wallrock, contemporaneous with vein mineralization, have the following paragenesis: 1) pervasive bleaching of the wallrock via pyritization of groundmass hematite with introduction of reduced hydrothermal vein fluids, 2) argillization (illite with 3-15 ± 2% interlayered smectite) of the wallrock and disseminated sulfide mineralization, and 3) vein related silicification overprinting earlier events. These reactions result from the introduction of low pH (~5.0), sulfur poor ($10^{-3} - 10^{-3.5}$ m), reduced (H_2S) hydrothermal fluids into the wallrock. Mineralization occurred over a decreasing temperature regime (~250 to 180°C) possibly coupled with a pH increase related to argillization. The nature and distribution of wallrock alteration is controlled by permeability, fluid composition, and temperature. (Author's abstract)

GOTTIKH, R.P., PISOTSKIY, B.I. and SVOREN', I.M., 1985, Some aspects of the metallogenesis of bitumens on the Siberian Platform (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 179-180 (in Russian; translation by D.A. Brown). Authors at All-Union Res. Inst. Nucl. Geophys. & Geochem. (VNIIYaGG), Moscow, USSR.

In recent years, there has been increasing interest in bitumens and heavy oils, as sources for obtaining an entire series of rare elements and metals. Whereas thermobarogeochemical data have led to the accumulation of a great deal of information about the conditions of formation of ore deposits, they have been extremely inadequate in the field of petroleum geology.

Uranium-bearing bitumens are widely distributed in sediments on the Siberian Platform. They are found both in sedimentary rocks, and in basement sequences.

Study of bitumens by petrography and luminescence, and the U distribution in them by f-radiography method, has shown that both bitumen content and the U associated with it are secondary, and are confined in the sequence to zones of increased permeability (stratigraphic unconformities, statified zones of crushing and jointing), which are often identified only by microscope studies based on U-fission tracks. U is associated both with solid, and also viscous resin-asphaltic bitumen. These inclusions, measuring 5-15 μm, are GLIs of H_2O-salt solution with L = 80-90%, pure HC, luminescing in bluish and light-yellow shades, or mixtures of the two with variable ratios of aqueous solutions and HCs. The liquid HC phase in the inclusions consists of oils and resin-asphalt components. The aqueous phase consists of Ca-Na-Mg chloride brines (results of aqueous extraction) with salt concentrations of 25.3-22.6 wt % (granite-gneiss and sandstone in the Bol'shaya Chonskaya area).

The composition of the gases in the inclusions, determined on an MX-1303 mass-spectrometer, showed a predominance of H_2O and CH_4 and its homologs up to C_3H_8 (Bol'shoye Chonskoye and Sobinovskoye deposits). They increase in relative amounts from 65 to 97% in the direction from granite to carbonate collector horizon. A decrease in CO_2 from 22 to 1.9% takes place in this same direction.

Homogenization of the multicomponent inclusions did not set in until 260°C, which agrees with the thermodynamic calculations based on water-oil systems[sic].

During movement of the fluid into the platform cover from (or through) the basement, as a result of a marked change in PT conditions, the fluid became stratified with the formation of liquid (aqueous and HC) and gaseous phases and their rapid separation in space. In this case, high-carbon compounds were precipitated from the liquid HC phase as a result of decrease in solubility and in increase in cyclicity as the gas separated and T fell.

Neutron-activation and radiochemical analysis of these compounds, consisting of a series from anthracolites to low-range kerites, has shown that concurrently with U, there was accumulation of Ti, Y, Zr, REE, and Th in them, which indicates their joint transfer along with the HCs. The amount of metals decreases upwards through the sequence as the T of the migrating solutions decreased and the partial pressure of CO_2 fell in the fluid, reaching minimal concentrations in the oil.

Thus, from relicts of mineral-forming media, differentiation in the composition of the metal-HC system has been established and a regular association has been revealed between the amount of CO_2 and the metals in the fluid. (From the authors' abstract)

GÖTZINGER, A., 1985, Characterization and quantification of inclusions by infrared spectroscopy (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 58-59 (in German). Author at Inst. Mineralogy, Univ. Wien, Austria.

Based on preceding investigations and by means of infrared spectroscopy (Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 115-116) information is given on quantities of H_2O, CO_2 and organic substances in inclusions in fluorite. The infrared investigations were carried out on small plates polished on both sides of a thickness of ca. 0.3 to 0.6 mm.

The detection limit for inclusion water amounts to ~50 ppm. In case of small concentrations the error may be up to 50 rel. %. In Table 1 the contents of inclusion water of fluorite of different evolution as well as relative contents of CO_2 and organic substances are presented.

The following minerals are suitable for such investigations: halite, sylvite, fluorite, (corundum), calcite, aragonite, dolomite, magnesite, anhydrite, celestite, barite, apatite, topaz, diopside, spodumene, nepheline, feldspars. Provisional results have been obtained for barite, celestite, sphalerite free of iron and spodumene. (Abbreviated abstract courtesy E. Horn)

Table 1:

		a	b	c	d
Schlaggenwald	(pegmatite)	6	1000 ppm	3	0
Freiberg	(hydrothermal veins)	22	3700 ppm	0	0
Stulln		10	1700 ppm	1	0
Cornwall		<0.5	<80 ppm	2	0
Bad Gastein	(alpine joints)	4	680 ppm	2	2
St. Götthard		1	170 ppm	2	1
Weisseck	(sedimentary, mobilized)	2	340 ppm	2	1
Laussa violet		30	5100 ppm	2	1
Laussa farblos		<1	<170 ppm	0	0
Mooseck		30	5100 ppm	20	4

a: relative water content (I_0-I)
b: "absolute" water content by calibration
c: relative CO_2 content (I_0-I)
d: relative content of organic substances (I_0-I). 0 means no absorption bands detected.

GOULD, W.W. and BARNES, H.L., 1985, Hydrothermal replacement of calcite by sphalerite in a temperature gradient (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 595. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

The replacement of calcite by sphalerite under near-neutral pH's was investigated experimentally and by numerical modeling: fluid compositions fixed by the reactions

$$CaCO_3(s) + 2H^+ (aq) = Ca^{2+} (aq) + H_2O + CO_2 (aq)$$
$$ZnCl_n^{2-n} (aq) + H_2S (aq) = ZnS(s) + 2H^+ (aq) + nCl^- (aq)$$

were calculated for fixed total Cl^- concentration. The results showed maximum solubility of Zn at 375°C, because at higher temperatures Na-Cl and Ca-Cl ion-pairing becomes nearly as strong as the Zn-Cl complexing, effectively scavenging the available chloride. Solubility decreases below 375°C because Zn-Cl complexes become less stable.

These calculations were confirmed experimentally: ZnS-saturated chloride solutions were pumped through various pure marble sands and gravels down a temperature gradient. CO_2-$CaCO_3$ reactions were used to buffer the input solution at temperatures 15° above those used for the temperature gradients during replacement. In runs cooler than 375°C, sphalerite was deposited when the solution cooled to cause ZnS supersaturation. In runs above 375°C, no sphalerite precipitated until the temperature fell well below 375°C. Such delayed replacement characteristically has sphalerite disseminated as isolated grains, and the marble showed evidence of dissolution. This process opened void space in solid marbles, permitting increased flow of sulfide-depositing solutions. Thus temperature changes may cause replacement of calcite by sphalerite even where there is no change in the reactivity of the host rock, or its accessibility to ore-forming solutions. (Authors' abstract)

GOZHIK, N.F., DEYCHAKOVSKAYA, K.A., KOVALISHIN, Z.I., PEN'KOVSKAYA, B.V., PLATONOVA, E.L., UDUD, R.V. and SHKLYANKA, V.M., 1985, The evolution of the composition of the mineral-forming fluids in the Beregovo deposit (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 91-92 (in Russian; translation by D.A. Brown). First author at IGGGI AN Ukr. SSR, L'vov, USSR.

The Beregovo deposit lies in volcanics and sediments in a horst. The gold-polymetallic mineralization of the Beregovo area has been controlled by subvolcanic bodies of dacite and rhyolite. Significant data have been obtained from water extracts and gas analyses. Emplacement occurred in several stages, yielding several types of ores. Each is characterized by a corresponding paragenesis of minerals and the peculiarities of chemistry of the solutions, based on inclusion analyses. The following genetic types are present: gold-quartz-adularia, gold-quartz-sulfide, gold-quartz-barites, and gold-quartz-hematite. A gangue of drusy amethystine quartz has also been recognized.

The results of 56 analyses of water extracts show that alkali-earth elements predominate, with high K in the gold-quartz-adularia bodies. Some fluids are high in halides and bicarbonate. Average analyses for each genetic type, calculated using Kurlov's formulae, show that sulfate-potassic solutions passed into sulfate-magnesium, and then into chloride-sulfate-magnesium-sodic solutions.

Volatile components played an important role in the transfer, concentration, and deposition of the ore components. The gas phase of the inclusions, in addition to major water includes carbon dioxide, nitrogen, and methane. The 79 gas analyses were made using a VTI-2 gas-analyzer and the MX-1303 and MX-1304 mass-spectrometers. Carbon dioxide increases with time during the process of change in the fluids, and nitrogen and methane diminish. (From the authors' abstract)

GRAETSCH, H., FLORKE, O.W. and MIEHE, G., 1985, The nature of water in chalcedony and opal-C from Brazilian agate geodes: Phys. Chem. Minerals, v. 12, p. 300-306. First author at Inst. Mineral. der Ruhr-Univ. Bochum, Universitätsstr. 150, 4630 Bochum, West Germany.

The water species ($H_2O(SiOH)$ and $H_2O(mol)$) of length-fast chalcedony and opal-C in Brazilian agates were studied with thermoanalytical, chemical and infrared absorption methods. Specific surfaces were measured with the BET nitrogen adsorption method and the specific densities were determined.

Chalcedony and opal-C have fully hydrated crystal surfaces at the open porosity. They contain additional water at inner surfaces, which are closed micropores in the case of opal-C and regions of accumulated defects (e.g., twin-lamellae boundaries) in chalcedony. All surfaces are covered with silanole groups, hydrogen-bonded to molecular water. Additional hydroxyl groups, weakly hydrogen bonded to the structural framework within the crystallites, are located at structural point defects. Wall-lining chalcedony ranges from translucent gray to milky white bands corresponding with decreasing total water content, the $H_2O(SiOH)/H_2O(mol)$-ratio, BET-surfaces and increasing density. The $H_2O(SiOH)/H_2O(mol)$-ratio is sensitive to subsequent hydrothermal treatment and indicates a low temperature formation of chalcedony. (Authors' abstract)

GRANOVSKI, A.G. and DAVIDOV, K.V., 1985, Fluid regime of post-magmatic mineralization associated with the development of Mesozoic magmatism in the Osetei Range (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 4-6 (in Russian; translation by S. Jaireth). First author at Rostov State Univ., Rostov-on Don., USSR.

Fluid inclusions in minerals of different polymetallic mineralizations associated with various stages of Jurassic magmatism in Digoro-Oseti have been studied.

Andesite flow and tuffs (Lower Liassic) altered to propyllites of quartz-chlorite-zoisite composition contain in their upper horizons stratiform ore bodies composed of pyrite, sphalerite, chalcopyrite and galena (rare), and a stockwork type of quartz-sulphide mineralization in the deeper levels (Buravidon deposit). All effusive rocks and metasomatites are characterized by similar decrepitometric parameters with maximum gas-release taking place between 80 to 150°C and 200 to 260°C. Quartz of this association has pseudosecondary inclusion ≤15 µm in size and gas-liquid ratio of 1:4. Gaseous phase in the inclusions (based on gaschromatography) is mostly CO_2. Concentration of CO and CH_4 increased up to about 20% by volume of gases towards final stages of effusive activity. Th L-V(L) lies between 235 and 270°C.

Carbonatized andesites and anamesites [intermediate between basalt and dolerite] following earlier effusive magmatism have generated hydrothermal solutions basically aqueous-carbonic in composition with gradually increasing concentration of Cl, Na, Fe, Si. Th L-V(L) in siderite 160-240°C, in calcite 140-220°C, in quartz 240-300°C. These inclusions contain <18 vol.% CO_2. Carbonate veins with polymetallic mineralization of this stage have been observed in deposits of Zgid and Sadon.

Quartz from pre-ore quartz-pyrite veins and metasomatic mineralization associated with subintrusive bodies of hornblende bearing microdiorites contain spherical, flat and irregular inclusions of 10-15 µm in size. Gas-liquid inclusions (gas-liquid ratio 2:3) have a salinity of 5 wt% total salts (freezing and leachate analysis).

K^+, Na^+, Cl^- and HCO_3^- are the dominant ions in the solutions. Inclusions homogenize into the liquid phase between 360 to 240°C and at a pressure of 60 MPa.

Hypabyssal intrusives of granodiorite porphyries and plagiogranite porphyries of the next stage of magmatism have undergone intense chloritization, silicification and carbonatization. Quartz-polymetallic mineralization of the Sadon group of deposits is associated with them. Primary and early secondary[sic] inclusions in the minerals are drop-like, flat irregular in shape, ≤15 µm in size. Gas-liquid inclusions (gas-liquid ratio 1:4) are aqueous-carbonic in composition and lack dms. HCO_3^-, Cl^-, SO_4^{-2}, K^+, Na^+, Ca^{++} are the dominant ions. Th L-V(L) - 320 to 180°C, P - 40 MPa and salinity 8 wt%. Post-ore quartz-carbonate veins are characterized by elongated, tubular and irregular shaped inclusions. They have a dominant Na-Ca-bicarbonate composition with salinity of 1.5 to 3.0 wt%. Th L-V(L) - 180 to 60°C.

Results indicate systematic changes in the thermobarometric and geochemical parameters of postmagmatic ore formation processes. (Authors' abstract)

GRATIER, J.-P., 1985, Kinetics of the deformation of minerals by dissolution-crystallization: The crucial effect of the state of the fluid phase (free or trapped) (abst.): Bull. Minéral., v. 108, p. 91 (in French, translated by C. Eastoe).

The rate of deformation of minerals by dissolution-crystallization depends on three successive processes: the kinetics of dissolution, the rate of transport (by diffusion in a fixed fluid, or by migration of the fluid) and the kinetics of crystallization. In certain simple cases where one of these processes is much slower than the others, that process limits the rate of deformation. Such deformation has been studied experimentally by observing on one hand changes in the shape of small cavities (fluid inclusions) under pressure, and on the other changes in the form of small grains under pressure, with diffusion in a fixed fluid in both cases. The process that limits the rate of deformation differs according to the state of the fluid phase. When the transport of material between zones of dissolution and crystallization takes place in a free fluid (case of the cavities), the rate of deformation is limited by the kinetics of reactions at the solid-fluid interfaces. In contrast, when the transport of material takes place in a film of trapped fluid along the contact between two solids under pressure, the rate of deformation is limited by the rate of diffusion along that interface. This is because the rate of diffusion is much higher in the first case than in the second (the ratio being 10^4 to 10^5). New experiments are necessary to study the transition between these two extreme cases, with successive transfer of material through free and trapped fluid phases, and for different ratios of free phase to trapped phase. (Author's abstract)

GRATZ, J.F. and MISRA, K.C., 1985, Fluid inclusions and mineral paragensis in a Mississippi Valley-type zinc deposit: Evidence for changing composition of mineralizing fluid (abst.): Geol. Soc. Am. Abstracts with Programs v. 17, p. 596. Authors at Dept. Geol. Sci., Univ. Tennessee, Knoxville, TN 37996.

A detailed fluid inclusion study was undertaken on samples from the Gordonsville mine in the central Tennessee district. Fluid inclusion homogenization temperatures and salintiy data were collected on several minerals in the paragenetic sequence: sphalerite, calcite, fluorite, and barite. The purpose was to trace the characteristics of the mineralizing fluids through time. This procedure was complicated by the occurrence of minerals, particularly calcite, at different stages in the mineralizing process.

Approximately 400 inclusion measurements on the preceding minerals yielded homogenization temperatures of 100° to 145°C for early and main stage sphalerite; 85° to 125°C for fluorite; 107° to 165°C for white calcite; 135° to 200°C for barite; and 135° to 200°C for late stage, clear to amber calcite. Freezing temperatures for inclusions in main stage minerals indicate salinity values of 18 to 23 equivalent weight percent NaCl whereas inclusions in later stage barite and clear and amber calcite show a distinct drop in fluid salinity: 4 to 12% for barite and 2 to 17% for amber calcite.

Fluid inclusion measurements on sphalerite indicate stable temperatures and salinities during mineralization. Temperature measurements on fluorite, however, show a slight decrease in temperature while salinities remain relatively constant. Later minerals formed at higher temperatures and progressively lower salinities suggesting the replacement of existing brines with hotter, more dilute water. Because of the constant temperature and salinity values for inclusions in main stage sphalerite, it appears that one fluid, rather than two or more fluids, may have been responsible for sphalerite mineralization. (Authors' abstract)

GREBENCHIKOV, A.M., ZAIRI, N.M., VASYUTA, Yu.V. and KOZHEVNIKOVA, L.I., 1985, Contribution to the method of prospecting for and evaluation of deposits on the basis of impregnation aureoles (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. I, p. 87-88 (in Russian). Authors at Central Sci.-Research Geol.-Prospecting Inst., Moscow, USSR.

Decrepitation activity, intensity of gas release and composition of gases of [wall] rocks, metasomatites and ores were studied in quartz-sulfide veinlet-disseminated deposits of arsenopyrite-pyrite type located in carbon-bearing sandy-clayey layers of Lower Paleozoic age. By acoustic decrepitation at T 100-400°C, no decrepitation activity was detected. Effects at higher T are connected with oxidation of sulfides and organic matter, decomposition of carbonates, etc. By vacuum decrepitation, methane from organic matter (and other hydrocarbons up to C_5H_{12} plus CO_2) is released beginning from 100 or 150°C. These and further presented data indicate that vacuum decrepitation records gases connected with dispersed organic and carbonate substance, not with fluid inclusions. As the correct method the authors recommend mechanical crushing of sample in vacuum for release of gas from inclusions. However, since they do not give details of the method used, the estimated CH_4/CO_2 ratios may be also due to unknown degree to mechanical decompositionof the mentioned organic matter and carbonates. (A.K.)

GREENBERG, A.E., TRUSSELL, R.R. and CLESCERI, L.S., eds., 1985, Standard methods for the examination of water and wastewater: Am. Public Health Assoc., Washington, DC, Publ., 1268 pp.

GREENLAND, L.P., ROSE, W.I. and STOKES, J.B., 1985, An estimate of gas emissions and magmatic gas content from Kilauea volcano: Geochimica Cosmo. Acta, v. 49, p. 125-129. First author at U.S. Geol. Survey, Hawaiian Volcano Observatory, P.O. Box 51, Hawaii Nat'l. Park, Hawaii 96718.

Emission rates of CO_2 have been measured at Kilauea volcano, Hawaii, in the east-rift eruptive plume, and CO_2 and SO_2 have been measured in the plume from the noneruptive fumaroles in the summit caldera. These data yield an estimate of the loading of Kilauean eruptive gases to the atmosphere and suggest that such estimates may be inferred directly from measured lava volumes. These data, combined with other chemical and geologic data, suggest that magma arrives at the shallow summit reservoir containing (wt.%) 0.32% H_2O, 0.32% CO_2, and 0.09% S. Magma is rapidly degassed of most of its CO_2 in the shallow reservoir before transport to the eruption site. Because this summit degassing yields a magma saturated and in equilibrium with volatile species and because transport of the magma to the eruption site occurs in a zone no shallower than the summit reservoir, we suggest that eruptive gases from Kilauea characteristically should be one of two types: a 'primary' gas from fresh magma derived directly from the mantle and a carbon-depleted gas from magma stored in the summit reservoir. (Authors' abstract)

GRIB, Ye.N., 1985, Physicochemical conditions of crystallization of silicic lavas in the Mutnovsk geothermal deposit (southeastern Kamchatka) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 145-147 (in Russian; translation by D.A. Brown). Author at Inst. Volc. Far Eastern Sci. Center, Petropavlovsk-Kamchatskiy, USSR.

The present-day geothermal deposits in Mutnovsk and the field of hydrothermally-altered rocks are associated with the complex Skalistaya and Dvugorbaya volcanic-extrusions of middle-late Pleistocene age. Amongst the lavas, there is a predominance of andesites and dacites, and rhyolites are developed to a lesser degree. The rock-forming minerals consist of plagioclase, quartz, biotite, pyroxene, and less commonly hornblende and olivine.

There are two groups of pl. The first group includes phenocrysts of oligoclase-andesine (An_{19-44}). They are ≤2-3.0, and less commonly ≤5-6.0 mm in size. The cores (An_{19-32}) have wide twin bands, and are turbid, fused, and saturated with glass inclusions; the glass in the large phenocrysts displays a honeycomb texture even macroscopically. The second group is made up of highly-calcic pl, <10-20% in the andesites and dacites, whereas in the rhyolites, they occur only occasionally in the form of small isolated cores with traces of corrosion or very fine impersistent zones. Their composition varies from labradorite (An_{62}) to anorthite (An_{92-94}). Labradorite-bytownite forms the outer zones around the anorthite cores. The most acid shells in such phenocrysts are An_{40-43}. The microlites and outer zones in certain acid plagioclases have the same composition.

The phenocrysts of the first group are marked by glassy two-phase inclusions measuring 10-150 µm. In the fused cores of the crystals, the inclusions are rounded, frequently with denticulate boundaries. They are marked by an anomalously large amount of the gas phase (< half the volume of the vacuole). When such inclusions are heated, solution of the gas phase in some of them takes place at ~1220-1250°C. With a 10-15°C rise in T, the crystal begins to underfuse[?], is covered with a fine network of cracks, and becomes turbid. The melt in the inclusions is highly siliceous (75-80% SiO_2), with increased K (microprobe analyses). In the outer (more basic) zones of the crystals, there are small (3-10 µm) vermiform, two-phase inclusions with normal relationships between the gas phase and the melt. Th ~1120-1170°C. The melt in the inclusions is a dacite (66% SiO_2) with alkalies in equal amount or a slight predominance of Na.

The highly-calcic plagioclases of the second group contain essentially crystallized inclusions with crystalline phases, consisting of pl (An_{40-62}) and cpx or hnb. Complete melting of the crystalline phases has been noted at T = 1150-1220°C. On heating to 1380-1400°C, the inclusions are close to Th.

It is evident that the pl of the second group are phenocrysts of a high-T basaltic melt, injected into the crustal chamber of a silicic magma, the products of which have been identified in the region, beginnning in Miocene time.

The fused acid pl with honeycomb texture are evidently relicts of crystals in granitoids, which have undergone the thermal effects of the basaltic melt. As a result, melting of the silicate phases in the inclusions of such phenocrysts, their decompression, and undermelting of the walls at the boundary with the surrounding crystal, take place, so that the inclusions have become anomalous[sic]. This explains the high Ths of The outer, more basic zones contain normal melt inclusions, reflecting the T (1120-1170°C) of the hybrid melt.

The highly-siliceous melts, rich in alkalies, that separate from the crustal chamber, may have been associated with pegmatite and quartz veins with polymetallic ores. A deposit of such a kind has been found in deep erosion sections in the Zhirovsk Volcano. (Author's abstract)

GRIGOR'YEV, I.F. and DOLOMANOV, Ye.I., 1985, Genetic classification and physico-chemical formation conditions of tin ore deposits in Transbaikalia (part two): Izvestiya Vyssh. Uchebn. Zavedeniy-Geologiya i. Razvedka, no. 12, p. 27-34 (in Russian). First author at the Moscow Geol.-Prosp. Inst., Moscow, USSR.

The authors describe the genetic types of Sn and Sn-W deposits, mostly using their own earlier published data and other authors' data. They distinguish I) the formation of cassiterite granites which have two types: a) cassiterite [-bearing] granites and b) cassiterite [-bearing] miarolytic granites; II) the formation of cassiterite granite pegmatites of two types: a) cassiterite (or cassiterite-columbite-tantalite) greisenized pegmatites, b) cassiterite-spodumene (and lepidolite) greisenized pegmatites; III) cassiterite-feldspar-quartz formations of two types: a) cassiterite-feldspar-quartz and b) cassiterite-topaz-feldspar-zinnwaldite-quartz; IV) formation of cassiterite skarns. The paper bears nonsystematic characteristics of habit, composition, trace elements, infrared absorption, isotope data (S, O) and color centers for cassiterite, micas, quartz, tourmaline and sulfides. Inclusions in ore-bearing quartz (formation II) from Malaya Kulinda contain gases: CO_2 0.657, SO_2 0.262, H_2O 1.838 (mm Hg x cm^3), cassiterite from the same location CO_2 1.000, SO_2 0.011, H_2O 0.176, Th 350-380°C; for other deposits of this formation Th = 370-620°C. Inclusions in amazonite of formation III contain CO_2 0.478, SO_2 0.001, H_2O 0.004 (mm Hg x cm^3) in quartz CO_2 0.794, SO_2 0.041, H_2O 0.970 (same units), from the deposit Etyka and CO_2 0.233, SO_2 0.001, H_2O 0.037 (same units), from the deposit Imalka; analyses by mass spectrometry. Td of cassiterite from the deposit Etyka is in ranges 340-460°C. (Abstract by A.K.)

GRIGOR'EV, I.F., DOLOMANOVA, E.I. and USPENSKAYA, A.B., 1985, Genetic characteristics of formation of the Onon tin ore deposit (Transbaikal region): Izv. Vyssh. Uchebn. Zaved., Geol. Razved. 1985, no. 7, p. 20-34 (in Russian). Authors at Mosk. Geologorazved. Inst., Moscow, USSR.

The Onon Sn ore deposit is genetically related to Upper Jurassic biotite granite intrusives emplaced under hypabyssal conditions. The ore-bearing quartz veins consist of muscovite, cassiterite, albite, fluorite, pyrite, and ring silicates. Paragenetic sequences of mineral crystallization in the ore-mineralized high-temperature veins are presented for the pneumatolytic-hydrothermal and supergene stages. Short-prismatic and dipyramidal cassiterite crystals are twinned. During crystallization of the granitic magma, Sn was concentrated in acid differentiates; the ore-bearing potential of the granite was determined by oxidization-reduction conditions. Fluid-inclusion studies show that H_2O, F, CO_2, and Cl played a major role in ore mineralization. Intense greisenization is observed near the contact of granites with ore veins. (C.A. 103: 145021n)

GRIGORYAN, S.S., 1985, Saline compositional characteristics of auriferous hydrothermal solutions and methods for their determination: Izv. Akad. Nauk Armyanskoy SSR, Nauki o Zemle, v. 38, no. 4, p. 24-31 (in Russian; English abstract). Author at Akad. Nauk Arm. SSR, Inst. Geol. Nauk, Yerevan, USSR.

The possibilities and limitations of analytical methods for saline solutions are considered, and the composition of fluids forming the Zod Au ore deposit are given. (From the author's abstract)

Analyses (22) are given mostly for K, Na, Ca, Mg, NH_4, F, Cl, HCO_3 and some SO_4. (E.R.)

GRINENKO, L.N., 1984, Hydrogen sulfide-containing gas deposits as a source of sulfur for sulfurization of magma in ore-bearing intrusives of the Noril'sk area: Dokl. Akad. Nauk SSSR, v. 278, no. 3, p. 730-732 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 3, p. 290-292).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 120, 1984. (E.R.)

GRISHINA, S.N., 1985a, Determination of hydrogen sulfide by cryometric method (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 63 (in Russian). Author at Inst. Geol. & Anal. Geophys. of Siberian Br. of Acad. Sci., Novosibirsk, USSR.

Usually solid phase with Tm between -56°C and -100°C is determined as CO_2 with lowered Tm due to such admixtures as CH_4, N_2 or CO; however, Raman spectroscopy proved that solid phase melting between -92°C and -103°C sometimes is H_2S, not CO_2. Essentially G inclusions in halite of the Cambrian salt rocks from the Nepsko-Botuobinskaya syneclise during freezing runs showed separate melting of solid H_2S and CO_2. Inclusion composition was determined by Raman microspectrometry (spectrometer OMARS-89/DILOR) and two types of filling were found: CO_2-H_2S and CO_2-H_2S-CH_4. Tm of CO_2 in the first type equals -61°C, in the second type ranges from -58°C to -60°C. After concentrating of "all" CO_2 in one crystal, it is possible to form a second solid phase with Tm -98°C in inclusions of the type CO_2-H_2S. In inclusions of the type CO_2-H_2S-CH_4, the observation of distinct melting of H_2S phase is not always possible, because immiscibility of H_2S and CH_4 makes difficult the operation of growing of one H_2S crystal. In the later inclusions Tm was -101 to -103°C. Thus, in presence of CO_2, melting of H_2S occurs in eutectic point (-98°C) not in triple point (-85.5°C). Presence of CH_4 decreases Tm of H_2S. (Author's abstract, translated and shortened by A.K.)

GRISHINA, S.N., 1985b, Comparison of results of volumetric analysis [of gases] with data of Raman spectrometry and chromatography (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 70-71 (in Russian). Authors at Inst. Geol. & Geophysics of Siberian Br. Acad. Sci., Novosibirsk, USSR.

Sufficiently exact evaluation of error of gas determinations in individual inclusions by volumetric method is difficult because of absence of independent quantitative method of analysis. The paper presents study of gases in the same inclusions by nondestructive Raman spectrometry and volumetry. Three types of inclusions were used: 1) pure-CO_2 and essentially CO_2-filled; 2) inclusions attributable to binary systems CO_2-CH_4 and CO_2-H_2S; 3) inclusions attributable to ternary system CO_2-H_2S-CH_4. Analyses were performed with use of Raman spectrometers "MOLE" (in Nancy and Lille) and "OMARS-89" (in Novosibirsk). Synthetic mixtures for volumetric determinations: CH_4-N_2, CO_2-N_2, CO_2-N_2-H_2, CO_2-CH_4-H_2-N_2, were analyzed by gas chromatography and the results were accepted as true. The comparison of the results leads to the following conclusions: 1) quantitative determination by the volumetric method is possible only for one-component compositions or for two-component ones if one component is poorly soluble (CO_2-N_2); 2) presence of several soluble gases: CO_2, CH_4, H_2S, H_2 causes a systematic error, which cannot be calculated due to unstable diffusion equilibrium of bubble in liquid; 3) for bubbles of dia. <50 μm, the process of inflow of gas dissolved in liquid has big influence. Thus, in purely CO_2-filled inclusions, up to 20% N_2 + rare gases [previously dissolved in the liquid from the air] may be detected due to this process. Use of gas-free (air-free? - A.K.) glycerine removes this error. (Author's abstract, translated by A.K.)

GRISHINA, S.N. and HOLDEEV, O.V., 1985, CO_2-H_2S-CH_4-H_2O inclusions in metamorphic halite (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 60. Authors at Inst. Geol. & Geophys., Siberian Br., Acad. Sci. USSR, Novosibirsk-90, USSR.

Microthermometry and Raman microprobe studies have been made on three core samples of Cambrian Siberian salts from contact zones with trap intrusions.

One-phase liquid inclusions at room temperature were determined to be pure CO_2 or mixtures of CO_2-H_2S and CO_2-H_2S-CH_4. Analyses were performed on Raman microsond type OMARS-89 (DILOR) (Table 1). All of the samples contain graphite-like solids as black opaque material, brown films, or thread-like formations. The carbon-rich material appears to be more likely kerogen than the result of precipitation from the fluid, because the same substance has been detected both in pure CO_2 inclusions and CO_2-H_2S or CO_2-H_2S-CH_4 inclusions.

Liquid water is present in cavities as a rim, sometimes detectable only on cooling, with Tm-ice -27°C; H_2S was never trapped in a clathrate structure. Solid H_2S has been observed after freezing CO_2. The melting temperature of solid CO_2 is -58°C in CO_2-H_2S inclusions and (-58) to (-60)°C in CO_2-H_2S-CH_4 inclusions. The second solid phase melts near -98°C in the first type inclusions and in the interval (-101 to -102) in the second one.

The value of -98°C agrees with the eutectic temperature in H_2S-CO_2 inclusions, reported in a previous E.C.R.F.I. symposium, but the shift to -101 to -102°C contradicts the results obtained on inclusions of similar composition in calcites. Data presented Guilhaumou et al. (1984) indicate that even significant amounts of CH_4 do not reduce the value of -98°C. One explanation of the disagreement can lie in difficult observation of final melting, because the existence of two immiscible liquids CH_4-H_2S does not allow growing a single crystal of H_2S. On the other hand, after freezing CO_2 it is easy to grow a single crystal of H_2S in a CO_2-H_2S inclusion, and the Tm in this case is constant.

Reference

Guilhaumou, N., Velde, B. and Beny, C. (1984).-Raman microprobe analysis of gaseous inclusion in diagenetically recrystallized calcites. Bull. Minéral., 107, 193-202. (Authors' abstract)

Table 1

	%CO_2	%H_2S	%CH_4	Tm CO_2	Tm H_2S
Sredne-Nepskaja	100	0.0	0.0	-56.6	-
	100	0.0	0.0	-56.6	-
Yurubchenskaja	97.3	2.3	0.0	-58.0	-97.8
	97.1	2.9	0.0	-58.0	-98.0
Gagenskaja	97.3	1.5	1.3	-58.2	-101.7
	93.6	3.5	2.8	-59.1	-101.3
	98.0	1.0	1.0	-58.9	n.d.
	96.4	0.8	2.8	-60.0	n.d.

GROVES, D.I., HO, S.E. and HOUSTOUN, S.M., 1984, The nature of Archean gold deposits in western Australia with particular emphasis on parameters relevant to geophysical exploration, in Geopysical exploration for Precambrian gold deposits, H.A. Doyle, ed., p. 1-63.

GROVES, D.I., PHILLIPS, G.N., HO, S.E. and HOUSTOUN, S.M., 1985, The nature, genesis and regional controls of gold mineralization in Archaean greenstone belts of the Western Australian Shield: A brief review: Trans. Geol. Soc. S. Afr., v. 88, p. 135-148.

Available constraints on gold mineralization in both volcanic/intrusive and banded iron-formation hosts are compatible with a metamorphic-replacement model for gold mineralization. In this model, the ore fluid and ore components were derived by devolatilization, in the absence of significant melting, of dominantly volcanic sequences during high-grade metamorphism at the base of the greenstone pile. Gold was transported as a reduced sulphur complex (e.g., $HAu(HS)_2$) in reduced, neutral to slightly alkaline, H_2O-CO_2 fluids of low salinity and low density. Fluid access to depositional sites was via faults and shear zones. Deposition occurred at minimum P-T conditions of 1 to 2 kb and 300 to 400°C, largely in response to fluid-wall rock interaction which resulted in sulphidation of Fe-rich host rocks, with synchronous gold and Fe-sulphide deposition; other reactions that control pH and fO_2 may be important and explain the enormous range in characteristics of some large and most smaller deposits. The origin of metamorphosed gold deposits in amphibolite facies domains is more equivocal, and genetic models are strongly debated. (From the authors' abstract)

GUAN, Xunfan, ZHOU, Yongquing, XIAO, Jinghua, LIANG, Shuzhao and LI, Jinmao, 1985, Yinyan porphyry tin deposit--a new type of tin deposit in China: Acta. Geol. Sinica, v. 59, no. 2, p. 155-161 (in Chinese; English abstract). Authors at 704 Geol. Team of Bureau of Geol. & Mineral Resources of Guangdong Province.

Yinyan porphyry tin deposit in Guangdong Province is situated in the Yunkai Caldeonian rise, lying to the west of Wuchuan-Sihui great fault. The exposed strata are mainly pre-Devonian schist, gneiss, migmatite, etc. The main geological features are as follows:

1. Yinyan tin-bearing prophyry is a pipe-like granite porphyry complex. Its K-Ar isotopic age is ~92 m.y. The petrochemistry of the rock body is characterized by being rich in silica, alkali, lithium, halogen and yttrium, while the contents of Na_2O and R^{2+} (FeO+MnO+CaO = 2.51) are low (K_2O>Na_2O). Explosion features are evident at the top of the porphyry.

2. According to their types and occurrence, four types of ore bodies have been distinguished: (1) inverted cup-like tin ore body occurring at the [top?] of the porphyry. The mineralization was controlled by multiple alterations and fractures; (2) W-Mo ore body occurring in the central part of the porphyry and surrounded by inverted cup-like tin ore body; (3) tin ore body occurring in the quartz-porphyry veins near the surface; (4) tin ore body of vein type occurring in the exocontact zone.

3. From the top to the bottom four alteration zones can be recognized: (1) chlorite-hornfels; (2) topaz-quartz-sericite; (3) K-silicate-quartz-sericite; (4) K-silicate. The corresponding mineralization zone may be divided into the upper tin zone, middle Sn-Mo-Bi zone and lower W-Mo zone. Fluid inclusion studies show that the mineralization temperature varies from 360-160°C.

4. Since the REE pattern is very similar to that of the granites of anatexis (of crustal) origin in south China, the Yinyan porphyry body may originate from a water-rich magma generated in the upper crust. The presence of the explosion breccias at the top of porphyry may be the direct result of the action of thermal fluids. The alteration and mineralization zoning around porphyry and the specific features of porphyry type deposits have been formed along with the evolution of thermal fluids and the change of various physical-chemical gradients. (Authors' abstract)

GUHA, Jayanta and KANWAR, Ram, 1985, The role of $CaCl_2$-NaCl-CH_4-rich fluids in the secondary gold concentration process at the Copper Rand mine, Chibougamau, P.Q., Canada (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A23. First author at Sci. de la terre, Univ. Quebec à Chicoutimi, Chicoutimi, Quebec, Canada G7H 2B1.

Calcium- and sodium chloride-rich fluids associated with mines in the Canadian Shield were known from as early as 1887. These fluids are generally accompanied by methane gas. Various workers are currently studying the chemistry and isotopic composition of these waters in an attempt to explain their origin and to examine their relationship to the mineralizing processes.

A systematic evaluation of $CaCl_2$-NaCl-CH_4 fluid-bearing pockets in the Copper Rand Mine in the Chibougamau mining district indicates that zones of anomalously high gold concentration are spatially associated to these pockets. They occur in late structures and the gold mineralization in them has a completely different character from that found in the majority of the deposit. The latter is in the form of finely dispersed native gold grains associated with pyrite and chalcopyrite whereas the former contains nuggets of varying dimensions associated with quartz and carbonate fillings.

Based on structure, lithology, fluid inclusions and isotope data of these deposits it is postulated that the formation of nugget type gold occurred after the initial mineralizing period. The fluids in the pockets which have comparable characteristic to the "deep mine waters" in their chemical and isotopic composition are modified formation waters that infiltrated from the Proterozoic sedimentary basin during the stages of shearing. The gold was leached from the existing orebody and concentrated in later structures which acted as collector or traps for the fluid thus indicating that $CaCl_2$-$NaCl$-CH_4 rich fluids have played an important role in the development of the orebody. (Authors' abstract)

GUILHAUMOU, N. and BENY, C., 1985, Characterization of hydrocarbons in fluid inclusions in quartz from the southern Subalpine Terres Noires (France) (abst.): Symp., European Current Res. on Fluid Inclusions, April 10-12, 1985, Göttingen, FRG, Program, p. 62 (in French). First author at E.N.S. Lab. de Géologie, 46 rue d'Ulm, 75230 Paris Cedex 05, France.

Fluid inclusions in black shales from the southern Subalps contain liquid and gaseous hydrocarbons. The gas phase of the inclusions was studied by Raman spectroscopy, and fluorescence microscopy was used to characterize the liquid hydrocarbons. Gas compositions show a gradual change from CH_4-C_2H_6-C_3H_8 mixtures with small amounts of H_2S and sometimes N_2 (similar to "wet gases" formed upon catagenesis of oil basins) in the western part, to pure CH_4 or CH_4-CO_2 mixtures (similar to gases formed upon metagenesis) in the eastern part. The CO_2-rich compositions resemble those described by Mullis (1979) in the upper- and middle anchizone of the external Swiss Alps. Parallel with the change in gas composition it is observed that fluorescent liquid hydrocarbon inclusions predominate in the eastern part (Orpierre, Vertegoux), become less abundant in the region of Rémuzat, and are nearly absent in the eastern part (Blégier, Col d'Allos) where the gas-rich inclusions predominate. This confirms the different thermal evolution of the western and the eastern part observed earlier by Barlier (1973, 1974). The difference in fluid inclusion composition between Orpierre and Rémuzat could be related to local thermal anomalies or may reflect a north-south gradient. (Authors' abstract, translated by R. Kreulen)

GUILHAUMOU, N., DAHAN,N. and COUTY, R., 1985, Microthermometry of fluid inclusions under confining pressure (abst.): Symp., European Current Res. on Fluid Inclusions, April 10-12, 1985, Göttingen, FRG, Program, p. 64 (in French). Authors at E.N.S. Lab. de Géologie, 46 rue d'Ulm, 75230 Paris Cedex 05, France.

A high-pressure-heating-freezing-stage has been constructed. Preliminary results are presented on the behavior of fluid inclusions in fluorite at 0 to 400°C and 0 to 700 bars. Th have been measured on fluid inclusions containing halite in a sample from Djebel Tirrémi (Eastern Marocco). This sample also contains CO_2-rich high-density inclusions which otherwise decrepitate upon heating, damaging the sample plate. At a confining P of 400 bars, Th was achieved at 140°C without problems.

Experiments on two-phase secondary H_2O-$NaCl$ inclusions and primary hydrocarbon inclusions (high compressibility, chemically inert with respect to the inclusion walls) in fluorite from Djebel Guebli (Tunisia) gives three main results:

- In the studied PT range, the confining P has no effect on Th (fluid density) as long as the inclusion has not been overheated. The confining P thus merely increases the strength of the mineral against the internal P of the included fluid.
- The amount of overheating needed to decrepitate or stretch an inclusion depends on the volume of the inclusion and the confining P; it increases with increasing confining P.
- The more the fluid inclusions have been stretched by overheating, the more their Th approaches the stretching T. Increasing the confining P tends to oppose this effect and Th decreases. This means that the fluid inclusion actually "sees" the variation in confining P. This could be related to mechanical action on the inclusion walls. It will be interesting to see whether there are simple relations between the confining P and the T at which these phenomena occur. (Authors' abstract, translated by R. Kreulen)

GUMENYUK, V.A., GRANOVSKIY, A.G., IVANISHENKO, A.K. and PROKOPOV, N.S., 1984, Relative effect of temperature, pressure and geochemical factors on ore and metasomatic zoning in one gold-lead-zinc deposit: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 979-984 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 4, p. 144-149, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 123. (E.R.)

GUNAWARDENE, Mahinda, 1985, Gemmological properties of synthetic corundums coated by Lechleitner: J. Gemmology, v. 19, no. 7, p. 557-570.

Includes some discussion of inclusions in synthetic corundum. (E.R.)

GUNNESCH, M., 1985, A fluid inclusions investigation of ore formation in the skarn of Milpo, central Peru (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 66-67. Author at Mineral.-Petrogr. Inst., Univ. Heidelberg, Im Neuenheimer Feld 236, D-6900 Heidelberg, FRG.

The Milpo mine is located in the Dept. of Cerro de Pasco, at lat. 10°35'S and long. 76°12'W. Zn-, Pb- and Ag-bearing skarns occur at or near the contact of a Tertiary calc-alkaline stock or dikes of granodioritic composition and Late Triassic-Early Jurassic limestones. The calcic skarns are characterized by a wollastonite-grossularite, andradite garnet-diopside pyroxene assemblage. The igneous rocks are affected by an intense pervasive potassic alteration.

The fluid inclusions study was carried out on the host minerals K-feldspar (valencianite), violet (I, II, III) and green fluorite, quartz and sphalerite. In the endoskarn the valencianite occurs in paragenesis with akerite - calcite ± anhydrite ± quartz ± Fe oxide. The assemblage K-feldspar-tremolite-phlogopite (annite), are found in veinlets which cut the diopsidic skarn.

Fresh crystals of valencianite appear on the walls of the veinlets of the endoskarn. The vein filling is violet fluorite I and calcite. Freezing data provide information about the three dissolved hydrate species: $CaCl_2 \cdot 6H_2O$; $MgCl_2 \cdot 12H_2O$; and $NaCl \cdot 2H_2O$. The presence of these hydrates is confirmed by analyses with the M.O.L.E. Raman microprobe. Th (halite) ranges from 210° to 370°C, indicating salinities between 31.5 and 43 NaCl wt %. The P fluid inclusions in violet I fluorite contain dm halite and sylvite. The freezing data of these inclusions correspond to those of the new K-feldspar; they homogenize both by vapor and by halite disappearance, between 290° and 410°C. The salinities are 29-42 NaCl and 14-19 KCl wt %.

The green fluorite formed contemporaneously with wolframite and scheelite at the contact. No evidence of boiling or CO_2 is observed in the inclusions associated with potassic alteration.

Prismatic quartz, a product of andradite alteration from the exoskarns, is found in paragenesis with sericite-pyrite-calcite. This association corresponds to the quartz-sericite alteration. The freezing data from vapor-liquid P inclusions both in quartz and violet fluorite II indicate the presence of $CaCl_2 \cdot 6H_2O$ and salinities between 8 and 12 NaCl wt %; Th = 210-320°C.

The actinolite-albite-chlorite ± muscovite association characterizes the propylitic assemblage. The wide range of Th (220°-350°C) and a wide range of salinities (10-35 NaCl wt %) from the euhedral inclusions in violet fluorite III, connected to the above mentioned alteration type, may be caused by unmixing. Boiling and alignments of dark, dry inclusions with euhedral shapes and traces of CO_2 (Raman spectroscopy) are observed. Raman spectroscopy made it possible to identify n - alkenes near some of these inclusions. It was also noticed that the limestones are rich in bituminous substances.

The P inclusions in sphalerite can be subdivided into two types, according to the time of formation and the chemical composition of the host mineral: those in red sphalerite occur parallel to alignments of chalcopyrite blebs on the crystal growth faces, near the contact. They contain both sylvite and halite and they homogenize between 350°-420°C; those in yellow sphalerite, younger than type 5.1, have Tm ice -9.1° to -4.3°C, and Th 240° and 282°C. (From the author's abstract)

GUO, Xiaoshan, XIAO, Zhenmin, OU, Yigun and LU, Qinxin, 1985, On the genesis of the Qixiashan lead-zinc ore deposit in Nanjing: Mineral Deposits, v. 4, no. 1, (Ser. No.: 11), p. 11-21 (in Chinese; English abstract). Authors at No. 810 Party of East China Geol. Explor. Corp., China Nat'l. Nonferrous Metals Industry Corp.

The Qixiashan lead-zinc polymetallic ore deposit is apparently controlled by strata, lithology and structure and has complicated mineral and chemical compositions, and relatively simple major minerals, as well as very weak wall rock alterations such as silicification, carbonitization and baritization characterized by medium-low metallogenic temperatures. The sulfur isotope compositions of the sulfide ore are scattered (δS^{34} values being -27.4 - +14.1‰), with a peak at 0‰ on an isotope frequency histogram.

The lead in the ore is normal-type, having model ages (ϕ values) of 568-707 m.y. and initial lead time of pre-Cambrian. The oxygen and carbon isotope compositions suggest that the ore-forming hydrothermal fluids originated mainly from the strata and the meteoric water. The circulation of the infiltrated thermal brine and the "fracturing-karstification" must have played an important role in the metallogenic process. No intrusive body has been observed at the surface of the mining area, but a medium-acid magmatic intrusion might exist at depth in the west of the mining area, which undoubtedly provided thermal energy and part of the ore-forming materials for the formation of the ore deposit. The mineralization process underwent three stages, i.e., Caledonian-Hercynian sedimentary stage, Indo-Sinian thermal brine circulation and paleokarstification stage and middle-late Yenshanian metallogenic stage.

Studies show that the metallogenic elements were derived predominatly from pre-Cambrian basement rock and partly from ore-localizing beds and magma. These ore-forming materials were first released from the basement and the strata as a result of deep circulation of thermal brine and paleokarstification, and then formed mineralization solution, which migrated along faults and eventually precipitated in favorable structures and carbonate beds. It is therefore conceivable that the metallogenic activities occurred later than the formation of ore-localizing strata and the ore deposit was finally produced in the middle-late Yenshanian period. Consequently the ore deposit can be considered to be of crust-derived epigenetic stratabound type. (Authors' abstract)

GURENKO, A.A., SOBOLEV, A.V., POLYAKOV, A.I. and KONONKOVA, N.N., 1985, The problem of the thermometry and composition of melt inclusions in a highly-magnesian tholeiitic basalt from Iceland (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 125-126 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

Magmatic inclusions in phenocrysts of olivine (87.9-91.6% Fo) and clinopyroxene ($Wo_{41}En_{53}Fs_6$) in one of the most magnesian samples from the Icelandic tholeiitic series (Mg' = 0.746), normal glass, partly to completely crystallized, and combined inclusions, containing xenogenic chromite and clinopyroxene.

In virtualy all initially glassy inclusions, crystallization of cpx starts at ~1050-1080°C; its complete melting systematically exceeds that of the disappearance of the fluid [vapor?] phase by 10-15°C. The stability of this cpx has been demonstrated even when held 1-4 hours at the T of disappearance of the fluid phase. Tm of the last crystal correlates with the composition of the host-olivine and lies in the 1195-1245°C range. On the other hand, simultaneous Tm dm and the fluid phase has been identified in the narrow range: 1195-1210°C.

Composition of homogenized melt inclusions (HMI), ('Camebax-Microbeam' microprobe) shows a correlation between the calculated T of equilibrium and Th, both for inclusions in olivine and cpx.

In olivine, as Th rises, the amount of CaO and MgO in the melt increases, and that of Al_2O_3 and Na_2O falls. However, for inclusions in cotectic olivines and cpx, which have an equal Th, a discrepancy is observed in MgO and FeO. Moreover, in comparison with the bulk composition of the rock, there is a systematic underestimate of FeO by 1-3 wt %.

The above information, and also thermodynamic calculations of the liquidus association for the HMI compositions in the olivines and cpx, suggest an intense undersaturation of the system in volatile components, as a result of which the Th of the inclusions do not correspond to Tt and during the course of experiments, a systematic underheating of the samples is tolerated until compositions and T are attained, truly corresponding to the captured melt.

The material examined indicates the possibility of forming cumulates, consisting of high-magnesian olivine and clinopyroxene, from melts corresponding to tholeiitic basalts. (From the authors' abstract)

GUSEVA, Ye.V., MEL'NIKOV, F.P., ORLOV, R.Yu. and USPENSKAYA, M.Ye., 1983, Raman spectroscopy of gas-liquid inclusions in minerals: Dokl. Akad. Nauk SSSR, 1983, v. 272, p. 197-200 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 272, p. 169-172, 1985). Authors at Univ. Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 97-98, 1983. (E.R.)

HAHN, Raimund and IKRAMUDDIN, Mohammed, 1985, Lithogeochemistry and fluid inclusions of an Au-Ag vein deposit in a granodiorite intrusive (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 601. Authors at Geochem. Lab., Dept. Geol., Eastern Washington Univ., Cheney, WA 99004.

Forty-eight samples of altered and unaltered rocks and quartz veins from the Acme mine in northeast Washington, an Au-Ag vein deposit in a granodiorite intrusive, have been analyzed for SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, H_2O, CO_2, Ag, Au, Ba, Cu, Pb, Rb, Sr, Tl, and Zn. A comparison of major and trace elements shows that the altered granodiorite is enriched in SiO_2, Fe_2O_3, K_2O, Ag, Au, Ba, Cu, Pb, Rb, Tl, and Zn and depleted in Al_2O_3, FeO, MgO, CaO, Na_2O, TiO_2, MnO, P_2O_5, and Sr. The average contents of Au in unaltered and altered granodiorite and quartz veins are 9 ppb, 270 ppb and 1020 ppb respectively. Heating and freezing measurements on 166 fluid inclusions reveal the presence of type 1 H_2O-CO_2 and type 2 H_2O-(CO_2) fluid inclusions. Type 1 fluid inclusions homogenized at temperatures of 203-316°C and type 2 at 160-202°C. The salinities range from 1-12 weight percent NaCl equivalent and the fluids were boiling.

The average Ba/Tl ratio in the altered samples decrease and average Rb/Sr and Tl/Sr ratios increase. K, Rb, and Tl are enriched in the altered granodiorite by factors of 1.5, 1.6, and 1.4 respectively. Tl is not enriched relative to Rb and K in the altered samples due to the high temperature of the deposit. The Ba/Tl, K/Tl and K/Rb ratios do not show complete separation of altered from unaltered samples. However, the Ba/Tl and K/Tl ratios in the quartz vein are significantly lower than the unaltered and altered granodiorite. This is due to the enrichment of Tl over K and Rb in the quartz veins. The Rb/Sr and Tl/Sr ratios are higher in the altered granodiorite and quartz veins compared to unaltered samples. The enrichment of Tl and presence of low Ba/Tl and high Rb/Sr and Tl/Sr ratios in a granodiorite indicate that the rocks are hydrothermally altered and represent a possible Au-Ag target. (Authors' abstract)

HALL, Wayne, 1985, Central Idaho black shale mineral belt (abst.): U.S. Geol. Survey Circular 949, p. 19-20.

A highly mineralized black shale belt 60 mi (95 km) long and 8-30 mi (13-48 km) wide of Ordovician to Permian age crops out on the east side of the Atlanta lobe of the Idaho batholith in central Idaho. These black shales occur in imbricated tectonostratigraphic plates separated by regional thrust faults. Mineralized resources include (1) small to moderate-sized high-grade Pb-Ag-Zn vein deposits that account for most past production, (2) two large Mo deposits associated with granodiorite stocks intruded into Mississippian black argillites, and (3) stratabound deposits of Zn-Pb-Ag, barite, and V, mostly in highly carbonaceous shale and limestone of the Devonian Milligan Formation and Mississippian Salmon River sequence. Geologic, stable-isotope, and fluid-inclusion data indicate that the sources of metals and sulfur for the vein deposits are the host black shales near intrusive bodies. These vein deposits may be used as guides to possible nearby syngenetic deposits. (Author's abstract)

HALSOR, S.P. and CHESNER, C.A., 1985, A color video tape introduction to fluid inclusions for economic geology classes: J. Geol. Education, v. 33, p. 269-270. Authors at Dept. Geol. & Geological Engrg., Michigan Tech. Univ., Houghton, MI 49931.

A 40-minute color videotape which introduces the novice student to fluid inclusions and some of the operations that can be performed on them has been produced at Michigan Technological University. Because fluid inclusions are studied microscopically, they are particularly well-suited for the videotape teaching medium. A microscope equipped with a TV camera allowed filming of fluid inclusion features and their reactions to heating and cooling. The tape focuses on microscopic aspects of fluid inclusions that are difficult to explain or diagram on the blackboard, and combines lecture materials and color diagrams for a complete presentation on the basics of fluid inclusions. (Authors' abstract)

HALTER, G., SHEPPARD, S.M.F., PAGEL, M. and WEBER, F., 1985, Lithogeochemistry of the alterations correlated with unconformity uranium deposits in the Carswell structure (Saskatchewan, Canada) (abst.): Terra Cognita, v. 5, p. 153. Authors at CREGU, BP 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

In the Carswell structure (Saskatchewan-Canada), uranium deposits are located near the middle Proterozoic unconformity and are hosted in altered rocks. Mineralogical, geochemical, isotopic and fluid inclusion data allow [recognition of] four main alteration pattern[s]. Regional retromorphism of the Hudsonian basement is characterized by the following association: albite, epidote, Fe-chlorite, illite, calcite, quartz and Ti-oxides. Locally, in faulted zones of the basement, albite, epidote and Ti-oxides are observed together with Mg-chlorite and the dissolution of quartz.

Alteration profile of the basement just below the Athabasca sandstones, is well developed. Three zones are distinguished from the bottom to the top of the profile: a green-red one with illite and magnesian chlorites, a red one with abundant illite and hematite and a kaolinite-hematite zone. This alteration is interpreted as a surface alteration profile strongly modified by reequilibration of minerals after deposition of the Athabasca sandstones. Diagenetic minerals in sandstones are quartz, illite 2M, chlorite, kaolinite, hematite. Hydrothermal alterations related to ore deposition, from 1300 m.y. to 900 m.y. are characterized by aluminous and magnesian chlorite, 1M aluminous illite and dravite. Mg, Al, B, Li and F contents are higher than in host rocks.

Zoneography in the halo around ore zone is described. The δD values for illite in Athabasca sandstones and illite in the halo are of the same order -46 to -67‰ while in the uranium oxide zone, Mg chlorite have δD values from -138 to -159‰. Illite crystallinity (3 to 7), fluid inclusion temperatures and salinities, and isotopic compositions show that minerals in the surface alteration profile have been reequilibrated by formation water. The hydrothermal fluids have also the characteristics of this formation water. (Authors' abstract)

HAMPTON, C.M. and BAILEY, D.K., 1985, Gases from volcanic glasses: Implications for melt structures and magmatic variations (abst.): Terra Cognita, v. 5, p. 199. Authors at Dept. Geol., Univ. Reading, Reading, UK.

Volcanic glasses are the closest derivatives of natural melts in terms of structure and composition. The analysis of gases, liberated by fusion under vacuum, by mass spectrometry provides a powerful technique to supplement other data from on site measurement of volcanic gases. A crucial part of the analysis is the pattern of gas release, which is influenced by structural changes during progressive heating. Melt structure also determines the effectiveness of gas release as a function of pressure,temperature, and rate of temperature change. Analysis of once-run charges for C, S, F and Cl using alternative methods of analysis show large variations of release with different heat treatment and glass chemistry. Gas extraction experiments have been carried out on glasses from volcanoes worldwide. Volatile abundances and gas release patterns vary systematically with bulk chemistry, providing new insights into melt structures, and raising fundamental questions about magma genesis. (Authors' abstract)

HANOR, J.S., 1984, On the non-importance of membrane filtration as a mechanism for producing subsurface brines in the Louisiana Gulf Coast (abst.): Clay Minerals Soc., Annual Meeting, Program with Abst., p. 55.

HANSEN, F.D., 1985, Deformation mechanisms of experimentally deformed Salina basin bedded salt: ONWI Tech. Report BMI/ONWI-552, 61 pp.

Includes photomicrographs of rhomboidal inclusions in salt (p. 42), from the laboratory deformation of cubic inclusions. (E.R.)

HARDIE, L.A., LOWENSTEIN, T.K. and SPENCER, R.J., 1985, The problem of distinguishing between primary and secondary features in evaporites: Sixth Int'l. Symp. on Salt, 1983, v. 1, p. 11-39. First author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD, USA.

A discussion of the various criteria, also involving fluid inclusions: low Th, shrinkage bubbles (no gas pressure) and growth banding, for syndepositional features, and high Th, gas under pressure, and lack of systematic salinity changes from core to rim, for post burial features. (E.R.)

HARRIS, Chris, 1985, Guano-derived rare earth-rich phosphatic amygdales in gabbroic inclusions from Ascension Island: Earth & Planet. Sci. Letters, v. 72, p. 141-148. Author at Dept. Geochem., Univ. Capetown, Rondebosch, 7700, South Africa.

Four analyzed gabbros from a suite of augite-plagioclase (An_{60-70})-olivine cumulates found as fragments in redistributed pyroclastic sediment on Middleton's Ridge, Ascension Island, have large negative Ce anomalies (Ce*/Ce up to 5). Along grain boundaries and in the interstices between the cumulus minerals, quenched intercumulus liquid is preserved. Contraction vesicles are filled with, and in places the quenched liquid is replaced by, a REE-rich phosphate mineral. (From the author's abstract)

HARRISON, T.M., DUNCAN, Ian and McDOUGALL, Ian, 1985, Diffusion of ^{40}Ar in biotite: Temperature, pressure and compositional effects: Geochimica Cosmo. Acta, v. 49, p. 2461-2468.

HARVEY, D.B., 1985, Occurrences and geochemical characterization of cassiterite mineralization in the Taylor Creek tin district (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 53. Author at Univ. Texas at El Paso, TX.

Tin mineralization occurs within rhyolite and ash-flow tuff in the Taylor Creek tin district. The occurrences of vein and disseminated mineralization in ash-flow tuff are in conflict with the age and spatial restrictions to the Taylor Creek Rhyolite as inferred by several previous investigators. Numerous mineralized localities are typified by irregular networks of hematite-cassiterite-silica veins with replacement and open-space textures.

Semiquantitative spectrographic analyses of surface and drill-hole samples demonstrate that As, Pb, Sb, and Zn enrichment as great as 5000 ppm, 15,000 ppm, 1000 ppm, 10,000 ppm, respectively, is associated with tin mineralization. Fluorine is highly enriched in mineralized zones in the form of microcrystalline fluorite. Alteration of hosts is primarily characterized by the introduction of hematite and corresponding iron enrichment, although silicification is locally significant.

Preliminary fluid-inclusion studies of cassiterite exhibit Th ranging from 344 to 417°C. Relatively high formational temperatures of crystalline cassiterite and intergrown wood tin are in contrast to low-T inferences commonly made. Daughter crystals are commonly abundant in fluid inclusions and reflect the complexity of mineralizing solutions.

Mineralization is not restricted to the domes and flows of the Taylor Creek Rhyolite (24 m.y.), and the occurrences in overlying Railroad Canyon Tuff (23.5 m.y.) indicate tin introduction to be significantly younger than Taylor Creek time. The T and chemical and mineralogical associations of cassiterite mineralization in the Taylor Creek tin district are compatible with a hydrothermal origin. (Author's abstract)

HARVILLE, D.G. and FRITZ, S.J., 1985, Occurrence of clays and their bearing on evaporite mineralogy in the Salado Formation, Delaware Basin (New Mexico) (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 604.

HATCH, J.R., HEYL, A.V. and KING, J.D., 1985, Organic geochemistry of wall-rock alteration, Thompson-Temperly mine, southwest Wisconsin (abst.): U.S. Geol. Survey Circular 949, p. 20-21.

Previous studies of the Thompson and Temperly zinc-lead ore bodies, southwest Wisconsin, show alteration aureoles in the Middle Ordovician host-rock limestones, dolomites, and shales extending laterally as much as 60 m from the ore. Texture, clay mineralogy, and major-, minor-, and trace-element and $\delta^{13}C$ and $\delta^{18}O$ compositions of the host rocks have all been significantly affected by mineralization processes. Fluid-inclusion studies indicate that maximum temperatures of ore deposition were about 120-130°C.

We performed organic geochemical analyses on samples of the basal 3-inch-thick (8-cm-thick) carbonaceous shale and the immediately overlying limestone bed of the Quimbys Mill Member of the Platteville Formation. The samples were collected from the ore body, the alteration aureole, and unaltered rock. Results and conclusions include the following:

1) The higher total organic carbon (TOC) of samples of limestone within the ore and in the alteration aureole are a result of solution of carbonates and residual concentration of organic matter.

2) Organic carbon $\delta^{13}C$ does not change systematically with distance from the ore body in either shale or limestone.

3) Carbon-normalized volatile hydrocarbon (HC) contents (S_1/TOC) decrease toward the ore body in both shale and limestone and carbon-normalized pyrolytic HC contents (hydrogen index, HI, S_2/TOC) are much lower in the shale near the ore body than in outer part of the aureole or unaltered rock. The temperature at which the S_2 peak reaches a maximum (T_{max}) indicates immature to marginally mature organic mater. T_{max}, however, shows no systematic changes with distance from the ore. The decrease in S_1/TOC towards the ore indicates loss of lower molecular weight organic compounds during mineralization. The decrease in hydrogen index for the shale indicates alteration of organic matter. The higher hydrogen index of the limestone within the ore may be an artifact caused by concentration of organic matter. The lack of change in T_{max} is a probable result of a relatively short time of hydrothermal activity.

4) Distributions of saturated hydrocarbons extracted from both shale and limestone sample show relative decreases in amounts of lower molecular weight compounds ($<n\text{-}C_{25}$) in and near the ore. This supports the loss of volatile hydrocarbons indicated by S_1/TOC. Biological-marker distributions for all samples are remarkably similar regardless of lithology or proximity to the ore body. Biological-marker maturity indicators indicate marginally

mature organic matter. The lack of effect on the biological marker maturity indicators by the alteration and mineralization suggests a relative short interval of hydrothermal activity; biomarker equilibration apparently requires more time than the duration of Upper Mississippi Valley-type mineralization. (From the authors' abstract)

HATCHER, P.G., 1985, Origin of sedimentary humic acids, potential carriers of ore-forming elements (abst.): U.S. Geol. Survey Circular 949, p. 21-22.

HAYNES, F.M., 1985, Determination of fluid inclusion compositions by sequential freezing: Econ. Geol., v. 80, p. 1436-1439. Author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109-1063.

Careful melting to yield a single nucleus of a given phase, followed by cooling, can yield larger and hence more readily identified crystals. Applied particularly to Ca-rich inclusions. See also Kozlowski, 1984b, Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 175. (E.R.)

HAYNES, F.M., STERNER, S.M. and BODNAR, R.J., 1985, Chemical analysis of individual fluid inclusions by SEM/EDA: An evaluation using synthetic inclusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 605. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

The compositions of individual synthetic fluid inclusions in the systems NaCl-KCl, NaCl-$CaCl_2$, and NaCl-KCl-$CaCl_2$ have been successfully determined by EDA of precipitates produced during thermal decrepitation. Inclusions containing known mixtures of 20 wt % total salinity were synthesized by healing fractures in natural quartz at 600°C and 7 kb for 10 days. The two-phase, daughter-free inclusions homogenized at 170 ± 10°C, began to decrepitate at 280-300°C, and by 350°C a significant number of decrepitates had formed on the polished surface. Peak areas generated by EDA (raster mode) of these decrepitates were standardized using both single salt standards and mixed salt standards evaporated to dryness in a vacuum. Although the mixed salts better approximate the decrepitate compositions, difficulties were encountered in producing micron-scale homogeneity and the single salts yielded more reliable results. Three different solutions from each system were run and in all 9 samples the average values of 10-20 decrepitates fell within 6 wt % (0.2 to 5.4) of the original chemistry suggesting that the decrepitates were chemically representative of their precursor inclusions. In all but one of the 9 samples (NK2) the known composition was within one standard deviation of the decrepitate average. Results from the 2 component systems (NK = NaCl-KCl, NC = NaCl-$CaCl_2$) are tabulated. (Authors' abstract)

HE, Luping and DIAO, Peiliang, 1984, A vacuum apparatus for extracting gaseous components in mineral inclusions: Acta Mineral. Sinica, 1984, no. 1, p. 179-182 (in Chinese; English abstract). Authors at Central-South Inst. of Mining & Metallurgy.

A vacuum apparatus used for extracting gaseous components in mineral inclusions is described. The apparatus consists chiefly of a vacuum heating decrepitation reactor, a micromodule device for vacuum grinding, $Mg(ClO_4)_2$ absorber of water and gas concentration sampler. It is suitable for extracting gaseous components from gas inclusions in various minerals. Results are generally satisfactory. The apparatus has the advantages of reasonable designing, simple structure, compact assemblage, reliable performance and convenient operations. (Authors' abstract)

HE, Y., JAYAPRAKASH, C. and ROTTMAN, Craig, 1985, Shapes of grain inclusions in crystals: The Am. Phys. Soc. Physical Review B, v. 32, no. 2, p. 12-22. Authors at Dept. Phys. & the Materials Res. Lab., The Ohio State Univ., Columbus, OH 43210.

The "equilibrium" shape of a grain (with fixed volume) embedded in a simple-cubic crystal of the same material and rotated by a small angle with respect to the [001] axis is studied. The dislocation model of grain boundaries of Read and Schockley is used to compute the grain-boundary energy as a function of orientation. (From the authors' abstract)

HEARN, P.P., Jr. and SUTTER, J.F., 1985, Authigenic potassium feldspar in Cambrian carbonates: Evidence of Alleghanian brine migration: Science, v. 228, p. 1529-1531.

The shallow-water limestones and dolostones of the Conococheague Limestone (Upper Cambrian) of western Maryland contain large amounts of authigenic potassium feldspar. The presence of halite daughter crystals in breached fluid inclusions, low whole-rock ratios of chlorine to bromine, and thermochemical data suggest that the potassium feldspar formed at low temperature by the reaction of connate brines with intercalated siliciclastic debris. Analyses of argon age spectra indicate that the authigenic feldspar probably formed during Late Pennsylvanian to Early Permian time. These results may indicate mobilization and migration of connate brines brought about by Alleghanian folding. The widespread occurrence of authigenic potassium feldspar in Cambrian and Ordovician carbonate rocks throughout the Appalachians suggests that this may have occurred throughout the entire basin. (Authors' abstract)

HEARN, P.P., SUTTER, J.F., KUNK, M.J. and BELKIN, H.E., 1985, Evidence for Alleghenian brine migration in the central and southern Appalachians: Implications for Mississippi Valley-type sulfide mineralization (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 606. Authors at U.S. Geol. Survey, Reston, VA 22092.

Authigenic K-feldspar has been found in rocks near Mississippi Valley-type (MVT) sulfide mineralization in lower Paleozoic carbonate rocks of Pennyslvania, Maryland, Virginia, and Tennessee. Synthetic $^{40}Ar/^{39}Ar$ age spectra for the authigenic K-feldspar (made by subtracting an age spectrum of complex grains with relict cores + authigenic overgrowths from an age spectrum of relict cores chemically stripped of their overgrowths) yield Carboniferous ages. Mass balance calculations indicate that the formation of the K-feldspar involved the flux of multiple pore volumes of fluid through the rocks. Estimates of vapor-liquid ratios and microthermometric homogenization temperatures of primary fluid inclusions in K-feldspar overgrowths, the presence of halite daughter crystals in some associated carbonate-hosted inclusions, and low whole-rock Cl/Br ratios indicate the K-feldspar formed by the interaction of connate brines with siliciclastic debris at temperatures between 100° and 200°C. The common occurrence of feldspathized rocks stratigraphically below mineralized zones and the similarity of primary fluid inclusions in K-feldspar overgrowths to those observed in ore and gangue minerals suggest the authigenic K-feldspar and mineralization are coeval. The Carboniferous age suggested by $^{40}Ar/^{39}Ar$ age spectra is consistent with estimates based on (1) paleomagnetic studies and (2) that MVT sulfide deposits in the central and southern Appalachians were emplaced by the migration of heated connate brines along structural pathways developed during the Alleghenian Orogeny. (Authors' abstract)

HEDENQUIST, J.W. and HENLEY, R.W., 1985, Hydrothermal eruptions in the Waiotapu geothermal system, New Zealand: Their origin, associated breccias, and relation to precious metal mineralization: Econ. Geol., v. 80, p. 1640-1668. Authors at Chem. Div., Dept. Sci. & Industrial Res., Wairakei, Private Bag, Taupo, New Zealand.

The distribution, petrography, and mineralogy are described for hydrothermal eruption breccias in the active Waiotapu geothermal system, New Zealand. Previously published discussions of the origin of these types of eruption, or equivalent breccias in epithermal mineralized districts, have focused on the development of substantial fluid overpressures in the upper silicified portion of a hydrothermal system. In this paper an alternative mechanism is proposed which requires only local sealing of near-surface discharge channels and the transmission of deeper reservoir pressures to the sealed area by the evolution of a compressible cap of exsolved gas (dominantly CO_2).

It is argued that about one hundred thousand ounces of gold have deposited beneath Champagne Pool since its formation but that the overall transport and depositional efficiency of the Waiotapu system is only 10 percent. In 10,000 years this is sufficient for the deposition of 1- to 6-million-ounce orebodies of the type under exploitation at Round Mountain (Nevada), McLaughlin (California), and in other epithermal districts.

Exploration programs for epithermal precious metal deposits should be based on our knowledge of the structural and chemical characteristics of active geothermal systems. Coupling patterns of trace element distribution, alteration assemblages, and fluid inclusion data with the location of hydrothermal breccias (vents and/or surficial deposits) provides a strategy for the targeting of exploration drilling by identifying flow paths along which boiling has occurred. (From the authors' abstract)

HEDENQUIST, J.W. and HENLEY, R.W., 1985, The importance of CO_2 on freezing point measurements of fluid inclusions: Evidence from active geothermal systems and implications for epithermal ore deposition: Econ. Geol., v. 80, p. 1379-1406. Authors at Chem. Div., Dept. Sci. & Indus. Res., Wairakei Private Bag, Taupo, New Zealand.

In studies of epithermal precious and base metal ore deposits, estimates of salinity (total dissolved salts) are frequently in error when based on fluid inclusion ice melting measurements in the absence of an independent determination of the CO_2 content of the inclusion fluid.

For a fluid of known composition, the melting point of ice (Tm) may be calculated from $Tm = -\Sigma K_i m_i$ where K_i is the molal freezing (or melting) point depression constant and m_i is the molality of a component i ($i = Na^+$, K^+, Cl^-, CO_2, etc.). For fully dissociated solute species such as Cl^-, in the salinity range considered here, K = 1.72 Kelvin/molal, and for undissociated, nonpolar species such as CO_2, K = 1.86 Kelvin/molal.

Fluid inclusion ice-melting data from New Zealand geothermal fields correlate well with values calculated using the above equation and the measured compositions of discharges from wells from which the inclusion samples were obtained. Loss of the dominant dissolved gas, CO_2, during boiling at depth results in large, systematic decreases in apparent salinity (in terms of Tm) in the Broadlands field.

Misinterpretation fo fluid inclusion freezing data may lead to substantial errors in the reconstruction of the physico-chemical environment of ore formation in fossil systems. For example, in the absence of CO_2 analyses, inclusion fluids similar in gas content to the Broadlands geothermal fluid ($NaCl \approx 0.2$ wt %, CO_2 up to 4.4 wt %) may be interpreted to have salinities of 0.85 wt percent NaCl, leading to errors of 23 percent in the estimated depth of formation at 280°C, -0.5 unit in the estimated pH of the ore fluid, and on the order of 200 times in the estimated solubility of an ore component such as lead. Such errors may be transmitted into subsequent estimation of fluid flux or duration of ore formation.

A review of published fluid inclusion studies shows that true salinities of inclusion fluids from epithermal precious metal deposits are coincident with those from the majority of explored geothermal systems but that the salinities of inclusion fluids from epithermal base metal deposits are substantially higher, indicating the presence of an evolved, high-salinity fluid during ore metal transport. In the case of low-salinity epithermal deposits, the extreme range in gold to silver ratios between deposits can be accounted for by variations in the H_2S to chloride ratio in the original hydrothermal fluid. These variations (primarily in the total gas) occur between active geothermal systems and can be recognized in epithermal deposits through fluid inclusion freezing and crushing studies. (Authors' abstract)

HEDENQUIST, J.W. and STEWART, M.K., 1985, Natural CO_2-rich steam-heated waters in the Broadlands-Ohaaki geothermal system, New Zealand: Their chemistry, distribution and corrosive nature: Geothermal Res. Council, Transactions, v. 9, Part II, p. 245-250. First author at Chem. Div., D.S.I.R., Wairakei, Private Bag, Taupo, New Zealand.

Severe external corrosion of 12 to 16 year old well casing has been noted at 300 to 600 m depth in the Broadlands-Ohaaki geothermal system. The corrosive fluid is a CO_2-rich steam-heated water. Chemical and isotope patterns of subsurface fluids indicate that this low chloride steam-heated water is widespread but probably discontinuous over the top and on the margins of the deep production fluid.

Some degree of corrosion has been noted in all of the seven wells so far examined in detail. Given the extent of the steam-heated fluid, more of the 44 wells at Broadlands will probably have corrosion problems. This corrosive CO_2-rich water exists in several other New Zealand systems, and may occur at shallow levels in any relatively gassy system, with external corrosion of existing wells yet to be discovered. (Authors' abstract)

A discussion of the effects of geothermal boiling and dilution in terms of chloride and enthalpy is pertinent to mixing problems in ore-deposit fluid inclusion studies. (E.R.)

HEIN, U.F. and TISTL, Michael, 1985, Characteristics of fluid inclusions in the porphyry copper deposit of La Granja/Peru (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 68-69. Authors at Inst. Angewandte Geol. der FUB, Wichernstr. 16, 1000 Berlin 33, FRG.

Triassic to Cretaceous sediments and volcanics were folded, intruded by diorites and granodiorites, block faulted, and overlain by Lower Tertiary andesites and rhyolites. A quartz-feldspar-porphyry of unknown age intruded the whole sequence followed by intensive hydrothermal alteration processes which are responsible for primary enrichment of ore minerals. The porphyry and the sediments were altered most intensively showing today the typical mineral assemblage of potassic alteration (eastern stock) and phyllic and advanced argillic alteration (central body). The surrounding rocks underwent propyllitic alteration; marly limestones were converted into skarn.

Fluid inclusions were studied in quartz of drill core and samples from the mineralized area as well as the surrounding rock units from an area of 7 x 5 km with the following results:

1) The relative abundance of fluid inclusions in quartz correlates well with the intensity of host rock alteration.

2) Generally the following inclusion types can be distinguished: Type I: Two-phase aqueous inclusions in the central alteration zone, together with inclusion type II and III. They have Th 380°C to 440°C and high salinities (close to the NaCl saturation). In the less altered rocks type I inclusions dominate. Here they have low salinities (~5% NaCl equiv.) and Th max. 300°C; Type II: Two-phase aqueous inclusions containing predominantly vapor. Th from 300°C to >500°C, salinities - as far as observable - are low; and Type III: Highly saline (up to 60% NaCl equiv.) three-phase inclusions generally with two dxls (NaCl, KCl) and Th from 240°C to 440°C. All types occasionally may contain trapped crystals of ore minerals. Liquid CO_2 was clearly identified during cooling in two samples only.

3) The relative abundance of single inclusion types differs over the studied area: Whereas type I inclusions are to be found in nearly all samples, type II and III inclusions occur especially in the central alteration body and in a second porphyritic stock characterized by potassic alteration. Furthermore, in the drilling samples type II inclusions are to be found predominantly in the upper part of the alteration body, indicating an enrichment of vapor by boiling. Consequently type III inclusions are interpreted as concentration of salts in the liquid phase during boiling.

So at La Granja, fluid inclusions, in correlation with petrographic data, prove useful for searching for hydrothermal alteration bodies and possibly related mineralizations. (From the authors' abstract)

HEINRICHS, T., 1985, The yoderite-bearing white-schist assemblage of Mautia Hill, Tanzania - fluid inclusions and petrography (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 70. Author at Inst. Geol. und Dynamik der Lithoshäre der Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

An assemblage of quartzites, amphibolites and marbles within migmatic gneisses at Mautia Hill hosts the sole known natural occurrence of yoderite (McKie 1959). Textural relationships indicate the breakdown reaction

$$9 \text{ kyanite} + 2 \text{ talc} + 1\ H_2O \rightarrow 3 \text{ yoderite} + 5 \text{ quartz}$$

which Schreyer (1966) estimated to take place around 10 kb and 700°C in a water-saturated system. Primary inclusions within kyanite of the white schists were found to contain only CO_2-rich fluids with equivalent densities ranging up to 1.03 g/cm^3 whereas strongly recrystallized quartz of various rock types contains low-density CO_2 and low-density, low to intermediate salinity, H_2O-rich inclusions.

The high-density inclusions in kyanite are interpreted as relics of the synmetamorphic fluid of the Mautia Hill white schists. Prograde migmatization is believed to be responsible for a CO_2-enriched residual fluid that stabilized the white-schist assemblage below 10 kb. Later, possibly in accord with migmatite crystallization, the rocks were percolated by water-rich fluids that triggered conversion of kyanite and talc to yoderite and quartz. This process must also have led to a considerable mobilization of manganese that is not only a typical component of purple Mautia yoderite, but is also conspicuously concentrated in other "retrograde" phases e.g. piedmontite, viridine, Mn-phlogopite. (Author's abstract)

HELGESON, H.C., 1985, Some thermodynamic aspects of geochemistry: Pure & Appl. Chem., v. 57, no. 1, p. 31-44.

HEMINGWAY, M.P. and NORMAN, D.I., 1985, The mineralogy and geochemistry of the southern Amethyst vein system at Creede, Colorado (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 53.

HENN, U., 1985, Investigations of kornerupine and sinhalite from Elahera, Sri Lanka: Z. Dt. Gemmol. Ges., v. 34, p. 13-19 (in German).

Describes inclusions of liquid and vapor, and apatite crystals. (E.R.)

HESSE, Reinhard, LEBEL, Jean and GIESKES, J.M., 1985, Interstitial water chemistry of gas-hydrate-bearing sections on the Middle America Trench slope, Deep-Sea Drilling Project Leg 84, in Orlofsky, S., ed., Initial Reports of the Deep Sea Drilling Project, v. 84, U.S. Govt. Printing Office, p. 727-738. First author at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec H3A 2A7, Canada.

On DSDP Leg 84, drilling was conducted at three gas-hydrate-bearing sites on the Middle America Trench slope off Costa Rica (Site 565) and off Guatemala (Sites 568 and 570). At Site 569, on the mid-slope off Guatemala, hydrates may be present, according to the seismic profile (GUA-13), although the pore-water composition does not provide clear evidence. Sites 566 and 567, on the lower Guatemala Trench slope, appear to be free of hydrates, except in fractures of serpentinite at the bottom of Hole 566.

Hydrate-bearing Sites 565, 568, and 570 show the effects of hydrate decomposition on pore-water chemistry that have been established during previous drilling at Sites 496 and 497 on the Guatemala Trench slope. These include a chlorinity decrease and $\delta^{18}O$ increase downsection. The new results, however, reveal more complex relationships between the chlorinity decrease and $\delta^{18}O$ increase than previously recognized. At Site 565, $\delta^{18}O$ values decrease in the middle section of the hole, whereas chlorinity continues to decrease from the top to near the bottom of the hole. Early diagenetic alteration of volcanic glass is suggested as a mechanism for the unexpected minimum in the O-isotope curve. Multiple fractionation by the pore-water/hydrate system is required to explain $\delta^{18}O$-values greater than 2.7‰ at the bottom of Hole 568, because with a fractionation factor of α = 1.0027, this is the maximum figure a single-stage fractionation could produce.

In situ water samples from hydrate zones in most cases failed to display the elevated salinities expected for the residual pore waters not involved in hydrate formation. This is probably because the in situ sampling device still allows a systematic pressure drop sufficient to trigger hydrate decomposition in the immediate vicinity of the sample port. (Authors' abstract)

HETHERINGTON, M.J. and CHENEY, E.S., 1985, Origin of the opalite breccia at the McDermitt mercury mine, Nevada: Econ. Geol., v. 80, no. 7, p. 1981-1987. Authors at Univ. Washington, Dept. Geol. Sci., Seattle, WA, USA.

Refers only to earlier published fluid inclusion studies. (E.R.)

HICKMAN, S. and EVANS, B., 1985, Diffusional crack healing in calcite (abst.): EOS, v. 66, p. 1065-1066. Authors at Dept. Earth, Atmosph. & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

As part of a study of the physics of diffusional crack healing and its effect upon transport properties in rock, we have undertaken an experimental study of crack healing in calcite. Small penny-shaped cracks were prepared for these experiments by subjecting samples of calcite to rapid heating and cooling cycles in order to decrepitate naturally-occurring fluid inclusions. The samples were then split to expose these cracks to the atmosphere and crack apertures were determined using both optical and short-wavelength ultraviolet interferometry. Crack healing experiments were conducted at 780° and 850°C in a dry carbon dioxide atmosphere over time intervals ranging from 0.5 to 700 hours. The crack healing process initiates with the formation of tubes around the leading edge of a crack, followed by the pinching off ("ovulation") of bubbles from these tubes. The outward growth of peninsular structures from cleavage steps and other irregularities in the crack surface greatly accelerates this process. As predicted by theory, the rate of crack healing at a given temperature is strongly dependent upon crack aperture. Thin cracks, with maximum apertures of less than 60 nm (6×10^{-8} m), were observed to completely heal in from 0.5 to 25 hours at 850°C; while fatter cracks, with maximum apertures of about 700 nm, showed very little healing during anneals of up to 700 hours at the same temperature. Further experiments, in wet cracks with controlled fluid chemistries, will be necesary in order to determine the effects of pore fluids on the crack healing process and to predict the lifetimes of cracks under more realistic geologic conditions. (Authors' abstract)

HIGGINS, N.C., 1985, Wolframite deposition in a hydrothermal vein system: The Grey River tungsten prospect, Newfoundland, Canada: Econ. Geol., v. 80, p. 1297-1327. Author at Bureau of Mineral Resources, Geol. & Geophys., Box 378, Canberra City, A.C.T. 2601, Australia.

Mineralization in the Grey River tungsten prospect, Newfoundland, is contained within a sheared Devonian K-feldspar megacrystic granite and metamorphic rocks. Fluid inclusion data indicate a complex evolutionary history for the hydrothermal fluid. The simultaneous trapping of CO_2-rich and H_2O-rich fluid inclusions, as well as solid inclusions of calcite, in quartz of the quartz + feldspar + molybdenite and quartz + bismuthinite vein types is evidence for the existence of a heterogeneous fluid during stage I and early stage II mineralization. Fluid phase equilibria indicate that the inclusions were trapped at temperatures of 330° to 360°C and fluid pressures of less than 500 bars.

In composite lodes, quartz + sulfide and quartz + Fe-poor wolframite veins were deposited in open spaces created by normal faulting. These movements prompted rapid decrease in fluid pressure and temperature and caused retrograde boiling of the hydrothermal fluid (at 200 bars and 300° to 330°C) during deposition of quartz + sulfide veins. Deposition of wolframite in quartz + Fe-poor wolframite veins occurred at 270° to 300°C from an aqueous fluid of low salinity (<0.5 wt % NaCl) and low CO_2 content (<1.0 wt % CO_2) and after separation of a CO_2 vapor phase by retrograde boiling. Isotopic and fluid inclusion data suggest that deposition of Fe-rich wolframite may have occurred at a slightly higher temperature (330°C) and from a fluid of higher CO_2 content than the bulk of the wolframite which has an Fe-poor composition.

Progressive CO_2 loss from the hydrothermal fluid by immiscibility and retrograde boiling had a marked effect on the solution pH which shifted from 5 (weakly acid) to 6 (weakly alkaline at 300° to 350°C) during tungsten deposition. Thermodynamic data on the solubility of wolframite suggest that a pH increase would provide an effective mechanism for tungsten deposition and explain the variation in wolframite composition, from Fe rich to Fe poor, with time.

The association of hematite, Fe-rich wolframite, and muscovite in the greisen suggests high fO_2 (10^{-20} - 10^{-30}) conditions and is supported by Eu behavior during alteration. Sulfides formed after tungsten deposition at temperatures less than 300°C and under fS_2 conditions of less than 10^{-11}.

CO_2-rich fluids are commonly associated with tungsten deposits from a variety of environments and the evidence from the Grey River tungsten prospect shows that CO_2 plays an important role in the transport and deposition of tungsten in the hydrothermal environment. (From the author's abstract)

HIGGINS, N.C. and KERRICH, R., 1985b, Progressive ^{18}O depletion during CO_2 separation from a carbon dioxide-rich hydrothermal fluid: Evidence from the Grey River tungsten deposit, Newfoundland: Reply: Canadian J. Earth Sci., v. 22, p. 1381-1382. First author at Bureau Min. Resources, Geol. & Geophys., Box 378, Canberra, ACT, Australia 2601.

A reply to discussion by Blattner (1985, this issue) of Higgins and Kerrich, 1985 (this issue). (E.R.)

HINKLE, M.E. and McCARTHY, J.H., 1985, Volatile elements and compounds in exploration geochemistry (abst.): U.S. Geol. Survey Circular 949, p. 25-26.

HITE, R.J., 1985, The sulfate problem in marine evaporites: Sixth Int'l. Symp. on Salt, 1983, v. 1, p. 217-230.

HLADKY, G. and WILKINS, R.W.T., 1985, A new approach to fluid inclusion decrepitometry II. Practice (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 72. Authors at CSIRO Div. Mineral. & Geochem., P.O. Box 136, North Ryde, NSW, Australia.

The decrepitometric technique of fluid inclusion study was originally proposed for the rapid determination of Th of inclusions in crushed mineral samples. The limitations inherent in the method stem from the fact that usually the origin and size frequency of the inclusions, and the composition and bulk density of their fluid contents are not known, and this information cannot be inferred with confidence from the decrepigrams themselves. Without such information, Th determined from the onset of massive decrepitation (Td) with a correction factor appropriate to the mineral, are only semiquantitative.

For this reason we have developed an approach which puts emphasis on sample comparison by analysis of decrepigrams. Deconvolution techniques based on the simplex method of minimizing estimated and real parameters of the component peaks, allow the mean temperature and area of the peaks to be determined. Because crushing may eliminate a generation of large inclusions, or preferentially open healed fractures containing fluid inclusions of one particular generation, uncertainties in the recognition of the peaks in complex decrepigrams may often be resolved by the examination of different size fractions. Comparison of sample is based upon total counts and parameters of the individual peaks rather than inferred Th.

Although an accurate estimation of Th is difficult to obtain by this method, trends in Th may be inferred if it is known that the fluid composition does not vary greatly within a set of samples. This can be demonstrated with samples containing P inclusions cut from successive growth zones in a crystal.

The decrepitometric technique is particularly useful in screening samples before heating-freezing stage examination, and it is an invaluable preliminary to any operation involving the decrepitation of minerals, such as the analysis of inclusion gases by mass spectrometry or gas chromatography. (Authors' abstract)

HO, S.E., GROVES, D.I. and PHILLIPS, G.N., 1985, Fluid inclusions as indicators of the nature and source of ore fluids and ore depositional conditions for Archaean gold deposits of the Yilgarn block, Western Australia: Trans. Geol. Soc. S. Afr., v. 88, p. 149-158.

A detailed study of fluid inclusions from vein quartz associated with Archaean gold deposits in Western Australia indicates that gold deposition was from low salinity (<2 wt% NaCl equiv.), H_2O-CO_2-rich (ca. 20-30 mol% CO_2), alkaline to near-neutral fluids with densities of 0.7-0.8 g/cm^3. Data from Red Hill suggest that Na/K ratios were ~9 and that H_2S and N_2 were present in the ore fluid. Vein quartz was deposited over a temperature range of 250 to 400°C and at pressures between 1 and 2 kb; the main gold mineralization event could have been at slightly higher temperatures and pressures. Early, minor phase separation occurred due to fluctuating P-T conditions, and later phase separation took place in limited, late-stage vugs at pressures as low as ~500 bars. Fluid/wall rock interaction is indicated by the inferred presence of CH_4 only in those inclusions from veins adjacent or in proximity to carbonaceous host rocks. Importantly, there are no detectable vertical temperature gradients over at least 200 m of exposed single lode systems, and no evidence from fluid inclusion studies of other physical controls on gold deposition; fluid/wall rock interaction is the most likely major mechanism.

The fluid inclusions, in isolation, cannot define unequivocal genetic models for gold mineralization. However, when combined with other constraints, they define a metamorphic-replacement model for gold genesis in which metamorphic fluids derived by devolatilization of lowermost greenstones under conditions of high-grade metamorphism were channelled upwards via faults and shear zones to the depositional sites; gold and associated sulphides were deposited by fluid/wall rock interaction at elevated P and T. The fluid inclusions in vein quartz of Archaean gold deposits may provide an exploration tool; data from barren veins are generally absent. (Authors' abstract)

HODGE, G. and NORMAN, D.I., 1985, Organic compounds in epithermal ore-depositing fluids (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 53. Authors at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Fluid inclusions in samples from epithermal-ore veins were analyzed by mass spectrometry to determine the volatile compounds present and their relative amounts. Identification of the organic constituents was of primary concern. Epithermal-ore fluids were characterized by a combination of N_2 and organics. A typical gas analysis from the St. Cloud-U.S. Treasury mines yielded the following values (in weight percent[sic]): H_2O, 94.690; CO_2, 2.856; SO_2, 1.102; N_2, 0.869; organics, 0.481; and H_2, 0.002. An analysis from the Cochiti-Bland mines contained: H_2O, 98.121; SO_2, 1.211; CO_2, 0.326; CO, 0.153; N_2, 0.117; organics, 0.042; H_2S, 0.027; and CS_2, 0.002. Organic content ranged from 1.203 to 0.006 wt. %. Compounds up to C_6 were present and tentatively identified as short straight-chain alkanes (methane, propane, butane, pentane), cycloalkanes (possibly cyclopentane, methylcyclopentane, cyclohexane), and aromatics (benzene, toluene). These compounds correspond with literature reports of the types of organics present in subsurface brines. The significance of organic compounds and their role in ore deposition has not yet been determined. (Authors' abstract)

HOERNES, S. and HOFFER, E., 1985, Stable isotope evidence for fluid-present and fluid-absent metamorphism in metapelites from the Damara Orogen, Namibia: Contrib. Mineral. Petrol., v. 90, p. 322-330. First author at Min.-Petrol. Inst. und Museum Poppelsdorfer Schloss, D-5300 Bonn-1, FRG.

A large difference of about 5‰ in the O-isotopic composition of quartz characterizes the transition from very low grade or even anchimetamorphic slates to pelites metamorphosed at greenschist facies conditions. A further increase in temperature does not result in systematic isotopic shifts (mean around +15.5‰). However, immediately at the isograds marking the transition from greenschist to amphibolite facies and amphibolite facies to higher amphibolite facies the quartz $\delta^{18}O$ values are significantly higher by >1‰. This increase is restricted to the area immediately at the isograds.

It can be shown that during the low grade transformation a fluid phase is present in excess; the metamorphism of this stage therefore can be described as "water present metamorphism." This fluid phase leaves the system during pervasive deformation of the rocks, during which large scale homogenization processes are possible.

At higher temperatures a free fluid phase is only present at specific isograds, where it is produced by mineral dehydration reactions. If the production rate of the fluid phase is sufficiently slow, this results in a re-equilibration of the mineral phases with the newly generated fluid phase, the isotopic composition of which is completely controlled by the primary mineral phases.

In intermediate regions with enlarged fluid production and escape rates, a free fluid phase is present only for short periods of time at fractures which form due to fluid overpressure. The high escape rate inhibits the solid phases from re-equilibration with the generated fluid. The term "water absent metamorphism" can be used to describe this state of reduced H_2O activity within a rock. (Authors' abstract)

HOFER, S.C., 1985, Pink diamonds from Australia: Gems & Gemology, v. 21, p. 147-155.

Pink diamonds, presumably from the Argyle deposits in NW Australia, have some large deep pits, believed to be from "etching along a zone of weakness." (E.R.)

HOFMEISTER, A.M. and ROSSMAN, G.R., 1985, A spectroscopic study of irradiation coloring of amazonite: Structurally hydrous, Pb-bearing feldspar: Am. Mineralogist, v. 70, p. 794-804.

HOFSTRA, A.H., LANDIS, G.P. and LEACH, D.L., 1985, Volatile evolution of ore fluids in Coeur d'Alene veins during metamorphism of the belt basin (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 612. Authors at U.S. Geol. Survey, Federal Center, MS 918, Denver, CO 80225.

Two major vein types are recognized in the Coeur d'Alene district, Idaho and Montana. Early, Zn-rich veins fill axial plane shears of WNW-trending folds in competent lithologies of Prichard Fm. and Ravalli Group metasediments. Later, Ag-rich veins occur predominantly in upper Revett Fm. quartzite in east- to northeast-trending fractures. Both vein types were deposited from fluids generated during regional greenschist grade metamorphism.

Volatile compositions of individual fluid inclusions in quartz and sphalerite from these veins were estimated using microthermometry and laser Raman spectroscopy. A high-sensitivity quadrupole mass spectrometer was used to obtain quantitative analyses of fluid extracted from whole crystals.

Fluid inclusions from both vein types generally contain less than 10 mole % total gases and 5-10 eq. wt. % NaCl. However, fluid inclusions in Zn-rich veins contain greater concentrations of CH_4, short chain hydrocarbons, and N_2 compared to Ag-rich veins in which CO_2 is the dominant volatile component.

The observed change in volatile compositions during metamorphism is consistent with a shift from relatively reducing to oxidizing conditions. Reduced fluids rich in CH_4, C_nH_n, and N_2 probably were derived from organic matter and NH_4-bearing phyllosilicates. Later changes in P-T, fO_2, and loss of volatiles may have contributed to the evolution of a more oxidized CO_2-rich fluid.

The change from Zn- to Ag-rich veins may reflect the combined effects of a) volatile evolution of the metamorphic fluids through time, b) episodic development of large fractures with different orientations, and c) different lithologies contributing metamorphic fluids to these fractures. (Authors' abstract)

HÖLL, Rudolf, 1985, Geothermal systems and active ore formation in the Taupo volcanic zone/New Zealand: Mon. Ser. Mineral Deposits, v. 25, p. 53-73.

Includes a discussion of the high concentrations of heavy metals. (E.R.)

HOLLOWAY, J.R. and JAKOBSSON, Sigurdur, 1985, C-O-H volatiles in mantle magmas: implications for volcanic gases (abst.): EOS, v. 66, no. 18, p. 417-418.

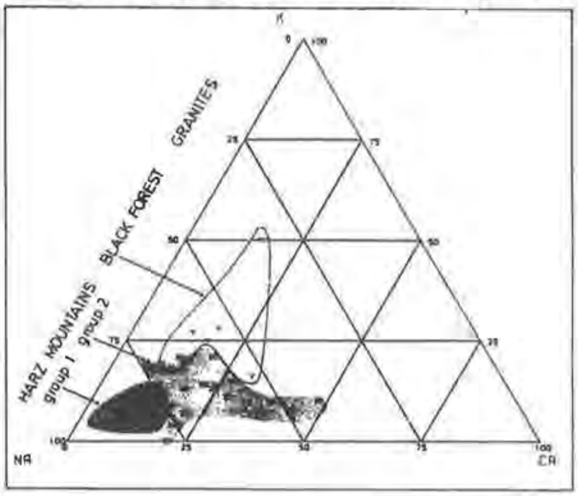
HOLMEN, B.A. and DELANEY, J.R., 1985, Fluid compositional constraints on recharge and upflow portions of a BOI, NFLD, hydrothermal system (abst.): EOS, v. 66, no. 18, p. 402.

HOMANN, K.D., 1985, Investigations on fluid inclusions of hydrothermally altered Variscan granites from the Harz Mountains and the Black Forest (Triberg pluton) - microthermometry and D-ICP method (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 74. Author at Geochem. Inst. Univ. Göttingen, Goldschmidtstr. 1, D-3400 Göttingen, FRG.

Figure 1 shows the cation ratios Na:Ca:K in the secondary (2-phase l-v) fluid inclusions (f. i.) of the Harz Mountains and the Black Forest granites which have been analyzed by the D-ICP method (Rankin et al 1982). Within the Harz Mountain samples, two groups can be distinguished. In group 1 (northern central area of the Brocken pluton) Na is by far the dominant cation. The salinity in the f. i. is low (Tm ice ~-2.5°C). The minerals of this group indicate a lower extent of alteration than the minerals of group 2. In the f. i. of group 2 granites (southern margin of the pluton) the Ca-content of the bulk f. i. increases to ~50%, also the K-content is more variable than in group 1 and reaches ~20%. The scatter of the f. i. composition in group 2 can be explained by the fact that quartz in these granites contains several generations of f. i. with low to high salinities (Tm ice -28 to +6°C; Te ice high saline inclusions -70°C). The minerals in this group show a higher extent of alteration. This is indicated by a reddish color of the K-feldspars, advanced chloritization of biotite, albitization of K-feldspar, sericitization and albitization of plagioclase. Th ($v \rightarrow l$) in both groups varies between 80-380°C (Th max 80-220°C). Ranges of Th values, Tm values and Ca concentrations of f. i. in both gangue minerals of vein ores (Behr and Horn 1984) and group 2 granites in the Harz Mountains correspond well. In addition the f. i. of group 2 granites contain concentrations of several of those elements (Mg, Fe, Mn, As, Li, Zn, Sr, and Ba) in the range of a few ppm to a few percent, which are required for the formation of ore and gangue minerals. A genetic link between ore deposition and granite alteration cannot be postulated until both formations are dated.

The f. i. from Black Forest granites (Triberg pluton, KTB) with low salinity and higher Th can be distinguished from those of the Harz Mountain granites by a higher K-content.

Rankin, A.H., Alderton, D.H.M., Thompson, M. and Goulter, J.E., 1982. Mineral. Mag., 46: 179-186.
Behr, H.J. and Horn, E.E., 1984. Sonderdruck, Hrsg. GDMB, Verlag Chemie.
(Author's abstract)



HONDA, M., REYNOLDS, J.H. and ROEDDER, E., 1985, Noble gases in diamonds from different locations (abst.): EOS, v. 66, p. 1117. First author at Dept. Physics, Univ. California, Berkeley, CA 94720.

Although this is ongoing research, we wish to report preliminary results, some of which require confirmation. Noble gas elemental and isotopic abundances were measured in 15, mostly well-documented, diamond samples: Premier type I; Finsch type II; De Beers pool type I and II; Zaire; Arkansas; Australian (2 samples); Brazilian (3); and industrial class diamonds, probably of South African origin (4). $^{3}He/^{4}He$ ratios are characterized by a large spread (10^{4}), ranging from values below atmospheric to values in excess of planetary (but not solar). The highest $^{3}He/^{4}He$ value $(1.57 \pm 0.75) \times 10^{-4}$ was observed for the Australian colorless diamond composite, while the lowest ($<4.5 \times 10^{-8}$) was for the Australian colored diamond composite, which interestingly came from the same kimberlite pipe. The Australian colorless sample gave an imprecise but intriguing $^{20}Ne/^{22}Ne$ ratio (12.6 ± 1.6) close to the solar value. The Arkansas diamond showed $^{40}Ar/^{36}Ar$ of 670 ± 140 and $[^{40}Ar] = 9.4 \pm 2.4 \times 10^{-8}$ ccSTP/g, unlike an Arkansas sample studied by Melton and Giardini (GRL, 7, 461, 1980) who reported $^{40}Ar/^{36}Ar = 189$. A high ^{4}He concentration ($= 1.8 \times 10^{-4}$ ccSTP/g) was observed from this sample as well as fissiogenic Xe. The ratio of fissiogenic ^{136}Xe to ^{4}He is 8.9×10^{-10}, which agrees with the current production ratio for radioactive decay of U and Th (assume Th/U = 3.3 by weight). The high enrichment of $^{4}He/^{40}He$ ($>10^{3}$ where typical values for mantle-derived materials are 1-20) may indicate that U was enriched relative to K in the source region and/or elementally fractionated during crystallization of the diamond. None of the samples contained excess ^{129}Xe. (Authors' abstract)

HOOKER, P.J., BERTRAMI, R., LOMBARDI, S., O'NIONS, R.K. and OXBURGH, E.R., 1985, Helium-3 anomalies and crust-mantle interaction in Italy: Geochimica Cosmo. Acta, v. 49, p. 2505-2513. First author at British Geol. Survey, Keyworth, Nottingham, NG12, 5GG, England.

The distribution of primordial ^{3}He in the crust of Italy has been investigated through a survey of groundwaters, hot-springs, exploration and production geothermal wells. The mantle-derived component varies from 0% to >60% and reaches a maximum at Vulcano in the Eolian Islands. ^{3}He anomalies occur where the conductive heat flow is relatively high, but the relationships between heat flow and anomaly are uncertain.

The distribution of ^{3}He in the main reservoir and cap rock to the Larderello geothermal system shows that the mantle-derived ^{3}He varies from ~5% to ~40% of total He and reaches a maximum in fluids extracted from a depth of ca. 3 km within the basement. Bomb-produced tritiogenic ^{3}He appears to make a near-negligible contribution. Well 107 at Larderello has been monitored over a period of 17 months and the ^{3}He/^{4}He ratio (R) varies from 1.4 to 1.6 times the atmospheric ratio (Ra) whilst He/Ne varies from 9 to 160. A model is proposed for the Larderello geothermal system whereby mantle-derived heat and volatiles are advected to shallow (6-8 km) depths in association with melts and released into the main geothermal reservoir at Larderello in a non-uniform manner possibly associated with fracturing. Isotopic and elemental equilibrium of gaseous species (C, O, H) appears to have taken place in the basement to the main reservoir from where fluid with R/Ra ≥ 3.2 has been extracted. (Authors' abstract)

HORIBE, Yoshio, SHIEGEHARA, Koji and LANGWAY, C.C., Jr., 1985, Chemical and isotopic composition of air inclusions in a Greenland ice core: Earth & Planet. Sci. Letters, v. 73, p. 207-210. First author at Ocean Res. Inst., Univ. Tokyo, Nakano, Tokyo 164, Japan.

Gas samples from the ice core of Camp Century, Greenland, were analyzed by mass spectrometry. It was found that the ^{18}O content of oxygen gas in bubbles at 555 m, 1002 m and 1248 m depth were higher than that of the present air by 0.61, 0.28 and 1.00‰, respectively. The nitrogen-argon ratio of gas in 1248 m core samples was higher than that of the present air. The solution of gas in melt water in bubbles and subsequent pressing out of solution might increase the nitrogen-argon ratio in gas. It was calculated that the original oxygen gas in bubbles of ice core decreased by 1.27%. The oxygen-argon ratio in the same gas was smaller than that of the present air, and the isotopic separation factor of the decrease of oxygen was 1.093, which is too high as a separation factor for solution by melting of ice and for oxygen consumption. These phenomena cannot be explained by processes involving melting of ice and mixing of supercooled droplets with snow. The change of isotopic content of oxygen in bubble air may be due to the change of isotopic content of seawater during glacial periods. (Authors' abstract)

HORN, E.E. and TRAXEL, K., 1985, Fluid inclusion investigations with the proton microprobe (PIXE) (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 76. First author at Inst. Geol. und Dynamik der Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

At Heidelberg a proton induced X-ray emission (PIXE) microprobe has been constructed and is being successfully applied for quantitative analysis of trace elements in single biological cells, in minute inclusions of lunar materials and of meteorites. The purpose of this paper is to demonstrate the feasibility of using PIXE to study the elements in selected fluid inclusions. Under controlled conditions individual closed fluid inclusions in minerals can be investigated with PIXE. Principally it is possible to detect elements with atomic numbers greater than 11, corresponding to Na, however, in reality this is matrix dependent. Between atomic number, matrix, beam and limit of detection there are distinct relationships. The detection limit increases with higher atomic numbers. Therefore it is possible to analyze heavier elements, e.g., Fe, Br, Sr, in inclusions from a depth of 10-40 μm beneath the sample surface. The provable percentages of three elements in dependency on the position under the sample surface (in μm) for a quartz matrix are given in the table as examples of the detection limits.

Table: Relationship of the element number (Z), depth of penetration, detection limit (in percentages still provable of the occurring element) and matrix. - Beam intensity 3000 MeV, 1 absorber, SiO_2 matrix.

Depth of inclusion from surface of sample (in μm)	element (Z)		
	Cl (17)	Ca (20)	Br (35)
10	4 %	25 %	65%
20	0.1%	6 %	40%
30	-	1.4%	20%
40	-	-	7%
50	-	-	-

For investigations with PIXE the samples can be used as for fluid inclusion studies. Therefore it is possible to observe microthermometric data and to study chemical composition of fluid inclusions in succession within the same sample. (Authors' abstract)

HORTON, D.G., 1985, Mixed-layer illite/smectite as a paleotemperature indicator in the Amethyst vein system, Creede district, Colorado, USA: Contrib. Mineral. Petrol., v. 91, p. 171-179. Author at Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352.

Ordered illite/smectite is the most abundant and widespread product of argillic alteration associated with the Oligocene, epithermal, Ag-Pb-Zn-Cu-Au Amethyst vein system, southwest Colorado. Hydrothermal illite/smectites exhibit all Reichweite from 1 to >3 and span the composition range from about 25% to about 3% illite. - The composition and Reichweite of illite/smectite vary smoothly with distance from the Amethyst vein. With increasing distance from the vein, percent illite and the Reichweite decrease. When composition-temperature relationships of illite/smectite from modern geothermal systems are applied to the fossil Amethyst system, isotherms describing the thermal regime at the time of argillization can be estimated. Temperatures near 240°C appear to have existed near the Amethyst vein; these temperatures agree with homogenization temperatures obtained from fluid inclusions in vein minerals. The most distal illite/smectites, sampled about 260 m from the vein, indicate temperatures near 110°C. Estimated thermal gradients are on the order of 0.4 to 1°C per meter. Although illite/smectite composition and structure vary systematically with distance from the Amethyst vein, there are no systematic trends associated with the numerous, smaller veins and veinlets in the hanging wall of the system. This indicates that temperatures of both wallrock and fluids in all but the major Amethyst vein were nearly the same during clay formation. Apparently, the hydrothermal system had reached a fairly steady, mature, thermal state at the time of argillization. (Author's abstract)

HORTON, R.A., Jr., 1985, Dolomitization and diagenesis of the Leadville limestone (Mississippian), central Colorado: Doctoral dissertation, Colorado Sch. Mines, Boulder, CO.

Indexed under fluid inclusions.

HOSTETLER, C.J., 1985, Thermodynamic properties of NaCl obtained by computer calculation: Am. Mineral., v. 70, p. 601-607.

HOVORKA, S.D., 1985, Model for deposition of bedded halite in a shallow shelf setting, San Andres Formation, Palo Duro Basin, Texas Panhandle (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 614.

HOWE, S.S. and HALL, W.E., 1985, Light-stable-isotope characteristics of ore systems in central Idaho: Symp. on Geol. & Min. Deposits of the Challis 1° x 2° quadrangle, Idaho, U.S. Geol. Sur. Bull. 1658P, p. 183-192.

Light stable isotopes in mineral deposits and their host rocks were investigated to place constraints on the sources of water and sulfur in hydrothermal systems of central Idaho. Analyses of inclusion fluids extracted from crushed sulfide and gangue minerals from Cretaceous porphyry and vein deposits give δD values of -130 ± 25 per mil, indicating the presence of meteoric water. Meteoric water, which continued to predominate in hydrothermal systems around Tertiary plutons within the Idaho batholith, created zones extremely depleted in deuterium and ^{18}O in areas larger than 15,000 km^2 through water-rock interactions. The $\delta^{34}S$ values of sulfide minerals from most of the Cretaceous and Tertiary mineral deposits are quite high, generally from +4 to +13 per mil; several samples from deposits considered to be of syngenetic or remobilized-syngenetic origin have $\delta^{34}S$ values as high as +23 per mil. No correlation between commodity and sulfur-isotopic composition exists. Mineral deposits in black shale, however, generally have $\delta^{34}S$ values higher than those in carbonate rocks, quartzite, or granite. Although many of the mining districts are isotopically inhomogeneous, individual deposits commonly have very similar sulfur-isotopic compositions.

These isotopic data support a model in which meteoric water, set into convective circulation by heat from granitic intrusions, leached ^{34}S-enriched sulfur from crustal sources, such as syngenetic sulfide minerals in sedimentary rocks, evaporite deposits, or pre-Cretaceous sulfide deposits. The sulfur then mixed locally in varying proportions with ^{34}S-depleted sulfur from the magmatic reservoirs of adjacent plutons. This hybrid sulfur was then homogenized isotopically before reaching the sites of ore deposition. (Authors' abstract)

HU, Xunsen, 1985, Physical state of fluid in high temperature geothermal reservoir and well-hydrothermodynamic analysis and calculation: Acta Geol. Sinica, v. 59, no. 1, p. 74-86 (in Chinese; English abstract). Author at Inst. Hydrogeology & Engrg. Geol., Chinese Acad. Geol. Sci.

After analyzing the physical state of fluid in high temperature geothermal reservoir[s], a series of more reliable calculation methods, including boiling temperature, interwell depth of starting boiling face, depth of the boiling face in dynamic equilibrium, distribution of the pressure both above and below the boiling face, and maximum working pressure at well-head etc., are proposed in this paper by using the essential theory of two-phase (saturated water and steam) flow rising along a wellbore with reduction of pressure. Calculated results for the geothermal field data in Yangbajing of China and in Otake of Japan are given as examples. Furthermore, estimation of transmissivities and hydraulic conductivities of the reservoir strata has been made on the basis of the results obtained. The effect of a single measured and selected parameter on the calculated results has also been computed and discussed by the so-called sensitive analysis, sorting out primary parameters from the secondaries, and recommending the accuracy of the parameters when measured and selected. Calculated results of the depth of the boiling faces had been proved to be more correct by the developmental practice of geothermal field, thus to the other analyses and calculations giving a more solid foundation[sic].

By these methods, the pressure depression in the well and the maximum working pressure at well head involve the case of unusual pressurization groundwater. (Author's abstract)

HUANG, Dianhao, WANG, Yichang, NIE, Fengjun and JIANG, Xiujie, 1985, A new type of molybdenum deposit; geological characteristics and metallogenic mechanism of the Huanglongpu carbonatite vein-type of molybdenum (lead) deposit, Shaanxi: Acta Geologica Sinica, v. 59, no. 3, p. 241-257 (in Chinese; English abstract). First author at Inst. Mineral Deposits, Chin. Acad. Geol. Sci.

The ore deposit consists mainly of groups of Mo(Pb)-bearing quartz-calcite carbonatite veins. The veins are commonly from some tens to more than one hundred meters long, the longest one being 500 m; they are from 0.1 to 1.0 m wide, and the widest vein is 20 m. Ore minerals are chiefly pyrite, galena and molybdenite, gangue minerals are essentially calcite, quartz, microcline and barytocelestine, with a small amount of radioactive and rare earth minerals. The molybdenite occurs as impregnation and impregnation ribbon in the calcite, and fills and replaces calcite and galena, etc. (Plate 1-6). Wall rock of the veins shows linear distribution of hydrothermal alterations, of which carbonatization is very common and strong.

The results of study show that ore-forming temperature ranges from 450 to 280°C [Th?]; $\delta^{34}S(\Sigma S)$, +1.0‰; $\delta^{13}C(\Sigma C)$, -5.0‰; $^{87}Sr/^{86}Sr$, 0.7085. Ore lead belongs to an anomalous type low in radiogenetic lead. The chondrite normalized REE patterns of calcite are essentially consistent with those of carbonatite calcite. As to the condition of ore-forming temperature, when water is in equilibrium with quartz and calcite, calculated $\delta^{18}O(H_2O)$ values range from +6.5 to +1.2 per mil.

On the basis of the above, it is suggested that the deposit originated from a silicate-carbonate melt-solution containing REE, Sr, Ba, Mo, Pb and S, etc., of upper mantle source, [which rose along a] regional deep fault zone (Fig. 5). When boiling of the ore-forming fluid took place, fO_2, pH and redox conditions were changed, and molybdenum and lead were deposited as sulfides under higher fS_2, weak acidity or weak alkaline reducing conditions. Therefore, the Huanglongpu carbonatite vein-type Mo(Pb) deposit is genetically of medium to higher temperature filling-metasomatic origin. (From the authors' abstract)

HUBERT, P., AHMADZADEH, H., CALLI, M., JEBRAK, M., OUSTRIERE, P., TOLLON, F. and TOURAY, J.C., 1985, Fluid inclusion studies in gold bearing quartz from Cros-Gallet (Massif Central, France) (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 78-79. First author at BRGM, Dept. Gites Minéraux, BP 6009, 45060 Orleans Cedex, France.

The 2 x 7 m quartz lens of the deposit of Cros-Gallet (~40 km S of Limoges, Haute-Vienne, France) belongs to the St. Yrieix auriferous district (H. Ahmadzadeh et al., 1984).

In the quartz lens we can distinguish 3 facies: 1) Quartz veins which intersect and cement the more or less silicified enclosing rocks; 2) Silicified enclosing rocks with a brecciated aspect, which are more or less rich in quartz; and 3) "Grey quartz breccias" with thin sulfides, made up with enclosing rocks elements (silicified or not) which are cemented with a milky quartz.

The gold mineralization, which is associated with the last facies, seems to be closely connected with stretched microzones. These microzones are accompanied by a subdued quartz crystallization (clear quartz). The gold mineralization appears to be earlier than brecciation and deformation phases which especially affected the milky quartz. Fluid inclusion studies were essentially carried out on the clear quartz.

Two types of fluid inclusions were determined: A - with CO_2 and H_2O, and B - with H_2O without visible CO_2. (See table.)

The fluids associated with the mineralization appear to be at first very hot, CO_2-rich, and slightly saline (A) to become afterwards aqueous and cooler (B). The variability of the CO_2 molar fraction in type A suggests an immiscibility phenomenon for the trapping of these fluids. Furthermore the fact that there is probably some sericite which has been trapped in subtype A1 and A2 fluid inclusions, should testify to hydrothermal alteration of gneissic enclosing rocks. This alteration seems contemporaneous with the mineralization.

Comparing various quartz samples shows a general association of sericite and CO_2-rich fluids at Cros-Gallet. However, in these facies the connection between this association and the auriferous paragenesis has to be still demonstrated.

Type A fluids are comparable to those of other gold deposits (Brioude-Massiac district, H. Bril) or even wolfram deposits (C. Ramboz) in the Massif Central. (Authors' abstract)

H. Ahmadzadeh, M. Auriol, M. Calli, H. de Vaucorbeil, F. Foglierini, M. Gelas, C. Olivie, P. Picot, F. Tollon (1984) - Le gisement aurifère de Cros-Gallet. Le Bourneix, district de St. Yrieix (Haute Vienne). Chronique de la Recherche Minière, BRGM, no. 474, 1984, p. 11-32.

H. Bril (1983) - Etude métallogenique des minéralisations à antimoine et associees du district de Brioude-Massiac (Massif Central français). Thèse de doctorat d'Etat, Université de Clermont-Ferrand II.

C. Ramboz (1980) - Géochimie et étude des phases fluides de gisements et indices d'étain-tungstène du sud du Massif Central (France). Thèse de doctorat de spécialité, Institut polytechnique de Lorraine, Nancy.

	TYPE A $CO_2 + H_2O$			TYPE B H_2O
Subtype	A1	A2	A3	
Arrangement	isolated or in a cluster			in strings, clusters, alone or with A, in planes corresponding to late cracks
Shape	"negative crystal," swollen			amoeboid, ovoid, sometimes hexagonal
Size	<5 - 10 μm			<15 μm
Phases	two-phase with clathrate formation	three-phase at Tm CO_2	three-phase at 18° (CO_2g+ CO_2l+H_2Ol)	two-phase without clathrate formation
Filling coefficient	0.4 - 0.6		<0.1 - 0.5	>0.8
Tm CO_2		-56.1°-58.0°	$\bar{x}$ -56.6°	
Thp CO_2			18 to 29° in liquid or vapor phases	
Th	mainly 300°-350° in "liquid" or vapor phases			120°-300° in liquid phases
Salinity			<8 wt % NaCl	
Observations	Present trapped solids which were analyzed with SEM and have been found to be aluminosilicate or K, probably sericite			

HULL, A.B. and WILLIAMS, L.B., 1985, Radioactive waste isolation in salt: Geochemistry of brine in rock salt in temperature gradients and gamma-radiation fields--a selective annotated bibliography: Argonne Nat'l. Lab.

ANL/EES-TM-290, 73 pp. Authors at Energy & Environ. Sys. Div., Geosci. & Engrg. Group.

Evaluation of the extensive research concerning brine geochemistry and transport is critically important to successful exploitation of a salt formation for isolating high-level radioactive waste. This annotated bibliography has been compiled from documents considered to provide classic background material on the interactions between brine and rock salt, as well as the most important results for more recent research. Each summary elucidates the information or data most pertinent to situations encountered in siting, constructing, and operating a mined repository in salt for high-level radioactive waste. The research topics covered include the basic geology, depositional environment, mineralogy, and structure of evaporite and domal salts, as well as fluid inclusions, brine chemistry, thermal and gamma-radiation effects, radionuclide migration, and thermodynamic properties of salts and brines. (Authors' abstract)

HULSEBOSCH, T.P., KOESTERER, M.E. and FROST, B.R., 1985, Late Archean intrusive charnockites from the west-central Wind River Mountains, Wyoming (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 616. Authors at Univ. Wyoming, Dept. Geol. & Geophys., P.O. Box 3006, Laramie, WY 82071.

Late Archean (ca. 2.5Ga) porphyritic granites to comprise about 25% of the crystalline rocks of the Wind River uplift. In most localities, they are typical biotite-hornblende granites but on the western margin of the range there is evidence that portions of at least one pluton were emplaced as charnockite. In the Burnt Lake area homogenous charnockite crops out over an area of at least 3 km while in the Boulder Creek Canyon, 8 km to the S.E. charnockite occurs locally as blotches in porphyritic biotite granite. One sample from Boulder Creek, 15 cm in the longest dimension, shows a complete transition from charnockite to biotite granite. Textures indicate that the transition occurred as subsolidus hydration, with hornblende and biotite replacing augite and orthopyroxene, respectively.

Pyroxene geothermometry from this sample yields maximum temperatures of around 900°C, with a cooling trend to 600°. Fluid inclusions of both CO_2 (ρ = .85 to .95) with H_2O (ρ = .8 - .9) are present. Intersection of the CO_2 isochores with a charnockite solidus of ca. 750° (Wendlandt, An. Min., 1981) yields emplacement pressures of between 4 and 5.5 kb. At these temperatures the water isochores give temperatures of 650° or below, which is consistent with the late hydration that is inferred from the textural evidence. (Authors' abstract)

HURAI, Vratislav and STRESKO, Valdimir, 1985, Quartz from fissures in central Slovakia - relations between morphology and fluid inclusions (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 80-81. Authors at Geol. Inst. of Comenius Univ., Zadunajska 15, 851 01 Bratislava, ČSSR.

Mineral-bearing alpine fissures are well-known over the Western, Central and Eastern Alps and Western Carpathians. They represent a tensional phase of low-grade metamorphism and thus yield valuable information about thermodynamic parameters and composition of metamorphic fluids.

Two episodes of fissure formation have been distinguished in the Slovenske Rudohorie Mts. The first one is represented by fissures containing smoky-colored quartz in the granitoids of the central zone. During the time of their formation the rocks were saturated by salt-rich solutions with 10-20 wt.% NaCl eq. at 420-500°C and 1800-2700 bars, as determined from the K/Na ratio (Fig. 1) and Th. T between 335-420°C accompanied fissure formation at the NW margin of central granitoid pluton. Crystallization of the second generation of alpine quartz was invoked by fracturing during the uplift of the area. Fractures and shear zones following SW-NE linear trend frequently contain white and colorless quartz with CO_2-rich inclusions. While the salinity of fluids reached 6-15 wt.% NaCl eq. in the granitoids, it rarely exceeded 3 wt.% NaCl eq. in the adjacent volcanic-sedimentary complexes. K/Na T in both environments are scattered between 330-420°C.

Two fissures in the Nizke Tatry Mts. formed at 360-375°C and 2100-2300 bars. Quartz contains polyphase inclusions with 27-30 wt.% NaCl and methane in vapor phase.

The quartz displays a wide variety of crystal forms. Most complicated developments have been found in fissures from central granitoids in the Slovenske Rudohorie Mts. (Fig. 2). In contrast, quartz crystals from other regions showed only r, z, m and s faces.

Generally, quartz morphology changes from simple to more complicated with increasing K/Na ratio in the fluids and thus probably reflects change in T. In other words, the special forms prevail at T ≤400°C, whereas T above this limit were found to be favorable for development of general forms.

Because of the presence of carbon dioxide and high amount of divalent cations in the fluids, the T-P data derived from K/Na ratio are not always very satisfactory. In this way, they need support from other independent geothermometers, now under study. (From the authors' abstract)

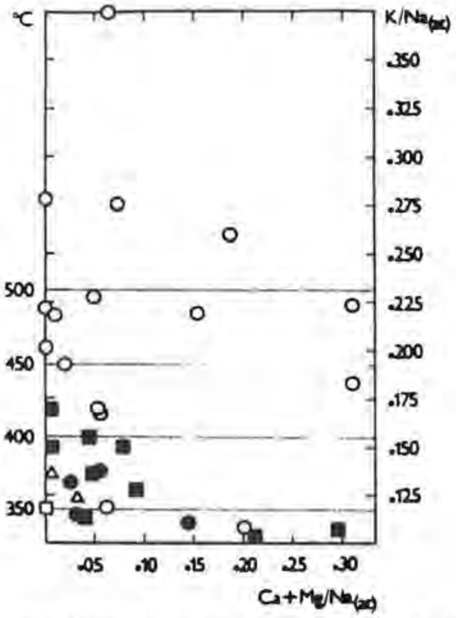


Fig. 1. Atomic absorption analyses of leachates from crushed quartz. Slovenské Rudohorie Mts.: circles - granitoids, squares - volcanic-sedimentary complex. Nizke Tatry Mts. - triangles. White - CO_2-free inclusions, black - CO_2-rich inclusions.

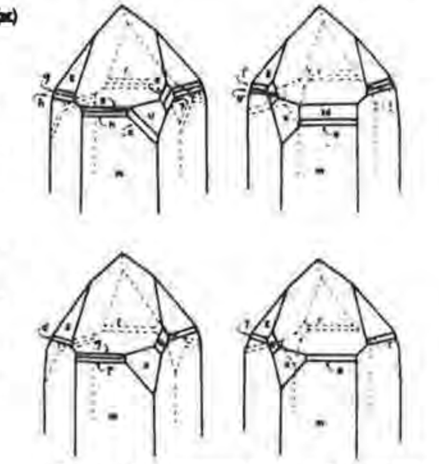


Fig. 2. Examples of quartz morphology from central granitoid pluton. Lower right crystal from its marginal part.

HUTASOIT, L.M. and HSUI, A.T., 1985, Numerial simulation of thermohaline convection within a porous medium (abst.): Geol. Soc. Am. Abst. with Programs, v. 17, p. 293.

IMAI, Hideki, KAWASAKI, Masashi, YAMAGUCHI, Mitsuo and TAKAHASHI, Mikio, 1985, Mineralization and paragenesis of the Huanzala mine, central Peru: Econ. Geol., v. 80, p. 461-478. Authors at Central Res. Lab., Mitsui Mining & Smelting Co., Ltd., Haraichi, Ageo City, Saitama Prefecture, Japan 362.

The Huanzala mine is a zinc and lead mineral deposit found in the Lower Cretaceous Santa Formation limestone and has associated copper and accessory polymetallic minerals. Early-stage mineralization began with pyritization and was followed by middle-stage zinc and lead mineralization, occasionally accompanied by skarnization. The lead and zinc mineralization stage was followed by late-stage copper ore deposition, together with small amounts of silver-tin-tungsten and miscellaneous minerals. (From the authors' abstract)

The fine-grained ores formed at 335-490°C and the iron-poor sphalerite at 250-330°C, based on Td. Very small inclusions gave Th of 330-400°C for iron-rich sphalerite (p. 474-476). (E.R.)

IRIFUNE, Tetsuo, 1985, Experimental study of the system $Mg_3Al_2Si_3O_{12}$-$Mg_3Cr_2Si_3O_{12}$ at high pressure and high temperature: J. Fac. Sci., Hokkaido Univ., Ser. IV, v. 21, no. 3, p. 417-451. Author at Research Sch. Earth Sci., Australian Nat'l. Univ., Canberra ACT 2601, Australia.

Includes a discussion of the formation and nature of solid inclusions in diamonds. (E.R.)

ISKANDAROV, F.Sh., 1985, Contribution to the method of determination of solution concentration in inclusions from its refractive index (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 61 (in Russian). Author at Tadzhik State Univ., Dushanbe, Tadzhikistan, USSR.

Fluorites of the rare-earth-fluorite occurrences of the Southern Pamirs bear polyphase inclusions with refractive indices of inclusion solution very close to that of fluorite, resulting in an invisible inclusion/fluorite boundary at room T. The inclusions contain LCO_2 and dms: halite, sylvite and anisotropic (probably carbonate). Determinations of refractive indices of artifical solutions proved that saturated solutions of NaCl, KCl, $MgCl_2$ and K_2CO_3 at 20°C have refractive indices equal respectively 1.379, 1.369, 1.362 and 1.420, i.e., lower than fluorite (1.442); saturated solution of $CaCl_2$ has index 1.468, i.e., higher than fluorite. Measured refractive indices of 15% solutions of the above salts prove that their relation to concentrations is a straight-line function; a 34% solution of $CaCl_2$ has n = 1.442 (fluorite). Solid phases of NaCl and KCl in $CaCl_2$ saturated solution increase refractive index of the latter only to 1.471. Thus, inclusion solution bears prevailing $CaCl_2$ plus NaCl and KCl. (A.K.)

ITIHARA, Yuuko and SUWA, Kanenori, 1985, Ammonium contents of biotites from Precambrian rocks in Finland: The significance of NH_4^+ as a possible chemical fossil: Geochimica Cosmo. Acta, v. 49, p. 145-151. First author at Dept. Geosci., Faculty of Sci., Osaka City Univ. Osaka 558, Japan.

The ammonium contents of biotites in Precambrian rocks from Finland have been determined, to examine the possibility that ammonium in biotites represents a chemical fossil. If biologic activity existed in Precambrian sedimentary environments, biotites formed from the sediments should contain distinctly larger quantities of NH_4^+ than biotites from igneous rocks.

Biotites from Svecokarelidic metasediments, which were originally products of sedimentation about 2400-1900 Ma ago, have high HN_4^+ contents (hundreds of ppm), while biotites from Svecokarelidic plutonic rocks of 1800-1900 Ma old and Postsvecokarelian rapakivi granites of 1650-1700 Ma old have low NH_4^+ contents (tens of ppm). The results may indicate that biologic activity was plentiful during sedimentation of the Svecokarelian strata. This agrees with evidence for ancient life found in dolomites and greywacke-slates of the Svecokarelides. Biotites from Presvecokarelidic schists of more than 2600-2800 Ma old have only tens of ppm of NH_4^+. This value is at the same level as those of biotites from the rapakivi granites and the Svecokarelidic plutonic rocks. Considering the rarity of fossils in Presvecokarelidic rocks, the low NH_4^+ content of biotite from a Presvecokarelidic pelitic schist may indicate less biologic activity during the sedimentation of the original sediments.

These data emphasize that ammonium in biotites of Precambrian metasediments may be a useful chemical fossil for identifying the geologic sites of ancient life. (Authors' abstract)

IVANOVA, G.F., KOPNEVA, L.A. and NAUMOV, V.B., 1985, Physicochemical parameters in the formation of scheelite in deposits of various genetic types according to the data of study of fluid inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 144-145 (in Russian; translation by Dorothy B. Vitaliano). Authors at Vernadsky Inst. Geochem. & Anal. Chem. (GEOKHI), Acad. Sci. USSR, Moscow, USSR.

The discovery of scheelite in deposits of various genetic types, and also in rocks of different composition, age and geologic position, poses the problem of evaluating the physicochemical parameters of the W-bearing solutions which deposited the scheelite. On the basis of data we obtained from a study of fluid inclusions and analysis of published results, the conditions of deposition of scheelite in scheelite-bearing associations of 40 deposits of W, Sn, Mo, Au, less often Pb, Zn, Sb, As and Hg, were studied. The investigations were made for deposits of different genetic types: skarn, vein-greisen, vein, stockwork, and also for W deposits of the stratified type.

The results on Th of P and PS inclusions in scheelite shows a broad range, from 600 to 150°C. The highest (600-340°C) are typical of the scheelite of skarns, explosion pipes and a number of gold deposits. Scheelite associated with cassiterite, wolframite and molybdenite has a lower T (360-220°C). The lowest T values (200-150°C) were measured in scheelite from quartz-carbonate bodies in metamorphic rocks.

The scheelite mineral associations considered are characterized by high pressure values, estimated from the phase equilibrium of H_2O-CO_2 and H_2O-NaCl in the fluid inclusions: from 2.5 to 0.3 kbar, in most cases from 1 to 0.5 kbar. According to the data of thermo- and cryometric study of fluid inclusions, the scheelite was deposited from solutions with various compositions and concentrations: highly saline chloride, highly carbonic, slightly saline. A relationship was found between Th and the concentration of salts: maximum Ts (600-400°C) are typical of fluid inclusions corresponding in composition to brines (65-20 wt.%), which is typical of the scheelite of a number of skarn and gold deposits, and also of explosion breccias. In Sn, Sn-W, W, W-Mo and Mo deposits of vein, vein-greisen and stockwork type, scheelite as a rule is deposited from dilute solutions (less than 10 wt.%), sometimes containing CO_2, CH_4 and N_2.

Thus investigations of fluid inclusions in scheelite and associated minerals indicates the extremely wide ranges of physicochemical parameters of formation of scheelite in deposits of different genetic types. (Authors' abstract)

IVANOVA, G.F., MAXIMYUK, I.E. and NAUMOV, V.B., 1985, Geochemical peculiarities of granitic rocks and wolframite ore mineralization of the Kyzyl-Tau deposit, western Mongolia: Geokhimiya, 1985, no. 6, p. 858-869 (in Russian; English abstract).

Granitic rocks of the Kyzyl-Tau massif are intermediate between the lithium-fluorine and the standard geochemical types of granites. From the study of the melt and fluid inclusions the main physico-chemical parameters of formation of the granites and wolframite ore mineralization of the deposit are deduced. (From the authors' abstract)

IVANTISHINA, O.M., 1985, The conditions of formation of the massive-sulfide ores of the Slavyansk ore-show in the northwestern Donbass (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 88-89 (in Russian; translation by D.A. Brown). Author at Inst. Geochem. & Physics of Minerals of the Acad. Sci. of Ukrainian SSR, Kiev, USSR.

In the Slavyansk mercury ore-show in the northwestern Donbass, DH No. A-2604, in the 485-587-m interval, passed through three thick ore bodies (from 14 to 25 m), consisting of massive or collomorphic pyrite and marcasite, with minor chalcopyrite, cinnabar, and brunckite. The ore bodies occur as a replacement of a clay-carbonate diapiric fault breccia in Permian dolomitic sandstones and limestones. The ore bodies consist of 85-90% of iron sulfides, with occasional relicts of the country rocks. The rocks have undergone pre-ore recrystallization, dolomitization, and solution of clasts of organogenic-carbonate rocks. In the thin-sections, idiomorphic crystals of siderite, dolomite, calcite, and quartz are sometimes observed. The carbonate of the country rocks evidently entered into the ore-bearing solution and was again precipitated during the process of ore formation. Judging by the large lumps of pyrite-marcasite composition, pisolitic carbonate and brunckite, the hydrothermal solution was an "inverse" emulsion hydrophobic ore gel at the moment of ore deposition. Late calcite in syneresis cracks and as cement in crushed pyrite has gas-liquid (10-30% of the gas phase) or essentially gaseous inclusions. Th of pre-ore calcite varies from 260 to 200°C, and in the later calcite, which contains inclusions of brunckite and needles of marcasite, from 180 to 150°C. In the late calcite, the gas-liquid inclusions are colored light cinnamon with oil-like hydrocarbons; when heated to 200°C, they release a solid (bituminous?) phase.

Pre-ore siderite, dolomite, and calcite in the sandstones have Th = 260-240°C. The ore association corresponds to that of the polymetallic ores in the sediments of the Dronovsk Group, which consist of pyrite, cinnabar (170°C), sphalerite, galena, and calcite (160-120°C). Judging by the kind of pre-ore changes and the composition of the ores, they were formed by hydrocarbon-chloride solutions (brines), which are usually associated under platformal conditions with the formation of stratiform deposits of the lead-zinc ore association. (From the author's abstract)

IVASIV, S.M., KUCHIYEV, A.A., MYAZ', N.I., POZDEEV, K.M. and SIMKIV, Zh.A., 1984, Discussion of paper of A.G. Granovskiy "Thermobarogeochemical zoning of polymetallic deposits of Northern Caucasus:" Geol. Rudn. Mest., v. 26, no. 3, p. 117-121 (in Russian). Authors at L'vov State Univ., L'vov, Ukraine.

The paper bears criticism of the Granovskiy's data on fluid inclusions published in Geol. Rudn. Mest. 1982, v. 24, no. 6, p. 63-73 (Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 81, 1982). (A.K.)

JACKSON, Brian, 1985, Note on inclusions in diopside from Ala, Piedmont, Italy: J. Gemm. & Proc. Gemm. Assoc. of Great Britain, v. 19, no. 6, p. 486-489. Author at Royal Scottish Museum, Edinburgh, Scotland.

Daughter crystals of NaCl (and several unidentified) are described. (E.R.)

JACKSON, K.J. and HELGESON, H.C., 1985, Chemical and thermodynamic constraints on the hydrothermal transport and deposition of tin: I. Calculation of the solubility of cassiterite at high pressures and temperatures: Geochimica Cosmo. Acta, v. 49, p. 1-22. First author at Dept. Earth Sci., Lawrence Livermore Nat'l. Lab., Livermore, CA 94550.

Estimation of equation of state parameters for Sn^{++} and calculation of the thermodynamic properties of other aqueous species and dissociation constants for various stannous and stannic complexes as a function of temperature permit prediction of the high temperature solution chemistry of tin and calculation of the solubility of cassiterite in hydrothermal solutions. The results of these calculations indicate that in the absence of appreciable chloride and fluoride concentrations, $Sn(OH)_2^0$ and $Sn(OH)_4^0$ are the predominant tin species in H_2O up to 350°C at $\sim 2 \leqslant pH \leqslant 7.5$. The calculations also indicate that chloride complexes of Sn^{++} predominate by several orders of magnitude over their fluoride and hydroxide counterparts in 1-3 molal (m) NaCl solutions, except in the presence of geologically unrealistic concentrations of fluoride or a pH greater than ~3.5 at 250°C or ~5.0 at 350°C. At higher pH values, most of the tin in solution is present as hydroxide complexes, even at concentrations of NaCl as high as 3 m. Calculated values of the solubility of cassiterite at high temperatures compare favorably with experimental data reported in the literature. Depending on the fugacity of oxygen and solution composition, the solubility of cassiterite in hydrothermal solutions may exceed 100 ppm under geologically realistic conditions. (Authors' abstract)

JACKSON, K.J. and HELGESON, H.C., 1985, Chemical and thermodynamic constraints on the hydrothermal transport and deposition of tin: II. Interpretation of phase relations in the southeast Asian tin belt: Econ. Geol., v. 80, p. 1365-1378. First author at Dept. Earth Sci., Lawrence Livermore Nat'l. Lab., Livermore, CA 94550.

Correlation of laboratory and field observations of mineral assemblages in quartz-cassiterite veins and adjacent greisen alteration zones of the Southeast Asian tin belt with equilibrium constraints generated from thermodynamic calculations can be used to assess the composition of the hydrothermal solutions responsible for the transport and deposition of tin. The hydrothermal mineral assemblage in the Southeast Asian tin deposits consists of quartz, cassiterite, muscovite, K-feldspar, topaz, magnetite, and rarely hematite, fluorite, tourmaline, and zinnwaldite. Depth estimates and fluid inclusion Th and Tm[ice?] indicate that this assemblage formed at ~350°C and ~500 bars in the presence of an electrolyte solution containing ~1 molal (m) total chloride. Thermodynamic calculations indicate that the solution pH, fugacity of oxygen, fugacity of H_2S, activity of K^+, activity of Ca^{+2}, and the total molality of F^- were ~4.5, $\sim 10^{-31}$, $\lesssim 10^{-1}$, ~0.1, $\sim 10^{-3}$, and $\sim 10^{-2.1}$, respectively, during the mineralizing process. Tin was apparently transported in solution primarily as stannous chloride and hydroxide complexes. The presence of topaz precludes significant transport of tin as fluoride complexes. Solubility calculations indicate a minimum total tin concentration in solution on the order of 10 ppm. The intimate association of cassiterite and the greisenized wall rock adjoining the veins suggests that tin mineralization occurred in response to increasing solution pH accompanying hydrothermal alteration of the host rock. (Authors' abstract)

JAMBON, A., WEBER, H.W. and BEGEMANN, F., L985, Helium and argon from an Atlantic MORB glass: concentration, distribution and isotopic composition: Earth & Planet. Sci. Letters, v. 73, p. 255-267. First author at GIS

CNRS-BRGM, 1A rue de la Ferollerie, 45045 Orléans, & Lab. Min., Univ. d'Orléans, Orléans, France.

Data are reported for detailed He and Ar measurements on single MORB glass from the Atlantic (CH 98-DR 11; 30°41'N, 41°49'W; depth ≈ 3500 m). Grain-size fractions prepared under ambient conditions are strongly affected by diffusive loss of He from grains and by adsorption of atmospheric argon on grain surfaces. Both effects could be controlled by crushing gram-sized chunks of glass under vacuum and analyzing the powder without any further handling, in particular without its exposure to the atmosphere.

Gases from vesicles, released upon crushing, are characterized by a $^4He/^{40}Ar$ ratio of 6 ± 1 and a $^{40}Ar/^{36}Ar$ ratio of up to 22,600. In dissolved gases the $^4He/^{40}Ar$ ratio was found to be (7.2 ± 1.6) times higher and the $^{40}Ar/^{36}Ar$ ratio to be about ten times lower than in vesicles. The difference of the elemental ratio He/Ar is as anticipated from the ratio of the solubilities (ca. nine) in the investigated basalt of He and Ar. Thus, while elemental abundance ratios are compatible with equilibrium between vesicles and basalt the grossly different argon isotopic ratios are not. It is proposed that two basalts, chemically very similar but with different $^{40}Ar/^{36}Ar$ ratios, were mixed shortly before eruption.

The overall $^4He/^{40}Ar$ ratio in the vesiculated basalt is 12 ± 2 so that, for the ratio in the primary magma, we find $6 \leq {}^4He/^{40}Ar < 12$ which is considerably higher than the radiogenic production ratio in all conceivable sources of MORB. Preferential removal from a melt of argon via vesicles is suggested to be the most likely explanation, whereas any metasomatic transfer seems unrealistic. (Authors' abstract)

JANECKY, D.R., CHARLES, R.W., BENJAMIN, T.M. and BAYHURST, G.K., 1985, Experimental hydrothermal investigation of the Na-K-Ca geothermometer at 250 to 350°C, 270 bars (abst.): EOS, v. 66, p. 1143-1144.

JAOUL, O, HOULIER, B. and LIEBERMANN, R.C., 1985, Non-stoichiometry of San Carlos olivine and its stability (abst.): EOS, v. 66, no. 18, p. 372. First author at Lab. de Geophys. et Geodyn. Interne, Univ. Paris-Sud, 91405 Orsay, France.

Annealing experiments on natural olivine single crystals (San Carlos, Arizona, spinel-lherzolite context) have been performed between T = 1100° and 1500°C for oxygen partial pressures $pO_2 = 10^{-3}$ to 10^{-13} bar and times of 1 to 140 hours in H_2/H_2O or CO/CO_2 gas mixtures. Even specimens annealed within the T-pO_2 theoretical stability field (TSF) calculated for stoichiometric olivine (Nitsan, 1974) show systematic alterations developed within the first few microns of the surface of the crystals. Pyroxene crystals or melt form on the original olivine surface even at T = 1100°C when chromium aluminum spinel inclusions were present in the starting material, rhyolite-like glasses were also observed. These observations are in contadiction with the TSF. Our intepretation is that this olivine may be non-stoichiometric $(Mg_{0.9}Fe_{0.1})_{2(1-x)}SiO_4$ with x small and positive. We extended the model that Nakamura and Schmalzreid (1983) developed for fayalite to our natural olivine composition, and under the assumption that the majority defects are magnesium vacancies, Fe^{3+} occupying octahedral and tetrahedral sites, and the more complex neutral defect corresponding to Coulombic attraction between neighboring Fe^{3+} ions. We have recalculated the olivine stability field in pO_2 vs. x space at T = 1300°C using this model and conclude that olivine is stable only in a very narrow range in pO_2 and x (except when x is close to zero) at a given T. Outside this domain, SiO_2-rich phases should form when x is positive. Of course, magnetite or iron precipitates may also coexist with SiO_2-rich exsolutions or pyroxene when pO_2 is close to the upper or lower boundaries of the TSF.

This model could help in the intepretation of the existence of partial melting and/or the low-viscosity/low-velocity zone in the upper mantle. (Authors' abstract)

JEBRAK, Michel, SMEJKAL, Vaclav and ALBERT, Dominique, 1985, Rare earth and isotopic geochemistry of the fluorite-barite vein deposits from the western Rouergue district (France): Econ. Geol., v. 80, p. 2030-2034. First author at Bureau Recherches Géol. et Minières, Det. Gîtes Min., B.P. 6009, 45060 Orleans Cédex, France.

Barite and yellow fluorite veins hosted by Paleozoic rocks make up an important group of deposits situated in the south of the French Massif Central. Th for the fluorite inclusion fluids are about 90°C.

The veins mark hydrothermal circulation which leached the basement of the Massif Central and precipitated when it encountered the Jurassic marine waters. (From the authors' text)

JEFFREY, A.W.A., PFLAUM, R.C., McDONALD, T.J., BROOKS, J.M. and KVENVOLDEN, K.A., 1985, Isotopic analysis of core gases at Sites 565-570, Deep Sea Drilling Project Leg 84, in Orlofsky, S., ed., Initial Reports of the Deep Sea Drilling Project, v. 84, U.S. Govt. Printing Office, p. 719-726. First author at Dept. Oceanography, Texas A&M Univ., College Station, TX 77843.

Methane carbon-isotopic compositions ($\delta^{13}C$ values relative to the PDB standard) at Sites 565, 566, 567 and 569 were lighter (enriched in ^{12}C) than -60‰, indicating a biogenic origin. In the deeper sections at Sites 568 and 570, $\delta^{13}C$ values were heavier, approaching -40‰, and therefore suggest a thermogenic source. A significant thermogenic source was discounted, however, because the carbon dioxide $\delta^{13}C$ values in these sections were also anomalously heavy, suggesting that the methane may have formed biogenically by reduction of the heavy carbon dioxide. $\delta^{13}C$ values of ethane and higher hydrocarbons were measured in several sections from Sites 566 and 570 that contained sufficient C_2-C_4 hydrocarbon concentrations. Ethane values in six sections (245-395 m sub-bottom) from Site 570 were fairly uniform, ranging from -24 to -26‰. These values are among the heaviest ethane values reported for natural gases. The isobutane/n-butane and isopentane/n-pentane ratios of the core gases suggested that the C_2-C_5 hydrocarbons are thermally produced by low-temperature chemical diagenesis of indigenous organic matter. This process apparently generates isotopically heavy C_2-C_5 hydrocarbons. High gas concentrations in the serpentinite basement rocks at Sites 566 and 570 appear to have resulted from migrated biogenic methane gas containing small amounts of immature C_2-C_5 hydrocarbons. (Authors' abstract)

JENSENIUS, Jørgen, 1985, Fluid inclusions in Danish Paleozoic sediments (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 136. Author at Inst. for Petrologi. Østervoldgade 10, 1350 København K, Denmark.

Fluid inclusions have been studied in both cores and surface samples of Paleozoic sediments from the island of Bornholm (the Baltic Sea) and in on-shore drill-cores from elsewhere in Denmark. The fluid inclusions studied occur in authigenic quartz and calcite, in cement and overgrowths on detrital grains in sandstones and in veins cutting sandstones, siltstones, shales and limestones. Aqueous liquid-vapor inclusions predominate, and only a small number of hydrocarbon (liquid and liquid-vapor) inclusions were observed. The salinity of the aqueous inclusions vary from about 1.7 wt. % for inclusions in calcite veins cutting shales to about 30 wt. % salts for inclusions in calcite veins cutting siltstones. Tm ice as low as -47°C indicate significant concentrations of salts other than NaCl, such as $CaCl_2$ and/or $MgCl_2$, in some of the aqueous inclusions. Th for all samples cluster around 75-90°C and 130-145°C, with the lower temperatures generally obtained on aqueous inclusions in veins, and the higher temperatures obtained on inclusions in veins and cement. In one calcite vein in limestone a group of inclusions was observed that homogenized to liquid between -44.5° and +56°C. No solidification was observed upon cooling to -140°C. The inclusions can be divided into two groups, one of which has a clear appearance, homogenizes in the range -44.5° to +56°C and fluoresces green, the others with a brownish color and with Th between +5° and +36°C. The former type of inclusions are interpreted as hydrocarbon inclusions, with a wet gas composition (less than 90% CH_4 and more than 10% C_2H_6 and C_3H_8 combined).

Assuming depths of burial in the order of 5-6 km during the trapping the fluid inclusion data suggest that temperatures of about 220-250°C were attained for the examined Paleozoic sediments. Vitrinite reflectance studies suggests a major thermal discontinuity between the Cambian-Ordovician and the post-Devonian sediments of the Danish area (Thomsen et al. 1983). The fluid inclusion data furthermore show that the present depth of burial is far too low to account for the temperatures attained in the Paleozoic sediments. This discrepancy may be explained by introducing the concept of a large Silurian-Devonian paleo-basin covering the Danish area. (Author's abstract)

JI, Ronglun, 1985, Equal capacity condition equation and its pressure calibration of inclusions in minerals: Yanshi Kuangwu Ji Cesh, v. 4, no. 2, p. 132-136 (in Chinese). Author at Chin. Acad. Geol. Sci., PRC.

A set of calibration equations are derived, relating the formation temperature (T) and pressure (P), decrepitation T and P, and homogenization T and P, of inclusions in minerals. Unrelated to homogenization T or the decrepitation T, the calibration pressure mononomial is $A\Delta P$, where A is the calibration coefficient. (C.A. 103: 198665g)

JOCKWER, Norbert and GROSS, Sabine, 1985, Natural, thermal and radiolytical gas liberation in rock salt as a result of disposed high-level radioactive waste, in Scientific Basis for Nuclear Waste Management, v. 6, p. Authors at Gesellschaft für Strahlen- und Umweltforschung mbH München, Inst. Tieflagerung, Theodor-Heuss-Strasse 4, D-3300 Braunschweig, FRG.

Includes determinations of the gases originally present and those generated by radiolysis. (E.R.)

JOHAN, Zdenek and WATKINSON, D.H., 1985, Significance of a fluid phase in platinum-group-element concentration: Evidence from the critical zone, Bushveld Complex (abst.): Program and Abst., Fourth Int'l. Platinum Sym., Toronto, Ontario, Canada, Aug. 2-4, 1985, The Canadian Mineralogist, v. 23, pt. 2, p. 305-306. First author at Cent. Rech. Synth. et Chim. Miner., Orleans, France.

The relationships of chromitites and platinum-group minerals to pegmatitic rocks, hydrous minerals, and abundant fluid inclusions in postcumulus quartz and feldspar were examined in a normal "reef" section (Union Section) from UG-1 to the Bastard Reef. Microprobe and SEM analyses of chromite (and coexisting cumulus and postcumulus minerals) revealed narrow compositional ranges in UG-1 and UG-2 of X(Fe) (0.537-0.593), Y(Cr) (0.561-0.576), Y(Al) (0.331-0.377), $Y(Fe^{3+})$ (0.055-0.098). UG-2 chromite is slightly enriched in TiO_2 (0.77-1.0 wt.%) compared to that from UG-1. Merensky Reef chromite has higher $Y(Fe^{3+})$ (0.14) and Y(Cr) (0.522), Y(Al) (0.338), TiO_2 (0.87 wt%).

Chromite from pyroxenite has even higher $Y(Fe^+)$ (0.120-0.230); Y(Cr) is 0.590-0.673 and X(Fe) is 0.739-0.897. Pseudoreef chromite has very high TiO_2 (5.30%) and $Y(Fe^{3+})$ (0.324), X(Fe) (0.858), and low Y(Cr) (0.423). Chromite from pegmatitic pyroxenite of the Merensky Reef has the lowest Y(Cr) (0.384) and the highest $Y(Fe^{3+})$ (0.344) of all chromite samples examined.

Two-pyroxene temperatures range from 1025 to 923°C below and from 990 to 920°C above the pseudoreef. Postcumulus mica (phlogopite with as much as 6.75% TiO_2) occurs throughout the Upper Critical Zone. Values as high as 1.0% Cl and 1.7% F were recorded in 170 analyses of mica, X(Fe) and Cl contents of mica are positively correlated with X(Fe) of coexisting chromite; no correlation is apparent with X(Fe) of orthopyroxene.

Inclusions of mica in chromite are very sodic (as much as 6.5% Na_2O), frequently in contact with En_{90}, $Wo_{46}En_{47}Fs_7$, rutile and sulfide inclusions. They are Cl-rich just above of PGE-bearing reefs. Fe variations in chromite imply rapid increases and decreases in $f(O_2)$ that may relate to varying partial pressure of fluids; corresponding variations in Cl contents of mica and occurrences of fluid inclusions indicate an important role for fluids in modifying the nature of liquidus phases. (Authors' abstract)

JOHNSON, J.W. and NORTON, Denis, 1985, Theoretical prediction of hydrothermal conditions and chemical equilibria during skarn formation in porphyry copper systems: Econ. Geol., v. 80, p. 1797-1823. Authors at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

A numerical model of heat and mass transfer within porphyry copper environments and equilibrium phase relations in the system $CaO-FeO-MgO-Al_2O_3-SiO_2-Cu_2O-H_2S-H_2SO_4-H_2O-CO_2$ are combined into a theoretical analysis of hydrothermal and chemical conditions during skarn formation in siliceous limestone. Equilibrium constraints indicate that aqueous CO_2 concentration (in nonideal H_2O-CO_2 fluid mixtures) during sub-400°C garnet precipitation is <0.05 mole fraction.

Equilibrium phase relations and preliminary mass transfer calculations suggest that the chemical evolution coincides with predicted hydrothermal events. Observed features such as gross outward zoning of garnet-chalcopyrite to wollastonite-bornite, amphibole selvages on fractures that cut anhydrous skarn, and core to rim iron enrichment of andradite-grossular garnet are consistent with the reaction paths, equilibrium constraints, and hydrothermal evolution presented in this study. (From the authors' abstract)

JOHNSON, M.L., 1985, The ammonia-water phase diagram II: Extent and significance of ammonia dihydrate, $NH_2\text{-}2H_2O$ (abst.): EOS, v. 66, no. 46, p. 944.

JONES, B.F. and BODINE, M.W., Jr., 1985, Normative salt characterization of natural waters (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A30. First author at U.S. Geol. Survey, 432 National Center, Reston, VA 22092.

Utilizing the computer program SALTEQ, normative salt assemblages have been calculated for water analyses from a wide variety of lithologic settings. These assemblages--the idealized equilibrium mineral suites that would crystallize on evaporation to dryness at 25°C--were then examined as diagnostic indicators of solute origin.

Although most natural water compositions represent multiple solute origins, three major categories can be recognized, with subgroups based on predominant mineral or solution interactions. The major categories include meteoric or weathering solutions, waters with solutes principally of marine origin, and diagenetic fluids. Meteoric water compositions derived primarily from normal carbonic-acid weathering yield carbonate-dominated salt norms, whereas significant sulfide oxidation leads to sulfate-dominated assemblages. Further subdivision is readily based on particularly diagnostic normative salts that result from dissolution of major minerals associated with specific lithologies. Thus, alkali sulfo-carbonates reflect feldspar hydrolysis and magnesium sulfate or carbonate indicates mafic mineral dissolution.

The salt norm assemblage for unaltered seawater yields the familiar bischofite-carnallite-kieserite association of final marine bitterns. Solute compositions derived from hypersaline marine liquors or the resolution of marine evaporites are reflected in quantitative deviations from the normative salt abundances for seawater. Waters characterized as diagenetic fluids can also be of marine origin but their normative salt assemblage suggests solute alteration by secondary mineral reactions. (Authors' abstract)

JUREWICZ, S.R. and WATSON, E.B., 1985, The distribution of partial melt in a granitic system: The application of liquid phase sintering theory: Geochimica Cosmo. Acta, v. 49, p. 1109-1121. Authors at Dept. Geol., Rensselaer Polytech. Inst., Troy, NY 12180-3590, USA.

Two series of experiments, four crystallization and four partial melting, were performed at 1000°C and 10 kilobars in the quartz-alkali feldspar-granitic melt system in order to determine the equilibrium melt distribution and textural adjustment processes. The melt distribution in both types of experiments was characterized by melt residing at grain edge intersections and in a few large pools scattered throughout the sample. Wetting angle measurements from both sets of experiments gave values of 44, 49, and 59 degrees for the feldspar/feldspar, feldspar/quartz, and quartz/quartz wetting angles, respectively. Interparticle welding, a process consistent with the measured wetting angles, resulted in the formation of a skeleton of solid grains with very few unattached grains in any sample. Analysis of wetting angle distributions indicates that the longest duration experiments closely approached textural equilibrium and that the distributions of observed wettng angles from both sets of experiments were nearly identical.

Measurement of quartz grain sizes from the 2, 4, 7, and 14-day crystallization experiments revealed: 1) a probable cube root of time dependence for the quartz growth rate; 2) a decrease in the number of quartz grains per square micron with increasing time; and 3) a normalized distribution of grain sizes that appeared stationary in time. These results were shown to be consistent with the processes observed during the liquid phase sintering of ceramic materials and suggest that identical processes may occur in natural partially-molten systems.

Finally, it was shown that interfacial energy considerations lead to a model of interparticle welding (clustering) in which it is discovered that there is an equilibrium melt fraction stable along grain edges of a partially-molten crystalline aggregate. This melt fraction may be greater, equal to, or less than the equilibrium fraction of melt dictated by the pressure, temperature, and chemical potential conditions. If the interfacial energy-derived equilibrium melt fraction is less than the P-T-u equilibrium derived melt fraction, then segregation of the melt in excess of the interfacial energy-derived equilibrium melt fraction may be expected to result in the formation of melt pools. (Authors' abstract)

KADIK, A.A. and LUKANIN, O.A., 1984, Paths of mantle outgassing during melting: The role of partial melting of upper mantle rocks in the evolution of fluid composition and redox regime: Geokhimiya, 1984, no. 12, p. 1821-1831 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 5, p. 563-572, 1985).

KADIK, A.A. and LUKANIN, O.A., 1985, The paths of mantle degassing in the process of its melting: Variation of redox and fluid regime of basaltic magmas during their way to the surface: Geokhimiya 1985, no. 2, p. 163-178 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 5, p. 573-586, 1985).

KADIK, A.A. and LUKANIN, O.A., 1985, Fractionation of volatile components by degassing of "magma ocean" (abst.): Lunar and Planetary Sci. XVI, p. 420-421.

KADKO, David, KOSKI, Randolph, TATSUMOTO, Mitsunobu and BOUSE, Robin, 1985, An estimate of hydrothermal fluid residence times and vent chimney growth rates based on ^{210}Pb/Pb ratios and mineralogic studies of sulfides dredged from the Juan de Fuca Ridge: Earth & Planet. Sci. Letters, v. 76, p. 35-44.

KAHLWEIT, Manfred and STREY, Reinhard, 1985, Phase behavior of ternary systems of the type H_2O-oil-nonionic amphiphile (microemulsions): Angew. Chem. Int. Ed. Engl., v. 24, p. 654-668.

KAISER, C.J. and OHMOTO, Hiroshi, 1985, A kinematic model for tectonic structures hosting North American Mississippi Valley-type mineralization: Implications for timing and hydrology (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 622. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Current theories on Mississippi Valley-type deposits postulate that the ore fluids were the products of dewatering of intracratonic basins and that mineralization occurred under an extensional environment. Tectonic structures (folds, faults, fractures) which host Mississippi Valley-type mineralization in the mid-continent and Appalachians of North America have been evaluated in context of a kinematic model of deformation to determine the tectonic setting and timing of mineralization. Although mineralization occurred in both extensional and compressional local tectonic environments, attitudes of ore-bearing structures and their relative movements indicate that the maximum principal stresses were oriented NW-SE in eastern North America and N-S in the Upper Mississippi Valley and on the Ozark Dome. Orientation of stresses and time of deformation are consistent with the late Paleozoic Appalachian-Ouachita-Marathon Orogeny.

Mineralization in most Mississippi Valley-type districts appears to have been roughly contemporaneous with the major deformation event. This timing constraint on mineralization precludes dewatering of intracratonic basins as a source of ore fluids. Instead, the tectonic setting during mineralization and the chemical, isotopic, and paleomagnetic trends among districts suggest that a gravity-driven, meteoric-water hydrologic system through foreland basins provided the mineralizing fluids. An exception to this model is Pb-Zn-Ba mineralization in Nova Scotia, which appears to have been associated with the development of the Fundy Basin in Carboniferous time. (Authors' abstract)

KALINICHENKO, A.M., PASAL'SHAYA, L.F., MATYASH, I.V., IVANITSKIY, V.P., GAMARNIK, M.Ya and SIROSHTAN, R.I., 1985, Origin of the hydrogen released on heating biotite and amphibole in an inert medium: Geokhimiya, no. 2, p. 254-258, 1985 (in Russian; translated in Geochem. Int'l. v. 22, no. 6, p. 102-106). Authors at Inst. Geochem. & Min. Physics, Acad. Sci. Ukranian

SSR, Kiev, USSR.

Hydrogen is released from OH-bearing minerals; may be pertinent as a possible source of hydrogen found in gas analyses of fluid inclusions? (E.R.)

KALINICHENKO, A.M., PASAL'SKAYA, L.F., PROSHKO, V.Ya. and MATYASH, I.V., 1985, Fluid inclusions in quartz according to PMR and gas chromatographic data: Dopov. Akad. Nauk Ukr. RSR, Ser. B., Geol., Khim. Biol. Nauki, 1985, no. 4, p. 23-26 (in Ukrainian; English abstract). Authors at Inst. Geokhim. Fiz. Miner., Kiev, USSR.

New data on the content of H_2O, CO_2 and other volatile matters [H_2, CH_4 and CO] in quartz of Volyn are presented. The distribution and origin of these materials are studied by PMR and gas chromatography methods. (Authors' abstract)

KALYUZHNYI, V.A., ed., 1985, Thermobarometry and geochemistry of ore-forming fluids (from inclusions in minerals): Abstracts of lectures of the 7th All-Union Conference (L'vov, September 30-October 2, 1985), volumes 1 (220 pp.) and 2 (272 pp.), 800 copies printed, price 1 rbl. 40 kopecks and 1 rbl. 80 kopecks (in Russian).

This two-volume issue contains 318 abstracts that were submitted to the All-Union Conference on fluid inclusions in L'vov. The abstracts are grouped in the following sections: Volume 1 1) Crystallogenesis of inclusions, scientific basis and methods of studies of mineral-forming fluids; 2) Petrologic aspects of studies of magmatic inclusions; 3) Fluids of processes of mineral genesis in sedimentary rocks; Volume 2 4) Geochemistry and thermobarometry of ore-forming fluids, practice of prospecting and evaluation of deposits of raw materials. All individual abstracts of Volume 1 are translated and listed alphabetically in this volume; abstracts of Volume 2 will be in the next volume (v. 19) of Fluid Inclusion Research. (A.K.)

KALYUZHNYI, V.A., SUSHCHEVSKAYA, N.M., RED'KO, L.R., SVOREN', I.M. and SAKHNO, B.E., 1985, Geochemical data on the volatile components in basic magmas of the ocean floor (CO_2 and H_2O in chilled glasses and minerals from tholeiites and boninites) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 131-132 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

1. Chilled glasses of basic magmas (Table 1), brought up from various sites on the floor of the Atlantic (9 samples), Indian (3), and Pacific (2) Oceans, and the Red Sea (3) were formed during almost instantaneous cooling of a melt as it came in contact with the water. Rapid chilling has contributed to preservation of the melt's primary composition (including volatiles). The resulting crust of volcanic glass, 1.0-2.0 cm thick, contains small (0.01-0.1 mm) olivine phenocrysts and gas bubbles of spherical shape; the latter rarely exceed 0.5 mm in diameter. The gas phase of the primary two-phase melt inclusions usually makes up 3-5% of the vacuole volume. Th - 1100-1200°C.

2. The composition of the gas bubbles in the glass corresponds to volatiles released from a magma boiling at depth (prior to its eruption on the ocean floor). This is supported by the following facts (allowing for the deep-seated crystallization of olivine): a) the primary melt inclusions, arranged in rows in the olivine crystal, frequently have a markedly different ratio of phases, amongst which isolated spheroidal gas bubbles may be encountered; b) incomplete (partial) capture of the gas bubbles by

olivine has been identified during the process of its growth; and c) the carbon-isotope ratio in CO_2 from the gas bubbles corresponds to a deep-seated value: $\delta^{13}C = -6.1 \pm 0.5‰$ (Sample No. 2173) and $\delta^{13}C = -7.8 \pm 0.5‰$ (Sample No. 838/I-G).

The boninitic glasses from the Pacific Ocean are distinguished from the tholeiitic forms by their low R.I. and by the presence of two kinds of gas bubbles, containing: a) aqueous solution + gas, and b) gas only. The former homogenize into the gas phase at 320°C, and the concentration of the solution is 3.7 wt. % NaCl equiv.; only low-density CO_2 has been found in the gas phase.

3. The volatiles from individually opened and analyzed bubbles in the tholeiitic glasses (Table 1) consist exclusively of CO_2; other components (including H_2O) have not been identified (limiting sensitivity of MSKh-ZA mass-spectrometer for $CO_2 = 1 \cdot 10^{-8}$ g; the mass of CO_2 in the bubbles analyzed varies from $1 \cdot 10^{-3}$ to $1 \cdot 10^{-5}$ g). The CO_2 composition of the fluids has been confirmed by cryometric measurements. H_2 has been found in minimal amounts during very fine grinding at room temperature of samples in the vacuum of the ancillary system of an MKh-1303 mass-spectrometer. Analytical data for CO_2 and H_2 in % for samples 838/I-G, IV-3 and Dr 22/5 (water previously absorbed by P_2O_5): 99.82, 0.18; 99.63, 0.37; 99.83, 0.17.

4. Judging by the density of CO_2 from isolated CO_2 inclusions in olivine (0.34 and 0.36 g/cm^3), the P during degassing of the magma under intratelluric conditions was 120-140 MPa. The internal P in the bubbles in the chilled glass at 25°C is equal to the vapor pressure of a two-phase equilibrium (5.5 MPa), and at 600°C (softening point of glass), to the weight of the water column above the erupting lava (Table 1).

5. The gases extracted from the previously powdered glass (CO_2, H_2O, CH_4, C_2H_6, and H_2) by heating it in the ancillary system of the MKh-1303 mass-spectrometer, in most cases occur in the structural ultra-micropores in the glass. The results, obtained by a micro-visual examination of the volume of the gas bubbles and with the mass-spectrometer, are presented in Table 2.

Thus, the studies indicate the relatively large amount of CO_2 in the tholeiitic magma and the diminished quantity of other volatiles; however, the overall concentration of both CO_2 and H_2O is quite low and is far from saturation. It is irrefutably evident that boiling (degassing) of the magma in depth was controlled by the presence of other gases in increased amounts, with H_2 in the forefront.

The volatiles in the boninitic magma are characterized by a large amount of water and by the low content of CO_2. (Authors' abstract)

Table 1

Sample Nos.	Lat. and Long.	Sampling depths, m	R.I. of glass	Gas Composition in individual bubbles	Density of CO_2 in gas bubbles, g/cm^3	P at T = 300°C, MPa
			Atlantic Ocean (tholeiitic basalts)			
D-56-02	49°48.3' Lat. N 28°38.9' Long. W	1760 -1860	1.594	100% CO_2	0.224	40
1351-1	71°03 Lat. N 13° Long. W	400- 650	1.598	100% CO_2	0.027	5
421	58°21.8' Lat. N 31°44.7' Long. W	---	---	100% CO_2	0.166	29
SN-98 Dr-12-d4	30° Lat. N	---	1.599	---	0.229	42
IV-3	26°02.6' Lat. N 44°36.6' Long. W	---	1.597	100% CO_2	0.235	43

Sample Nos.	Lat. and Long.	Sampling depths, m	R.I. of glass	Gas Composition in individual bubbles	Density of CO_2 in gas bubbles, g/cm^3	P at T = 300°C, MPa
Sn-98 Dr-12-d3	30° Lat. N	---	1.604	100% CO_2	---	--
283	58°30' Lat. N				0.087	15
838/1-G	25°09.4' Lat. S 13°43' Long. W	3200-3600	1.598	100% CO_2	0.223	40
845/3	28°37' Lat. S 12°34.4' Long. W	3000-3500	1.594	100% CO_2	0.188	33
Indian Ocean (tholeiitic basalts)						
5327	34°18' Lat. S 77°56' Long. E	3080	1.595	100% CO_2	---	--
28 Dr-22/5	5°24.8' Lat. N	3200	1.599	---	0.220	39
2173	---	3800	1.595	100% CO_2	0.205	36
Red Sea (tholeiitic basalts)						
407	21°22.3' Lat. N. 38°04.7' Long. E	2070	1.607	100% CO_2	0.124	21
391	21°17.2' Lat. N 38°04.3' Long. E	2030	1.604	100% CO_2	0.146	25
319	18°09.15' Lat. N 39°58.5' Long. E	1550-1470	---	100% CO_2	---	--
Pacific Ocean (boninites)						
16-28/1	14°52' Lat. S 173°58.2' Long. W	2960	1.531	H_2O+ CO_2	---	--
26-3	14°52.2' Lat. S 173°46.7' Long. W	3000-3100	1.570	— " —	---	--

Table 2*

Sample Nos.	CO_2 in gas bubbles (micro-visual) determinations	CO_2 (mass-spectrometer analysis)			H_2O (mass-spectrometer analysis)
		in gas bubbles (at 25°C)	in micropores in glass at (500-1130°C)	total amount	in micropores in glass at (500-1130°C
838/1-G, Atlantic Ocean	0.0018	0.0172	0.00087	0.018	0.00033
421, Atlantic Ocean	---	0.0223	0.0029	0.0252	0.00093
2173, Indian Ocean	0.029	0.0143	0.0102	0.0245	0.01748

*Amounts of CO_2 and H_2O in wt %

KAMENETSKIY, V.S., SOBOLEV, A.V., DANYUSHEVSKIY, L.V. and KONONKOVA, N.N., 1985, Factionation of primitive tholeiites from the oceanic rifts of the Atlantic Ocean based on magmatic inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 137-138 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

Dmitriyev et al. (1978-1984) have recognized two spatially discrete kinds of tholeiites in the oceanic rifts (TOR), located in the peripheral (TOR-1) and central (TOR-2) parts of the Atlantic Ocean. It has been suggested that the existence of these two kinds has been controlled by the presence of two different primary melts, formed under the conditions of the spinel (TOR-1) and plagioclase (TOR-2) depth facies of a mantle lherzolite. Using the method of mathematical modelling of the inverse course of fractional crystallization, the authors have calculated the compositions of the primary melts for both kinds. The present work deals with the problem of experimental confirmation of the theoretical conclusions.

Magmatic inclusions have been examined in olivine (ol), plagioclase (pl), chrome-spinel (crsp), and clinopyroxene (cpx) in the most primitive TOR-1 ('FAMOUS' area) and TOR-2 basalts (Vema Fault area). P melt inclusions have been identified in all crystalline phases, and these are confined to zones of crystal growth. Syngenetic fluid inclusions, consisting of CO_2 (triple point -57.1°C for TOR-1, and -57.8°C for TOR-2, and density (from Th data) of 0.47 g/cm^3 and 0.40 g/cm^3 respectively), have been identified in ol and pl. The Th of melt inclusions and their composition (electron microprobe), have established the T intervals of crystallization and the melt compositions of both kinds. It has been shown that the highest-T melts of these tholeiites differ significantly and correspond to the calculated values. Crystallization of TOR-1 began at 1280°C, with the formation of an ol-crsp association at a maximum identified pressure of 2.2 kbar. For TOR-2, it began at 1240°C, with simultaneous ol, pl, and crsp at a maximum established P of 1.5 kbar. The fluid composition was, in both cases, essentially CO_2.

The composition of the crsp and the P melt inclusions in it revealed a significant difference in the $f(O_2)$ values during crystallization of TOR-1 and TOR-2. The $f(O_2)$ values for TOR-1 are $10^{-9.9}$ at T = 1210°C, and $10^{-8.9}$ at T = 1265°C, which corresponds to a hypothetical FeO/Fe buffer; for TOR-2, the values are from $10^{-8.9}$ at 1175°C to $10^{-8.0}$ at 1230°C, which corresponds to a hypothetical QFM buffer.

Significant correlation has been established between Th of the P melt inclusions and the composition of the surrounding ol, confirming the fractionation of ol in the system.

A comparison between Th and the calculated liquidus T of the homogenized melt inclusions for both kinds of TOR, indicates the insignificant amount of water in the melts during their crystallization. (Authors' abstract)

KAMINENI, D.C., 1985, Halogen-bearing minerals in plutonic rocks: A possible source of chlorine in saline groundwater in the Canadian Shield (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A30. Author at Atomic Energy of Canada Ltd., Geol. Survey of Canada, 601 Booth St., Ottawa, Ontario, K1A 0E8, Canada.

Since the advent of electron microprobe analysis, chlorine has been widely recognized and reported in a variety of rock-forming minerals. A literature search indicates that the halogens, chlorine and fluorine, can concentrate in significant amounts in hornblende, biotite, serpentine, scapolite, feldspathoids (e.g., sodalite), apatite and humite group minerals, occurring in plutonic rocks of various geologic ages. Degradation and dissolution of halogen-bearing minerals during water-rock interaction can release significant amounts of chlorine, particularly near some fractures in plutonic rocks.

Microprobe study of various alteration minerals from the East Bull Lake gabbro-anorthosite complex, in northeastern Ontario, showed that chlorine is concentrated in hornblende and biotite. Among the coexisting calcic amphiboles, chlorine occurs preferentially in hornblende. Near open fractures, chlorine-bearing hornblende and biotite are replaced by low-grade metamorphic, chlorine-free minerals such as prehnite, laumontite, clays and gypsum. Mass balance calculations suggest that chlorine is conserved in the fluid phase. The breakdown of halogen-bearing minerals may account for the high concentrations of chlorine in groundwater encountered at depths in plutonic rocks. (Author's abstract)

KAMINSKII, F.V. and SOBOLEV, N.V., 1985, The carbon isotopic composition variations within diamond crystals: Dokl. Akad. Nauk SSSR, v. 285, no. 6, p. 1436-1439 (in Russian).

KÄMPF, H., BANKWITZ, P., STRAUCH, G., STIEHL, G., GEISLER, M., GERSTENBERGER, H., HAASE, G., KLEMM, W., THOMAS, R. and VOLGER, P., 1985, Local and regional processes and zoning in a hydrothermal late Variscan vein mineralization from the southern part of the G.D.R.: Gerlands Beitr. Geophysik, v. 94, p. 426-434.

Using modern analytical methods in connection with the analysis of local and regional processes in the G.D.R. fluorite research a new way is taken in the material and minerogenetic characterization of vein mineralizations. The investigations deal with the geochemistry of the trace elements and isotopes and the thermobarogeochemical characterization of Permian formed late Variscan polymetal-sulphide-quartz and fluorite-quartz-adularia vein mineralizations from the SW-Vogtland.

About 100 fluorite samples are investigated by the instrumental neutron activation analysis (INAA) and the ICP technique estimating 40 trace elements. The analysis of primary and secondary fluid inclusions and their contained compounds comprised:

- the determination of the isotopic variations of hydrogen and carbon in water and CO_2,
- the thermometric and cryometric measurements of Th, the formation pressure, and the salinity of the inclusion fluids,
- the chemical investigations of the inclusion fluids.

In the local range - i.e., three vein profiles of different depths in a fluorspar deposit - a cyclic development of the formation process and an episodic superimposed process were derived by the isotope- and element geochemical and the paragenetic parameters. From this conclusions are derived for the transport and the precipitation process of the hydrotherms. The transport process is supposed as a seismic pumping, the precipitation and the deposition of the minerals were proceeded by a fractional crystallization. Measured on 10 samples of 5 hydrothermal minerals (fluorite, barite, carbonate) the $^{87}Sr/^{86}Sr$ initial values of the four fluorite samples (0.714) suggest a crustal genesis of Sr and probably of Ca. (From the authors' abstract)

KANE, R.E., 1985, Natural rubies with glass-filled cavities: Gems & Gemology, v. 20, no. 4, p. 187-199. Author at GIA Gem Trade Lab., Inc., Los Angeles, CA.

X-ray diffraction and chemical analysis indicated that the filler was indeed a glass; it was probably added in conjunction with heat treatment. (From the author's abstract)

KANE, R.E. and LIDDICOAT, R.T., Jr., 1985, The Biron hydrothermal synthetic emerald: Gems & Gemology, v. 21, p. 156-170. First author at GIA Gem Trade Lab., Inc., Los Angeles CA.

Numerous large two-phase L+G inclusions are present, some trapped along with solid inclusions. (E.R.)

KAPUSTIN, Yu.L., 1985, A differentiated analcime basalt sill with segregated calcite: Zap. Vses. Mineral. Obsh., 1985, v. 114, no. 3, p. 275-288 (in Russian; translated in Int'l. Geol. Review, v. 27, no. 8, p. 964-976, 1985).

This article presents a convincing example of silicate-carbonate immiscibility in a shallow intrusive. (IGR abstract)

KAUKLER, W.F. and FRAZIER, D.O., 1985, Observations of a monotectic solidification interface morphology: J. Crys. Growth, v. 71, p. 340-345. First author at Univ. Alabama in Huntsville, Dept. Chem., Huntsville, AL 35899, USA.

For detailed studies of the region around a solidification interface on a microscopic scale, a very thin (essentially two-dimensional) test cell may be translated across two temperature-controlled heating/cooling blocks and viewed with a microscope. Such a device is sometimes referred to as a temperature gradient microscope stage (TGS). Of particular interest in this study is the behavior of a monotectic type solution during solidification. Succinonitrile based model system for metallic monotectic alloys, when solidified on a TGS, form an unusual "worm-like" micromorphology. These interfaces are observable in situ under high optical magnification during growth. (Authors' abstract)

Unusual textures developed might be analogs for some natural immiscibility and for the resultant trapping of inclusions. (E.R.)

KAY, Alexandra, 1985, Hydrothermal mineralization and alteration of the Lagalochan Au-Co-Mo prospect, Western Scotland: Ph.D. dissertation, Imperial College, London.

Early polymetallic, porphyry style mineralization is located within a highly altered and brecciated subvolcanic complex of granodioritic composition. Early Co-Mo mineralization is overprinted by a late Pb-Zn-Ag carbonate veining event. The fluid inclusion and isotopic evidence suggests that the fluids resposible for hypogene mineralization and K-silicate and phyllic alteration were high T (>400°C) polycomponent, hyposaline "boiling" fluids of dominantly magmatic origin. Early fluids carried carbon dioxide which was preferentially lost from the system during episodic boiling. (From the author's abstract)

KAZAHAYA, Kohei and MATSUO, Sadao, 1985, A new ball-milling method for extraction of fluid inclusions from minerals: Geochem. J., v. 19, p. 45-54. Authors at Dept. Chem., Tokyo Inst. Tech., O-okayama, Meguro-ku, Tokyo 152, Japan.

In order to extract fluid inclusions in minerals, a new type ball-mill made of Pyrex glass designed by Kita (1981) was used. Samples used in this study were hydrothermal vein quartz, fluorite and arsenopyrite. Under suitable conditions, gases in primary inclusions could be extracted with little contribution of secondary inclusions. The conditions found adequate for quartz and fluorite samples from the Takatori mine are as follows: 1) initial grain size of the sample is 6 ~ 10 mesh, and the amount of sample is about 4 g, 2) preheating temperature of sample is set at the filling temperature of primary inclusions, and the preheating period is more than 12 h in vacuum, 3) the duration period of crushing using an alumina ball for 30 ~ 60 min is necessary, and 4) the duration of gas-recovery procedure for more than 3 h with the heating of the mill at the same temperature of preheating is necessary for the recovery of gases adsorbed on the powdered sample.

For quartz and fluorite samples, isotopic compositions of extracted gases including H_2O, CO_2 and CH_4 were reproduced well. The CO_2/H_2O ratio obtained for fluid inclusions in quartz from the Takatori tungsten mine, Japan, varied considerably according to the difference in the condition of ball-milling. For arsenopyrite sample the isotopic results were scattered widely because SO_2 was evolved during crushing even at room temperature, which may be due to the reaction between arsenopyrite and H_2O. When this method is applied to extracting fluid inclusions in minerals, the experimental conditions such as 1) and 2) should be changed depending on the nature of samples, especially the filling temperature of primary inclusions is important to set the preheating temperature.

Disadvantages inherent in the ball-milling method are 1) incomplete extraction of fluid inclusions and 2) the adsorption of gases onto the powder surface. The latter can be overcome by heating the powdered sample during the recovery process of gases, which was proven by the simulation test. As far as the isotopic compositions of H_2O, CO_2 and CH_4 extracted from fluid inclusions are concerned, disadvantages given above have no effect on the result. (Authors' abstract)

KEELEY, D.F. and MERIWETHER, J.R., 1985, Aromatic hydrocarbons associated with brines from geopressured wells, in Dorfman, M.H. and Morton, R.A., eds., 1985, Geopressured-Geothermal Energy, Proc. 6th U.S. Gulf Coast Conf.: New York, Pergamon Press, p. 105-113.

KELLER, W.D., STONE, C.G. and HOERSCH, A.L., 1985, comparison of chert/novaculite textures from the Ouachita Mountains, U.S. Virgin Islands, Scotland and other localities (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 163. First author at Dept. Geol., Univ. Missouri-Columbia, Columbia, MO 65211.

The textures of chert/novaculite heated by geothermal processes are remarkably similar whether the chert is from a folded sedimentary belt region in the Ouachita Mountains, Arkansas-Oklahoma, from a volcanic arc province in the U.S. Virign Island, or from a contact metamorphic aureole, Isle of Skye, Scotland.

Scanning electron micrographs (SEMs) of all those rocks show a complete range of textures from cryptocrystalline, anhedral quartz in nonmetamorphosed chert/novaculite to coarse, polygonal triple-point quartz over 30 μm in diameter in metamorphosed counterparts. Additional examples of triple-point texture in chert collected from overseas localities, and ranging in age from Precambrian to Tertiary, further show that such rocks and metamorphic effects are world-wide in occurrence. Our studies indicate that triple-point texture is related to the thermal history of these rocks.

Temperature estimates from limited studies of mineral-chemical phase relationship in associated rocks, fluid inclusions, and stable isotope ratios suggest that maximum temperatures as high as approximately 760°C have been reached by small portions of the chert/novaculite. Other variables, such as geologic time, crystal deformation and mineralizing compounds, have not been evaluated for possible effects on recrystallization. Chemical compounds other than silica in the chert that may possibly inhibit recrystallization, or somewhat modify the morphology, are under study.

Nonetheless, small samples of chert/novaculite can yield evidence of a history of high temperature resulting from deep burial by sedimentation, tectonism, volcanogenic events, and/or from exposed or concealed intrusions. Such evidence may be used in determining maturation or degradation of hydrocarbons in the rocks, and to furnish clues during exploration for thermally related metallic and non-metallic minerals. (Authors' abstract)

KELLEY, D.S. and DELANEY, J.R., 1985, High temperature, high salinity aqueous fluids from the Kane fracture zone, Mid-Atlantic Ridge (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 626. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195.

Microthermometric studies of fluid inclusions in isotropic and cumulate gabbros recovered by DSRV Alvin from the western wall of the axial valley on the Mid-Atlantic Ridge near 24°N, provide evidence that high temperature, high salinity fluids permeated the gabbros at temperatures in excess of 400°C. Multiple generations of fracture-controlled fluid inclusions in plagioclase, augite, hornblende, epidote, and apatite are characterized by distinct temperature ranges, vapor-to-liquid ratios and by the presence or absence of daughter minerals.

The most complex history of inclusion formation is recorded by apatite, in which three distinct generations of inclusions are preserved: 1) Vapor- and liquid-dominated inclusions which commonly contain halite and an opaque daughter mineral. Homogenization is not complete at 700°C. Halite dissolution temperatures indicate salinities of 32 to 43 wt% NaCl equivalent. 2) Vapor-dominated inclusions which homogenize to the vapor phase at temperatures between 380-420°C. 3) Liquid-dominated inclusions which homogenize to the liquid phase at temperatures of 300°C. Freezing experiments indicate inclusion types 2 and 3 have variable salinities ranging from 0.5 wt% NaCl equivalent to 2.3 times that of seawater. Other host minerals for type 2 inclusions are epidote and augite. Type 3 inclusions occur in plagioclase.

The high temperature, variable salinity fluids of types 1 and 2 may be the result of two-phase separation from a seawater-like fluid in the supercritical region. Fracture-controlled temperature-compositional relationships observed in the gabbros may record the fluid-rock interaction within distal feeder systems which ultimately provide high-temperature recharge for shallower zones of major upflow in a submarine hydrothermal system. (Authors' abstract)

KELLY, W.C., and NISHIOKA, G.K., 1985, Precambrian oil inclusions in late veins of the White Pine copper deposit, Michigan (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 626. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Excellent primary inclusions of petroleum were trapped in calcite crystals filling late veins which crosscut and offset the main copper ore zone at White Pine. The inclusions are now solid, but their spherical to hemispherical shapes indicate an original liquid state. Some inclusions were completely solidified by water-washing and/or bacterial degradation prior to enclosure by the calcite, whereas others (with one or more vapor bubbles) were still liquid at the moment of entrapment. P-T conditions of maturation and entrapment of this oil are defined by Nishioka and others (see abstract, this volume). Some of the Cu-Fe sulfides in the veins are closely associated with these hydrocarbons, forming crusts on the oil droplets and, in some cases, appearing to have veined and replaced oil solidified prior to its enclosure by younger calcite. In some veins, clots and spheres of dead oil are embedded in native copper in a manner indicating that the oil is at least as old as the metal. The age of the inclusion-bearing vein calcite (1047 ± 35 Ma; Ruiz et al., 1984) provides a minimum age for the oil, and confirms the long-standing assumption (based on more debatable evidence) that the White Pine petroleum is truly Precambrian in age. (Authors' abstract)

KELLY, W.C. and NISHIOKA, G.K., 1985, Precambrian oil inclusions in late veins and the role of hydrocarbons in copper mineralization at White Pine, Michigan: Geology, v. 13, p. 334-337. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Liquid oil was trapped as primary fluid inclusions in calcite crystals in late Cu-Fe sulfide-bearing veins that crosscut and offset the cupriferous shale deposit at White Pine. The age of the calcite (1047 ± 35 Ma) is an entrapment age and thus a minimum age for the oil. Close temporal and spatial associations of oil and metallic sulfides in the late veins suggest that liquid and solid hydrocarbons may have been dominant controls of the mainstage White Pine copper mineralization. (Authors' abstract)

KELSALL, P.C. and NELSON, J.W., 1985, Geologic and engineering characteristics of Gulf region salt domes applied to underground storage and mining: Sixth Int'l. Symp. on Salt, 1983, v. 1, p. 519-544. First author at IT Corp., Albquerque, NM, USA.

Includes a discussion of brine seeps, gas inclusions, and "pressure pockets." (E.R.)

KENNEDY, B.M., 1985, Noble gases in vent fluids from the Juan de Fuca Ridge (abst.): EOS, v. 66, no. 46, p. 929.

KENNEDY, B.M., LYNCH, M.A., REYNOLDS, J.H. and SMITH, S.P., 1985, Intensive sampling of noble gases in fluids at Yellowstone: I. Early overview of the data; regional patterns: Geochimica Cosmo. Acta, v. 49, p. 1251-1261.

KENNEDY, B.M., REYNOLDS, J.H. and SMITH, S.P., 1985, Noble gases from a continental hot spot: The Yellowstone caldera (abst.): Lunar & Planet. Sci., v. 16, p. 428-429.

KEPEZHINSKAS, K.B. and KEPEZHINSKAS, V.V., 1984, Metamorphic formations of Northern Mongolia: Geologiya i Geofizika, no. 12, p. 126-135 (in Russian; English abstract). Authors at Inst. Geol. and Geophysics of Siberian Br. Acad. Sci., Novosibirsk, USSR.

Rocks of metamorphic formations of ophiolite zones were subjected to short-period regional metamorphism at ~500°C under $P \leq 7$ kbar, determined from inclusions of L CO_2 and L CH_4. (A.K.)

KEPEZHINSKAS, K.B. and TOMILENKO, A.A., 1985, Dynamics of varying fluid composition during metamorphism in ophiolite zones: An example from Eastern Prikhubsugul'ye [Mongolia]: Dokl. AN SSSR, v. 285, no. 4, p. 963-966 (in Russian; translated in Int'l. Geol. Rev., v. 27, p. 1461-1464, 1985). Authors at Inst. Geol. & Geophysics of Siberian Div. USSR Acad. Sci., Novosibirsk, USSR.

The investigated complex of Precambrian-Lower Cambrian age in E. Prikhubsugul'ye (Mongolia) consists of metamorphosed Pre-Riphean continental formations, Lower- and Middle Riphean sediments of epicontinental basins, and Upper Riphean-Lower Cambrian oceanic stage rocks, including ophiolites, which formed during late Riphean-Vend. Gas chromatographic analyses (22) were made of magmatic and terrigenic rocks of ophiolite complex: 1) lower gabbro from lower tectonic sheet in the basin of the river Alar-Tsari-gol, 2) orbicular basic and intermediate lavas of the upper sheet in the same region, 3) volcanic-sedimentary rocks overlapping magmatic rocks of the ophiolite complex (a) and the same rocks from the zone of contact with continent (b). The entire complex was regionally metamorphosed. Inclusions formed during metamorphism in quartz yielded the following values of P at T of metamorphism determined from the paragenetic relations: gabbro (N_2 + H_2O ± CO_2 inclusions, Th* -168 to -185°C), at 600°C P = 5-7 kbar (Th of inclusions of silicate melt equals 880-900°C); orbicular lavas (inclusions as in gabbro, same Th and CO_2 + H_2O + salt inclusions, Th* -20 to -45°C), at 500°C P = 4-6 kbar; volcanic-sedimentary rocks (inclusions of CO_2 + H_2O + salts, Th* -10 to -20°C), at 500°C P = 4-4.5 kbar. Chromatographic studies

showed that metamorphic fluid had essentially $CO_2 + H_2O$ + salt composition with variable CO_2/H_2O ratio and variable N_2 content. Maximum N_2 concentrations comparable with content of H_2O and CO_2 occur in orbicular lavas of the upper sheet (2.3-160 mg/kg); lower gabbro contains intermediate concentrations of N_2 (2.0-47 mg/kg) and volcanic-sedimentary rocks of upper sheet contains practically no N_2 (0.0-5.2), except in zones of reaction with pre-Riphean sialic basement. The other gases are as follow: lower gabbro CO_2 21-200, CO traces 22, CH_4 0.0-1.5, H_2 0.0-3.2, H_2O 92-960; orbicular lavas CO_2 11-200, CO 6.5-14, CH_4 traces, H_2 0.0-0.4, H_2O 45-390; volcanic-sedimentary rocks CO_2 39-260, CO traces-19, CH_4 traces, H_2 0.0-0.3, H_2O 58-940, all concentrations in mg/kg of quartz. The composition of fluid mostly depends on the proportion of original magmatic and sedimentary rocks in the ophiolite complex. (Abstract by A.K.)
*Th of $LCO_2 + GCO_2$

KEPEZHINSKAS, K.B., TOMILENKO, A.A., PRUSEVICH, N.A. and FOMINA, L.N., 1985, Composition of fluid inclusions in quartz of Precambrian-Lower Cambrian formations of the eastern Hubsugul area (Mongolia) (abst): Zap. Vses. Mineral. O-va., v. 114, no. 5, p. 569-575 (in Russian).

In the geological structure of the eastern Hubsugul area, 3 rock complexes of diverse age are observed: (1) the pre-Riphean complex of the continental-crust formation stage, (2) the Early-Middle Riphean complex of the stage of epicontinental basins, and (3) the Upper Riphean-Lower Cambrian complex of an oceanic stage. Quartz (Q) was separated from schists, gneisses, amphibolites, migmatites, etc. Results are presented of the chromatography analysis of the gas phase of fluid inclusions in Q, with determinations of CO_2, CO, CH_4, H_2, H_2O, and N_2. The $(CO_2 + CO)/H_2O$ value is plotted against the N_2 concentration; 3 distinct fields are observed in relation to the lithol. of the host rock of Q. The composition and pressure of fluids in individual inclusions in Q are calculated. (C.A. 104: 22142r)

KERRICH, R. and VIBETTI, N.J., 1985, Evolution of Ca-chloride brines in Cyprus ophiolite: Evidence from C and O isotopes (abst.): EOS, v. 66, p. 1128-1129. Authors at Dept. Geol., Univ. Western Ontario, London, Ontario, Canada N6A 5B7.

Pervasive Ca-metasomatism of basalt-gabbro is encountered at depths of 400 to 1,600 m in drill hole CY-4 penetrating the Troodos ophiolite of Cyprus. High-temperature (actinolite, anorthite, epidote, albite, quartz) and low-temperature (laumontite, calcite) alteration assemblages are present. In quartz-actinolite veins, $\delta^{18}O$ quartz values are restricted (+5.8 to +7.6‰) whereas actinolite spans 1.1 to 6.7‰. Based on filling temperatures of hypersaline $CaCl_2$ fluid inclusions in the quartz (Vibetti et al., 1985, this volume), and assuming that solute effects on mineral-brine fractionations are small, the veins grew in equilibrium with solutions where $\delta^{18}O(H_2O)$ = 3.6 (400°C) to -0.5 (300°C). During equilibrium exchange with serpentine ($\delta^{18}O$ ~5.7) under conditions of low water/rock, marine water may evolve from $\delta^{18}O$ = 0‰ to +3.4‰ (200°C) or +6.2‰ (400°C). Such exchange conditions can account for the estimated $\delta^{18}O(H_2O)$ and hypersaline $CaCl_2$ character of the brines. Late-stage calcite + laumontite occupy shear zones, tensile fractures and vugs. In the first ($\delta^{13}C = +1.5 \pm 1.0$, $\delta^{18}O = 11.7 \pm 2$) calcite and laumontite coprecipitated from fluids $\delta^{18}O = 2 \pm 2$‰ at 150 to 200°C, in the low-temperature domain of the $CaCl_2$-thermal brine system. The second population ($\delta^{13}C$ = -16 to -12, $\delta^{18}O$ = 17 to 23) involved some C contributed from a reduced C-reservoir, and was precipitated at ≤100°C, either in the submarine environment or during obduction. (Authors' abstract)

KERRICK, D.M., MULLIS, Joseph and KLEIN, H.-H., 1985, Al_2SiO_5-bearing segregations in the Lepontine Alps, Switzerland: Aluminum mobility in metapelites (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 627. First author at Geosci. Dept., The Pennsylvania State Univ., University Park, PA 16802.

Segregations containing Al_2SiO_5 minerals are common in amphibolite facies metapelites of the Lepontine Alps. Within the Ticino culmination, pretectonic kyanite within segregations was replaced by postectonic andalusite; however, kyanite is generally the only Al_2SiO_5 mineral in the host metapelites. Correlation between the regional distribution of kyanite and sillimanite in the segregations and host rocks, coupled with textural features, suggest that the segregations formed when the Lepontine thermal regime was well established. Biotite-rich rims around the segregations probably represent a significant source of components via fluid-phase transport of solutes derived from the dissolution of quartz, muscovite and plagioclase originally contained within such rims. Transport of Al as alkali complexes, as suggested by recent experimental data of G.M. Anderson and coworkers, is supported by the apparent breakdown of alkali silicates within the host rock. Confinement of andalusite to the segregations is attributed to localized pressure diminution within a dilational tectonic regime. Fluid inclusions in kyanite and andalusite contain H_2O-CO_2 mixtures with variable H_2O/CO_2 ratios, and salinities of 4 to 7 mole % equiv. NaCl. The fluid inclusion data support the argument that segregations formed when low-CO_2, low-chloride fluids from the host metapelite mixed with CO_2-rich, high chloride fluids within fracture zones. These segregations attest to the efficacy of Al mobility in metapelites containing chloride-poor fluids, and invalidate an Al-immobile reference frame for metasomatic modeling of such systems. (Authors' abstract)

KERRIDGE, J.F., 1985a Measurement and interpretation of D/H in meteorites: A reappraisal (abst.): Lunar and Planetary Sci. XVI, p. 432-433.

KERRIDGE, J.F., 1985b Nitrogen isotopes in lunar regolith: A continuing puzzle (abst.): Lunar and Planetary Sci. XVI, p. 430-431.

KESLER, S.E., JONES, L.M. and RUIZ, J., 1985, Sr and S isotopic geochemistry of the Galena barite district, Nuevo Leon, Mexico: A test of the mixing model for barite deposition (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 628.

KETO, L.S. and JACOBSEN, S.B., 1985, The causes of $^{87}Sr/^{86}Sr$ variations in seawater of the past 750 million years (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 628.

KHARAKA, Y.K., CAROTHERS, W.W. and LAW, L.M., 1985, Origin of gaseous hydrocarbons in geopressured geothermal waters (abst.), in Dorfman, M.H. and Morton, R.A., eds., 1985, Geopressured-Geothermal Energy, Proc. 6th U.S. Gulf Coast Conf.: New York, Pergamon Press, p. 125. Authors at U.S. Geol. Survey, Water Resources Div., 345 Middlefield Road, MS/427, Menlo Park, CA 94025.

Geopressured geothermal waters in sedimentary basins are saturated with methane at subsurface temperature, pressure and water salinity. Methane is the dominant hydrocarbon gas in these waters comprising over 90% of the total, with decreasing proportions of ethane, propane, butane, and other gases. These waters also contain high concentrations (>1,000 mg/L) of short-chain aliphatic acid anions. Acetate is the dominant organic anion comprising over 90% of the total, with decreasing proportions of propionate, butyrate, and valerate. Dissolved monocarboxylic acid anions (C_6-C_9) and dicarboxylic anions (C_4-C_{10}) have also been identified in these waters.

A large portion and probably the bulk of gaseous hydrocarbons dissolved in these waters is produced from thermal decarboxylation of these organic acid anions. This conclusion is based on: (1) natural distribution of these acid anions--the highest concentrations (up to 10,000 mb/L) are at subsurface temperatures of about 80°C and decrease to zero at about 200°C; (2) $\delta^{13}C$ values of total carbonate and methane that indicate decarboxylation; (3) a good correlation between the proportions of the organic acid anions and their decarboxylation gases; and (4) laboratory experiments showing that acetic acid can be decarboxylated to CO_2 and methane. (Authors' abstract)

KHARDIKOV, A.E., 1985, Peculiarities of sulfur-forming fluids in the sulfur prospects in the Gaurdak-Kugitang region (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 208-210 (in Russian; translation by D.A. Brown). Author at Rostov State Univ., Rostov-on-Don, USSR.

In the native sulfur from this region, the P inclusions are ≤25 μm in size, and occur singly or in small groups, both in the center, and on the margins of the grains. There are approximately equal numbers of gas and liquid inclusions. Solid inclusions of oxykerite [ozocerite?] form a special group, and bituminoids are present (0.000n wt. %).

Gas chromatography shows that the sulfur-calcite aggregates, developed from the sulfate rocks, contain H_2O, CO_2 and butane, and in the Kyzyltumshuk sector, H_2S predominates.

The coarsely-crystalline calcites with pyrite in geodes and vugs in the Neogene conglomerates, overlyng the sulfur-bearing sequences in the Kyzyltumshuk sector, contain a predominance of H_2O over CO_2 and H_2S. In the exposed part, on the flank of the sulfur deposit in the Kyzyltumshuk sector, H_2O predominates in the finely-crystalline calcite. Aqueous extracts from the mineral aggregates show $CaSO_4$, or Na, Mg, and Cl. These various features are characteristic and may be used both for determining the genetic category of the sulfur ores, and also as tests for predicting sulfur mineralization of the infiltration-metasomatic type, which is of the greatest practical interest. (From the author's abstract)

KHEANG, Lao, PERRAULT, Guy and AUDET, Andre, 1985, Thermo-chemistry of aqueous fluid related to the formation of Sigma-2 gold deposit, Val d'Or, Quebec (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A31. First author at Dépt. Génie Min., Ecole Polytech., Montréal, Québec, H3C 3A7, Canada.

Fluid inclusions in gold-bearing quartz veins from Sigma-2 deposit consist of 86% aqueous inclusions, 8% carbonic-aqueous inclusions with variable CO_2/H_2O and 6% inclusions filled with CO_2.

Most aqueous inclusions are moderately saline (salinity ranging from 9.8 to 13.8 wt% eq NaCl, and filling temperatures varying between 270 and 390°C), and only 5% of those inclusions are highly saline (salinity ranging from 29.2 to 30.8 wt% eq NaCl, and filling temperatures from 114 to 157°C). The vapor phase in highly saline inclusions is usually less than 10% of the total cavity volume.

From fluid inclusion data, the ore-bearing fluid in quartz veins of Sigma-2 deposit has a low salinity (average of 10.9% wt% eq NaCl), a temperature ranging from 300 to 370°C, a high content of Na (average $Na/(Na^+K) = 0.94$), a high content of chlorine (average $Cl/(Cl^+S) = 0.97$), an imporatnt amount of Ba (average $Ba/(Na^+K) = 0.20$) and a very low CO_2

content. The impure CO_2-rich phase has a melting temperature, ranging from -57.1 to -59.6°C, lower than the normal melting temperature of pure CO_2-ice (-56.6°C). A late escape of H_2O-vapor is assumed to be responsible for the generation of some highly saline inclusions.

The gold-bearing fluid of Sigma-2 deposit with its low CO_2 content and low salinity (10.9 wt% eq NaCl) contrasts with the usual reported gold-bearing fluids that are described to have a high CO_2 content and a very low salinity of generally less than 3.5 wt% eq NaCl. (Authors' abstract)

KHOTEEV, A.D., 1985, Problems in the use of gas-dynamic decrepitation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 80-81 (in Russian). Author at Inst. Geochem. & Anal. Chem. Acad. Sci., Moscow, USSR.

Td was measured on the basis of recording of gas release in vacuum. G release due to inclusion opening has strongly expressed "impulse" character, whereas G coming from decomposition of minerals or desorption are of laminar type. Sensitivity of the decrepitometer permits recording of inclusion breaks that contained 10^{-9} g of fluid, thus microadmixtures of carbonates, etc., may strongly influence the type of recorded curves. High resolution ability makes possible the recording of two peaks of gas release differing in Td for 5-7°C from sample bearing two generations of quartz at T of α-β inversion. The necessary vacuum is 10^{-1} to 10^{-2} mm of Hg, sample weight 1-50 mg. (A.K.)

KHOTEEV, A.D., SHUL'TS, A.M. and SAPOZHNIKOV, R.M., 1985, Set of microscope stages for studies of gas-liquid and melt inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 54 (in Russian). Authors at IGEM, Moscow, USSR.

The set of three replaceable inserts in the microscope stage is described. The first insert UMTK-700 is used for determinations of Th of GLI, T measurements up to 700°C, using current of 5V, 5A; the second insert UMTK-1500 may work up to 1500°C; the heating element is made from Pt 70 Rh 30, water cooling is used and mirror filters protect the optics of microscope; the current is 1V, 50A; the insert UMTK-krio consists of a semiconducting cryoelement, working current supply: 9V, 9A. (A.K.)

KIDNAY, A.J., MILLER, R.C., SLOAN, E.D. and HIZA, M.J., 1985, A review and evaluation of the phase equilibria, liquid-phase heats of mixing and excess volumes, and gas-phase PVT measurements for nitrogen + methane: J. Phys. Chem. Ref. Data, v. 14, no. 3, p. 681-694.

KIGAI, I.N. and SAMOVAROV, Yu.V., 1985, On the properties of the fluids of the early stages of mineralization of the Trudovoye tin deposit (Kirghizia) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 140-141 (in Russian; translation by Dorothy B. Vitaliano). Authors at Inst. Geol. of Ore Deposits, Pet., Min. & Geochem., Acad. Sci. USSR, Moscow, USSR.

According to an earlier-developed model, in each stage of mineralization acid leaching is accomplished by condensates of the gas phase of a stratified subcritical fluid, and subsequently ore deposition is initiated by liquid solutions enriched in haloids of bases, silica, and ore-forming metals relative to the condensates (Kigai, 1975, 1979).

According to the data of A.B. Pavlovskiy (oral communication), the Trudovoye deposit was formed no deeper than 2 km from the paleo-surface, which corresponds to a lithostatic pressure of about 50 MPa.

The aggregate state of the fluids of stage I (early barren calcite then quartz) varies, presumably, from supercritical gaseous in the period of alkaline metasomatism to liquid in the period of quartz deposition, with brief boiling when pressure dropped as a result of unsealing of the system. In the quartz of this stage various inclusions are found: liquid-gas with Th = 300-470°C, gas-liquid and multiphase with temperature of partial homogenization of 336-418°C; as a second fluid phase, CO_2 is often present in various amounts, but it does not form independent inclusions. According to the data of cryometry, NaCl (from 21.5 to 2.0 wt.%) and KCl (from 7.5 to 16.0 wt.%) are the main components in the fluids of this stage. When heated, all multiphase inclusions decrepitate before Th. From this it can be concluded that at Tt, the pressure of the fluids was >86 ± 5 MPa, i.e., the average pressure of the massive decrepitation of the inclusions in quartz (V.B. Naumov et al., 1966), and consequently was a little higher than lithostatic. This indicates mineralization under conditions of a hydrodynamically closed system.

At the base of the quartz crust associated with wolframite and cassiterite of stage II, a broad zone of growth was found with abundant small synchronous inclusions of three types: (1) gas-liquid, with about 16 wt.% equiv. NaCl and Th ~450°C; (2) liquid-gas, with Th = 454-515°C; (3) pure CO_2 with Th(L) at 24°C, which corresponds to a density of 0.717 g/cm^3 and pressure of 165 MPa (for Th = 450°C). There are [also] transitional inclusions. The coexistence of such inclusions convincingly shows that the beginning of deposition of quartz of the greisen stage and greisenization occurred from heterogeneous fluids. As in stage I, the process went on without leakage of fluids to the surface, as the fluid pressure, being more than 3 times the lithostatic, could not have been maintained long in a circulating system.

These data are in good agreement with the model of hydrothermal mineralization mentioned above. Apparently, the need has already matured[sic] to distinguish brief boiling of liquids upon unsealing of the ore-forming system from long-term heterogeneous state of the fluids in the period of formation of pre-ore acid metasomatites. (Authors' abstract)

KIM, C.J. and PARK, H.-I., 1984, Mineral paragenesis and fluid inclusions of Geoje copper ore deposits: J. Korean Inst. Mining Geol., v. 17, no. 4, p. 245-258 (in Korean; English abstract).

Geoje copper ore deposits are fissure filled copper veins which developed in late Cretaceous pyroclastics, andesite and shale. Mineral paragenesis reveals a division of the hydrothermal mineralization into three stages: Stage I, pyrite, magnetite, specularite, quartz and chlorite; Stage II, chalcopyrite, sphalerite, galena, tetrahedrite, aikinite, cosalite, electrum, quartz and chlorite; Stage III, barren calcite. Th of fluid inclusions in quartz of stage I range from 171 to 282°C whereas fluid inclusions in quartz and sphalerite of stage II range from 213 to 262°C and from 186 to 301°C respectively. Salinities of fluid inclusions in quartz of stage I range from 5.2 to 11.2 wt.% NaCl equiv. Salinities of fluid inclusions in quartz and sphalerite of stage II range from 6.6 to 10.9 and from 7.1 to 14.4 wt.% NaCl equiv.

Salinities of ore fluid during major mineralization stage in this deposit reveal nearly the same ranges as those of many copper deposits in Koseong copper mining district which located about 30 km apart from Geoje mine. But Th of fluid inclusions formed during major copper mineralization stage in this deposit are slightly lower than those of copper deposits in Koseong copper mining district. (Authors' abstract)

KIMBALL, K.L., SPEAR, F.S. and GERLACH, D.G., 1985, Evolving hydrothermal systems in the Islas Orcadas Fracture Zone (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 629. First author at Dept. Earth Sci., SUNY-Albany, Albany, NY 12222.

Petrographic and isotopic evidence suggest that the chemical and isotopic composition of fluids responsible for alteration of ultramafic rocks from the Islas Orcadas Fracture Zone evolve with time. Reaction space analyses of high T alterations indicate these reactions release small amounts of Mg, Fe and Si to the fluid. Calculations of equilibrium fluid compositions indicate fluids concentrated in metallic chloride species, suggesting 1) low water/rock ratios (<<1) or 2) reaction of the fluid with other rocks prior to its reaction with the ultramafics. Reaction space analyses of low T alterations show production of larger quantities of metallic species and are compatible with calculated field compositions at water/rock = 1.

In vein mineral separates, high T minerals have lower 87/86Sr and higher Sr than later, lower T minerals, suggesting MORB contamination of the early fluids and more seawater component in late fluids. In samples containing multiple generations of a mineral in one vein, earlier minerals have lower 87/86Sr (more MORB at ~.703? (58-24: Chl1 = .70421 ± 3, Chl2 = .70476 ± 4, Chl3 = .70471 ± 4: Prehnite1 = .70559 ± 3, Prn2 = .70574 ± 5: 60-44: Chl1 = .70753 ± 3, Chl2 = .70771 ± 4, Serp1 = .70779 ± 4, Serp2 = .70866 ± 8, Serp3 = .70912 ± 3: 56-41: Chl = .70389 ± 6, Prn = .70501 ± 9, Serp = .70536 ± 8: 61-75: Serp1 = .70786 ± 3, Serp2 = .70890 ± 5)) than later minerals (more seawater at ~.709?). Oxygen isotopes show MORB affinities (60-44: δ18O: Cpx = +5.9 Chl = +5.89 Serp1 = +6.34 Serp 3 = +6.16). (Authors' abstract)

KINNAIRD, J.A., 1985, Hydrothermal alteration and mineralization of the alkaline anorogenic ring complexes of Nigeria: J. African Earth Sci., v. 3, no. 1/2, p. 229-251. Author at Dept. Geol., Univ. St. Andrews, St. Andrews KY16 9ST, UK.

The Jurassic alkaline anorogenic granitic ring complexes in central Nigeria are discordant high level intrusions emplaced by piecemeal stoping through a collapsed central block. Biotite granites predominate over fayalite or amphibole bearing variants and are important for their ore deposits. A series of alteration processes, with related mineralization, can be recognized. Early high temperature sodic metasomatism may introduce niobium mineralization as pyrochlore in peralkaline facies and columbite in biotite granites. Later processes, beginning with potash metasomatism affect only the biotite granites. Accessory monazite, zircon, cassiterite, rutile, molybdenite and occasionally wolframite are associated with mica distribution. Subsequent acid metasomatism results in greisenization. The ore assemblage deposited at this stage is dominantly of oxides with early monazite, zircon and ilmenite followed by cassiterite - the major ore, wolframite, sometimes columbite or siderite and always rutile. During silica metasomatism early cassiterite is followed by abundant sphalerite, chalcopyrite, galena and occasionally arsenopyrite or pyrite. Chloritization and argillization are important but more restricted alteration processes. Fluid inclusion studies indicate that there are an initial separation of dense saline brine from the residual melt followed by vapor phase separation, to evolve a low density fluid. Fluids responsible for early metasomatic alteration and pegmatite development are highly saline and may contain glassy fluorosilicate phases. Th values are between 380 and 550°C. Later fissure-filling veins form in the range 300-380°C at salinities up to 15 eq. wt% NaCl, with the latest mineralized quartz veins in the range 200-300°C and salinities <10 eq. wt% NaCl. In addition, low temperature, monophase inclusions occur which are probably associated with late stage argillic alteration. Superimposed on this general pattern of decreasing temperature and salinity are important stages of immiscible phase separation related to CO_2 loss and local increase of salinity due to boiling as pressure is released.

Mineralization may take the form of: (i) late magmatic pegmatites, (ii) pervasive metasomatic disseminations, (iii) pre- and postjoint pegmatitic lenses, (iv) quartz rafts, stockworks, sheeted veins and altered wall rock, (v) fissure-filling veins, (vi) irregularly shaped replacement bodies, (vii) quartz veins, (viii) ring-dykes, (ix) alluvial and eluvial deposits. The different processes of alteration and associated mineralization characterize different parts of a granite pluton: (i) the roof zone, (ii) marginal zone, (iii) contact zone, (iv) the country rock, (v) the ring-dyke zone. (Author's abstract)

KINNAIRD, J.A., BOWDEN, P., IXER, R.A. and ODLING, N.W.A., 1985, Mineralogy, goechemistry and mineralization of the Ririwai complex, northern Nigeria: J. African Earth Sci., v. 3, no. 1/2, p. 185-222. First author at Dept. Geol., Univ. St. Andrews, St. Andrews KY16 9ST, UK.

The Ririwai complex represents the eroded roots of an alkaline volcano developed as part of a sequential chain of anorogenic centers in early Jurassic times. An outer ring-dyke fracture which formed a volcanic feeder is filled with quartz porphyry, and granite porphyry surrounds and partly encloses a caldera-collapsed volcanic pile into which peralkaline granite and biotite granite have been emplaced. The volcanic rocks are dominantly rhyolitic ignimbrites with minor basalts, showing petrological and geochemical features of magmatic crystallization and subsolidus re-equilibrium. The volcanic feeder intrusions are partly quenched and partly degassed representatives of the original granite magma but petrological and geochemical data testify to the limited interaction of an alkaline residual fluid phase. The effects of the fluid phase are seen as a series of metasomatic reactions generating peralkaline granites, biotite granites and their mineralization. The interactions between crystal and fluids have been monitored by XRD, XRF, INAA, wet chemical analyses and fluid inclusion studies. Ore mineralogy confirms the paragenetic columbite (pyrochlore)-cassiterite-sphalerite evolution. The metasomatic reactions commence with Na^+ metasomatism followed by K^+, then H^+ and finally Si^{4+}. The latter reactions are best displayed in the Ririwai lode where particle track studies have delineated the relative mobility of U and Th. Mineralization in biotite granite can be grouped according to the dominant metasomatic process. Columbite, minor cassiterite and sphalerite can be equated with albitite formation. Potash metasomatism generated columbite, wolframite, cassiterite and sphalerite deposition, which continued into greisen formation as H^+ metasomatism developed. This was accompanied by molybdenite, chalcopyrite and galena deposition during silica metasomatism. According to isotopic data the source of the ore metals and the granite magma was probably the Pan-African continental crust with contributions from the mantle. (Authors' abstract)

Inclusion types include: liquid-rich, gas-rich, liquid-vapor-NaCl, devitrified melt, H_2O-CO_2, monophase H_2O. (E.R.)

KITA, Itsuro, TAGUCHI, Sachihiro and MATSUBAYA, Osamu, 1985, Oxygen isotope fractionation between amorphous silica and water at 34-93°C: Nature, v. 314, p. 83-84.

KITANO, Y., ed., 1985, Water-rock interaction, Special issue: Chem. Geol., v. 49, no. 1-3.

Includes 28 articles on a wide variety of aspects. Three of the most pertinent are separately listed in this volume. (E.R.)

KLATT, E. and RAITH, M., 1985, Microthermometrical investigation of the prograde charnockitization of garnet-biotite-sillimanite metatexites from Kerala, southern India (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 82-83. Authors at Univ. Bonn, Bonn, FRG.

An extended segment of Archaean crust in the southernmost part of India (Kerala State) shows all stages of progressive charnockitization of garnet-biotite gneisses and migmatites. By this process these rocks are transformed to massive orthopyroxene-garnet bearing charnockites along a complex system of fractures. It has been suggested that charnockitization was induced by the influx of CO_2-rich fluids derived from a deep seated source (decarbonitization of subducted sediments and/or upper mantle) (Kumar et al. 1985). The results of geothermobarometry indicate P-T conditions of 770 ± 50°C and 6 ± 1 kbar for the granulite facies metamorphism.

The aim of this study is to characterize the metamorphic fluids and to examine if the conversion of amphibolite grade gneisses into charnockites can be correlated to changes in the fluid phase composition, e.g. to an increase in CO_2. Fluid inclusions in quartz and garnet were studied in samples from Punalur (south Kerala) showing incipient charnockitization.

In the garnet-biotite gneisses two-phase CO_2 inclusions and three-phase CO_2-H_2O inclusions occur commonly, but rare two-phase H_2O inclusions were found as well. Tm CO_2 range from -56.6 to -58.0°C with a max. at -57.6°C, indicating hydrocarbon contents between 0 and 8 mol. % equiv. CH_4. Th CO_2 occurs between 10 and 28°C with a marked peak at 24°C and two further peaks at 16 and 12°C, yielding densities of 0.73; 0.81 and 0.84 g/cm^3. The three-phase inclusions give similar CO_2 densities and estimated $CO_2/(CO_2 + H_2O)$ ratios between 0.9 and 0.6.

Aqueous inclusions have salinities below 4 mol. % equiv. NaCl. The formation of clathrates (Tm 8°C) indicates the presence of minor CO_2 in these inclusions. Th ranges from 80 to 180°C with distinct peaks at 130 and 180°C, corresponding to densities of 0.93 and 0.89 g/cm^3 respectively.

The charnockites have the same types of fluid inclusions as observed in the unaltered garnet-biotite gneisses, but the CO_2 inclusions show two clearly separated peaks for the melting temperature, i.e., -56.7 and -57.6°C which indicates hydrocarbon contents of 0 and 6 mol. % equiv. methane. Th range of CO_2 is wider (8 to 28°C) than in the gneisses and three peaks occur at about 26, 18 and 10°C, corresponding to density values of 0.70, 0.79 and 0.86 g/cm^3. Estimated $CO_2/(CO_2 + H_2O)$ ratios of the three phase inclusions vary between 0.9 and 0.6. The rare watery inclusions have the same properties as those of the gneisses.

No significant change in the fluid inclusion types and hence fluid phase regime was observed when passing from the gneiss into the charnockite. The occurrence of at least four different generations indicate a complex buffer-controlled evolution of fluid phase composition during metamorphism of the graphite-bearing gneisses and the subsequent charnockitization.

Isochores for the three-phase CO_2-H_2O inclusions determined according to Swanenberg (1980) pass through the P-T field drived from geothermobarometry and thus indicate entrapment during granulite facies metamorphism. The denisty data for the nearly pure CO_2 inclusions, however, indicate variable and lower fluid pressures (2-4 kbars) of entrapment. Judging from the textural relations the high density H_2O inclusions could have formed during the peak stage of gneiss formation. If this proves true this metamorphic event would be characterized by much higher fluid pressures (8-10 kbars at 600-700°C) than the subsequent charnockitization. (Authors' abstract)

Literature:

Kumar, G.M.R.; Srikantappa, C.; Hansen, S.: Charnockite in the making at Ponmudi, Kerala, South India. Nature, in press, 1985.
Swanenberg, H.E.C.: Fluid inclusions in high-grade metamorphic rocks from S.W. Norway. Geologica Ultraiectina, No. 25, Utrecht, 1980.

KLINGER, Jürgen, et al., eds., 1985, Ices in the solar system, NATO Adv. Research Workshop, 1984, Nice, France: Dordrecht, D. Reidel Publ. Co., 954 pp.

Contains many discussions of low-temperature phase equilibria (and properties) including H_2O, CO_2, CH_4, NH_3 and numerous other compounds. (E.R.)

KNAUSS, K.G., BEIRIGER, W.J., PEIFER, D.W. and PIWINSKII, A.J., 1985, Hydrothermal interaction of solid waters of Topopah Spring tuff with ground water and distilled water at 90°C, 150°C and 250°C using Dickson-type, gold-bag rocking autoclaves (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 630.

KNAUTH, L.P. and BEEUNAS, M.A., 1985, Origin of fluid inclusion water in bedded salt deposits, Palo Duro basin, Texas: Office Nuclear Waste Isolation Tech. Rept. No. BMI/ONWI-569, 59 pp. Authors at Arizona State Univ.

Salt horizons in the Palo Duro Basin being considered for repository sites contain fluid inclusions which may represent connate water retained in the salt from the time of original salt deposition and/or external waters which have somehow penetrated the salt. The exact origin of this water is important to the question of whether or not internal portions of the salt deposit have been, and are likely to be, isolated from the hydrosphere for long periods of time.

The $^{18}O/^{16}O$ and D/H ratios measured for water extracted from solid salt samples show the inclusions to be dissimilar in isotopic composition to meteoric waters and to formation waters above and below the salt. The fluid inclusions cannot be purely external waters which have migrated into the salt.

The isotope data are readily explained in terms of mixed meteoric-marine connate evaporite waters which date back to the time of deposition and early diagenesis of the salt (>250 million years). Any later penetration of the salt by meteoric waters has been insufficient to flush out the connate brines. (Authors' abstract)

KNAUTH, L.P., KEALY, Sarah and LARIMER, Sarah, 1985, Isotopic composition of Silurian seawater (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 630. Authors at Dept. Geol., Arizona State Univ., Tempe, AZ 85287.

Direct isotopic analyses of 21 samples of the Silurian hydrosphere preserved as fluid inclusions in Silurian halite deposits in the Michigan Basin Salina Group yield $\delta^{18}O$, δD ranging from 0.2 to +5.9 and -26 to -73, respectively. $\delta^{18}O$ has the same range as observed for modern halite facies evaporite waters and is a few ‰ higher than 100 analyses of fluid inclusions in Permian halite. δD is about 20 to 30‰ lower than modern and Permian examples.

The trajectory of evaporating seawater on a δD-$\delta^{18}O$ diagram initially has a positive slope of 3-6, but hooks strongly downward to negative values, the shape of the hook depending upon humidity. Halite begins to precipitate at δ values as observed for the fluid inclusions. The fluid inclusion data can be readily explained in terms of evaporating seawater and are consistent with the degree of evaporation deduced from measured bromide profiles.

These data are strongly inconsistent with arguments that Silurian seawater was 5.5‰ depleted in ^{18}O. $\delta^{18}O$ for evaporite waters is systematically related to that of seawater, and does not show a -5.5‰ shift in the Silurian, even allowing for variables which affect the isotope evaporation trajectory. The lower δD may indicate a component of gypsum dehydration waters or may suggest a D-depleted Silurian hydrosphere. (Authors' abstract)

KNUTSON, Craig, PEACOR, D.R. and KELLY, W.C., 1985, Luminescence, color and fission track zoning in apatite crystals of the Panasqueira tin-tungsten deposit, Beira-Baixa, Portugal: Am. Mineralogist, v. 70, p. 829-837. First author at MOEPSI, 1250 Poydras Building, New Orleans, LA 70113.

Pertinent to recognition of inclusion/zone growth relationships. (E.R.)

KOBAYASHI, Katsuhiko and NAGASHIMA, Akira, 1985, Measurement of the viscosity of sea water under high pressure: High Temperatures-High Pressures, v. 17, p. 131-137.

KOGARKO, L.N., KRIGMAN, L.D. and BELYAKOVA, Ye.N., 1984, The nepheline-diopside-apatite system and liquid evolution during the crystallization of an apatite-bearing ijolite-urtite magma: Geokhimiya, no. 4, p. 472-493 (in Russian, English abstract; translated in Geochem. Int'l., v. 21, no. 4, p. 38-58, 1985). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

The nepheline-diopside-fluorapatite phase diagram has been studied experimentally. Local microprobe analysis has been used to determine the compositions of the mineral phases and the liquids coexisting with them as well as the partition coefficients for trace elements.

The data are used in considering the behavior of liquids of ijolite-urtite composition, and it is shown that the Khibiny apatite-nepheline deposits are due to crystallization differentiation of a single ijolite-urtite magma and cannot be the product of liquid immiscibility between phosphate and aluminosilicate melts. (Authors' abstract)

KOIVULA, J.I. and KELLER, P.C., 1985, Russian flux-grown synthetic emeralds: Gems & Gemology, v. 21, p. 79-85. First author at Applied Gemology Sec., Research Dept., Gemological Inst. America, Santa Monica, CA.

Describes the various types of inclusions of lead vanadate flux in Russian synthetic emerald. (E.R.)

KOLODIY, V.V. and KOYNOV, I.M., 1984, Groundwater hydrogen and oxygen isotope compositions and origins in the Carpathian region: Geokhimiya, no. 5, p. 721-723 (in Russian, English abstract; translated in Geochem. Int'l., v. 21, no. 5, p. 101-113, 1985). Authors at Inst. Fossil-Fuel Geol. & Geochem., Acad. Sci. Ukrainian SSR, L'vov.

Hydrogen and oxygen isotope compositions have been examined in groundwaters in the Precarpathian and Transcarpathian troughs as well as in the folded Carpathians, and it has been found that there are three groups differing in deuterium and oxygen 18 contents. Correlations are established between the modes of occurrence of the groundwaters, their salt contents, and their chemical compositions on the one hand and their isotope compositions on the other, which indicate that a detailed interpretation of all the data is required in order to elucidate the origins of the waters. It has been found that in the region examined, brine arising from leaching of the salt-bearing Miocene molasse plays an appreciable role in producing the sodium-calcium chloride brines in the flysch in the Precarpathian trough and the folded Carpathians. It is possible for hydrogen isotopes to become separated in petroliferous basins by underground distillation and condensation, which can give rise to specific fresh or brackish waters with high contents of deuterium and oxygen 18. (Authors' abstract)

KONNERUP-MADSEN, Jens, 1985a Composition of gases in the Earth's upper mantle, in Ten papers in the exact sciences and geology, Part 1 of 16 research repts. by Niels Bohr Fellows of Royal Danish Acad. Sci. & Letters: Det Kongelige Danske Videnskabernes Selskab, Matematisk-fysiske Meddelelser 41, Copenhagen, October 7, 1985, p. 399-429 (in English). Author at Inst. Petrol., Univ. Copenhagen, Ostervoldgade 10, DK-1350 Copenhagen K, Denmark.

There is considerable evidence suggesting the continuous release of gases from deeper parts of the Earth. A review is given of geological data pertinent to deep gas compositions, emphasizing information of relevance to upper mantle conditions, and to possible degassing mechanisms. Data from experimental and theoretical studies relating to the existence and composition of upper mantle gases are presented, and information on deep gas compositions from natural rocks, comprising volcanic gases, gases in ocean-floor basalt glasses, in phenocrysts and upper mantle minerals, is reviewed. The available evidence is not decisively in favor of any single upper mantle gas composition. H_2O and CO_2 appear to be the major species, whereas more reduced gases are present in only subordinate concentrations and are of only minor importance for Earth degassing processes. Very low total gas contents, in the order of less than 0.1 weight % gases for some upper mantle regions, are indicated, but an upper mantle heterogeneous in its gas content and composition seems likely. (Author's abstract)

KONNERUP-MADSEN, Jens, 1985b Fluid inclusions associated with the Fe-Zn-Pb massive sulfide ores of the Black Angel mine, central West Greenland (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 83a. Author at Inst. Petrology, Univ. Copenhagen, Øster Voldgade 10 DK-1350 Copenhagen, Denmark.

The stratabound massive Fe-Zn-Pb sulfide 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. The stratabound sulfide sheets may be interpreted as a sabhka-type deposit which was subsequently metamorphosed and deformed under middle greenschist facies conditions. During deformation, 3 types of ore tectonites developed: massive and banded ore, porphyroclastic ore, and 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 stages of deformation of the ore bodies.

Three main types of fluid inclusions were observed: aqueous, CO_2-CH_4, and mixed aqueous-CO_2-CH_4.

Aqueous inclusions vary in salinity from about 1 to 48 wt. % (mainly 30-45) salts and Th total 175-300°C. Some of the aqueous inclusions contain one or more of the dms halite, sylvite, and (?) nahcolite.

CO_2-CH_4-bearing inclusions vary in composition from pure CO_2 to more than 80 mole % CH_4, the higher CH_4 contents being attained in the porphyroclastic ore tectonite. Equivalent CO_2 densities for the CO_2-CH_4 fluid average 0.85-0.9 g/cm^3, irrespective of CO_2/CH_4 ratios.

Aqueous-CO_2-CH_4 inclusions show CO_2-CH_4 compositions similar to the pure CO_2-CH_4 inclusions but generally have lower equivalent CO_2 densities. Th total occurs at 192-316°C and ~2 kbar.

The spatial distribution of the different fluid inclusion types, together with their compositional characteristics, suggests 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, and deformation of the ores. General conditions of 300-400°C and about 2 kbar are indicated but higher fluid pressures, and more CH_4-rich carbonic fluids, may have prevailed during stages of shearing and porphyroclastic ore formation and may have been influential in the deformation of the ore. Escape of CO_2-rich fluids appears to have succeeded this stage and may have been important for the formation of the remobilized ore types. (Author's abstract)

KONNERUP-MADSEN, J., DUBESSY, J. and ROSE-HANSEN, J., 1985, Combined Raman microprobe spectrometry and microthermometry of fluid inclusions in minerals from igneous rocks of the Gardar province (south Greenland): Lithos, v. 18, p. 271-280. First author at Inst. Petrology, Univ. Copenhagen, Øster Voldgade 10, 1350-DK, Denmark.

Raman microprobe spectrometry has been applied to analysis of the gaseous phase in individual fluid inclusions in minerals from alkalic igneous rock types and associated hydrothermal veins from the Gardar province, south Greenland. Quantitative analyses are given for CO_2, CH_4, C_2H_6, H_2 and H_2S. Traces of CO were observed in one CO_2 inclusion.

In conjunction with data from microthermometry, the results permit calculation of the bulk chemical composition of entrapped fluids and evaluation of the possible pressure, temperature, oxygen fugacity and sulphur fugacity during entrapment of the individual fluid inclusions. Calculated oxygen fugacity values correspond to those of the NNO and QFM buffer reactions at temperatures of 300-400°C and pressures of 0.5-1.0 kbar. Calculated sulphur fugacity values are within the range of normal ore forming solutions (log fS_2: -6 to -10). (Authors' abstract)

KÖRBER, Ch., RAU, G., COSMAN, M.D. and CRAVALHO, E.G., 1985, Interaction of particles and a moving ice-liquid interface: J. Crys. Growth, v. 72, p. 649-662. First author at Helmholtz-Inst. für Biomed. Tech. an der RWTH Aachen, Pauwelsstrasse, D-5100 Aachen, FRG.

A cryomicroscope was used to determine critical velocities marking the transition between repulsion and entrapment of spherical latex particles by an advancing ice-liquid interface. The employed freezing stage yields a planar ice front which propagates with increasing velocity into a region of decreasing thermal gradients. It was found that the critical velocity associated with the transition is inversely proportional to the particle radius as suggested theoretically under the assumption of the flat front (no cusping behind the particle). The critical velocity increases about linearly with the imposed thermal gradient which seems to stabilize the front against the perturbation induced by the particle. On the other hand, concentration gradients did not show a major effect: the addition of solute (0.56 mol% $NaMnO_4$) did not result in a significant change of the transition points as compared to the results obtained in pure water. (Authors' abstract)

KORMUSHIN, V.A., 1985, Determination of liquid carbon dioxide volume in microinclusions (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 84-85. Author at Inst. Geol. Sci., Acad. Sci. Kazakh SSR, Alma-Ata, USSR.

The difficulty of measuring the volume of liquid CO_2 lies in that microinclusions as a rule possess complex irregular form and, therefore, experimental volume measurements of liquid CO_2 are seldom made (e.g., when the form is geometrically regular).

Our studies have revealed a mathematical relation between the volumes of gaseous and liquid CO_2 in the microinclusions and Th CO_2. It gives the opportunity of determining the overall volume of liquid CO_2 in the microinclusions irrespective of their forms.

The established interrelation is based on the following:

1. A gas bubble in a microinclusion has an ideal spherical form.
2. Both gaseous and liquid CO_2 in microinclusions are in equilibrium. On heating (or cooling) the phase densities vary along the two-phase curve.

We use the following abbreviations:

V - unknown (general) CO_2 volume in microinclusions;
v_1 - volume of liquid CO_2 at t;
v_2 - volume of gaseous CO_2 at t; i.e., gas bubble volume;
M - the overall mass of CO_2 in microinclusions;
m_1 - the mass of liquid CO_2 at t;
m_2 - the mass of gaseous CO_2 at t;
m_3 - the mass of liquid CO_2 at Th;
ρ_1 - liquid CO_2 density along the saturation line at t;
ρ_2 - gaseous CO_2 density along the saturation line at t;
ρ_3 - liquid CO_2 density along the saturation line at Th;
d^3 - gas bubble diameter at t.

At t microinclusions include both liquid and gaseous CO_2 in the form of a gas bubble with ϕ d and then the following equations hold:

$$V = v_1 + v_2 \qquad [1]$$

$$M = m_1 + m_2 \qquad [2]$$

If a microinclusion is heated to Th liquid CO_2 fills out the whole volume V, and equation (2) becomes:

$$M = m_3 \qquad [3]$$

The overall mass of CO_2 in microinclusions remains invariable at any T value and, therefore, the right members of equations (2) and (3) are equal, i.e.

$$m_1 + m_2 = m_3 \qquad [4]$$

Each mass of CO_2 in equation (4) is then expressed as the sum of volume and density values

$$v_1\rho_1 + v_2\rho_2 = V\rho_3 \qquad [5]$$

The value of v_2 in equation (5) is then, according to equation (1), changed into the difference $V - v_2$ and the gas bubble volume v_2 which has an ideal spherical form, into

$$\frac{\pi d^3}{6}$$

and solving the equation as to V we have the resultant formula for determining the overall volume of liquid CO_2 in microinclusions:

$$V = \frac{\pi d^3(\rho_1 - \rho_2)}{6\,(\rho_1 - \rho_3)}$$

The values of ρ_1, ρ_2 and ρ_3 are known from reference literature (Voukalovich, M.P., Altounin, V.V. 1965), and the determination of liquid CO_2 in microinclusions is then limited to measuring of gas bubble diameter and temperature at the point of gas bubble diameter measurements (d) and at Th. (Author's abstract)

KORSAKOV, O.D., KOVALISHIN, Z.I., MARUSHKIN, O.I., MORDVIN, V.A. and KRUGLYAKOV, V.V., 1985, Genesis of feldspar megacrysts from the bottom of the Pacific Ocean: Dopovidi Akad. Nauk Ukra. RSR, Ser. B: Geol., Khim. & Biol. Nauki 1985, no. 4, p. 33-36 (in Ukrainian; English abstract).

Magmatic genesis and reduced conditions of crystallization were established for megacrystals of anorthoclase and anorthite from [cores] of bottom sediments from the Pacific Ocean on the basis of the data from the study of primary inclusions in these minerals. (Authors' abstract)

KORZHINSKY, M.A., 1985, Diopside-wollastonite equilibrium in the chloride supercritical fluid: Geokhimiya, 1985, no. 10, p. 1430-1440 (in Russian; English abstract).

KOSKI, R.A., NORMARK, W.R. and MORTON, J.L., 1985, Massive sulfide deposits on the southern Juan de Fuca Ridge: Results of investigations in the USGS study area, 1980-83: Marine Mining, v. 5, no. 2, p. 147-164.

KOSTYUK, V.P. and KOSTYUK, Ye.A., 1984, Potassium alkaline magmatism of continents and its connection with mantle processes: Geologiya i Geofizika, no. 7, p. 70-79 (in Russian; English abstract). Authors at Engrg.-Construction Inst., Kuybyshev, USSR.

The authors suppose that it is very probable that potassium-high melts form at great depths in upper mantle at least under conditions where pressure is about 30 kbar (i.e., depth 90-100 km) and T $\leqslant$1300°C (Th of inclusions in pyroxene megacrysts 1300-1340°C, in pyroxene phenocrysts 1230-1270°C). Evidence for this opinion includes the nodules of phlogopite and magnophorite (sometimes with pyrope) brought up by kimberlites, ultrabasites, very basic kalsilite-leucite rocks (sometimes with biotite), connection of potassium-high rocks exclusively with rift structures or diatremes in the continents, and the frequent spatial and seemingly also genetic connection of lamproites with kimberlites.

Studies of chemical composition of the deepest products of upper mantle and experiments on phlogopite stability under P >60 kbar suggest that geochemical behaviors of K and Na at elevated PT values are different. Certain minerals included in diamonds, like omphacite, bear 7 wt.% Na, or like garnet up to 0.22%. However, Na forms only either jadeite minal in pyroxene or isomorphous substitution of Ca in garnet, but K under the same conditions may form its own minerals (e.g., phlogopite) or it enters the amphibole structure in significant amount. The unusually high T of leucite crystallization (1300°C) indicates that potassium-rich melts may exist and they may give K-rich rocks like ugandites and maphurites. Obviously besides nepheline basalts and basanites, all other Na-rich alkaline rocks are of crustal origin, but K-rich magmas form at relatively deep levels of upper mantle. (Abstract by A.K.)

KOSUKHIN, O.N., 1985, Thermobarogeochemical data on the role of component-modifiers in granitoid melts (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 112-113 (in Russian; translation by D.A. Brown). Author at Siberian Res. Inst. Geol., Geophys. & Miner. Resources of Ministry of Geol. of USSR (SNIIGGiMS), Novosibirsk, USSR.

The magmatic crystallization of granitoids is possible over an extremely wide T range. The final crystallization, Te, of granitoid magmas depends substantially on the pressure at the time of crystallization, and on the presence or absence of fluxing components (or modifiers) (water, fluorine,etc.).

Melt inclusions in the minerals from 'dry' granitic magmas begin to crystallize at high T (>1200°C); water-saturated granite magmas crystallize <700°C.

Various kinds of melt inclusions in the ongonite minerals have been studied (glassy, and partially and completely crystallized). Optical data indicate that they contain a significant number of crystalline phases that are not typical of melt inclusions in minerals of other kinds of granitoids.

Th studies on melt inclusions in ongonite minerals from individual regions of the USSR and Mongolia, have shown that there is no narrow T field of formation for these rocks in general. Like other granitoids, the ongonites may crystallize at extremely different T both from 'dry' and also from water-enriched magmas. The high Te (up to 1100°C) of 'dry' ongonite melts point to the insignificant role of fluorine and other soluble modifier components. The water-enriched ongonite magmas have markedly lowered Te (down to 550°C). Results of experiments, carried out with melt inclusions in ongonite minerals, indicate the markedly decreased viscosity of the low-T ongonite melts as compared with other kinds of granitoid magmas.

Water also intensifies the fluxing properties by other component-modifiers, dissolved in the magma. Therefore, granitic melts of the ongonite or pegmatite type, enriched in fluorine and other fluxing components, as well as water, may crystallize at temperatures comparable with those of the hydrothermal processes. (From the author's abstract)

KOSZTOLANYI, Charles and MULLIS, Joseph, 1985, The measurement of the gypsum-anhydrite transition temperature, in solid inclusions in quartz, by microthermometry and Raman microprobe techniques (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 86. First author at Centre Rech. Géol. de l'Uranium, BP 23, 54501 Vandoeuvre les Nancy Cedex, France.

Solid inclusions in quartz samples collected in Switzerland were studied by heating stage microthermometry and Raman microprobe techniques. Microthermometry showed that the solid inclusions changed between 130 and 170°C from clear and transparent to dark and opaque, a temperature range corresponding to the gypsum-anhydrite phase transition. Further experiments by Raman microprobe showed that the Raman vibrational spectra, at ambient temperature, gave peaks at band positions of gypsum only. Heating to 100, 150, and 200°C showed a partial transformation; at above 150°C the gypsum band intensity diminished and those of anhydrite appeared. The bands of water shifted toward higher frequency range. The transition is complete at 200°C in 24 hours. The Raman spectra are those of anhydrite only; bands of gypsum have disappeared. These experiments permit in situ observation of the transformation of gypsum inclusions to anhydrite, and the determination of the transition temperature[sic]. (Authors' abstract)

KOTEEV, A.D., KRYLOVA, T.L., MAKSIMOVA, I.G. and SONYUSHKIN, V.Ye., 1985, Possibilities of determination of uranium and other components in liquid phase of individual inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 57-58 (in Russian). First author at IGEM, Moscow, USSR.

Inclusions were opened in a "wet chamber" by needle made of hard alloy placed, instead of diamond pyramid, in a micorhardness instrument. The needle contacts the desired point with an accuracy 1-2 µm and makes possible the opening of inclusions of tens µm in size placed up to 150 µm below the preparation surface. Solution was removed from inclusion by fine-pore filter "Sinpor," next dried and salts precipitated on filter. Size of wet circle on filter was used for determination of volume of reduced liquid from inclusion. The filter was placed between two solid-state detectors glued to plates of organic glass, and put into beam of thermal neutrons. Next detectors were etched and tracks counted under microscope. Sensibility of U detection was 10^{-10} g U per g [of solution? - A.K.]. Studies of this method were performed for artificial inclusions in $KAl(SO_4)_2 \cdot 12H_2O$ crystals grown at 40-60°C from solutions bearing $5 \cdot 10^{-5}$% of uranyl nitrate and for few natural specimens. Other elements were determined by energy-dispersive microprobe LINK-860; in inclusions in low-temperature natural fluorite the following elments were found: Ca, K, Na, Si, P, S, Cl. (A.K.)

KOTEL'NIKOV, A.R. and KOTEL"NIKOVA, Z.A., 1985, Fluid inclusions in scapolites synthetized at 600-800°C, 2 kbar, in salt-water-carbon dioxide solutions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 38-39 (in Russian). First author at Inst. of Experim. Mineralogy, Chernogolovka near Moscow, USSR.

Plagioclase glass + calcite + scapolite nuclei were put in a NaCl + $CaCl_2$ + $CaSO_4$ + HCOOH solution containing 0.14-0.45 mole fraction of CO_2 at 600-800°C and 2 kbar; Pt ampoules were used. Fluid was in homogeneous state at the runs conditions, Ni-NiO and hematite-magnetite buffers were used for controlling O_2 fugacity. Durations of runs were from 2 to 11 days. Scapolite crystals are of homogeneous composition, their size was 50 x 500 µm, habit-prismatic. Inclusions in scapolite were prismatic or tubular, and they occurred along cleavage planes. At 600°C the inclusions that formed were filled by G+L (G 40-60 vol.%); CO_2 was not observed in the inclusions, even when mole ratio $H_2O:CO_2 = 1:1$. Inclusions formed at 800°C contained L + G + NaCl + $CaCl_2$, and if $H_2O:CO_2 = 1:1$, LCO_2 was found in inclusions. Thus, simple relations between parent and inclusion solutions were not found. (A.K.)

KOVACHEV, V. and STRASHIMIROV, S., 1985, Topomineralogical and genetic features of copper ore mineralizations in the eastern Srednogorie Mountains [Bulgaria]: God. Vissh. Khim.-Tekhnol. Inst., Sofia, v. 31, no. 2, p. 157-185 (in Bulgarian).

In the ore fields of Malko Tarnovo, Rosen, Varli Briag, Zidarovo, Bakadzhika, and in the Prohorovo deposit, the topol.-mineralogy was studied of some mineral complexes (Upper Cretaceous intrusive, skarn and pegmatite-hydrothermal complex). The temperature ranges of crystallization of different mineral complexes, subcomplexes and associations in the region were determined. Intraplutonic, skarn and pegmatite-pneumatolitic associations formed at high temperatures (390-650°). The Cu and polymetallic mineralizations originated at 200-360°. Temperatures dropped to ~100° towards the end of the mineralization process. Normal temperature zoning and relatively low salt concentrations of ore-bearing fluids are typical of these ore fields. The Rosen and Zidarovo ore fields show a more distinct zoning which is explained by the specific distribution of thermal sources. The established differences in the mineral composition, zoning, and sequence of processes may be explained by differences in the localization of the associations. (C.A. 105: 82532y)

KOVACHEV, V., STRASHIMIROV, S., BAKYRDZHIEV, S., NAFTALI, L. and MARINOV, T., 1985, Mineralogical-genetic characteristics of the Undur-Tsagan molybdenum-tungsten deposit (northestern Mongolia): Geol. Rudn. Mestorozhd., v. 27, no. 4, p. 60-70 (in Russian). Authors at Sofia, Bulgaria.

The Undur-Tsagan stockwork Mo-W ore deposit, in the central Mongolian

Caledonides, is localized in Lower Devonian volcanic-sedimentary rocks associated with Upper Paleozoic gneisses, schists, leucocratic granites, etc. The orebody is located >500 m away from the ore-generating intrusive emplaced in regionally metamorphosed rocks. The mineralogy of the orebody includes 8 parageneses: quartz-microcline, biotite-fluorite, quartz-muscovite, quartz-molybdenite, quartz-wolframite, quartz-chalcopyrite-galena, marcasite-arsenopyrite, and calcite-kaolinite. The major typomorphic elements are W, Mo, Ti, Bi, Fe, Ag, Sn, and Te. During mineral formation, the geochemical trend changed from oxides through sulfides and sulfosalts to carbonates. Fluid-inclusion data were used to determine the homogenization temperature (T) in each association (295-430°). The NaCl concentration of the fluid increased initially with T and then decreased. Ore localization is related to Jurassic magmatism and subsequent pneumatolytic and hydrothermal processes. (C.A. 103: 181192c)

KOVACHEVA, Z., 1985, Temperature and salt content [of fluids] during mineral formation in the Ustrem ore field [Bulgaria]: God. Vissh. Khim.-Tekhnol. Inst., Sofia, v. 32, no. 2, p. 133-142 (in Bulgarian).

Results are presented of mineral-thermometric studies of ores from the Pb-Zn ore deposits of Lesovo, Barita, and Ustrem in the Ustrem ore field. Mineral-thermometric studies were made of inclusions in quartz, fluorite, an calcite from the different parageneses. The temperature of mineral crystallization gradually decreased with the ore development. The com.-grade ores formed over a wide temperature range: Ustrem (220-330), Lesova (230-340), and Barita (230-360°). Cryometric studies of quartz from the chalcopyrite-sphalerite paragenesis in Lesovo deposits determined a relatively low salt concentration in the solutions during the beginning of ore mineralization (5% NaCl equiv.) which gradully increased during the deposition of the chalcopyrite-sphalerite and galena parageneses (7.5-9 and 11.5% NaCl equiv.). (C.A. 105: 82531x)

KOVALENKO, N.I., RYZHENKO, B.N. and BARSUKOV, B.L., 1985, Solubility of cassiterite in water and supercritical aqueous chloride solutions at fixed redox conditions: Dokl. Akad. Nauk SSSR, v. 285, p. 217-220 (in Russian).

KOVALEVICH, V.M. and POBEREZHSKIY, A.V., 1985, Features of studying the composition of solutions from inclusions in sulfur from Cis-Carpathia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 195-196 (in Russian; translation by D.A. Brown). Authors at IGGGI Acad. Sci. Ukrainian SSR, L'vov, USSR.

The composition of inclusions in sulfur have been examined by many investigators, with divergent results. To a large degree these result from inadequacies in the extraction procedure, P vs S inclusions, leakage, dissolution of solid inclusions, etc.

The ultra-microchemical analysis procedures for individual inclusions (Petrichenko, 1973) was used on crystalline sulfur from the Yazovsk, and partly crystalline material from the Rozdol'sk and Porodozhno deposits. Solutions from individual P inclusions contain exclusively NaCl, plus minor Ca, Mg, K, and SO_4, with total concentration varying but ≤120 g/L. Waters of similar composition and concentrations have been found in the underling sediments of sulfur deposits in Ciscarpathia (literature data). (From the authors' abstract)

KOVALEVICH, V.M. and ZAKIROVA, F.A., 1985, Conditions of post-sedimentational transformation of salts in the Inder Rise based on a study of inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 196-197 (in Russian; translation by D.A. Brown). Authors at IGGGI Acad. Sci. Ukrainian SSR, L'vov, USSR.

Inclusions in halite, sylvite, and certain boron minerals from the Inder Rise, have been studied. The extremely intense recrystallization of the salts within the potash zones indicate the virtually complete absence of skeletal sedimentational halite textures. Two- and three-phase inclusions in recrystallized halite, and gas inclusions in sylvite, point to an increased T (>80°C) and P (~300 bars), under which conditions transformation of the salts took place.

The composition of the solutions during recrystallization differed essentially from the saline basin brines and varied somewhat in accordance with the composition of the country rocks. Effervescence of liquid inclusions in halite and the presence of gas inclusions in sylvite suggest high gas concentrations. The HC composition of the gases in halite most probably indicates that these gases came from the underlying petroliferous sediments. (From the authors' abstract)

KOVALISHIN, Z.I., 1985, Classification of gases in the Earth's crust and position of gas components of inclusions occurring in rocks and minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 46-47 (in Russian). Author at Inst. Geol. & Geochem. of Mineral Fuels, L'vov, Ukraine.

The abstract gives a review of the classification of natural gases since 1912. (A.K.)

KOZŁOWSKI, A., 1984, Calcium-rich inclusion solutions in fluorite from the Strzogom pegmatites, Lower Silesia: Acta Geol. Polonica, v. 34, no. 1-2, p. 131-137 (in English).

This is the full paper corresponding in an abstract published previously - see Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 175, 1984. (E.R.)

KOZLOWSKI, Andrzej, 1985, Do melt inclusions lose volatiles during homogenization studies? (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 88-89. Author at Inst. Geochem., Mineral. and Petrography, Warsaw Univ., 02-089 Warszawa, al. Zwirki i Wigury 93, Poland.

The problem of possible fluid inclusion leakage was discussed many times in the literature, but the first who expressed the opinion that melt inclusions should lose volatiles at Th was Volokhov (1985). He pointed out that at elevated temperatures close to 1000°C H_2O dissociates, forming oxygen and hydrogen, and the latter is able to diffuse through the crystal lattice. Decrease of H_2O in the inclusion melt causes a significant increase in Th, and hence the present Th measurement techniques do not yield values of petrologic validity. The problem was also discussed by Anderson and Sans (1975) and Roedder (1984). Dolgov (1982) and Kalyuzhnyi (1982) presented results of experiments with low-density gas-liquid inclusions strongly suggesting that they did not leak even in runs at very high T.

The author made a series of experiments with melt inclusions that lasted over four years (Sept. 1980 - Jan. 1985). Three melt inclusions were selected for studies: No. 1, 100 µm, in pyroclastic quartz from Holy Cross Mts., Poland, filled by a melt rich in volatiles, with Th 810

± 5°C (Kozlowski 1981); No. 2, 20 µm, in a quartz phenocryst in porphyric granite from Tyomnaya Mt., Sikhote Alin', USSR, filled by muscovite, quartz, and volatile bubble, Th 910 ± 5°C; and No. 3, 10 µm, in a quartz phenocryst in rhyolite from Lomnica, Lower Silesia, Poland, filled by melt and shrinkage bubble probably of low-pressure gas filling, Th 1280 ± 10°C.

Inclusion No. 1 was heated at 815-820°C for 33,950 hours, No. 2 - at 915-920°C for 24,020 hours and No. 3 - at 1290-1300°C for 9220 hours. After each 1700-2000 hours of heating Th was remeasured by the quenching method. All these Th measurements are the same as the respective Th determined before heating runs, within the accuracy of the method. At least inclusion No. 2 contained H_2O (since muscovite occurred in it), probably 2.5-3 wt.%. Time of run was incomparably longer than time of Th procedure, which lasts usually 5-8 hours. If one assumes that homogenization may cause a decrease in the H_2O content in the inclusion melt, then the loss must occur in a very short time, because the melting of muscovite introduced water into the melt in the last minutes of homogenization. However, as water dissociation and hydrogen diffusion through solids have finite and not very large rates, a gradual Th increment might be expected during the experiments. On the other hand, the contents of inclusion No. 2, after the decrepitation that finished the twenty-four-thousand-hour run, became vesicular (like "micropumice") due to volatiles that were released from the melt, although the composition of these volatiles was not obtainable.

These experiments suggest that volatile diffusion through the quartz lattice, if it occurs at elevated temperatures, probably is not measurable by Th determinations in the temperature ranges studied. (Author's abstract)

KOZŁOWSKI, A., 1985, Studies of fluid inclusions in agates from Płóczki Górne and Nowy Kościół, Poland: Archives of Inst. Geochem., Mineralogy and Petrogr. of Warsaw Univ., unpublished, 4 pp. (in Polish). Author at Inst. Geochem., Min. & Petr., Geol. Fac., Warsaw Univ., 02-089 Warszawa, al. Zwirki i Wigury 93, Poland.

Permian rhyolites and rhyodacites in Lower Silesia, Poland, have been silicified in a number of locations. Of the known locations, agates occurring at Płóczki Górne and Nowy Kościół are of commercial value, and range from several mm to about thirty cm. Their mineral composition is simple: alternating layers of chalcedony and fine-grained quartz, plus quartz inner cores with minor calcite and barite; hematite, goethite, Mn oxides and very rare chlorite occur as inclusions ("pigment") in quartz and chalcedony. The investigated material consists of 25 specimens from Płóczki Górne and 17 specimens from Nowy Kościół. Only four specimens from the first location and six specimens from the second one contained inclusions suitable for studies, all in quartz laminae.

Inclusions in quartz crystals in specimens from Płóczki Górne range from a few to 10-15 µm; only one was found with length 56 µm. The habit of inclusions ranges from irregular to "negative rhombohedrons." Inclusions occur most frequently in the contact of two neighboring quartz crystals. These inclusions are arranged along parallel striae, presumably the edges of introduction faces, and are filled by G and L in various proportions (L, L>G, L<G, G); common evidence of epigenetic alteration and possible inclusion leakage make such inclusions between neighboring crystals unsuitable for Th determinations. Only sometimes was it possible to distinguish P and S inclusions.

Inclusions filled mostly with G are dark and recognition of phases is very difficult. Only very flat inclusions show very small amounts of L in the corners. Fiber optics illumination reveals also small amount of L in equant G inclusions, distinctly <5 vol. % (enough only to wet the inclusion walls and form a meniscus rounding one or two corners of the vacuole). Th determinations for such inclusions are difficult and have low accuracy; Th ranges from 200 to 230. Probably inclusions of lower density (and lower Th) are also present, because some inclusions seem to have no liquid phase; perhaps there are inclusions of "dry" gases without H_2O vapor.

G<L inclusions (homogenizing in L) are not numerous and freedom from alteration (necking down, etc.) cannot always be verified. Nevertheless, among the undoubtedly unaltered inclusions, a sufficiently numerous group of inclusions for good Th measurements was found; Th ranged 110-170°C. Individual inclusions with Th 300, 346°C etc., are most probably epigenetically altered. Cryometrically determined salt concentrations are 2-4.5 wt. % of NaCl equivalent. One-phase L inclusions have almost the same NaCl equivalent concentrations: 1.3-3.2 wt. %.

Thus, quartz in agates, both earlier and later than chalcedony, crystallized from dilute solutions at 230-200°C (and lower?) from G solutions and 170-110°C from L solutions. Higher values do not necessarily characterize the earlier (closer to wall rock) laminae.

Quartz from agates from Nowy Kościoł bears the same types of fluid inclusions in similar distribution. Inclusions bearing G>>L homogenize at 220 to 260 (and possibly to 270) °C, inclusions of G<L type - at 100 to 215°C. Solution concentrations in G/L inclusions range from 1.8 to 5.6 wt. % and in L inclusions - from <1 to 3.3 wt. % of NaCl equivalent. (Abstract by A.K.)

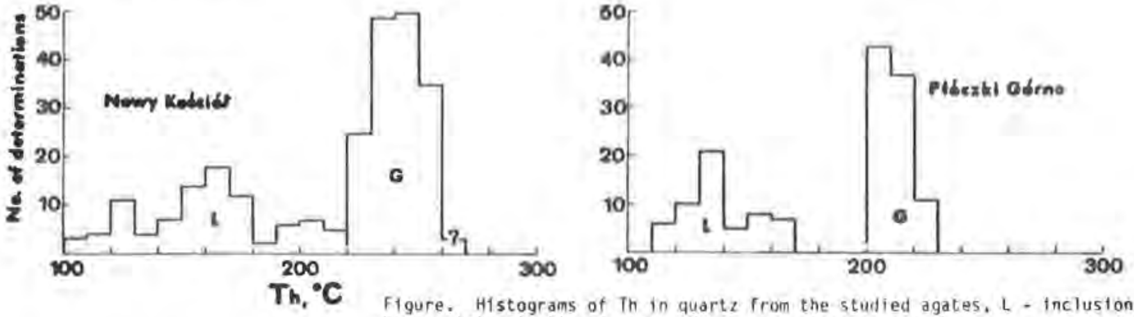


Figure. Histograms of Th in quartz from the studied agates, L - inclusions homogenizing in liquid phase, G - homogenizing in gas phase.

KOZLOWSKI, Andrzej and METZ, Paul, 1985, Origin of quartz-filled inclusions in pyrogenic quartz: Neues Jahrb. Miner. Mitt., no. 6, p. 277-288.

Pyrogenic quartz from pyroclastic sediments cropping out at Kowala near Kielce, Central Poland, bears unusual inclusions filled either by chalcedony, or by quartz, in addition to less than 5% by volume of volatiles. Microscope and electron microprobe studies suggest that such inclusions were formed by the silicification of epigenetically fractured primary melt inclusions. Other types of epigenetic alterations of primary melt inclusions are also characterized: refilling by a gas, by a liquid or by a pyrite aggregate. The possibility of derivation from an ultra-acid (i.e. pure silica) magmatic melt is discussed. (Authors' abstract)

KRASOV, N.F., RYABOV, V.V. and KONENKO, V.F., 1985, Liquation of natural melts based on thermobarogeochemical data (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 110-111 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. & Geophys. Sib. Div. Acad. Sci. USSR, Novosibirsk, USSR.

We have examined liquation phenomena in andesitic volcanics (Karmskiy Volcano, Kamchatka) and in intrusive traps (Khungtukun Intrusion, north of the Siberian Platform).

In the former, liquation phenomena have been found only in inclusions in plagioclase (An_{82-57}) phenocrysts, belonging to the early phase of crystallization of an andesitic magma. The low $P(O_2)$ in the magma during this phase has suppressed crystallization of the femic minerals and magnetite, so that in the end the liquidus (and in a certain T and P interval, the sole) mineral in it is plagioclase. As a consequence, crystallization differentiation during this phase has been achieved along the so-called Fennerovskiy route, unusual for orogenic magmas (towards enrichment of the residual melt in iron). The Fe-enriched residual melt, at 1280-800°C, has undergone liquation into two immiscible silicate liquids (of rhyolite and pyroxenite composition), sometimes with subsequent liquation of the pyroxenite liquid into silicate and ore units. All three kinds of liquid have been found in the inclusions, both as products of differentiation of drops of the original andesitic melt and inclusions, and as products of the process in the magma chamber itself (syngenetic inclusions of each of the three different melts separately).

Liquation phenomena are limited not only by the composition of the system: the fall in P during experimental decrepitation of the inclusions leads to mixing of the liquefied phases.

Convincing evidence for this hypothesis has been the discovery of liquation in the Khungtukun sill, stratified in olivine-bearing and olivine gabbro-dolerites. In its upper endocontact zone, there is a discontinuous horizon of taxitic gabbro-dolerites, with enclosed discrete bodies of gabbro-pegmatites, ferrogabbros, granophyres, and native iron. Crystallization differentiation of the Khungtukun intrusion, as with the entire series of trap sills on the Siberian Platform, has been achieved according to the Skaergaard plan, with accumulation of iron in the residual melt.

Liquation phenomena in the form of an emulsion of rhyolite and pyroxenite glasses have been encountered both among the silicate portion of taxitic gabbro-dolerites, and also within the segregations of native iron. They have also been found in melt inclusions, captured by the outermost growth zones of the pyroxene phenocrysts. As a consequence of evolution of the process of fractionation of immiscible liquids, isolated in the native iron and in inclusions in the pyroxenes, a third phenomenon has been noted (an ore liquid). Experiments with these inclusions have established that the immiscible silicate and ore melts coexist in the 1200-960°C range. In the magma chamber itself, micro-portions of the ore melt in this T interval have become enlarged and concentrated, and have formed ores with spongy structure or continuous segregations of native iron.

The direction of fractionation for both liquation phenomena examined is the same: in the rhyolite melts, Al, K, and Na have been concentrated, whereas in the pyroxenite melts, there has been concentration of Fe, Ti, and P, and Mn, Ca, and Mg in part. Both examples of liquation also have in common the fact that they have been achieved as a consequence of deep-seated crystallization differentiation of the original magmas under conditions of low $P(O_2)$. But in the first case, lowering of the total P in the system and a rise in $P(O_2)$ in the magma during its advance towards the surface, have prevented liquation on a geological scale amongst the volcanics. (From the authors' abstract)

KRENTZ, Ottomar, 1985, Temperature conditions and age position of the regional metamorphism in the middle part of the Erzgebirge Mts. (G.D.R.): Freiberger Forschungshefte, v. C390, p. 12-28 (in German). Author at Bergakademie Freiberg, 9200 Freiberg/Sa., Schliesfach 47, GDR.

This paper contains results of petrographic-petrogenetic investigations and Rb/Sr-age determinations of Upper Proterozoic to Cambrian parametamorphic rocks from the middle part of the Erzgebirge-anticlinorium, southern part of the G.D.R. The thermodynamic data, obtained from investigations on fluid inclusions in quartz, on the chemistry of muscovite and garnet and on the oxygen isotope ratio of the quartz-muscovite mineral-pair agree with the observed mineral association and show a clear dependence on the P/T-conditions of the regional metamorphism. According to this data, the garnet-mica schists and gneisses, belonging to the Raschau-suite and Niederschlag-series, crystallized between 600 and 500°C and P between 6 and 5 kb. After results of Rb/Sr-age determinations on three isochrons from different stratigraphic levels the age of the regional metamorphism ranges between 500 and 470 m.y. Based on a modified model, a reconstruction of the metamorphic history of the investigated area is given. (English abstract by R. Thomas)

KRING, D.A., 1985, Use of melt inclusions in determining liquid lines of descent (abst.): EOS, v. 66, no. 18, p. 404. Author at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

Clues to the liquid line of descent (llod) of a magma can be obtained from melt inclusions trapped in high-temperature minerals if the trapped melt is representative of the magma at the time of entrapment.

Chemical diffusion gradients adjacent to growing crystals would change the composition of trapped melts. 20 to 40 μm wide chemical boundary zones have been observed in glass adjacent to olivines that grew in experimental charges of low-Ti mare basalt. Relative to bulk glass, MgO in the boundary zone decreased 26% (11.7 to 8.7 wt % oxide), FeO decreased 9% (13.8 to 12.5 wt %), CaO increased 10% (9.5 to 10.5 wt %), and Al_2O_3 increased 17% (9.0 to 10.5 wt %). Zones of similar width but much larger chemical gradients were observed in natural lunar green glass vitrophyres (e.g., MgO decreased 40%), although narrower boundary zones were observed in synthetic low-K Fra Mauro basalts.

An interesting aspect of the chemical gradients in the experimental mare basalts is that they are a result of crystallization during the quench and not of primary crystal growth. Hence, the melt, when trapped, is representative of the magma. But during the quench a thin crystalline layer can grow along the host-inclusion interface. Very little crystallization is required to significantly alter the inclusion's composition, because the surfaced area of the inclusion, relative to the volume, is so large. The new crystalline layer may be so thin as to be undetectable by conventional microprobe techniques.

Undetected crystallization within the inclusion will mislead inferences of the llod unless crystallization is similar to that in the bulk magma. Since the host can grow without nucleation while other minerals must first nucleate, crystallization within the inclusion will fractionate the inclusion melt differently than crystallization in the bulk magma and the analyzed inclusion will be discordant to the actual llod. (Author's abstract)

KRONENBERG, A.K. and KIRBY, S.H., 1985, The hydrolytic weakening defect in quartz: Equilibrium or metastable? (abst.): EOS, v. 66, p. 1140. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

Critical experimental observations pertinent to hydrolytic weakening are: (1) Fast-grown synthetic quartz crystals are reproducibly weak and contain a metastable molecular water defect, which precipitates in fluid inclusions when heat treated at low pressure. (2) High pressure annealing tends to suppress this precipitation. (3) Initially dry Brazilian quartz crystals hydrothermally annealed at high pressure are weak in some experiments but not in others, a reproducibility problem not generally understood. (4) This reproducibility problem parallels measurement of water content in hydrothermally annealed natural quartz using infrared techniques. (5) Recent IR measurements on quartzites which are initially "wet" and hydrothermally annealed at high pressure show no changes in water content and hydrogen speciation. The conventional interpretation of the above observations is that molecular water has a significant solubility in quartz that increases with increasing water pressure. However, the crucial test of equilibrium, that of reversibility in water content, has not been met. It is equally probable that the hydrolytic weakening defect is a metastable one, incorporated via non-equilibrium processes (e.g., during growth, recrystallization, or perhaps dislocation motion). The true solubility may be orders of magnitude lower than the 300-1000 ppm range previously estimated, for PH_2O = 1.0-1.5 GPa an T = 800-900°C. The above considerations may be responsible for the puzzling problems of reproducibility and they emphasize the importance of thermodynamic and thermo-mechanical histories, as well as the initial defect state. A metastable origin of the water-weakening defect complicates the application of laboratory studies to naturally deformed quartz-bearing rocks. (Authors' abstract)

KRUUS, Peeter, HAYES, A.C. and ADAMS, W.A., 1985, Determination of ratios of sulfate to bisulfate ions in aqueous solutions by Raman spectroscopy: J. Solution Chem., v. 14, no. 2, p. 117-128.

KUCHER, M.I., 1985, Various phase states of fluids in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 41-42 (in Russian). Author at Moscow Geol.-Prospecting Inst., Moscow, USSR.

Volatiles in crystals may occur as: 1) fluid in vacuoles, i.e., GLI, 2) separate atoms or molecules in crystal lattice defects, 3) ultramicro-inclusions, formed by concentration in one point molecules or atoms dispersed in crystal lattice. The last have a composition which is not comparable to the parent solutions of minerals for an individual inclusion, but as the total of huge amount of such ultramicroinclusions, it would be very similar in composition to the parent solution. This supposition was confirmed by decrepitation studies of inclusions in quartz of hydrothermal origin. (A.K.)

KUDRIN, A.V., 1985, Experimental study of solubility of tugarinovite MoO_2 in aqueous solutions at high temperatures: Geokhimiya, 1985, no. 6, p. 870-883 (in Russian; English abstract).

KUDRYAVTSEVA, G.P., 1984, Nature of the Angara-Ilim negative magnetic anomalies: Geol. Rudn. Mest., v. 26, no. 3, p. 103-106 (in Russian). Author at Moscow State Univ., Moscow, USSR.

Metasomatic wall-rocks of magnetite deposits yielded the following Th values: garnet + pyroxene about 500°C, serpentine + chlorite + calcite + quartz + magnetite 180-225°C. (A.K.)

KUEHN, C.A. and GIZE, A.P., 1985, Textural and P-T-X characteristics of the hydrocarbon-bearing stages of the paragenesis at Carlin, Nevada (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 635. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Early stages of the paragenesis at the Carlin, Nevada, sediment-hosted gold deposit are represented by veinlets and/or cleats filled with calcite, quartz and organic matter that has been thermally altered to non-graphitizing mesophase. The pyrobitumen has a mean reflectance of 3-4.5%, and consists of a fine mosaic of micron-sized anisotropic domains. Bitumen in the host rocks has migrated to low-pressure zones. In veinlets and cleats the organic matter was introduced as an organic phase; more rarely it has been introduced as micelles. Multiple generations of pyrobitumen ± calcite and quartz occur, often within a single veinlet. Alteration of some of the pyrobitumen, shown by changes in the mean reflectance and relative size of anisotropic domains, is speculatively interpreted as "oxidation."

Fluid inclusions in the adjacent quartz and calcite appear to contain either 1 or 2 fluid phases in various proportions at room temperature. Combined crushing, heating/freezing and laser Raman microprobe studies have revealed 3 general types of inclusions in this stage of the paragenesis. Two-phase inclusions contain either (I) H_2O liquid (L) + a vapor (V) phase, or rarely (II) CO_2 (L+V). One-phase inclusions contain (III) a CH_4-dominated, CH_4-CO_2 (L) phase. Type I inclusions homogenize between 140-220°C, with 160 ± 20°C being most common. Type II inclusions homogenize below 31°C, and melt very near -56.6°C. Type III inclusions homogenize between -114 and -85°C and have melting events at approximatley -182°C and a second at Tm<Th. Temperatures, compositions and geobarometric constraints provided by type I and III inclusions, as well as textural characteristics of the pyrobitumen are consistent with the metagenesis of indigenous organic matter under near lithostatic conditions. (Authors' abstract)

KUL'CHETSKAYA, A.A., 1985, The use of inclusions in gypsum for resolving some problems of sedimentary mineral-formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 191-192 (in Russian; translation by D.A. Brown). Author at Inst. Phys. & Geochem. Minerals of Acad. Sci. Ukrainian SSR, Kiev, USSR.

Little attention has been paid to the study of inclusions in minerals of sedimentary origin. Inclusions in gypsum not affected by metamorphism, have shown that certain exogenic processes of the past have no equivalents at the present time.

1. In modern saline basins, significant precipitation of anhydrite is unknown, even when the conditions correspond to its stability field. Syngenetic inclusions of anhydrite in gypsum of certain porphyritic gypsum-anhydrite rocks in the Dnestr region suggest formation corresponding to the gypsum-anhydrite equilibrium.

2. The precipitation of gypsum from sea-water takes place after condensation of the sea-water by 3-4 times and continues until the precipitation of halite begins, corresponding to a change in the NaCl concentration in the water of 9 to 23 wt %. Inclusions in gypsum from the Miocene sediments of the Carpathian region and Kerch' Peninsula has shown that although the qualitative composition does not contradict their marine origin, the maximum concentration of NaCl in the inclusions is ≤9 wt %, and some inclusions have a salinity < sea-water. Gypsum can precipitate from fresher water if it is enriched in sulfate.

The spatial association between organic substances and the gypsum and sulfur deposits, suggests that the sulfate came from emanations of deep-seated gases, enriched in H_2S and S-bearing organic compounds. The varying degree of oxidation of H_2S controlled the precipitation of either gypsum or sulfur, which enables us once again to approach the problem of the origin of the sulfur deposits. (From the author's abstract)

KUL'CHETSKAYA, A.A. and VOZNYAK, D.K., 1985, An estimate of the PT-conditions of carbonatite-formation in the Chernigovka Complex (Azov region) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 155-157 (in Russian; translation by D.A. Brown). Authors at Inst. Geochem. & Phys. Miner. Acad. Sci. Ukrainian SSR, Kiev, USSR.

The carbonatites of the Chernigovka Complex have attracted attention both in the unusual linear structure of the massif, and in its mineralogical-geochemical peculiarities, associated with the conditions of crystallization. There is still the question as to the method of formation of the rocks in the complex. Recently, as a result of petrological and mineralogical studies, and also the discovery of melt inclusions in baddeleyite, much greater support has been given to the magmatic origin of the carbonatites. A study of the inclusions in the Chernigovka carbonatite complex has been undertaken to confirm the PTX parameters of the conditions of crystallization.

In the growth pyramid of the <0001> pinacoid in an apatite from a calcitic carbonatite (sövite), primary inclusions of a carbonate melt and syngenetic inclusions of a CO_2 fluid, have been discovered, which has enabled the authors to estimate the crystallization parameters of the apatite.

The preserved carbonate melt consists of completely crystalline inclusions, varying in composition from essentially calcitic to complex multiphase, in which, besides the calcitic matrix, a CO_2 fluid and an isotropic mineral phase are present in variable amount, and also a number of other translucent and opaque phases. No aqueous solution has been found. The quantity of CO_2 fluid and the mineral phase in the melt inclusions is directly correlated with the quantity of syngenetic, essentially CO_2 inclusions, regularly diminishing from the center towards the marginal part of the apatite grain. The shape of the carbonate inclusions varies from typical negative crystals of apatite (convex polyhedra and elongate prisms) to rhombohedral crystals of calcite, unusually elongated along L_6 of the host-mineral.

Melting of the essentially clacitic and multiphase inclusions takes place over a wide T range. At ~500-600°C, separation of gas bubbles (incongruent melting) begins, these being located initially along the contour of the inclusions, and later, throughout the entire volume, and this continues until mass decrepitation of the inclusions occurs (900-1000°C). The surviving inclusions having, as a rule increased their volume as a result of partial spalling, lose their translucence. Evidently, as a result of falling P, partial dissociation of the carbonate occurs with the release of CaO, which melts at ~1000°C. The clear inclusions contain enlarged gas bubbles and an anisotropic matrix (calcite), melting of which takes place at a single point (from 1100-1200°C according to the inclusions). According to the experimental data for the $CaO-CO_2$ system, equivalent phase transitions for pure $CaCO_3$ are completed in a higher-T field. The low values obtained may be explained by the multicomponent composition of the melt. Spalling of the inclusions and decrease in their total density leads in this case to staged melting of their contents and to an underestimate of the T of final melting. Homogenization of the inclusions has not been achieved.

The syngenetic inclusions of CO_2 fluid are high-density, an contain a trace of CH_4 and an isotropic dm. Homogenization of CO_2 into the liquid phase takes place at -16 - -32°C. The density of the CO_2 fluid, allowing for a trace of CH_4, is 0.09[sic] - 1.04 g/cm^3.

These inclusions emphasize that crystallization of apatite from sövite took place from a heterogeneous carbonate-salt melt, saturated in CO_2, at

T ≥1200°C and P = 800-900 MPa. These exceed the corresponding values, calculated for the Chernigovka Complex on the basis of the mineral parageneses. A comparison of the results with the available thermobarometric determinations based on carbonatite complexes of the globe, suggests that the Chernigovka carbonatite complex be assigned to the high-T and extremely high-P formations. (Authors' abstract)

KULIK, Zh.V. and KUZNETSOVA, S.V., 1985, Qualitative determination of amino acids in water leachates from gas-liquid inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 55-56 (in Russian). Authors at Inst. Geochem. & Physics of Minerals, Kiev, Ukraine.

Cleaning of samples from surficial contamination by amino acids was the most important problem. It was made by washing of samples with 5% HCl or/and doubly distilled water. Next 8 g of cleaned sample in grain class 0.5-1.0 mm was powdered in agate mortar under 12 ml of doubly distilled water and filtered through glass filter. Twelve drops of the leachate is put on china plate (five parallel determinations were made) and from 5 to one drop of ninhydrine plus copper nitrate solution was added. China plates next were put on hot plate (110°C) until a color rim appears; the reaction is characteristic for amino acids. Positive reaction is shown by blue-violet color. Intensity of color depends on concentration of amino acids in leachate; thorough cleaning of samples and evaluation of possibility of biological contamination are necessary. Presence of amino acids is characteristic for mineral-forming processes connected with volcanic-explosive processes and gas flows under high P, as well as with tectonic stresses and impact phenomena. (A.K.)

KULIKOV, I.V. and PETROVA, M.G., 1985, Banded structures of rare-metal granitic pegmatites and their genetic significance: Mineralogicheskii Zhurnal, v. 7, no. 5, p. 13-24 (in Russian; English abstract).

Banded structures of fine-grained quartz-albite aggregates are a result of metasomatic replacement of earlier microcline zones of coarsely crystalline pegmatite. "Fluidal" structures of such aggregates originated during albitic replacement of irregularly brecciated microcline pegmatites. Morphology of the composite bands depends on the configuration of the larger microcline relics, which remain behind the replacement front. The reason for intensive albitization of rare-metal pegmatites is the highly unstable conditions due to the pressure drop, which led to rapid precipitation of fine-grained albite. Banded structures of albitites are very common in rare-metal pegmatites of the world, and together with data on fluid inclusions in minerals testifies to very intensive metasomatic processes which have occurred in pegmatites during formation of their secondary zones from concentrated solutions. (Authors' abstract)

KUMAR, G.R.R., SRIKANTAPPA, C. and HANSEN, E., 1985, Charnockite formation at Ponmudi in southern India: Nature, v. 313, p. 207-209. First author at Centre for Earth Sci. Studies, Trivandrum 695 010, India.

Charnockites, constituents of most Precambrian high-grade terrains, are essential for understanding the evolution of the early continental crust. The arrested development of charnockite in shear veins at Kabbaldurga, in the state of Karnataka in India, suggests flow of CO_2-rich water-deficient fluids through deep-seated rocks as a mechanism of granulite grade metamorphism. We report here an occurrence of arrested charnockite formation well south of Kabbaldurga, in the khondalite belt of southern Kerala, where rocks with amphibolite facies give way to the vast southern

India-Sri Lanka charnockite terrain, indicating that metamorphism due to CO_2-rich fluids (carbonic metamorphism) may have operated over a large area in southern India. If such localities prove to be widespread, the present level of exposure throughout much of the high-grade terrain probably does not extend far beyond an isofacial surface marking the boundary between upper and lower crust in the late Archaean. (Authors' abstract)

KUPRIYANOVA, I.I. and SOKOLOV, S.V., 1984, Conditions of formation of phlogopite-margarite-beryl mineralization: Geol. Rudn. Mest., v. 26, no. 6, p. 32-44 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 3, p. 306-318). Author at All-Union Inst. of Mineral Raw Materials, Moscow, USSR.

Mineralization developed at exocontact of large differentiated granite massif of thickness 6-8 to 10-12 km. The granites intruded a metamorphic complex (amphibolites, siliceous schists, serpentinized ultrabasites, serpentinites and talc schists). Post-magmatic processes of this intrusion caused formation of pegmatites, beryl-plagioclase veins and veinlet-metasomatic phlogopite zones. Beryl from the beryl-plagioclase veins bears P G/L or crystallized inclusions that decrepitated before homogenization at 380-450 to 520-550°C, and S inclusions filled by G + LH_2O ± LCO_2 with Th 265-295°C or 330-385°C (in veins of various position). Fluorite from the same veins bears G/L inclusions with Th 265-280°C. Beryl from veinlet-metasomatic zones has P inclusions filled by G + LH_2O with Th 315-360 and 420-435°C, and by dms + fluid (G + LH_2O?, A.K.) that also decrepitated before homogenization; S inclusions of G + LH_2O ± crystal phases fillings yielded Th 215-330°C. The crystallized inclusions indicate the possibility of crystallization of early beryl from melt, but essential beryl mineralization formed from melts-solutions and high-temperature hydrothermal solutions. (Abstract by A.K.)

KURAT, G., NTAFLOS, Th., PALME, H., DREIBUS, G., SPETTEL, B. and TOURET, J., 1985, Upper mantle vein pyroxenites: Evidence for non-magmatic origin (abst.): Second Int'l. Eclogite Conf., Terra Cognita, v. 5, p. 439-440. First author at Naturhistorisches Museum, A-1014 Vienna, Austria.

Detailed study of pyroxenite veins from Zabargad Island, Red Sea, revealed the following results: .... (6) Pyroxenites are rich in halogens and have approximately chondritic Cl/I ratios. (7) REE contents are high (up to 8 x CI), mostly LREE-depleted, and incompatible with pyroxene crystallization from a basaltic melt. (8) "Fluid" inclusions are abundant but consist solely of solids (NaCl, $MgCO_3$, sulfates) ± a gas phase (CO_2 or N_2 or mixtures).

Conclusions: Vein pyroxenites of Zabargad Island are of non-magmatic origin and apparently represent precipitates from fluids (high T-P conditions). The fluids were highly saline, moved through pathways opened by tectonization, and came from different mantle sources. We believe that most vein pyroxenites of other occurrences throughout the world are of similar origin as well as most other monomineralic vein rocks like olivinites, hornblendites, plagioclasites, phlogopitites, chromitites, garnetites and others. (From the authors' abstract)

KUSCHEL, Frank and SEIDEL, Jürgen, 1985, Osmotic and activity coefficients of aqueous K_2SO_4-$MgSO_4$ and KCl-$MgCl_2$ at 25°C: J. Chem. Eng. Data, v. 30, p. 440-445.

KUZNETSOVA, S.V. and LAZARENKO, Ye.Ye., 1985, Formation of inclusions of spiral habit in quartz (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 26-27 (in Russian). Authors at Inst. Geochem. & Physics of Minerals, Kiev, Ukraine.

Quartz from hydrothermally altered granitoids bears inclusions of spiral habit. They are filled by L, L+G or G+L+solid phases resorbed by dissolution. Inclusions have the shape of a narrow helicoid channel with length to diameter ratio from 50 to 300; length varies from tens to a few hundreds of µm, a cross section is irregular and multiangular. The surface of the inclusion is either smooth or has traces of etching.

The described inclusions formed due to dissolution of spiral metacrysts of rutile. These metacrysts originated in the process of decomposition of biotite by hydrothermal solutions. Growth of string-like rutile crystals might be stimulated by admixtures of organic substances or by dislocation in crystals (Maleev 1971, Grigor'yev & Zhabin 1975). The host quartz contains hydrocarbons and oxygen-bearing organic matter. Organic substances plus alkaline components cause Ti migration (Shcherbina 1966).

Dissolution of helicoid rutile crystals occurred due to sharp change of chemical composition of fluids. A similar origin [is ascribed to] straight acicular inclusions. Thus, the described inclusions in quartz are secondary and prove the changes of mineral-forming solutions. (Authors' abstract; translated by A.K.)

KVENVOLDEN, K.A. and McDONALD, T.J., 1985, Gas hydrates of the Middle America Trench - Deep Sea Drilling Project Leg 84, in Orlofsky, S., ed., Initial Reports of the Deep Sea Drilling Project, v. 84, U.S. Govt. Printing Office, p. 667-682. First author at U.S. Geol. Survey, Menlo Park, CA 94025.

On DSDP Leg 84, gas hydrates were found at three sites (565, 568 and 570) and were inferred, on the basis of inorganic and organic geochemical evidence, to be present at two sites (566 and 569); no evidence for gas hydrates was observed at Site 567. Recovered gas hydrates appeared as solid pieces of white, icelike material occupying fractures in mudstone or as coarse-grained sediment in which the pore space exhibited rapid outgassing. Also a 1.05-m-long core of massive gas hydrate was obtained at Site 570. Downhole logging indicated that this hydrate was actually 3 to 4 m thick. Measurements of the amount of methane released during the decomposition of these recovered samples clearly showed that gas hydrates had been found. The distribution of evolved hydrocarbon gases indicated that Structure I gas hydrates were present because of the apparent inclusion of methane and ethane and exclusion of propane and higher molecular weight gases. The water composing the gas hydrates was fresh, having chlorinities ranging from 0.5 to 3.2‰ . At Sites 565, 568 and 570, where gas hydrates were observed, the chlorinity of pore water squeezed from the sediment decreased with sediment depth. The chlorinity profiles may indicate that gas hydrates can often occur finely dispersed in sediments but that these gas hydrates are not recovered because they do not survive the drilling and recovery process. Methane in the gas hydrates found on Leg 84 was mainly derived in situ by biogenic processes, whereas the accompanying small amounts of ethane likely resulted from low-temperature diagenetic processes. Finding gas hydrates on Leg 84 expands observations made earlier on Leg 66 and particularly Leg 67. The results of all of these legs show that gas hydrates are common in landward slope sediments of the Middle American Tench from Mexico to Costa Rica. (Authors' abstract)

LABOTKA, T.C., PAPIKE, J.J. and NABELEK, P.I., 1985, Fluid evolution in the Notch Peak aureole (abst.): EOS, v. 66, no. 18, p. 389.

LABUTIN, A.N. and NAUMOV, V.B., 1985, Formation conditions of cassiterite-feldspar deposit Butugychag: Geokhimiya 1985, no. 2, p. 179-185 (in Russian; English abstract).

Ore bodies of the Butugychag deposit, Magadan district are typical representatives of the quartz-feldspar type of the cassiterite-quartz formation. A genetic relation [was found between the] ore mineralization [and the] leucocratic granite massif, [which] crystallized, according to melt inclusion study, under 910 to 750°C, 0.9 to 4.1 kb of water pressure and 2.1-8.4 wt.% water in the melt. According to results of thermometric and cryometric study of fluid inclusions formation of cassiterite-feldspar veins took place under high temperature (more than 410°C) from high-concentration (>25 wt.%) chloride solutions. In the process of formation of the post-ore associations a sharp change of composition and concentration of solutions took place resulting in temperature lower than 400°C, concentration less than 7.5 wt.% and probable fluoride content. (Authors' abstract)

LAMB, W.M., VALLEY, J.W. and BROWN, P.E., 1985, CO_2-rich fluid inclusions from fluid absent granulites, Adirondack Mountains, N.Y. (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 638. Authors at Dept. Geol. & Geophys., Univ. Wisconsin, Madison, WI 53706.

Examination of 5 to 20 micron diameter fluid inclusions in low fO_2 charnockites from the Adirondack Mountains, N.Y., indicate the presence of numerous generations of fluids, including: 1) H_2O-rich, 2) three-phase (H_2O liquid and CO_2 liquid + vapor), and 3) high density, CO_2-rich. These inclusions are in samples in which the temperature and oxygen fugacity have been determined from coexisting magnetite and ilmenite (Bohlen and Essene, 1977). Fluid calculations in the C-O-H system place limits on the fugacity of CO_2 in these rocks (Lamb and Valley, 1984). The table below summarizes results from the most dense CO_2-rich inclusions in these samples: included are the homogenization temperatures (Th), the melting temperature (Tm), the pressure derived from the CO_2 density at the peak metamorphic temperature (PFI), the metamorphic temperature (T) and pressure (P), fO_2, and XCO_2 from C-O-H calculations.

Sample	Th	Tm	PFI	T	P	log fO_2	XCO_2
IN-10	-17.9	-57.2	6.1	710	7.0	-17.0	<0.15
TP-5	- 5.7	-56.9	5.4	730	7.5	-16.0	<0.52
TP-11	- 2.7	-58.3	5.1	720	7.5	-16.1	<0.81
SR-31	10.9	-57.5	3.8	720	7.8	-17.2	<0.02
78-LB-1	-17.0	-58.5	5.6	650	7.0		

Many of these samples are orthopyroxene + K-feldspar bearing indicating reduced H_2O activities. Low CO_2 + H_2O samples such as IN-10 and SR-31 indicates vapor absence. The presence of CO_2-rich fluid inclusions have been interpreted as indicating that the peak of granulite facies metamorphism is dominated by and possibly caused by CO_2-rich fluids. Our results suggest that high density CO_2-rich fluid inclusions do not, in at least some cases, represent the primary metamorphic fluid. (Authors' abstract)

LAMB, W.M. and VALLEY, J.W., 1985, C-O-H Fluid calculations and granulite genesis, in A.C. Tobi and J.L.R. Touret, eds., The Deep Proterozoic Crust in the North Atlantic Provinces, D. Reidel Pub. Co., p. 119-131. Authors at Dept. Geol. & Geophys., The Univ. Wisconsin, Madison, WI 53706, USA.

Pervasive flooding of CO_2 into the deep crust has been proposed as the cause of granulite facies metamorphism. One effect of CO_2 infiltration would be the dilution of H_2O and the stabilization of orthopyroxene-bearing assemblages. Calculations in the C-O-H system indicate that infiltration of CO_2 into rocks whose oxygen fugacities are buffered to within the stability of graphite will cause graphite to precipitate. Oxygen fugacities determined from coexisting magnetite and ilmenite from three granulite facies terranes are sufficiently low so that it can be shown that most of these samples have not been flooded by sufficient CO_2 to form granulites as graphite is not reported. Instead, most of these fO_2 values are consistent with either H_2O-rich or vapor absent conditions assuming the fraction of non C-O-H components is relatively small. If these values of fO_2 are common in rocks which are metamorphosed under conditions of low fH_2O then vapor absent metamorphism may be common in granulites. (Authors' abstract)

LANDIS, G.P., 1985, Gas analysis of ore-forming fluids (abst.): U.S. Geol. Survey Circular 949, p. 28.

Precise analysis of the volatiles or gaseous fluids trapped in fluid inclusions during mineralization is used to determine physical and chemical parameters of metal transport and deposition and to better understand the environments of ore formation. Knowledge of the abundance of such gases as CO_2, CH_4, SO_2, H_2S, N_2, O_2, NH_3, Ar, H_2, and H_2O in mineralizing fluids enables us to significantly refine ore-genesis models. The new mass spectrometer instrumentation developed for these analyses will also permit isotopic analyses of both stable isotopes (C, O, S, H, N) and radiogenic isotopes (Ar, Ne, Xe, Kr, He) for very small samples extracted from fluid inclusions.

Gas in fluid inclusions and other geologic materials is analyzed using a newly developed high-performance quadrupole mass spectrometer system, equipped with rods 30 cm in length by 1.6 cm in diameter, electromagnetically focused cross-beam ion source with dual iridium filaments, an off-axis electron multiplier (gain to 10^8)/faraday cup collector, and 16K-data-point digital oscilloscope. A mass change (m/e) range of 1-255 atomic mass units (AMU) is achieved, with at least unit resolution (10 percent valley), scan speeds of 100 s to 30 s/AMU, and a minimum detectable partial pressure of 8×10^{-15} mbar (8 ppb sensitivity). Instrument monitoring and control are completely computerized. FORTRAN- and MACRO-based software transfers data, makes computations, and produces tabulated analyses and graphical reports.

Gas samples are liberated from host minerals either by mechanical crushing or by thermal decrepitation. Inlet sample gas pressures (to 10 Torr) are monitored with a capacitance manometer, whereas the high vacuum attained by turbo-molecular pumps ($<10^{-9}$ Torr) is measured with standard Bayard-Alpert gauges. Inlet design includes a low volume internal resistive heating coil for work on small samples. An Nd-YAG (yttrium aluminum garnet) laser coupled through a microscope is being developed to enable opening individual inclusions for analysis while the sample is positioned in the mass spectrometer high-vacuum inlet. Other features of the instrument include cryopump traps and charcoal traps, Zr-Al gettering alloys, a CuO finger, and an ion pump.

Special applications of the gas analysis system that are progressing along with the final stages of instrument development include (1) study of complex H_2O-CO_2-CH_4-N_2-rich metamorphic fluids of upper greenschist facies rocks as possible ore-forming fluids in the Coeur d'Alene silver district, Idaho (with D.L. Leach), (2) evaluation of the importance of magmatic volatiles during comagmatic evolution and formation of Black Range (Taylor Creek) tin occurrences, New Mexico (with R.O Rye and M.D. Wasserman), (3) assessment of the role of volatiles in the complex zonation and evolution of the Ta-bearing Harding pegmatite, northern New Mexico, (4) examination of organic components in the fluid inclusion gas from epigenetic sulfides in coal beds (with J.F. Whelan), and (5) development of data processing methods for quadrupole measurement of the carbon and oxygen isotope ratio of carbon dioxide fluid inclusions. By using appropriate collection procedures, inexpensive analytical methods for gas can be applied empirically to geochemical exploration for base- and precious-metal deposits. (Author's abstract)

LANGE, M.A., LAMBERT, Philippe and AHRENS, T.J., 1985, Shock effects on hydrous minerals and implications for carbonaceous meteorites: Geochimica Cosmo. Acta, v. 49, p. 1715-1726. First author at Alfred-Wegener-Inst. for Polar Res., Columbus Center, D-2850 Bremerhaven, FRG.

New infrared absorption spectra, thermo-gravimetric analyses and optical-and scanning electron microscopy of shock-recovered specimens of antigorite serpentine from the pressure range between 25 to 59 GPa are reported. Optical and scanning electron microscopy of shocked antigorite reveal a number of textures thought to be unique to shock loading of volatile-bearing minerals. Gas bubbles, which probably are the result of shock-released H_2O appear to be injected into zones of partial melting. This process may produce the vesicular dark veins which are distributed throughout heavily shocked samples. The present observations suggest several criteria which may constrain possible shock histories of the hydrous matrix planes of carbonaceous condrites. A model is proposed for explaining hydrous alteration processes occurring on carbonaceous chondrite parent bodies in the course of their accretion. We speculate that shock loading of hydrous minerals would release and redistribute free water in the regoliths of carbonaceous chondrite parent bodies giving rise to the observed hydrous alterations. (From the authors' abstract)

LANGE, S., CHAUDHURI, S. and CLAUER, N., 1985, Strontium isotopic evidence for the origin of barites and sulfides from the Mississippi Valley-type ore deposits in southeast Missouri - a reply: Econ. Geol., v. 80, p. 775-776. First author at Dept. Ecology, Kansas State Univ., Manhattan, KS 66506.

A reply to discussion by Ruiz et al. (this volume). (E.R.)

LANGMUIR, Donald and MELCHOR, Daniel, 1985, The geochemistry of Ca, Sr, Ba and Ra sulfates in some deep brines from the Palo Duro Basin, Texas: Geochimica Cosmo. Acta, v. 49, p. 2423-2432. First author at Dept. Chem. & Geochem., Colorado Sch. Mines, Golden, CO 80401.

The geochemistry of Ca, Sr, Ba and Ra sulfates in some deep brines from the Palo Duro Basin of north Texas, was studied to define geochemical controls on radionuclides such as ^{90}Sr and ^{226}Ra. Published solubility data for gypsum, anhydrite, celestite, barite and $RaSO_4$ were first reevaluated, in most cases using the ion interaction approach of Pitzer, to determine solubility products of the sulfates as a function of temperature and pressure. Ionic strengths of the brines were from 2.9 to 4.8 m, their temperatures and pressures up to 40°C and 130 bars. Saturation indices of the sulfates were computed with the ion-interaction approach in one brine from the arkosic granite wash facies and four from the carbonate Wolfcamp Formation. All five brines are saturated with respect to gypsum, anhydrite and celestite, and three of the five with respect to barite. All are undersaturated by from 5 to 6 orders of magnitude with respect to pure $RaSO_4$. ^{226}Ra concentrations in brines, which ranged from $10^{-11.3}$ to $10^{-12.7}$ m, are not controlled by $RaSO_4$ solubility or adsorption, but possibly by the solubility of trace Ra solid solutions in sulfates including celestite and barite. (Authors' abstract)

LAZAR, Boaz, FRIEDMANN, T.J. and HOLLAND, H.D., 1985, The composition of Permian seawater (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 640. Authors at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

We demonstrated earlier that fluid inclusions in Miocene halite can be used to define the composition of contemporary Miocene seawater. During the past year we have extracted inclusion fluids from halite in the Lower Permian Wellington Formation near Lyons, Kansas, and from the Upper Permian Salado Formation near Carlsbad, New Mexico, to define the composition of Permian seawater. The extracted inclusion fluids were analyzed by ion chromatography. The concentration of Na^+, Cl^-, and Mg^{+2} in these fluids falls along the evaporation path of present-day seawater. Compared to evaporated modern seawater the solutions are slightly enriched with respect to Br^- and K^+. The excess of these ions is probably due to their transfer from enclosing halite to the inclusion fluids during recrystallization.

The concentration of SO_4^{-2} in the inclusion fluids is lower than in evaporated modern seawater. The SO_4^{-2} deficit in the fluids from halite in the Wellington Formation is almost certainly due to dolomitization followed by gypsum and/or anhydrite precipitation. No difference between the SO_4^{-2} concentration of Lower Permian and present-day seawater is required to explain the SO_4^{-2} deficit in these fluids. This explanation does not account for the SO_4^{-2} deficit in the inclusion fluids from the Salado Formation.

The concentration of Li^+ in the inclusion fluids is higher by a factor of ca. 4 than the concentration to be expected from the evaporation of modern seawater. With this exception, the composition of Permian seawater appears to have been remarkably similar to that of modern seawater. (Authors' abstract)

LAZARENKO, E.A., SHUKAYLO, L.G., KOZLOVSKIY, L.M. and BARANOV, P.N., 1985, Certain non-traditional aspects of information obtainable from inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 25-26 (in Russian). Authors at Geol. Inst. Dnepropetrovsk, USSR.

Minerals of hypabyssal intrusions of the Vyshkovo region in Ukrainian Transcarpathians commonly bear inclusions of the immiscibility (liquation) type. Syngenetic inclusions in early apatite have compositions either of gabbro-porphyrite, diorite-porphyrites, quartz diorite-porphyrites, and granodiorite porphyrites in hypabyssal intrustions. According to experimental data, all those melts are products of evolution of an andesite magma, also by liquation processes. Inclusions were used also for correlation of rocks and unambiguous determination of primary magmatic nature of many Archean metamorphosed rocks. (A.K.)

LAZ'KO, Ye.M. and PIZNYUR, A.V., 1985, Essential problems of methods of fluid inclusion studies in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 48-49 (in Russian). Authors at L'vov State Univ., L'vov, Ukraine.

The authors describe briefly methods of determination of Th, Td (indicating the decrepitation as "very perspective method for determining the true temperatures very fast and also for opaque minerals" and to be improved), pressure, composition and concentration of inclusion fluids. (A.K.)

LEACH, D.L., LANDIS, G.P. and HOFSTRA, A.H., 1985, Precious and base metal mineralization in the Coeur d'Alene district, Idaho, during Proterozoic metamorphism of the Belt basin (abst.): U.S. Geol. Survey Circular 949, p. 28-29.

Silver and lead-zinc-copper veins in the Coeur d'Alene district in northen Idaho occur in the most intensely and complexly deformed parts of the Proterozoic Belt Supergroup rocks. The rocks were regionally metamorphosed to upper greenschist facies during the late Precambrian, and this metamorphism, coincident with intense structural deformation, produced the vein mineralization. The veins were pathways for the escape of large volumes of metamorphic fluid and are believed to have formed along sites of hydraulic fracture or dilation of pre-existing fractures when fluid pressure exceeded load pressure.

Fluid-inclusion studies provide strong evidence that vein mineralization was produced by greenschist metamorphic fluids. These studies indicate that the temperature of the mineralizing fluid was about 350°C, the pressure was more than 1-2 kbar, and the salinity was 5-10 weight percent. Fluid compositions are dominated by H_2O, CO_2, CH_4, N_2, and NaCl. Some fluid inclusions rich in CO_2, N_2 or CH_4 are believed to have trapped immiscible fluids present in the veins under metamorphic conditions. In addition to these components, other volatiles in the ore fluid represent refractory compounds of nitrogen and light-chain hydrocarbons that include alkenes, aliphatic nitriles, and primary amides. Water present in the fluid inclusions has variable strontium isotopic compositions (initial $^{87}Sr/^{86}Sr$ of >1.000 to 1.420) that are characteristic of unhomogenized, greenschist-grade metamorphic fluids. (From the authors' abstract)

LEACH, D.L., LANDIS, G.P., LEVENTHAL, J.S. and HOFSTRA, A.H., 1985, Analysis of gases in Mississippi Valley-type ore fluids (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 641. Authors at U.S. Geol. Survey., P.O. Box 25046, MS 912, Denver, CO 80225.

Volatiles in fluid inclusions in ore and gangue minerals from Mississippi Valley-type deposits in Missouri, Arkansas, and Kansas have been analyzed by mass spectrometry, gas chromatography, and laser Raman spectroscopy. The application of these techniques together with detailed fluid inclusion petrography is a powerful approach to characterization of gases in fluid inclusions. The most important gases determined were CO_2, N_2, and CH_4. The hydrocarbon content of the fluids is low [<0.1 mole%] and consists largely of CH_4 with traces of C_2H_6. Because the amount of CH_4 present is low, post trapping production of CH_4 from organic matter within the inclusions could not have significantly affected the filling temperatures reported for these deposits.

High CO_2 contents of up to 2 mole % have been measured by mass spectrometry in sphalerite from northern Arkansas. Comparable CO_2 contents were obtained by both thermal decrepitation and room temperature crushing. Thermal gas evolution profiles show that peak CO_2 release occurs at a higher temperature than for H_2O release. These observations suggest the presence of CO_2-rich inclusions. Although CO_2-rich inclusions have not been observed optically, they may reside among the many, small, dark, inclusions with strong internal reflections commonly seen in sphalerite. The CO_2-rich inclusions could represent periods of CO_2 effervescence during host rock dissolution and sulfide deposition. The thermal maturity and low concentration of hydrocarbons, together with the high CO_2 content, suggest that these ore-forming fluids are highly evolved basinal brines. (Authors' abstract)

LEACH, David and ROWAN, Lanier, 1985, An anomalous geothermal gradient in the Mid-Continent and its possible relationship to the Late Pennsylvanian-Early Permian Ouachita orogeny (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 164. Authors at U.S. Geol. Survey, P.O. Box 25046, MS-918, Denver, CO 80225.

Studies of fluid inclusions in sphalerite and hydrothermal dolomite from mining districts and unmineralized areas in Missouri, Arkansas, and parts of Oklahoma and Kansas show that an anomalously high regional geothermal gradient (80° to 100°C/km) prevailed during or after Late Pennsylvanian time north of the Ouachita fold belt. Neither "normal" heat flow by conduction from basement rocks nor localized magmatic activity provides an adequate explanation for the observed gradient. Rather, migration of heated brines out of the 12 to 18 km thick sedimentary section in the southern portion of the Ouachita-Arkoma basin system is believed responsible for the high heat flow. Flow of hot basin fluids onto the southern flank of the North American craton was driven by some combination of compaction, uplift and gravity draining, and geopressuring in response to tectonic stresses during the Late Pennsylvanian-Early Permian Ouachita orogeny.

The migration of hot brines from the Ouachita-Arkoma basin may also have been responsible for widespread Mississippi Valley type Pb-Zn mineralization. Inclusions in Northern Arkansas zinc district dolomite and sphalerite record the passage of hot (110°-130°C), highly saline (>22 wt.% NaCl equiv.) fluids. Volatiles in these inclusions consist primarily of thermally refractory, light, chain hydrocarbons (methane, ethane, and propane), and relatively high proportions (3 mole %) of CO_2. These compositions are consistent with those expected for basin fluids evolved under low-grade metamorphic conditions such as prevailed during the Ouachita orogeny in the southern portion of the Ouchita-Arkoma basin system. (Authors' abstract)

LEACH, T.M., UMALI, D.U. and del ROSARIO, R.C., 1985, Epithermal mineral zonation in an active island arc: The Bacon-Manito geothermal systems, Philippines: Proc. 7th NZ Geothermal Workshop 1985, p. 109-114. First author at KRTA Ltd., Auckland, NZ.

The Bacon-Manito geothermal field exhibits chemical zonation of thermal features that is typical of island arc andesite hydrothermal systems. Zonation of hydrothermal minerals in the vadose zone in the production wells reflects this chemical distribution of surface fluids. The interface between the vadose zone and the chloride reservoir fluids is marked by distinct changes in hydrothermal minerals: the influx of anhydrite and calcite, and the transition of kaolinite to chlorite and cristobalite to quartz. The hydrothermal mineralogy and fluid inclusion data indicates that the epithermal region of the eastern sector of Bac-Man approximated "boiling point with depth" conditions in the past. Cooling of the system and downward percolation of cool acid sulphate and neutral sulphate-bicarbonate fluids from the vadose zone into the hot chloride reservoir has caused precipitation of quartz, anhydrite and calcite in fractures, and produced a 800 m sealed cap on a neutral chloride reservoir, locally trapping two phase, gas rich pockets. (Authors' abstract)

LeBAIL, C., THOMASSIN, J.-H. and TOURAY, J.-C., 1985, A study of the partition of CO_3^{2-} and SO_4^{2-} ions between aqueous solutions and structures of the hydrotalcite type. Contribution of Raman spectrometry; application to the study of basaltic-glass-seawater interactions (abst.): Bull. Minéral., v. 108, p. 91 (in French).

LEE, I.S. and PARK, H.-I., 1982, Fluid inclusion studies on the Wolak tungsten-molybdenum deposits, Korea: J. Korean Inst. Mining Geol. (1982), v. 15, no. 1, p. 17-32. Authors at Dept. Geol. Sci., Seoul Nat'l. Univ., Seoul 151, Korea.

The Wolak tungsten-molybdenum deposits are tungsten-molybdenum-bearing quartz veins which filled the fractures in Pre-Cambrian pebble-bearing calcareous hornfels, hornfels and Cretaceous granite. There are two vein groups in this mine, Dongsan vein group in the west and Kwangcheon vein group in the east.

The ore minerals are wolframite, scheelite, molybdenite, native bismuth, bismuthinite, pyrite, arsenopyrite, chalcopyrite, cubanite, stannite, pyrrhotite, sphalerite, galena, marcasite, Pb-Bi sulfosalt and ilmenite. Quartz, calcite, beryl, fluorite, muscovite, rhodochrosite and siderite are gangue minerals.

Fluid inclusion studies were carried out for the quartz, beryl, scheelite, early and late fluorite. Fluid inclusion studies reveal that liquid-gas inclusions are most common and occur in all the minerals examined. Filling degree of the inclusions in the late fluorite is much higher than that of the inclusions in quartz and early fluorite. Liquid CO_2-bearing liquid-gas inclusions occur in quartz and early fluorite. Liquid, gas and solid phase inclusions occur in quartz, beryl and scheelite. Salinities of inclusions in quartz and beryl from Dongsan vein group range from 3.9 to 8.0, from 5.3 to 7.7 wt.% NaCl equiv. respectively. Salinities in the late fluorite range from 1.5 to 3.2 wt.% NaCl equiv. In Kwangcheon vein group salinities range from 3.9 to 9.6 wt.% NaCl equiv. in quartz, from 2.8 to 7.3 wt.% NaCl equiv. in early fluorite, from 1.3 to 1.5 wt.% NaCl equiv. in late fluorite. Th of inclusions range from 239° to higher than 360°C in quartz, over 360°C in scheelite, from 288°C to higher than 360°C in beryl, and from 159° to 202°C in late fluorite of the Dongsan vein group. In Kwangcheon vein group, Th range from 240°C to higher than 360°C in quartz and from 250° to 328°C in early fluorite.

As a whole, in Dongsan and Kwangcheon vein groups it seems that there are no distinct differences in mineralogy, salinities and Th. No distinct variations in Th are revealed through about 300 m vertically in both districts. The faint trend of increase in salinities in the lower level can be detected. The salinity, CO_2 content and the temperature of ore fluid were much higher in the early vein stage and then dropped off in the late stage of mineralization as represented by the quartz and fluorite inclusion data. (Authors' abstract)

LEE, Y.I. and FRIEDMAN, G.M., 1985, Deep-burial dolomitization in basins of the southwestern United States (abst.): Abstracts, SEPM Ann. Midyear Meeting, Aug. 11-14, 1985, Golden, Colorado, v. 2, p. 54. Authors at Dept. Geol., Brooklyn College and Rensselaer Center of Applied Geol., City Univ. of New York, P.O. Box 746, Troy, NY 12181.

Carbonates below 10,000 ft are exclusively dolostone showing evidence of deep-burial dolomitization, such as the presence of coarsely crystalline dolomites, euhedral dolomite rhombs replacing quartz and chalcedony which in turn had replaced coarse crystalline dolomite, high fluid-inclusion Th, and overgrowths of dolomite from core wells. (From the authors' abstract)

LEEDER, Otto, 1985, On the importance of liquation for the formation of rocks and deposits: Zeitschrift fur Geologische Wissenschaften, v. 13, no. 5, p. 601-612 (in German; English abstract).

LeGUERN, F., 1985, Mt. Etna volcano survey from the plume chemistry (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

LeGUERN, F. and SHINOHARA, H., 1985, Etna 1983 composition of the magmatic gases (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

LEPEZIN, G.G. and MIRIYEVSKAYA, O.S., 1983, Behavior of metapelite- and metamafite-forming elements in regional metamorphism: Dokl. Akad. Nauk SSSR, v. 273, no. 2, p. 452-455 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 273, p. 157, 1985).

LEPEZIN, G.G., OSORGIN, N.Yu. and SHVEDENKOV, G.Yu., 1984, Determination of the diffusion coefficients of CO_2 in cordierites: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 970-974 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 4, p. 125-128, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 193-194. (E.R.)

LEROY, J., FRITZ, B., CATHELINEAU, M. and NAHON, D., 1985, Phyllosilicate alteration in granite-hosted hydrothermal uranium deposits: Analysis and modeling of fluid-mineral reactions (abst.): Bull. Minéral., v. 108, p. 92 (in French, translated by C. Eastoe).

The studies concerned the two principal types of alteration associated with hydrothermal uranium deposits hosted by granites: pre-pitchblende micaceous episyenitization [trans. ?], and the argillic type contemporaneous with the alteration of pitchblende to coffinite. The principal results are: 1. The two alteration types form zoned, phyllosilicate-dominated systems. These extend far beyond the volume of the mineralized episyenite (sensu stricto), confirming the results of the microstructural study. 2. The phyllites are potassic, a characteristic that persists with time and from one type to another. 3. Models for 300°C, along with fluid inclusion data, predict mineral assemblages comparable with those observed in nature. 4. The transition from a white mica zone to a smectite zone cannot be brought about by cooling the early fluids. 5. In no case can the montmorillonite-kaolinite zonation observed in the deposits result from fluid percolation perpendicular to the main channelway. (Authors' abstract)

LESPINASSE, M., 1985, The fluid inclusions trails: A microstructural marker of paleostressfield, relations with fluid chronology (abst.): Terra Cognita, v. 5, p. 255-256. Authors at CREGU, BP 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

Study of the deformation of a granitic massif (1) indicates a relation between the paleostressfield and the geometry of microfissure[s] as defined by fluid inclusion trails (2). The trails are direct effects of ancient hydrothermal fluid conduits. A statistical study of the distribution of fluid inclusions shows that (i) at the grain scale, fluid inclusions trails exhibit distinct preferred orientations which may be observed in many samples, (ii) the orientation of the trails is similar to that of micro and meso-scale fracture in the granite, (iii) the dominant direction of trail orientation is parallel to the main direction of regional shortening.

Fluid inclusion trails seem to be excellent microstructural markers of paleostressfield (analogous to the tensional microfissures). They also act as the pathways of fluid circulation which caused the alteration of the granite (3).

(1) M. Lespinasse (1984): Contexte structural des gisements d'uranium de la Marche Occidentale - fracturation, circulations fluides, propagation de l'épisyénitisation. Geol. Geochim. Uranium, Mém. Nancy, 8, 200 p.

(2) M. Lespinasse and A. Pecher (1985): Microfissuration and regional

stressfield: A study of the preferred orientation of fluid inclusions planes in a granite from the Massif Central, France. Submitted to Journal of Structural Geology.

(3) A. Pecher, M. Lespinasse and J. Leroy (1985): Relation between fluid inclusion trails and regional stressfield: a tool for fluid chronology. The example of an intragranitic uranium ore deposit, North West Massif Central, France (submitted to Lithos). (Author's abstract)

LEUNG, I.S., 1985, Unusual inclusions found in a natural diamond (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 642-643. Author at Dept. Geol. & Geography, Herbert H. Lehman College, City Univ. New York, Bronx, NY 10468.

Three pale yellow minerals, 100-200 microns in their longest dimension, were extracted from a diamond 2.5 mm in size and examined in an SEM equipped with an X-ray energy-dispersive spectrometer. These inclusions were found to be two grains of garnet and a coesite, all of which contain a microscopic grain of Ti-rich biotite, a small amount of sanidine and a number of other minerals.

(1) Garnet-biotite-apatite-rutile-sanidine-(Fe,Ca) melt. Attached to one end of this garnet inclusion is a crystal of biotite (50 x 30 μm) in which an apatite and a rutile are embedded. A thin lamella of sanidine occurs in the biotite near the garnet boundary. Two droplets of melt were found at the garnet-diamond host interface.

(2) Garnet-biotite-apatite-sanidine-rutile-pyrrhotite-(Fe,Ca,K) phase (unidentified). This garnet inclusion partially encased a biotite crystal while all other phases occur as minute prismatic needles or irregular and globular masses on the inclusion surface.

(3) Coesite-biotite-sanidine-calcite. On one side of this coesite inclusion is a double rim of sanidine and calcite. They are considered primary phases because the diamond host contains neither internal nor external fractures.

Garnet, coesite, biotite and apatite are syngenetic inclusions in this diamond based on their relatively large sizes and their intergrown relationships. All other phases may also be primary or derived from biotite which, in the presence of sulfur, may produce phlogopite + sanidine + pyrrhotite + rutile. The droplets of melt and thin lamella of sanidine in inclusion (1) seem to be products of incongruent melting of biotite during the emplacement of kimberlite. (Author's abstract)

LEVELT SENGERS, J.M.H., STRAUB, J., WATANABE, K. and HILL, P.G., 1985, Assessment of critical parameter values for H_2O and D_2O: J. Phys. Chem. Ref. Data, v. 14, no. 1, p. 193-207. First author at Thermophys. Div., Center for Chem. Engrg., Nat'l. Engrg. Lab., Nat'l. Bureau Standards, Gaithersburg, MD 20899.

Includes most likely values for critical density, critical pressure, and critical temperature, supporting data, and assessment of their reliability. (E.R.)

LEVENTHAL, J.S., CLENDENIN, C.W. and VIETS, J.G., 1985, Spatial relationships and characterization of types of organic matter in Mississippi Valley-type Pb-Zn deposits, Viburnum trend, Missouri (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 643. Author at U.S. Geol. Survey, Federal Center, MS 916, Denver, CO 80225.

To investigate the role of organic matter in Mississippi Valley-type deposits we have systematically sampled and characterized organic matter in the Upper Cambrian Bonneterre Formation from ores of the Viburnum trend and from rocks as much as 8 km away from the trend. The organic matter far from ore consists of insoluble disseminated kerogen in carbonates. The kerogen from brown rock units yields mainly n-alkane pyrolysis products up to ~ C_{30}; however, the gray and white rock units poorer in organic carbon give much smaller quantities of pyrolysis products. Within meters to centimeters of ore, the organic matter occurs as solid partly soluble bitumen and insoluble pyrobitumen blebs of millimeter to centimeter size. These hydrocarbon blebs also yield n-alkane pyrolysis products, but only up to ~ C_{21}. The preserved organic matter in contact with ore is paragenetically late and usually coats late chalcopyrite or galena. Products from pyrolysis-gas chromatography-mass spectrometry of this ore-associated material are quite different from the kerogen or blebs, being mainly substituted aromatic molecules (such as toluene and methyl naphthalene) rather than n-alkanes.

This sample suite documents the progression of kerogen (far from ore) through oil generation (near ore) and subsequent degradation (in contact with ore). Fluid-inclusion filling temperatures of ore-stage minerals (Rowan, et al., 1984, GSA Abst. v. 16, p. 64)) within the trend and in barren rock away from the ore indicate temperatures were within the oil generation window (115°C), but that the Viburnum trend was not a local thermal anomaly. Therefore, the change from alkane to aromatic character of the organic matter associated with sulfide ores suggests that chemical reactions such as nonbiological sulfate reduction may be responsible for organic degradation and sulfide precipitation. (Authors' abstract)

LI, Binglun, 1985, Study on the metagenetic fluid inclusions: Acta Petrol. Sinica, v. 1, no. 4, p. 54-60 (in Chinese; English abstract). Author at Inst. Geol., Academia Sinica.

A review, apparently dealing with inclusions in metamorphic rocks. (E.R.)

LI, Binglun, XIE, Yihan, ZHAO, Rui and LI, Ruomei, 1985, Magmatic process and geochemistry of calc-alkaline complex from Yangchuling, Jiangxi Province: Acta Petrol. Sinica, v. 1, no. 2, p. 1-16 (in Chinese; English abstract). Authors at Inst. Geol., Acad. Sinica.

Includes histogram of Td for quartz from various igneous rocks and ores (Td = 100-900°C). (E.R.)

LI, Tongjin, LU, Jialan, ZHAO, Bin and YI, Dongshan, 1985, Experimental studies of leaching and albitization in intermediate-basic rocks: Chem. Geol., v. 49, p. 115-125. Authors at Inst. Geochem., Acad. Sinica, Guiyang, Guizhou Province, PRC.

Experimental studies combined with geological evidence indicate that gaseous thermal fluids enriched in NaCl (or other chlorides) leach and metasomatize intermediate-basic and intermediate-acidic rocks. In this process, part or all of the rock- and ore-forming materials are mobilized and enriched to form skarns and Fe deposits.

When gaseous thermal fluids enriched in NaCl (or other chlorides) act on intermediate-basic rocks, the mobilities of the main components in the rocks are, in decreasing order K (or Na), Fe, Ca, Si, Mg and Al. The mobility of Al is extremely small and the mobility of Mg is not large either.

The leaching capacities of high-temperature fluids for rock- and ore-forming elements, depend mainly on the kinds and numbers of negative and positive ions, pH and Eh, temperature and pressure, etc. Acidic solution and high temperature favor the leaching of Fe whereas alkaline solution and high pressure favor the leaching of SiO_2.

At 550°C and 750-1000 bar, weak alkaline solution enriched in NaCl favors the formation of albite. Acidic solution favors the formation of minerals such as amphiboles and chlorites while wollastonite can form in wider ranges of pH. The mobility of Fe and albitization represent the change in pH-values of the solutions at different mineralized stages. (Authors' abstract)

LI, Yinqing, 1985, Evolution mechanism of inclusions and metallogenic pH condition of some major porphyry copper (molybdenum) deposits in China: Kuangchuang Dizhi, v. 4, no. 3, p. 51-60 (in Chinese; English abstract). Author at Inst. Mineral. Deposits, Chin. Acad. Geol. Sci., Beijing, PRC.

Besides summarizing the type, Th, salinity, composition, fluid boiling and evolution mechanism of inclusions in porphyry copper (molybdenum) deposits of China, this paper discusses particularly the pH condition during quartz-sericite and potash silicate alteration. If the Th, KCl and NaCl concentration and chemical composition of K-feldspar and sericite are obtained from fluid inclusions in those alteration zones, the pH and $a(K^+)$ values of ore-forming fluids can be calculated without difficulty.

The data gained in the Yulong, Malasongduo and Dexing porphyry copper deposits show that at the stages of quartz-sericite, potash-silicate alteration and the precipitation of large quantities of metalliferous ores, the ore-forming fluids had $a(K^+)$ values of 0.1-2.5 mol with the average of 0.67 mol, and pH values of 4.0-4.7.

The uninterrupted change of magmatic and postmagmatic fluids with the variation in temperature, pressure and composition resulted in different types and associations of fluid inclusions in minerals for different rock-forming and ore-forming stages. Above the magmatic solidus line primary gas-inclusions with high temperature (900°C) can be found, sometimes coexisting with melt inclusions. However, at the stage most favorable for ore deposition, polyphase-inclusions rich in daughter minerals are predominant; they are associated with gas inclusions and a few liquid inclusions, and have Th 250-500°C. At the late stage of mineralization, mixing with meteoric water led to a decrease of salinity, and the temperature of fluid phase also decreased to 200°C, accompanied by the evolution of liquid inclusions into biphase gas-liquid inclusions. (Author's abstract)

LI, Zaolin and HUAN, Lanying, 1985, The physicochemical condition for the formation of Sanshan Island gold deposit: Mineral Deposits, v. 4, no. 4, p. 35-46. First author at Dept. Geol., Nanjing Univ., PRC.

The gold deposits (western Jiaodong Peninsula) are closely related to the intrusion of the Linglong granite. The Linglong and Guojiaoling granites were formed mostly by melting of the Jiaodong Group and partly by metasomatism caused by regional migmatization. Melt inclusions formed from 780° to 940°C have been found in the Linglong granite, showing that the granite is of magmatic origin. During the formation of the granite, the local differentiation could have occurred in the magma. With decreasing temperature, rock-forming minerals crystallized, and aqueous solutions separated from the melt, replacing the rock-forming minerals, and forming the massive sericite-quartz gold-bearing rock (the Sanshan Island gold mine). The solutions also formed the gold-bearing fractured zones or vein gold deposits (e.g., Jiaojia and Linglong gold mines). The altered rocks in Sanshan Island formed at 280-420°C, which is close to the Th (300-460°C) of the gas-liquid inclusions in the quartz of the mother rocks. Moreover, the compositions of the liquid and trace gases in the inclusions of the two kinds of rocks are similar. All these facts indicate that the deposits formed as a result of metasomatism by solutions from the granite. In the altered rocks, there is a close correlationship between the intensities of the mineralization and the alteration. The analyses of the ore-forming solutions show the characteristics of $SO_4>Cl>HCO_3>F$, $K/Na>1$, and $H_2O>CO_2>CH_4$.

The source of the gold must have been the Jiaodong Group, whose gold content is decades times higher than that of normal metamorphic rocks. During the formation of the granite through the melting of the gold-bearing metamorphic rocks, gold would be transferred into the granite and then concentrated by the action of the solutions. (From the authors' abstract)

LI, Zhaolin, ZHANG, Jinzhang, WU, Qizhi and OUYANG, Zhonghui, 1982, The geological and geochemical characteristics of some pegmatites of rare metals in Fujian Province: Mineral Deposits, v. 2, no. 2, p. 1-5 (in English). Authors at Dept. Geol., Nanjing Univ., PRC.

On the basis of the mineral association, the grade of replacement and the mineralization of rare elements, in this region the pegmatites are divided into five types: I. biotite, microcline and albiclase; II. muscovite, albiclase and microcline; III. low albitized muscovite and microcline; IV. albitized spodumene and microcline; V. high albitization pegmatites.

Th of inclusions in the pegmatitic minerals decreases from type I to IV (400-180° C). The high-Ta pegmatites are formed at the lower temperature (260-180° C). The increase and decrease in the contents of CO, in inclusions have a connection of synchronism with the contents of Nb and Ta in pegmatite. (From the authors' abstract)

LI, Zhaolin, ZHANG, Jinzhang, WU, Qizhi and OUYANG, Zhonghui, 1983, Geological and geochemical characteristics of a certain pegmatite ore field of rare metals in Fujian Province: Mineral Deposits, v. 2, no. 2, p. 49-58 (in Chinese; English abstract). Authors at Dept. Geol., Nanjing Univ., PRC.

Pegmatites in this ore field can be divided into five types: I. biotite-microcline-albiclase[sic] pegmatite; II. muscovite-albiclase-microcline pegmatite; III. weakly albitized muscovite-microcline pegmatite; IV. albitized spodumene-microcline pegmatite; V. intensely albitized pegmatite.

Th of inclusions in pegmatitic minerals fall from type I to IV (400-180°C) and Ta-abundant pegmatites were formd at lower temperatures (260-180°C). CO_2 content in inclusions increases or decreases in direct proportion to the contents of Nb and Ta.

The formation of pegmatites is evidently related to the intrusion of granites on both east and west. Following this intrusion, melt-solutions were formed at the late stage of crystallization differentiation, which migrated and subsequently produced pegmatites under relatively closed conditions. Late stage hydrothermal replacement further concentrated rare elements, forming Nb, Ta-rich pegmatites. (From the authors' abstract)

LI, Zhaolin, ZHAO, Meifang and YI, Fenghuang, 1984, The mechanism and its relation to intergranular solution of the formation of the ore body No. 69 in the Daijishan tungsten deposit, Jiangxi Province: J. Nanjing Univ., Natural Sci., Spec. Issue on Geol. Science, no. 4, p. 19-28 (in Chinese; English abstract). First author at Dept. Geol., Nanjing Univ., PRC.

Genetically, the Daijishan tungsten ore deposit has close relation to the evolution of its host granitic complex composed of multiple-stage comagmatic intrusives. The discovery of crystallized melt inclusions with Th = 1105°C in the earlier stage intrusive, the granodiorite, is eloquent proof that the granites distributed in this district are formed by magma derived from partial remelting of the lower crust . The tungsten ore deposit has particularly strong [relation to] the later stage intrusion, a fine-grained muscovite granite. The magma forming the later stage intrusive was of melt-solution character and during the process of crystallization and local differentiation, aqueous solution separated out of it as intergranular solution, which brought about the albitization, greisenization and W, Nb, Ta mineralization forming the 69th ore body at the top of the granite body, and the vein-type tungsten ore body in the exocontact zone of the parental granite. Based on the measurements of Th of fluid inclusions in quartz, the ore-forming T of the 69th ore body ranged from 220-320°C, the exocontact vein-type tungsten ore body from 160-280°C, and the forming T of parental granite itself was in the range of 190-340°C (which represent the lower limits). The above temperature ranges are very close in value and this means that the ore bodies were formed by the intergranular solution derived from the parental magma.

The ore-forming fluid of the deposit is characterized by $HCO_3^- > SO_4^{-2}$, $Cl^- > F^-$, and $Na^+/K^+ > 1$. It is rich in Na^+ and weakly basic. Under such circumstances, tungsten can be conveyed in the ore-forming fluid in the form of complex carbonyl hydroxo tungsten compounds or in the form of sulftungstate (M_2WS_4). The higher the content of CO_2 and W in the ore-forming fluid, the more favorable the tungsten mineralization. And the contents of CO_2 and W [in the inclusions?] are important geochemical marks in geological survey of tungsten deposit. (Authors' abstract)

LIANG, Zihao, ZHU, Qingtao, HAN, Menghe, XIA, Anning, WANG, Yanbin, YU, Wenjuan and ZHANG, Yinzhen, 1985, Metallogenic conditions of the Zhilingtou gold-silver deposit in Zhejiang province: Geological Review, v. 31, no. 4, p. 330-339 (in Chinese; English abstract). First author at Zhejiang Inst. Geol. Sci.

The Zhilingtou gold-silver deposit orebodies occur as veins and are strictly controlled by the NE-trending tenso-shear basement fracture. The principal ore minerals include electrum, kustelite, argentite, hessite, pyrite, galena, sphalerite, pyrrhotite and chalcopyrite. The gangue minerals comprise quartz, chlorite, rhodonite, calcite, rhodochrosite and garnet. The well-rock alteration include silicification, sericitization, pyritization and chloritization.

The formation of the deposit may be divided into two metallogenic epochs. The early mineralization occurred in the Caledonian cycle and is associated with the Caledonian regional metamorphism. This is the most important metallogenic epoch of gold and silver mineralization . The late mineralization occurred in the Yanshian cycle, mainly manifested by overprinting of Ag, Pb and Zn mineralizations, which are related to volcanic activity. The mineralizations of the two metallogenic epochs show obvious differences in mineralogy, fluid inclusions and stable isotopic composition. The deposit was formed by overprinting of metamorphic hydrothermal fluids and volcanic hydrothermal fluids. (From the authors' abstract)

LINDBLOM, Sten, 1985, Fluid inclusion evidence from fracture filling minerals in granitic rocks from Finnsjön (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 90. Author at Ore Research Group, Geol. Inst., Stockholm Univ., Stockholm, Sweden.

Fluid inclusions in fracture fillings have been studied. Homogenization, freezing and melting temperatures from late stage calcite and prehnite were recorded. The evidence shows fluid-mineral interaction indicating a complex history of fracturing and infilling, dissolution and redeposition in the last calcite phase.

Three events of fluid activation were documented in the fractures:

(1) deposition at 80°C from a solution with 17 eq. wt. % NaCl,

(2) deposition at 135°C from 3.6 eq. wt. % NaCl solution,

(3) deposition or rehealing at 100°C or lower from a fresh to brackish water solution.

The inclusions frequently display metastable behavior with regard to vapor phase nucleation, indicating that formation at a low temperature may be a dominate event. The low temperature is then connected both with a low salt and a high salt solution. This could mean deposition from alternately a circulated seawater and a subsurface brine, sometimes accompanied by boiling.

The fractures may have been active quite recently as shown by low-temperature freshwater inclusions and tectonic textures. (Author's abstract)

LINDBLOM, Sten and WICKMAN, F.E., 1985, Fluid inclusions in quartz from a quartz breccia in the Siljan Ring structure, central Sweden: Geologiska Föreningens i Stockholm Förhandlingar, v. 107, Pt. 1, p. 53-58. First author at Malmforskningsgruppen, Geol. Inst., Stockholms Univ., S-10691 Stockholm, Sweden.

The Siljan structure represents a deep erosion level of an astrobleme. Post-impact formation of minerals as various types of vein fillings is common. Non-shocked milky quartz from a large vein revealed fluid inclusions of three types: (1) one-phase, regularly shaped inclusions, <1 to 10 µm in size, (2) two-phase, regularly to irregularly shaped inclusions, 2 to 7 µm, (3) larger irregular two-phase inclusions, 8-20 µm. The one-phase inclusions dominate; density of inclusion occurrence is estimated at 46×10^4 inclusions per cm^2. Melting temperatures indicate a total salinity of 1.0 eq. wt. % NaCl. Th range between 165 to 309°C. The fluid inclusion data imply a complex origin of the quartz. It consists in part of breccia fragments formed after the impact. The quartz vein was cemented by deep circulating meteoric waters at successively lowered temperatures initially over 300°C. (Authors' abstract)

LINNEN, R., 1985, Contact metamorphism, wallrock alteration, and mineralization at the Trout Lake stockwork molybdenum deposit, southeastern British Columbia: Masters thesis, McGill Univ., Montreal, PQ, Canada, 220 pp.

Indexed under fluid inclusions.

LIPMAN, P.W., BANKS, N.G. and RHODES, J.M., 1985, Degassing-induced crystallization of basaltic magma and effects on lava rheology: Nature, v. 317, p. 604-607. First author at U.S. Geol. Survey, MS-913, DFC, Denver, CO 80224, USA.

During the north-east rift eruption of Mauna Loa volcano, Hawaii, on 25 March-14 April 1984, microphenocryst contents of erupted lava increased from 0.5 to 30% without concurrent change in either bulk magma composition or eruption temperature (1,140 ± 3°C). The crystallization of the microphenocrysts is interpreted here as being due to undercooling of the magma 20-30°C below its liquidus; the undercooling probably resulted from separation and release of volatiles as the magma migrated 12 km from the primary summit reservoir to the eruption site on the north-east rift zone. Such crystallization of magma during an eruption has not been documented previously. The undercooling and crystallization increased the effective viscosity of the magma, leading to decreased eruption rates and stagnation of the lava flow. (Authors' abstract)

LITOVCHENKO, Ye.I. and KOVAL, V.B., 1985, On the relation of pegmatite formation to metamorphism (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 14-15 (in Russian; translation by S. Jaireth). Authors at IGFM Inst. Geol. & Physics of Mantle, Acad. Sci., Ukraine SSSR, Kiev, USSR.

Study of gas-liquid inclusions in pegmatites of the Ukrainian Shield has revealed that the initial stages of pegmatite formation are associated in time with metamorphism of country rocks and are the result of response of these rocks to local decrease in the lithostatic pressure in axial parts of domes, interboudinaged spaces and in fracture zones. Release of pressure and addition of volatiles create favorable conditions for rock melting and for fluid saturation of the melts during reequalization of pressure. In regions of metamorphic rocks, metamorphosed to granulite and lower amphibolite facies, evolution of melts leads to the formation of protopegmatitic bodies and later to the formation of zoned pegmatites. Most intensly zoned pegmatites are associated with recrystallization of granitic and aplitic bodies and represent a stage of reworking against a background of declining temperature and pressure within molten[sic] blocks of metamorphosed and granitized rocks.

Fluid pressure of 2.5-3.5 kbars (based on inclusions in metamorphic minerals) dropped to 0.8-0.5 kbars (based on inclusions in the minerals of pegmatites). Temperatures of formation of pegmatite veins or their specific zones varies between 1100°C[sic] and 150 to 100°C. Fluid composition varied from predominantly CO_2-rich to chloride-carbonate, enriched in Cl, Li, F etc., causing recrystallization of aplitic, granitic and similar rocks. Variation in the concentration of fluids depends upon the type of tectonic regime, determining increase in free space [and hence] controlling boiling and separation of fluids.

Pegmatites of the central part of the Ukrainian Shield and some individual pegmatite veins of western Preazov region developed within rocks, metamorphosed to upper amphibolite and lower green schist facies, have a basically similar history of formation but the water-saturated nature of the rocks led to the generation of alkali-rich, water-saturated melts during equalization of fluid pressure. During folding and lateral compression of rocks this melt is pressed out into regions of lower pressure. Evolution of such melt corresponds with the classical scheme outlined by A.I. Fersman. Temperature of formation of pegmatite bodies varies between 620 and 150°C with pressure dropping from earlier to later stages (2.5-0.5 kbars).

Differences in the conditions of formation of the two types of pegmatites is reflected in their potential economic value. The first type are basically barren, ceramic-grade pegmatites while the second type, bear numerous accessory rare metal mineralizations. (Authors' abstract)

LIU, Bin, 1985, Deduction and application of the thermodynamical equations for unitary two-phase fluid inclusions: Diqiu Huaxue (Geochimica), 1985, no. 1, p. 90-97 (in Chinese; English abstract). Author at Xi'an Inst. Geol. & Min. Resources, Chinese Acad. Geol. Sci., Xi'an, PRC.

Three thermodynamical equations for unitary two-phase fluid inclusions have been deduced.

(1) The thermodynamical 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 thermodynamical 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 thermodynamical 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[sic]. (Author's abstract)

LIU, Bin, 1985, Fluid inclusion studies of the Xitieshan lead-zinc deposit with a special discussion on physicochemical conditions for ore deposition: Mineral Deposits, v. 4, no. 1, (Ser. No.: 11), p. 22-30 (in Chinese; English abstract). Author at Xian Inst. Geol. & Min. Resources, Chinese Acad. Geol. Sci.

Ore bodies of the deposit in question occur in Upper Ordovician metamorphosed volcanic-sedimentary rocks. According to the geologic characteristics of these ore bodies, two different mineralization stages could be distinguished, i.e., initial volcanic-sedimentary stage and late superimposed mineralization stage. Quartz and calcite of these two stages contain four types of fluid inclusions: A, B, C and D; inclusions of different stages are quite different in nature.

In rocks of initial volcanic-sedimentary stage, no inclusions of type A and B have ever been found and those of type C and D are irregular in shape, minor in quantity and relatively low in Th and salinity. In rocks of late superimposed mineralization stage, inclusions are somewhat abundant and are regular in shape, comparatively coarse in granularity and relatively high in Th and salinity. Significant variations could be observed in granularity, Th, salinity, density and quantities of fluids from the first ore-bearing zone to the third ore-bearing zone or from the rich ore zone to the poor ore zone.

Hydrothermal activities were not obvious during the initial volcanic-sedimentary stage but became intense in the late superimposed mineralization stage. Mineralization got increasingly strong with the intensification of hydrothermal activities.

Physicochemial conditions responsible for ore deposition seem to have been: (1) ore-forming temperature: 110-140°C for the initial volcanic-sedimentary stage and 180-360°C for the late superimposed mineralization stage; (2) ore-forming pressure: 320-360 bar for the late superimposed mineralization stage; (3) weak acid ore-forming environment: pH = 5.83 for the late superimposed mineralization stage; (4) salinity of ore-bearing fluids: fluids of the initial volcanic-sedimentary stage were of low salinity (3.2-5.1 wt% NaCl) whereas those of the late superimposed mineralization stage were of high salinity (32-34.7 wt% NaCl) or moderately high salinity (7.5-11.0 wt% NaCl).

Volcanic activities furnished abundant materials for mineralization; sedimentation led to a preliminary concentration of metallic elements; late stage high salinity and high density hot brine also played an important role in ore deposition. (Author's abstract)

LIU, Guobin and GUO, Jiugao, 1985, Growth process and origin of color-banding tourmaline from Xinjiang: Acta Mineral. Sinica, v. 5, no. 3, p.

199-207 (in Chinese; English abstract). Authors at Inst. Geochem., Acad. Sinica, Guiyang, PRC.

Various studies were conducted on color-banded tourmaline from Altai granitic pegmatite, Xinjiang, to investigate the mechanism of its color change. According to the distribution features and Th of fluid inclusions in tourmaline, it can be concluded that there are two distinct growth stages separated by partial dissolution in hydrothermal process. (From the authors' abstract)

LIU, Guobin and LU, Huanzhang, 1985, Fluid inclusion study of gem tourmaline from Xinjiang: Geochimica, 1985, no. 3, p. 264-268 (in Chinese; English abstract). Authors at Inst. Geochem., Acad. Sinica.

Reported in this paper are the results of geological and fluid inclusion studies of gem tourmaline in pegmatite from Altai, Xinjiang. Th of fluid inclusions in tourmaline range from 230° to 350°C with a salinity of 0.2-4.5 NaCl % equiv. The composition of fluids corresponds to the $NaCl-CaCl_2-H_2O$ system in terms of the measurements of first melting temperature of fluid inclusions. By comparing Th of different color zones in the gem tourmaline, it is suggested that the crystal has undergone an intermittent growth process. Careful observation of the section parallel to the c axis of greenish-blue tourmaline provides evidence of the occurrence of chatoyant tourmaline similar to that found in Brazil and other parts of the world. Attention should be paid to such kind of tourmaline in consideration of its economic importance. (Authors' abstract)

LIU, Lin-gun, 1985, Effect of H_2O on phase transformations of mantle silicates at high pressures and temperatures: Geophys. Res. Letters, v. 12, no. 8, p. 530-533. Author at Res. Sch. Earth Sci., Australian Nat'l. Univ.

The effect of H_2O on the high-pressure phase transformations in a 1:1 mixture of forsterite and enstatite has been investigated on the basis of experimental data available in the $MgO-SiO_2-H_2O$ system at pressures up to 280 kbar. It has been found that the modified spinel phase of Mg_2SiO_4 does not occur at high pressure in this system, where more than about 4 wt % H_2O is present. In addition, the spinel phase of Mg_2SiO_4 does not appear at its equilibrium transition boundary (modified spinel $\leftrightarrow$ spinel) if more than about 3 wt % H_2O is present in the system. Thus, if more than about 4 wt % H_2O is present in the chemical composition of downgoing slabs, the so-called 400 km seismic discontinuity in the normal mantle may not occur in the subduction zone at all. (Author's abstract)

LIU, Yingjun, LI, Zhaolin, WU, Qizhi, ZHAO, Meifang and JIANG, Haoshen, 1985, Melting inclusion study of minerals in some basalts from eastern China: Diqiu Huaxue, 1985, no. 3, p. 216-226 (in Chinese; English abstract). Authors at Dept. Geol., Nanjing Univ.

The widespread Cenozoic basalts in eastern China constitute an important part of the circum-Pacific Cenozoic basalt belt. Basalt samples were collected from Wudalianci (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 basalt series, and partly to tholeiites.

A variety of inclusions commonly occur in the rock-forming minerals of these basalts. The physicochemical conditions of basalt formation in different areas have been studied in special reference to the inclusion data. Our study has shown that there is a close relationship between the features of the inclusions and the physico-chemical conditions of basalt formation, which can, therefore, be regarded as a guide to understanding the mechanism of basaltic petrogenesis. The results of research in this aspect are described in the present paper. (Authors' abstract)

LIU, Yingjun, LI, Zhaolin, WU, Qizhi, ZHAO, Meifang and JIANG, Haoshen, 1985, Melting inclusion study of minerals in some basalts from eastern China: Geochemica, v. 3, p. 216-226 (in Chinese; English abstract). Authors at Dept. Geol., Nanjing Univ.

Silicate melt inclusions in Cenozoic basalts yield Th of 890 to 1450°C. (E.R.)

LIU, Yuqing and FAN, Tianyi, 1985 A synthetic apparatus for stable isotope analysis of multi-elements and a study of the experimental method: Bull. Inst. Min. Deposits, Chinese Acad. Geol. Sci., no. 15, p. 157-179 (in Chinese; English abstract). Author at Inst. Min. Deposits, Chinese Acad. Geol. Sci.

Includes application to volatiles released by heating or by crushing inclusions. (E.R.)

LONDON, D., 1985a Formation of tourmaline-rich gem pockets in miarolytic pegmatites (abst.): EOS, v. 66, no. 18, p. 396. Author at Sch. Geol. & Geophy., Univ. Oklahoma, Norman, OK 73019.

Lithium and boron (as the component $Li_2B_4O_7$) and tourmaline may play important roles in the generation of gem-bearing pockets in miarolytic pegmatites. Concentration of the component $Li_2B_4O_7$ through fractional crystallization leads to increased if not complete silicate fluid - H_2O miscibility toward the end stage of primary crystallization. Crystallization of Li-rich tourmaline (together with micas) depletes the residual hydrous borosilicate fluid in the $Li_2B_4O_7$ flux, with resultant deposition of quartz and feldspars and evolution of large molecular quantities of acidic but low-salinity (1-4 equiv. wt. % NaCl) aqueous fluid that represents the final medium from which pocket minerals crystallize. Vesiculation (pocket formation) is not restricted to the site of tourmaline crystallization, but can occur anywhere in the pegmatite fluid where the activity of $Li_2B_4O_7$ is diminished. Estimated volume change on crystallization is ~ +10%, which is sufficient to create pocket space and ultimate pocket rupture. The presence of spodumene in many gem-bearing miarolytic pegmatites of Brazil, Afghanistan, and USA constrains the P-T conditions of pocket formation. Isochores for fluid inclusions in gem spodumene and associated pocket minerals from Afghanistan project into the spodumene stability field and indicate entrapment conditions ranging from ~500°C, 3000 bars to 350°C, 2000 bars. Low salinity of aqueous fluid (1-3 equiv. wt. % NaCl) provides additional evidence that high halide concentrations are not necessary or responsible for chemical segregation and material transport in typical miarolytic rare-element pegmatites. (Author's abstract)

LONDON, David, 1985b Origin and significance of inclusions in quartz: A cautionary example from the Tanco pegmatite, Manitoba: Econ. Geol., v. 80, p. 1988-1995. Author at Sch. Geol. & Geophys., Univ. Oklahoma, Norman, OK 73019.

Fine-grained intergrowths of quartz and spodumene, formed at ≥470°C and believed to be pseudomorphs after petalite ($LiAlSi_4O_{10} \rightarrow LiAlSi_2O_6 + 2SiO_2$), contain primary-looking fluid inclusions in both quartz and spodumene. Those in the spodumene have abundant dms, and high Th, appropriate for the transition, but those in the quartz are CO_2-H_2O fluids, similar to those believed present during subsequent lower T, P conditions. The discrepancy is explicable if the quartz has recrystallized at lower temperatures, without destroying the inclusions in the spodumene or the textural evidence of pseudomorphism. (E.R.)

LONDON, David and MORGAN, G.B., VI, 1985, Wall rock alteration around the Tanco rare-element pegmatite, Manitoba: Relations to pegmatite evolution (abst.): EOS, v. 66, p. 1154. Authors at Sch. Geol. & Geophys., Univ. Oklahoma, Norman, OK 70319.

Heat loss from the exceptionally large Tanco pegmatite induced recrystallization of amphibolitic wall rocks at T ≥500°-550°C, but most metasomatic alterations as a result of pegmatitic fluid influx occurred in the approximate range of 350°-500°C. Incipient K-metasomatism was most pervasive along the footwall, where loss of K to wall rocks may have followed from extensive sericitization of microcline within the pegmatite. Subsequent addition of Li and B to wall rocks in the form of holmquistite and tourmaline resulted from the breakdown and loss of a $Li_2B_4O_7$ component that fluxed the late-stage pegmatitic melt; fluid inclusion evidence from the pegmatite indicates that the $Li_2B_4O_7$ component was removed between 420°-470°C. Based on fluid inclusion evidence within the pegmatite, loss of this alkali borate component promoted exsolution of large quantities of H_2O and CO_2 at T ≤420°C, which led to the generation of a calcite-rich propylitic assemblage of epidote + chlorite + calcite + sphene + quartz + clays ± actinolite ± holmquistite that is the most extensive alteration assemblage in the amphibolitic wall rocks. These observations appear to confirm that exsolution of H_2O from pegmatitic magma was driven by the loss of $Li_2B_4O_7$ to wall rocks and took place comparatively late in the history of pegmatite consolidation. Unmixing of H_2O-CO_2 within the pegmatite occurred at T <400°C; upward migration of the less-dense CO_2 fluid may explain why calcite is more abundant in hanging wall vs. footwall alteration assemblages. (Authors' abstract)

LOOSER, H., EHRENSPERGER, M. and AREND, H., 1985, On the determination of inclusions in crystals grown from aqueous solutions: J. Crys. Growth, v. 72, p. 743-744. Authors at Lab. Solid State Phys., Swiss Fed. Inst. Tech., CH-8093 Zurich, Switzerland.

Growth solution inclusions were determined in gel grown $PbHPO_4$ crystals by means of differential scanning calorimetry. The detection limit corresponds to 20 ppm H_2O. (Authors' abstract)

LOREDO PEREZ, Jorge and GARCIA IGLESIAS, Jesus, 1984, Thermo-optical analysis of fluid inclusions in hydrothermally synthesized fluorite: Revista de Minas, v. 4, p. 73-81 (in Spanish; English abstract). Authors at Dept. de Metalogenia, Escuela Tecnica Superior de Ingenieros de Minas, Univ. de Oviedo, Spain.

Th was determined on fluid inclusions in fluorite obtained by hydrothermal synthesis at 90 and 100°C under low pressure.

An acceptable correlation was found between the experimental results and Tf of the fluorite. This confirms the validity of Th to assess the genesis conditions for fluorite. (Authors' abstract)

LORIUS, C., JOUZEL, J., RITZ, C., MERLIVAT, L., BARKOV, N.I., KOROTKEVICH, Y.S. and KOTLYAKOV, V.M., 1985, A 150,000-year climatic record from Antarctic ice: Nature, v. 316, p. 591-596. First author at Lab. Glaciologie et de Géophys. de l'Environ., CNRS, BP96, 38402 Saint Martin d'Héres Cedex, France.

Includes discussion of ^{18}O data and of data on CO_2 in gas inclusions, using literature data. (E.R.)

LOSH, Steven and BRADBURY, Harry, 1985, Fluid flow across brittle-ductile transitions within Pyrenean crystalline basement (abst.): EOS, v. 66, no. 18, p. 376. First author at Dept. Geol. & Geophys., Yale Univ., New Haven, CT, 06511.

Integrated structural, geochemical, and fluid inclusion investigations performed on two retrograde shear zones permit identification of fluid sources and description of the large-scale plumbing system utilized by interacting fluid reservoirs. Quartz-bearing ductile shear zone products exchanged with a metamorphic ($\delta^{18}O$ = 10% -12‰) fluid, derived from the overplated metasediments, at water/rock volume ratios of at least 3:1. One shear zone contains a band of feldspathic, quartz-deficient protocataclasite which has deformed in a brittle manner hundreds of meters below the brittle-ductile transition of the quartz-bearing products. Calcite was precipitated in the cataclasite by downward-flowing connate fluids derived from the now-eroded carbonate cover: $\delta^{18}O$ of these fluids was around 3‰. These seismically-pumped fluids followed propagating fractures downward and subsequently mixed with metamorphic fluids: $\delta^{18}O$ of ductile products and syntectonic quartz veins are locally shifted to significantly lighter values. (Authors' abstract)

LOUCKS, R.R. and SOMMER, M.A., II., 1985, Selective decrepitation and analysis of individual fluid inclusions: Hydrodynamic implications of superhydrostatic fossil fluid pressure gradients in epithermal Ag-Au veins (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 647. First author at Dept. Geosci., Purdue Univ., West Lafayette, IN 47907.

Fluid pressure gradients were reconstructed from heating/freezing data and analysis of CO_2, CH_4 and H_2S in fluid inclusions (fi's) that trapped the liquid phase of boiling solutions in three meteoric hydrothermal systems. A 30 μm-diameter, 0.4 MW, Q-switched laser light pulse was fired down the vertical tube of an optical microscope to decrepitate in vacuo selected individual fi's; mol ratios gas/H_2O were analyzed by mass spectrometry and recast as partial pressures using trapping temperature-salinity data and appropriate Henry's Law coefficeints. Regression of $P \simeq PH_2O + PCO_2 + PCH_4 + PH_2S$ vs sample elevation above MSL yields estimates of fluid pressure gradients. In a vein system near Chloride, NM, P vs depth data of four veins overlap and yield dP/dz in the range 8.7 to 9.5 b/100 m (n = 22, r^2's ≃ .9) in a vertical interval Δz = 381 m in the boiling fluid columns. Elsewhere in the Black Range, NM, three veins yield coincident P vs depth trends and a collective dP/dz = 9.6 b/100 m (n = 16, r^2 = .90) over Δz = 287 m. At Topia, Durango, 6 samples (PH_2O and PCO_2 only) imply dP/dz ≃ 9.1 b/100 m over Δz = 725 m. In each system, dP/dz exceed by $\gtrsim$1 b/100 m the maximum possible hot liquid hydrostatic gradient; this is the Darcy difference (dP/dz)-ρg that drives flow. Measured dP/dz's comply with theoretical predictions that, in meteoric hydrothermal systems with free surface discharge and recharge, dynamic equilibrium requires similar dynamic gradients in the downwelling and upwelling regions. Comparison with published dP/dz's in active geothermal systems suggests ore-forming systems may be characterized by higher recharge permeability, which promotes radial constriction of the upwelling column and focussed mineral deposition. T-P data for fi's in vein outcrop and dP/dz estimates can provide clues to drilling depth to ore. (Authors' abstract)

LOWELL, R.P. and RONA, P.A., 1985, Hydrothermal models for the generation of massive sulfide ore deposits: J. Geophys. Res., v. 90, no. B10, p. 8769-8783.

LU, H.-Z., 1985a The origin of tungsten mineral deposits in south China (abst.), *in* R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 179-181. Author at Inst. Geochem., Acad. Sinica, Guiyang, Guizhou Province, PRC.

See Lu, 1983b, Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 159-160. (E.R.)

LU, Huanzhang, 1985b Fluid inclusion studies of a new type of ore deposit: Porphyry tungsten occurrence in China: Geochemistry, v. 4, no. 1, p. 41-53.

See Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 160, 1983. (E.R.)

LU, Yumei, YIN, Haoran and SHEN, Ruijin, 1984, Genetic-model of the Qibaoshan polymetallic ore deposit: Mineral Deposits, v. 3, no. 4, p. 53-60 (in Chinese; English abstract). First author at 402 Geol. Party, Bureau of Geol. & Mineral Resources of Hunan Province.

The genesis of the Qibaoshan ore deposit, a well-known large-sized polymetallic deposit in Hunan Province, has long been a subject of much controversy. In addition to sulfides, copper, lead, zinc and iron, the deposit has considerable amounts of associated rare earth elements and precious metals.

From large quantities of laboratory data cited in this paper, the following conclusions have been drawn: the deposit was formed at moderate to small depths - from several hundred meters to some 2 kilometers below the surface; major sulfides crystallized from 200°C to 300°C; sulfur isotopic composition of sulfides is basically that of meteorite sulfur; isotopic composition of lead indicates fundamentally a normal lead. The metals, from lower crust or upper mantle, were transported as chloride complexes. The fluid was a mixed magmatic water. Thus this deposit is a high-medium temperature hydrothermal filling-replacement type. (From the authors' abstract)

LUCE, R.W., CYGAN, G.L., HEMLEY, J.J. and D'ANGEOLO, W.M., 1985, Some mineral stability relations in the system $CaO-MgO-SiO_2-H_2O-HCl$: Geochimica Cosmo. Acta, v. 49, p. 525-538.

LUCIDO, G. and TRIOLO, R., 1983, Magma as a critical ionic-fluid system: Miner. Petrogr. Acta., v. 27, p. 117-127. First author at Istit. Min., Petrogr. e Geochim., Univ. Palermo, 90123, Italy.

It is concluded that when a magma (initially in one phase) is quenched into a metastable state, incipient differentiated droplets of a second [immiscible] phase will spontaneously grow in size until non linear effects limit the growth rate. (From the authors' abstract)

LUKANIN, O.A. and KADIK, A.A., 1985, Influence of the redox regime upon the melting of the upper mantle rocks in the presence of the volatile components of the C-O-H system (abst.): Lunar and Planetary Sci. XVI, p. 507-508.

LUKANIN, O.A. and KADIK, A.A., 1984, A possible influence of partial melting on the redox conditions and the behavior of fluids in the upper mantle: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 996-998 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 4, p. 154-156, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 205. (E.R.)

LUNINE, J.I., 1985, The role of clathrates in the outer solar system (abst.): EOS, v. 66, no. 46, p. 944.

LUO, Taichen, JIANG, Yongoai and JIANG, Naixing, 1985, Clinopyroxenes in the volcanic rocks of the Lishui area, Jiangsu Province: Bull. Nanjing Inst. of Geol. & Min. Resources, Chin. Acad. Geol. Sci., v. 6, no. 2, p. 62-68 (in Chinese; English abstract). Authors at Nanjing Inst. Geol. & Miner. Resources, China.

The optical constants, chemical composition, site occupancy, cell parameters, pO_2, etc., are discussed and temperatures (Th?) of 973-1169° are given. Depths ≤63 km are suggested. (E.R.)

LUPTON, J.E., DELANEY, J.R., JOHNSON, H.P. and TIVEY, M.K., 1985, Entrainment and vertical transport of deep-ocean water by buoyant hydrothermal plumes: Nature, v. 316, p. 621-623.

LUTH, Robert and BOETTCHER, Art, 1985, Hydrogen and the melting of silicates: The system SiO_2-H_2O-H_2 (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 649.

LUX, Gayle, 1985, The behavior of noble gases in silicate liquids: Preliminary results (abst.): Lunar and Planetary Sci. XVI, p. 511-512. Author at Dept. Physics, Univ. California, Berkeley, CA 94720.

Includes experimental measurements of the solubilities and diffusion rates of Ne, Ar, Kr and Xe in various silicate melts from basic to andesitic. (E.R.)

LYASHKEVICH, Z.M., KOVALISHIN, Z.I. and MARUSHKIN, A.I., 1985, Volatile components in the mantle magmas of the Pripyat-Dneprovsk-Donets paleo-rift (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 122-123 (in Russian; translation by D.A. Brown). Authors at IGGGI Acad. Sci. Ukrainian SSR, L'vov, USSR.

On the basis of petrochemical features, three magmatic associations have been recognized here: alkaline-ultramafic, trachybasalt-trachyrhyolitic, and basalt-doleritic. Data based on a study of primary melt inclusions, titanomagnetite geothermometry, and the peculiarities of chrome-picotite, point to the mantle origin of the original melts. In this respect, the great depths (of the order of 100 km) and T (1100-1400°C) of formation of magmas of the alkaline-ultramafic association as compared with those of the later basalt-dolerite and trachybasalt-trachyrhyolite associations (50-60 km, 900-1000°C), have been demonstrated.

The gases found (MSKh-ZA mass-spectrometer) in primary inclusions of the main rock-forming minerals vary as follows (vol. %): alkaline-ultramafic association, 0.8-39.1 (average 10.7) CO_2, 0-33.1 (23.9) N_2, 0.9-8.8 (3.6) CH_4, 36.9-57.9 (43.2) H_2, 0-29.5 (19.3) H_2O; basalt-dolerite association, 2.3-2.7 (2.6) CO_2, 22.8-34.4 (25.7) N_2, 9.1-50.9 (23.0) CH_4, and 24.0-58.3 (41.3) H_2.

The dominance of H_2 reflects the reducing environment; the total proportion of the primary mantle gases, H_2 and N_2, amount to about 70% and indicates the great depths of magma-formation.

Conditions in the upper mantle are optimal for generation of CH_4, whereas in depth, the concentration falls (Lutts, 1980). Thus, the amount of CH_4 reflects the greater depth of the alkaline-ultramafic association as compared with the basalt-dolerite association. The presence of water in samples of alkaline-ultramafic rocks points to the more complete melting of the mantle substrate during formation of the original magma. (From the authors' abstract)

LYNCH, W.C., BEATY, D.W., GONZALEZ-URIEN, Eliseo and REISBICK, Fred, 1985, The Mt. Bellview, Colorado igneous-hydrothermal-breccia complex: A calc-alkaline molybdenite occurrence (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 253. First author at Noranda Exploration, Inc., P.O. Box 15638, Denver, CO 80215.

The intrusive complex at Mt. Bellview comprises a granodiorite stock, a later quartz monzonite porphyry stock and dikes and a final hydrothermal breccia pipe. A pulse of hot magmatic water ($\delta^{18}O$ = 4-7) apparently formed the breccia and vein system as shown by high-^{18}O quartz-MoS_2 veins (7.5-10.1) and breccia matrix minerals (qtz 11.9, cc 12.2, gar 7.1). High T is shown by fluid inclusions (380 to >450°C) and isotopic fractionations (400-480°C). Some breccia minerals, however, show meteoric effects (anhy 0.3, scap -3.9). (From the authors' abstract)

McBRIDE, E.F., 1985, Timing diagenetic events in sandstones and shales: Successes and problems, *in* Timing of Siliciclastic Diagenesis: Relationship to Hydrocarbon Migration: Sixth Ann. Res. Conf., Gulf Coast Sec., Soc. Econ. Paleontologists & Mineralogists Foundation, Program & Abstracts, p. 22-23. Author at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78713.

A brief review of the use of fluid inclusion studies to understand the PVT conditions during diagenesis. (E.R.)

McCAFFREY, M.A., 1985, The evolution of seawater during evaporation in salinas on Great Inagua, Bahamas, and the Br^- and K^+ content of halite from this locality: B.S. thesis, Harvard Univ., Cambridge, MA, 64 pp.

At the Morton Bahamas solar-salt production facility on the island of Great Inagua, Bahamas, the evaporation path of seawater was sampled to concentrations of 40-times seawater. The change in composition of seawater during evaporation was determined. Calcium carbonate begins to precipitate at brine concentrations ≈ 1.8-times seawater. Calcium sulfate begins precipitating when the degree of evaporation reaches 3.8; at brine concentrations 10.6 times that of seawater, halite first precipitates. The K^+ and Br^- distribution coefficients between brine and halite (precipitated at the beginning of the halite facies) were calculated to the $D(K^+) \approx .016$ and $D(Br^-) \approx .033$. The variations of $[K^+]$ and $[Br^-]$ in halite as functions of crystal size and as functions of degree of evaporation of parent brine were also examined. (Author's abstract)

K^+ and Br^- are present in halite both as solutes in fluid inclusions, and as ions substituting for Na^+ and Cl^- in the halite structure. Virtually all Mg^{2+} present in halite exists as a solute in fluid inclusions. Since the ratios $[K^+]/[Mg^{2+}]$ and $[Br^-]/[Mg^{2+}]$ are almost constant during the evaporation of seawater to the end of the halite facies, the Mg^{2+} content of the halite solution was used to distinguish K^+ and Br^- originally present in fluid inclusions from K^+ and Br^- originally in the halite structure. (From the text)

McCALLUM, M.E., 1985, Experimental evidence for fluidization processes in breccia pipe formation: Econ. Geol., v. 80, p. 1523-1543.

McCORKLE, D.C., EMERSON, S.R. and QUAY, P.D., 1985, Stable carbon isotopes in marine porewaters: Earth & Planet. Sci. Letters, v. 74, p. 13-26.

McGLASHAN, M.L., 1985, Phase equilibria in fluid mixtures: Pure & Appl. Chem., v. 57, no. 1, p. 89-103. Author at Dept. Chem., Univ. College London, 20 Gordon St., London WC1H 0AJ, UK.

Phase diagrams for binary fluid mixtures are reviewed with respect to experimental methods used for their study; the kinds of phase diagram obtained in practice, especially those including one or more of azeotropy, the coexistence of three fluid phases, and the coexistence of two fluid phases ("gas-gas immiscibility") at temperatures above the critical temperature of either pure component; and the extent to which modern theoretical treatments can be used to predict what actually happens at different pressures, temperatures, and compositions. (Author's abstract)

McKEEGAN, K.D., WALKER, R.M. and ZINNER, Ernst, 1985, Ion microprobe isotopic measurements of individual interplanetary dust particles: Geochimica Cosmo. Acta, v. 49, p. 1971-1987. Authors at McDonnell Center for the Space Sci., Phys. Dept., Washington Univ., St. Louis, MO 63130.

Ion microprobe measurements of D/H ratios in individual fragments of eight stratospheric dust particles give δD values ranging from -386 to +2534‰ relative to SMOW. The δD values in five particles far exceed those in terrestrial samples and prove that the samples are interplanetary dust particles (IDPs).

Carbon isotopic measurements on fragments of three IDPs give ratios similar to terrestrial values and show a largely uniform isotopic composition for a given particle. Small, but significant, differences in $\delta^{13}C$ of ~40‰ between particles are seen. No correlations between the hydrogen and carbon isotopic compositions are observed.

The magnesium and silicon isotopic compositions of fragments of three IDPs are found to be normal within measurement errors. (From the authors' abstract)

Of pertinence to the interpretation of isotopic measurements on fluid inclusions found in various meteorites. (E.R.)

McKENZIE, W.F. and HELGESON, H.C., 1985, Phase relations among silicates, copper iron sulfides, and aqueous solutions at magmatic temperatures: Econ. Geol., v. 80, p. 1965-1973.

McKIBBEN, M.A. and ELDERS, W.A., 1985, Fe-Zn-Cu-Pb mineralization in the Salton Sea geothermal system, Imperial Valley, California: Econ. Geol., v. 80, p. 539-559. Authors at Dept. Earth Sci. & Inst. Geophys. & Planet. Physics, Univ. California, Riverside, CA 92521.

The Salton Sea geothermal system is an area of active metamorphism in a Plio-Pleistocene deltaic sedimentary sequence. Within it, hypersaline brines containing up to 250,000 ppm total dissolved solids and temperatures up to 365°C are causing incipient sulfide and oxide mineralization.

The phase relations of the presently sealed sulfide-carbonate ± silicate veins require that earlier fluids, if formed at the same temperature and pH, had to be more reduced and sulfur-rich than the present slightly oxidized, sulfur-poor brines. Contrasting fluid redox states may be caused by a late lateral or fault-controlled influx of more oxidized surficial waters. Lack of acid alteration implies boiling has not occurred to produce the oxidized fluids. Early formed diagentic iron sulfides are commonly replaced by later Cu-Pb-Zn sulfides and iron oxides and enveloped and resorbed by veins, acting as nuclei and sources of S and Fe for later mineralization. Precipitation probably occurs when seismic or hydraulic fracturing allows the metal-rich, sulfur-poor brines to interact with earlier pyrite sulfur in the host rocks. Thus the geothermal system as presently explored is best classified as an incipient stratabound sulfide deposit that is being overprinted by hydrothermal and metamorphic processes. (From the authors' abstract)

MACKWELL, S.J. and KOHLSTEDT, D.L., 1985, Solubility of water in olivine single crystals (abst.): EOS, v. 66, p. 1140. Authors at Dept. Materials Sci. & Engrg., Cornell Univ., Ithaca, NY 14853.

Experiments have previously been performed on olivine single crystals that show a weakening effect due to the presence of water at high pressures and temperatures (Mackwell et al., 1985). Although Justice et al. (1982) found no water weakening of olivine in 1 atm deformation experiments, Poumellec and Jaoul (1985) reported a factor of about two decrease in creep rate under similar hydrous conditions. In the present investigation, we have also carried out heat-treatment and deformation experiments on San Carlos olivine specimens at 1 atm, using mixtures of H_2/Ar and H_2O/Ar to control the oxygen and water partial pressures. We have detected no increase in the hydroxyl bands in the infrared absorption spectra from these specimens, as predicted by a linear extrapolation from solubility measurements made at 300 and 1500 MPa (Mackwell et al., 1985). Also, the creep rates of specimens run using wet H_2/H_2O/Ar gas mixtures were not significantly different from the creep rates of those run in dry CO/CO_2 gas mixtures. To extend our preliminary measurements on the solubility of water-derived species in olivine at 300 and 1500 MPa to lower partial pressures of water, specimens of San Carlos olivine have been heat-treated under wet conditions in a gas-medium apparatus at 1000°C and pressures from 10 to 500 MPa, with the oxygen partial pressure controlled near the wustite/magnetite oxygen buffer. Infrared absorption measurements of the uncracked specimens from these experiments are currently being performed. (Authors' abstract)

MACKWELL, S.J., KOHLSTEDT, D.L. and PATERSON, M.S., 1985, Water weakening of olivine single crystals (abst.): EOS, v. 66, no. 18, p. 373.

MACKWELL, S.J., KOHLSTEDT, D.L. and PATERSON, M.S., 1985, The role of water in the deformation of olivine single crystals: J. Geophys. Res., v. 90, no. B13, p. 11,319-11,333. First author at Res. Sch. Earth Sci., Australian Nat'l. Univ., Canberra.

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^2s^{-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)

McLAUGHLIN, R.J., SORG, D.H., MORTON, J.L., THEODORE, T.G., MEYER, C.E. and DELEVAUX, M.H., 1985, Paragenesis and tectonic significance of base and precious metal occurrences along the San Andreas fault at Point Delgada, California: Econ. Geol., v. 80, p. 344-359.

Studies of sulfide vein mineralization at Point Delgada, California, suggest that the mineralizing process was intimately associated with the San Andreas fault system and/or plate-margin tectonism. The deposits occur along north-south to northeast-southwest-trending tension faults that intersect and cross a major northwest-trending fault previously considered to be a major trace of the San Andreas fault. Galena and sphalerite are concentrated near the intersection of the principal mineralized vein with the fault, suggesting that brecciated rocks at this intersection acted as a major conduit for hydrothermal circulation.

Fluid inclusion data show that the sulfide mineralization occured at a depth of at least 400 m, probably at a temperature of about 250°C. Mineralization fluids were in the salinity range of 10.5 to 5.2 equivalent weight percent NaCl. Sodium and potassium were depleted from the mineralizing fluids in the early stages of mineralization, and traces of argentian tetrahedrite and cassiterite in the fluid inclusions probably account for some of the anomalous values of silver and tin in galena and sphalerite.

The age of mineralization, based on K-Ar dating of adularia, is 13.8 ± 0.4 m.y. This age suggests that the purported trace of the San Andreas fault crossed by the sulfide veins has been largely inactive since middle Miocene time.

Lead isotope and geochemical data suggest that base and precious metals in the sulfide veins were derived largely from arc-related sedimentary rocks. The heat source for hydrothermal circulation may have been associated with intrusion of asthenosphere into a triangular slab window opened southeast of the northward-propagating Mendocino triple junction shortly before 13.8 m.y. ago. (Authors' abstract)

The crystals of cassiterite, argentian tetrahedrite, sphalerite, and anhydrite found by SEM in 2-3-μm inclusions are believed to be trapped crystals, not daughter crystals. (E.R.)

MACLEAN, W.H. and WALKER, D.A., 1985, Experimental partitioning of Sc, T, V, Cr and Mn between iron sulfide and silicate liquids and iron (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 650. Authors at Dept. Geol. Sci., McGill Univ., Montreal, Quebec, Canada, H3A 2A7.

Experiments on the partitioning of Sc, T, V, Cr and Mn between immiscible silicate and sulfide liquids saturated with iron were run in alumina containers in sealed, evacuated silica glass capsules using a vertical resistance furnace, 30 minute run duration, and a NaCl brine quench. The system studied was $FeS\text{-}FeO\text{-}SiO_2$ at 1150°C, 10°C above the invariant temperature for the assemblage fayalite-tridymite-sulfide liquid-silicate liquid-iron. Immiscible sulfide and silicate liquids and iron were the primary phases in each run. fS_2 and fO_2 are low and internally buffered by the invariant assemblage. Microprobe analyses, using a 20 micron moving beam and 60-100 seconds counting times, yielded partition coefficients (KMe = wt % metal in silicate liquid/wt % metal in sulfide liquid): Sc >100, Ti = 96, V = 6.4, Cr $\sim$ 4, Mn = 7.2. Partitioning in this particular group of transition metals is a complex function of valence states, ionic radii, ligand field effects, and coordination sites.

The metals were not detected in either equilibrium of quench crystals of iron.

The data explain the lack of these elements in magmatic Ni-Cu-PGE ores. In particular, ilmenite, ulvöspinel, vanadiniferous magnetite or chrome spinel may be a phase of the co-magmatic silicate rocks, but only a relatively pure magnetite forms in the sulfide ore. (Authors' abstract)

McLIMANS, R.K., 1985, Migration and maturation of hydrocarbons - Evidence from fluid inclusions (abst.): AAPG Bull. v. 69, no. 2, p. 286-287. Author at Conoco Inc., Ponca City, OK.

Oil-filled fluid inclusions occur in cements in petroleum reservoirs and are evidence for the generation and migration of hydrocarbons in a basin. Generally, oil-filled inclusions occur together with aqueous inclusions in the same cement crystal. Geothermetric studies of the aqueous inclusions provide thermal and compositional data pertinent to interpreting the time of cementation and hydrocarbon migration relative to source rock maturation.

Oil-filled inclusions occur both in random locations and in alignment with crystal cleavages or fractures. Random distributions of fluid inclusions suggest oil entrapment during growth of the cement crystal into primary porosity whereas the occurrence of fluid inclusions along sealed fractures suggests migration through secondary porosity. Generally, the oil-filled inclusions consist of liquid hydrocarbon and a gas phase, but inclusions containing oil, water, and gas also occur. Those different compositions suggest differences in the migration and mechanism of petroleum[sic].

Oil-filled inclusions are characterized by fluorescence spectra. In many cases, different episodes of hydrocarbon migration are indicated by the occurrence in the same crystal of oil-filled inclusions whose fluorescence spectra are different.

The organic chemical compositions of aqueous and oil-filled inclusions are determined by decrepitation-gas chromatography. Those compositions are compared to organic compositions of whole reservoir rock, reservoir oils, and source rock to decipher the history of oil emplacement and maturation. Oil alteration effects, possibly induced during the early stages of migration, are also detected. (Author's abstract)

McLIMANS, R.K. and VIDETICH, P.E., 1985, Reservoir diagenesis and petroleum migration in the Great Oolite formation, Jurassic of the Wealden Basin, England: Impact on exploration (abst.): Abstracts, SEPM Ann. Midyear Meeting, Aug. 11-14, 1985, Golden, Colorado, v. 2, p. 62. Authors at Conoco Inc., Ponca City, OK.

Tight carbonates occur where porosity is occluded by coarse calcite spar. That spar contains both aqueous and two types of oil-filled inclusions as identified from fluorescence spectra. Geothermetric studies of the aqueous inclusions indicate coarse spar was deposited near maximum burial depth, a few thousand feet greater than present depth. Hence, source rocks were buried deeper than present and migration of hydrocarbons and cementation were in part geologically synchronous. The inclusion data indicate a Cretaceous age for those events followed by later post-Mesozoic uplift. Hence Mesozoic age traps have the greater potential for hydrocarbon accumulation.

Oils entrapped in fluid inclusions were analyzed by decrepitation-gas chromatography techniques. Those analyses indicate the entrapped oils are of different composition and maturity at different basin locations. Those data enable interpretation of the type, source, and timing of hydrocarbon migration into different parts of the basin. (From the authors' abstract)

McMILLAN, W.J., 1985, Geology and ore deposits of the Highland Valley Camp: Geol. Assoc. Canada, Min. Deposits Div., Field Guide and Reference Manual Series No. 1. Author at Geol. Br., Mineral Res. Div., Ministry of Energy, Mines & Petro. Res., Parliament Bldgs., Victoria, B.C. V8V 1X4, Canada.

Fluid inclusions in mineralized quartz veinlets from the Valley Copper deposit are extremely small, about 0.005 millimeter in diameter; they tend to occur in planar clusters and linear zones and may not be primary. Most are composed of 70 to 80 per cent liquid and 20 to 30 per cent gas phases, although daughter crystals of chloride and carbonate have been identified. Average salinity, as indicated by freezing techniques, is 5 weight per cent (Osatenko and Jones, 1976). A few inclusions contain liquid CO_2, indicating pressures between 100 and 300 bars and a depth of formation of about 1 to 2 kilometers.

The structurally dependent arrangement and low homogenization temperatures (<200°C) of the fluid inclusions suggest formation by dominantly secondary processes, perhaps during the waning stages of hydrothermal activity. (From the author's text, p. 86)

McNUTT, R.H., 1985, Strontium isotope ratios as an indicator of water-rock interaction (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A39. Author at Dept. Geol., McMaster Univ. Hamilton, Ontario, L8S 4M1, Canada.

While the use of stable isotopes as indicators of water-rock interaction is well established, that of radiogenic isotopes is relatively new, particularly as applied to igneous and metamorphic rocks. Because of the geochemical similarity of Sr to Ca, the $^{87}Sr/^{86}Sr$ ratios are sensitive indicators of Ca exchange, and by inference other major elements, between water and the enclosing host rock. Published work by McNutt, Frape and Fritz (1984) show that the more saline brines (400-2000 mg/ℓ Sr, >100,000 mg/ℓ TDS) have a $^{87}Sr/^{86}Sr$ range that completely overlaps the present-day whole rock values. This indicates extensive exchange with all major Sr (and Ca) bearing mineral phases. The more dilute waters (2-20 mg/ℓ Sr, <10,000 mg/ℓ TDS) gives values at the high end of the whole rock range, suggesting incomplete exchange or exchange only with certain more Rb-rich (and hence ^{87}Sr enriched) phases.

Water samples from drill holes in the East Bow Lake layered gabbro-anorthosite intrusive, northeastern Ontario, are dilute (<1 mg/ℓ Sr) and give a very limited range in $^{87}Sr^{86}Sr$ (.712-.713). Whole rock core samples vary from .705-.710, i.e. no overlap at all. Taken together with our published data, it suggests that the most dilute water is also the youngest in terms of contact with its present host rock. The implications of this relative chronology for the water in these and other areas will be discussed. (Author's abstract)

McSWEEN, H.Y., Jr., MISRA, K.C. and LABOTKA, T.C., 1985, Importance of core-sample petrology in an ultra-deep drill hole in the southern Appalachians (abst.): EOS, v. 66, no. 18, p. 354. Authors at Dept. Geol. Sci., Univ. Tennessee, Knoxville, TN, 37996.

Includes mention of use of fluid inclusions in understanding the metamorphic and tectonic history. (E.R.)

MAGAKYAN, R., SOBOLEV, A.V., ZAKARIADZE, G.S. and KONONKOVA, N.N., 1985, The petrology of the boninites of the 'andesite' belt of the Lesser Caucasus (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 131-132 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

The primary magmatic inclusions in the cpx phenocrysts of the boninites consist of solid-phase (chrome-spinels, orthopyroxenes, amphiboles, and magnetites) and melt (crystallized melt + fluid, glass + fluid, and homogeneous glass) varieties, and also low-density fluid inclusions without any apparent phase boundaries; combined inclusions with different combinations of the above phases have been found. Experimental Th studies of the primary melt inclusions have enabled the authors to determine the crystallization interval of cpx (1210-920°C); their composition correlates with T. During the experiments, a rise in the Th of the melt inclusions has been identified (accompanied by the appearance of a magnetite phase in the inclusions), if the experiments were extended to more than seven minutes, a qualitative indication of water in the melt. A comparison between Th and the calculated T(eq) for an homogenized melt inclusion with a cpx-host, has enabled the authors to make a quantitative determination of the amount of water in the melt (2 wt %). A comparison between Th and the two-pyroxene T has demonstrated their agreement within the limits of error of the calculation method (±30°), which indicates the reliability of the results obtained.

The combined data obtained have enabled the authors to determine the composition of the andesite-dacite melt (a derivative of an original boninitic magma) and to trace changes in its composition as the temperature of the system fell. For the first time, it has been demonstrated that a boninitic melt has been fractionated into the field of silicic, rhyolitic melts. (From the authors' abstract)

MAGRO, G., FERRARA, G. and GIULIANI, O., 1985, $^{40}Ar/^{36}Ar$ variations in the fumarolic gases of Vulcano (Aeolian Islands) and Solfatara (Phlegraean fields) (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

MAHTAB, M.A., TRENT, B. and YEGULALP, T.M., 1985, A numerical analysis of the mechanics of gas outbursts in salt: Sixth Int'l. Symp. on Salt, 1983, v. 1, p. 549-560. First author at Henry Krumb Sch. Mines, Columbia Univ., New York, NY, USA.

In (large?) part these are caused by high pressure gas inclusions. (E.R.)

MAISKII, Yu.G, 1985, Physicochemical characteristics of hydrothermal ore deposits at Donets Basin: Izv. Sev.-Kavk. Nauchn. Tsentra Vyssh. Shk., Estestv. Nauki 1985, no. 1, p. 62-64 (in Russian). Author at Rostov. Gos. Univ., Rostov, USSR.

Hydrothermal Au, Hg, and polymetallic ore mineralization occur in quartz, quartz-carbonate, and carbonate veins traversing Carboniferous arenaceous-schistose beds of the Donets Basin (USSR). Fluid inclusions in ore-associated minerals were studied for their Th, salt composition of ore-forming solutions, and decrepitometric data. Hypothetically, the ore-localizing solutions had compositions containing (Na,K)Cl, $CaCl_2$, $MgCl_2$, NH_4Cl, $(Na,K)HCO_3$, $(NH_4)HCO_3$, $Ca(HCO_3)_2$, $MgSO_4$, $(Na,K)_2SO_4$, and $(NH_4)_2SO_4$. (C.A. 103: 181178c)

MAKAGON, V.M. and KUZMINA, T.M., 1985, Conditions of formation of beryl in muscovite pegmatite of Eastern Siberia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 11-13 (in Russian; translation by S. Jaireth). Authors at Inst. Geol., Siberian Branch Acad. Sci. USSR, Irkutsk, USSR.

Beryls of different colors but broadly similar composition from veins of muscovite pegmatites have been studied. The studied beryls belong to sodic and non-alkalic varieties (as per classification of T.A. Sosedko and V.A. Frank-Kamenetski) and are characterized by low concentrations of alkalies, particularly Cs and Li, and very high concentration of BeO.

Beryl, which is accessory in muscovite pegmatites, is usually observed either in pegmatoid zones or in the quartz core, where it is associated with albite and green muscovite. It is also seen in quartz-muscovite zones of albitized veins along with green muscovite, sometimes pink garnet, schorl and albite.

Various types of primary fluid inclusions have been recorded in beryl. The first type consists of liquid aqueous solution, liquid CO_2, and gas. Halite and other dms are rare. These tubular and negative-crystal shaped inclusions are distributed parallel to the c-axis of the crystal. Th L-V(L) = 215-365°C. Pressure during crystallization was between 1.5 and 2.6 kbars.

The second type of inclusions is the glassy inclusion, of tubular and negative crystal shapes, [also] oriented parallel to the c-axis. These often contain either a gaseous phase or an aqueous solution with gas or rarely aqueous solution with liquid CO_2. Phase ratios are highly variable. Predominantly glassy inclusions are seen along with inclusions in which liquid or gaseous phases predominate. Inclusions showing different grades of recrystallization, bearing at places, crystals of beryl[sic] are also associated with the second type. Such recrystallized inclusions are observed locally along cracks cutting across crystal zones, bearing primary glassy inclusions. On heating, the liquid phases in them homogenize at temperature similar to those observed of the first type of inclusions. Solids start melting at 430°C but subsequent heating up to 950°C did not lead to complete homogenization.

Formation of beryl in muscovite-pegmatite took place in two stages: 1) during a decrease in alkalinity (transformation from pegmatoid zone to quartz core): fractures in crystals at places have been healed by quartz and 2) during initial stages of late albitization.

Second type of inclusions are observed in the internal crystal zones of beryl from pegmatoid zones or from peripheral parts of the quartz core. Their presence indicates crystallization of beryl from heterogeneous mineral-forming media, when an abrupt drop in pressure caused release of CO_2 and H_2O from silicate melt - solution, which led to the entrapment of glass (with variable amounts of gaseous phase and aqueous solution) and liquid CO_2 or two-liquid inclusions. The outer zone of the crystals, devoid of glassy inclusions, crystallized from aqueous solutions with H_2O and CO_2 as dominant components. In some pegmatite veins the effect of late metasomatic processes on beryl crystals is observed; as a result, primary glassy inclusions have been retained only in a few portions; the main portions of these crystals either contain reworked inclusions or fluid inclusions of first type.

Beryl crystals formed during initial stages of late albitization bear fluid inclusions of first type. (Authors' abstract)

MAKAGON, V.M., KUZMINA, T.M. and TAUSON, L.S., 1985, Role of physicochemical factors of mineral formation in the evaluation of ore bearing potential of East Siberian pegmatites (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 9-11 (in Russian; translation by S. Jaireth). Authors at Inst. Geol., Siberian Branch Acad. Sci. USSR, Irkutsk, USSR.

Formation of muscovite and rare metal pegmatites of Eastern Siberia is divided into two stages - stage of magmatic crystallization and stage of postmagmatic replacement. The two types of pegmatites have been formed at similar temperatures but different pressures. Differences in the role of volatiles, in the acidity-alkalinity, and in the processes of immiscibility are connected with this important fact.

Ore specialization of pegmatites is controlled by pressure of formation. For muscovite pegmatites which are formed at high pressures (≤7 kbar), in addition to H_2O, the other main component of melts and postmagmatic solutions is CO_2, higher concentration of which increased hydrolysis of feldspar leading to the formation of large crystals of muscovite.

Spodumene-type, rare metal pegmatites are formed at high initial pressure (<5 kbar) which drops steeply during crystallization leading to the formation of azonal pegmatite bodies and veins and also causes zoning in the distribution of mineralized pegmatites--Li-bearing in high pressure conditions and complex Ta-Cs-Li-bearing in low pressure conditions.

Petalite bearing rare metal pegmatites are formed at low pressures (~2 kbar). These are characterized by high initial temperatures of crystallization, gradual drop in which led to the development of zonal and partially zonal bodies.

Fluid inclusion studies have revealed that crystallization of spodumene bearing rare metal pegmatites began at high $P(CO_2)$ and formation of pegmatites with complex mineralization was accompanied by abrupt loss of CO_2. Lower fluorine concentration in the melt helped accumulation of Cs and formation of pollucite in pegmatite. Fluorine seemed to have played a significant role in the formation of petalite bearing rare metal pegmatites as well.

In order to evaluate ore bearing potential of pegmatites, data on the composition of fluid inclusions in minerals (particularly quartz) can be used. In contrast to barren pegmatites, having inclusion-fluids rich in Cl^-, rare metal pegmatites with Li (spodumene and petalite bearing) and complex mineralization have inclusions fluid rich in Li^+ and HCO_3^{-2}[sic] respectively. (From the authors' abstract)

MAKHNACH, A.A. and SIANISYAN, E.S., 1985, The interpretation of temperatures of vacuum decrepitation of gas-liquid inclusions in catagenic minerals in areas with a complex geothermal history (as exemplified by the Pripyat Trough) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 202-203 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. & Geochem. Acad. Sci. Beloruss. SSR, Minsk, USSR.

Any attempt to decipher the temperatures of vacuum decrepitation, which defines the statistically-generalized effect from the break-up of inclusions of different genetic forms, in regions which have undergone a complex progressive-regressive geothermal regime, is of great importance. Under these conditions, the minerals may, after formation, be subjected to metasomatism, recrystallization, and other changes, with the formation of new inclusions at different temperatures.

From a study of the sequence of crystallization of minerals in the cavity space in carbonate rocks, and the hydrogeochemical evolution of the inter-salt sequence in the Pripyat Trough, and also allowing for the nature of the tectonic development of the region, the route seems to have been: early-syneclise phase - rift-graben phase - late-syneclise phase; it has been established that the formation of catagenic calcite and anhydrite took place mainly during the course of development of geothermal activity in the region, and for halite, during the time when it died down. The main stage of dolomitization of the calcareous rocks coincided with the interval of maximum geothermal activity (Dankovo-Lebedyansk time). A comparison between these data and the results of a decrepitation analysis of the rocks and minerals of the inter-salt sequence in the Pripyat Trough has suggested a procedure for interpreting the Td values (105-150°C for calcite, anhydrite, and halite; 100-240°C for the dolomitic rocks (depending on depth of occurrence); and 145°C for a layered halite from the upper salt sequence).

The relationship between Td of the dolomitic rocks and their depth of occurrence and the correspondence between these values and those for maximum T, established from the reflectivity of vitrinite, and in the light of hypotheses on the dominantly catagenic nature of this dolomitization, indicate Td records the T during dolomite metasomatism. Td in calcite and anhydrite is 35-110°C lower than in the country rocks. Since their formation was connected with a rising T, after formation of these minerals in the rock cavities, they were subjected to higher T and were recrystallized, which led to the formation of the S inclusions. Nevertheless, the Td does not reflect the T conditions of recrystallization. This, in the authors' view, is related to the fact that recrystallization occurred under nonmetamorphic conditions, affecting mainly the marginal parts of the grains, and therefore the number of newly-formed, high-T inclusions is extremely small as compared with that of the earlier, low-T forms. The formation of halites in the cavities of carbonate rocks took place mainly during a fall in T, and there was not significant recrystallization, so no new, higher-T inclusions were formed. Therefore, Td = Tf for halites in this instance. Td for the layered rock salt (145°C) that has been recrystallized during catagenesis is significantly higher than the Tf for sedimentary basin halite and lower than T_{max} in the depth range, estimated from the reflectivity of vitrinite (190°C).

Hence, if the metasomatic origin of a mineral or rock has been established, then Td reflects the conditions of metasomatism; if the mineral has undergone T above that during its precipitation, then the closer the Td for vacuum decrepitation is to the Tf of the mineral, the lower is the mineral's capacity towards recrystallization. (From the authors' abstract)

MALLEY, P., JOURDAN, A. and WEBER, 1985, Fluid inclusions in silicified sandstones from the Brent formation, North Sea (abst.): Terra Cognita, v. 5, p. 296. Authors at Centre Sedimen. & Géoch. Surface, 67084 Strasbourg Cedex, France.

Eleven explored drill-holes in the Brent silicified sandstones of the Alwyn oil-field revealed the presence of three different types of fluid inclusions. They respectively contain: (1) a two phase hydrocarbon fluid which homogenizes into a liquid phase when heated at about 85°C, (2) a two phase aqueous fluid homogenizing into a liquid phase near 110°C with a 4% NaCl equiv. content, and (3) a two phase aqueous fluid homogenizing into a liquid phase near 90°C with a 4 to 12.5% NaCl equiv. content. (1) and (2) extend widely and are found either separately or together. There is statistically no variation of the Th or Tf either versus depth or geographic position of drill-holes. (3) is restricted to a single hole. The contemporarity of such fluids with silica overgrowth is in favor of a late silicification of the rocks; at present day, no petrographic or inclusion evidence for an early one has been found. Minimum trapping temperatures for fluids (1) and (2) combined with K-Ar dating [1] and [2] that propose the Lutetian times for the crude-oil emplacement, lead to a new concept of the evolutionary history of this oil-field which includes:

- during Lutetian times, a silicification process contemporaneous to oil migration and which could have taken place at the beginning of the hydrocarbons production,
- an upwards migration of the crude-oil from the deeper and hotter source-rocks to the reservoir rocks situated near 1800 m at the time of migration.

[1] Clauer, N., Liewig, N. and Sommer, F. Paper submitted to AAPG Bulletin.

[2] Malley, P., Clauer, N., Jourdan, A. and Sommer, F., (1985): AAPG Research Conference, Abstract. (Authors' abstract)

MALYUK, G.A. and VOZNYAK, D.K., 1985, Contribution to the problem of determination of gas components of inclusions of mineral-forming solutions released by heating (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 69-70 (in Russian). Authors at Inst. Geochem. & Physics of Minerals, Kiev, Ukraine, USSR.

The authors present the method of determination of gases relased from inclusions by use of mass-spectrometer MSKh-4 with sensitivity H_2O $4 \cdot 10^{-6}$ g, CO_2 $5 \cdot 10^{-7}$ g, CO and N_2 $3 \cdot 10^{-7}$ g, H_2 $5 \cdot 10^{-8}$ g, relative error of determination 10%. Gases were released from inclusions in quartz vessel by heating. The vessel was first cleaned by heating for 1 hour at T 1000°C with continuous pumping (P 10^{-4} Pa). Grain class of quartz used for determinations was 5-6 mm. If determinations of gases released at high T are necessary, the heating of sample should be stopped at 600°C, sample removed, the vessel for release of gases cleaned by heating at 1000°C, sample put again in the vessel and determination continued.
(A.K.)

MANGAS, J. and ARRIBAS, A., 1985, Fluid inclusion study in different types of Sn deposits associated with the Hercynian granites of western Spain (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 92-93. First author at Dpto. Geol., Centro Superior de Ciencias del Mar. Apdo. 550, Las Palmas de Gran Canaria, Spain.

The Spanish tin deposits related to acid intrusive rocks correspond to intra and peribatholitic quartz veins and pegmatite dikes, disseminations in altered apogranites, and skarns. The two first types of Sn deposits, which are the most important and abundant in the Spanish Hercynian basement, are associated with the late Westphalian and Autunian granites, emplaced between 350 ± 10 and 280 ± 10 m.y.

The study of the fluid inclusions, carried out in quartz, cassiterite and scheelite crystals of veins and greisenized rocks, has been made by different methods--microthermometry, Raman microprobe and decrepitation--in the following types of deposits:

a) Disseminations of cassiterite in apogranites: Golpejas (Salamanca) and Penouta (Orense).

b) Stanniferous pegmatites: Fregeneda (Salamanca).

c) Quartz veins and stockworks with cassiterite: Teba (Cáceres); with cassiterite and wolframite: San Finx (La Coruna); and with cassiterite and scheelite: La Parilla (Cáceres).

Taking into account their chemical composition, the fluid inclusions belong to the following types: 1) Complex-CO_2-aqueous inclusions (H_2O-NaCl-CO_2-CH_4-N_2-H_2S); 2) Complex-CO_2 inclusions (CO_2-CH_4-N_2); 3) Low salinity aqueous inclusions (H_2O-NaCl); and 4) Unusual aqueous inclusions (H_2O-NaCl-KCl-$MgCl_2$-$CaCl_2$).

According to the Th and physical-chemical characteristics of these inclusions, 3 stages of fluid circulation have been established:

1) Trapping of fluid inclusions belonging to types 1, 2, and 3--some of the latter have a small CO_2 content--at temperatures ranging between 500° and 250°C and pressures below 2000 bars. Within these physical conditions, type 1 is characteristic of deposits a and b; type 3, of deposit c.

2) Low salinity (<9% wt. eq. NaCl) type 3 inclusions, trapped at Th between 300° and 60°C and pressures about 200 bars.

3) Type 4 inclusions, trapped at Th between 170° and 60°C and low pressures.

The results obtained by this study indicate that, in general, with descending temperature, the chemical evolution of the mineralizing fluids is characterized by a progressive increase of the total density and H_2O content and a progressive decrease of the salinity and the CO_2 and volatile content of the inclusions. However, the salinity increases greatly when the fluids were trapped at lower temperatures (~100°C), due to the presence of Ca^{++}, Mg^{++}, Na^+, K^+.

Taking into consideration all these data, it is assumed that these Spanish Sn mineralizations originated from chloride, carbonate and/or bicarbonate complexes. Then, the successive changes, sudden or continuous, in temperature, pressure, density and composition gave place to the alterations and mineral deposition when the mineralizing fluids reacted with the wall rocks and/or other solutions. In any case, in all these deposits, pressure has been high enough to prevent boiling or effervescence of the fluids.

The data are compared with those from other Sn deposits of the European Hercynian basement. (Authors' abstract)

MANGAS, J. and ARRIBAS, A., 1985, Fluid inclusion study associated with wolfram mineralizations of Virgen de la Encina (León, Spain): IX Reunion de Geologia del Oeste Peninsular, Oporto (Portugal), October, 1985 (in Spanish). First author at Dept. de Geol., Facul. de Cien. del Mar. Univ. Politec. de las Palmas, Spain.

Virgen de la Encina orebody is located in the Hercynian basement in the western Iberian Peninsula, and consists of a stockwork of quartz with scheelite, wolframite, molybdenite, bismuth, bismuthinite, pyrite, chalcopyrite and arsenopyrite, crossing Cambrian and Ordovician quartzites and schists. The orebody is associated with intrusions of syn- and late-kinematic Hercynian granites. Microthermometry, Raman microprobe and crushing tests were made on several samples from quartz veins.

Most of the fluid inclusions examined occur along more or less well-healed fracture planes and a few are isolated. In general, their distribution, size, form and degree of filling are very variable. On the basis of their chemical composition, they are of three types: 1) Complex CO_2-aqueous inclusions (H_2O, NaCl, CO_2, CH_4, N_2, H_2S); 2) low salinity aqueous inclusions (H_2O-NaCl); and 3) unusual aqueous inclusions (H_2O-NaCl-KCl-$MgCl_2$-$CaCl_2$).

Total Th varies between 380° and 50°C and Ph was high enough to prevent boiling.

The successive variations of the fluid chemical composition, density, T and P indicate that the hydrothermal evolution consisted of a discontinuous sequence of specific events, each corresponding to opening of fractures, active fluid circulation and healing of fissures. According to the paragenic data and the physical-chemical characteristics of the fluid inclusions, 3 stages of fluid circulation have been established:

The trapping of aqueous (type 1) and carbonic fluids (type 2) was simultaneous. Then, the intersection of two isochores in a P-T diagram, one corresponding to an aqueous inclusion with Th 270°C and density 0.8 g/cc, and the other corresponding to a carbonic inclusion with density 0.25 g/cc, give a trapping pressure of about 250 bars. In any case, during hydrothermal evolution the pressure has been high enough to prevent the fluids from boiling. (Authors' abstract, translated courtesy Dr. Mangas)

MANGAS, J. and ARRIBAS, A., 1985, Physical chemical features of the mineralizing fluids in Sn deposits of western Spain (abst.): Terra Cognita, v. 5, p. 150. Authors at Dept. Geol., Univ. Salamanca, Spain.

The Spanish Sn deposits related to intrusive rocks correspond to intra and peribatholitic quartz veins and pegmatite dikes, disseminations in apogranites, and skarns. The two first types, which are the most important in the Hercynian basement, are associated with granites emplaced between 350 ± 10 and 280 ± 10 m.y.

The study of the fluid inclusions, carried out in quartz, cassiterite and scheelite, has been made by different methods--microthermometry, Raman microprobe and decrepitation--in the folliwng types of deposits: a) disseminations of cassiterite in apogranites, b) stanniferous pegmatites, c) quartz veins and stockworks with cassiterite, wolframite and scheelite.

Taking into account their chemical composition, the fluid inclusions belong to these 4 types: 1) Complex-CO_2-aqueous (H_2O-NaCl-CO_2-CH_4-N_2-H_2S), 2) Complex-CO_2 (CO_2-CH_4-N_2), 3) Low salinity aqueous (H_2O-NaCl), and 4) Unusual aqueous (H_2O-NaCl-KCl-$MgCl_2$-$CaCl_2$).

According to the homogenization temperatures and physical-chemical characteristics of the fluid inclusions, 3 stages of fluid circulation have been established: the 1st is characterized by inclusions belonging to types 1, 2, and 3, trapped at temp. ranging from 500° to 250°C, and below 2000 bars; the 2nd is represented by low salinity, type 3 inclusions, trapped at homogenization temp. between 300° and 60°C, and about 200 bars. The 3rd is characterized by type 4 inclusions trapped at homogenization temp. between 170° and 60°C and low pressure.

The thermobarogeochemical data obtained in the study of the Spanish deposits are compared with those belonging to other world Sn deposits of the same type, namely those of the European Hercynian basement. (Authors' abstract)

MANNING, D.A.C. and PICHAVANT, M., 1985, Volatiles and their bearing on the behavior of metals in granitic systems (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 184-187.

MARAKUSHEV, A.A., 1983, Genesis of andesite and associated rocks from immiscible phases: Dokl. Akad. Nauk SSSR, v. 273, no. 6, p. 1456-1459 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 273, p. 118-121, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 168, 1983. (E.R.)

MARAKUSHEV, A.A., 1985, Nature and metallogenic role of abyssal fluids: Zakonomern. Razmeshcheniya Protezn. Iskop., v. 14, p. 211-221 (in Russian).

The origin of the ore-bearing deep-seated (subcrustal) fluids (AF) was studied and their role was determined in the geotectonic development of the Earth's crust accompanying endogenous ore mineralizations. The published composition of fluid inclusions in diamonds (peridotitic and eclogitic) indicate that the AF were formed at great depths (150-200 km). The AF played a major role in the metamorphic and magmatic activities. The AF acted as source for ore matter in the mineralization of ore deposits in the crustal fluid-magma system. The reaction of AF with hydrothermal solutions proceeded at <300-40° and below the critical temperatures of the region. (C.A. 103: 163783s)

MARSHALL, W.L., 1985, Aqueous inorganic phase equilibria at high temperatures: some experimental, theoretical, and applied aspects: Pure & Appl. Chem., v. 57, no. 2, p. 283-301. Author at Chem. Div., Oak Ridge Nat'l. Lab., Oak Ridge, TN 37831, USA.

Experimental studies generally performed at this laboratory on the solubility of particular salts and oxides in dilute and concentrated aqueous solutions of electrolytes at temperatures up to 400°C are presented. The techniques used are described. Some of this work applied an extended Debye-Huckel equation as a function of the ionic strength of the solution at the high temperatures. From the variation with temperature of a particular ionization or solubility equilibrium obtained from the studies, thermodynamic functions at infinite dilution of electrolyte are calculated. The studies describe solubility behavior of sulfate salts in exhibiting retrograde solubilities with increasing temperature. But some 2-2 sulfate salts, like magnesium or nickel sulfates, hydrolytically precipitate oxysulfates or hydroxides in nearly neutral solutions at about 200°C. Other sulfate, fluoride, and phosphate salts form two liquid phases at temperatures of 250-400°C at saturated vapor pressures. The solubility behavior of quartz and amorphous silica in salt solutions is reviewed. Some liquid-vapor critical phenomena are also presented. The studies are shown to apply to several fields such as water desalination, power plant steam generator chemistry, geochemistry, and chemical oceanography of deep ocean hot springs. (Author's abstract)

MARTY, B., ZASHU, S. and OZIMA, M., 1985, Distribution of noble gases and CO_2 in MORB glasses (abst.): Terra Cognita, v. 5, p. 200. First author at Bureau Recherches Géol. & Min., Inst. Mixte de Recherches Géotherm., BP 6009, 45060 Orléans la Source, France.

The distribution of noble gases in six MORB glass samples from three ridges has been investigated. The results indicate that, like helium, Ne, Ar, (and probably other noble gases) are concentrated in CO_2-rich fluid inclusions. The depletion of noble gases in the melt makes them very sensitive to contamination by atmospheric components. This contamination can occur before or during lava emission and can induce Ar isotopic heterogeneities. The identification of a deep-seated component therefore needs to document the vesicle characteristics of samples. Differential solubility is able to increase the original $^{4}He/^{40}Ar$ ratio but may not account for the Ne enrichment generally observed in samples of deep origin.

The CO_2 contents and $\delta^{13}C$ ratios have also been investigated in the vesicles using vacuum crushing and decrepitation. The derived $C(CO_2)/^{3}He$ ratio in the vesicle gas is equal to $\sim 10^9$. This value may represent the C-He balance at depth and appears to be consistent with $C/^{3}He$ ratios in volcanic emanations, but not with the computed "atmospheric" (volatiles degassed through geological time) ratio, the latter suggesting a depletion of carbon in the "atmosphere." A similar trend is suggested using ^{36}Ar as a volatile tracer. (Authors' abstract)

MARUEJOL, P. and CUNEY, M., 1985, Xihuashan tungsten-bearing granites (Jiangxi, China): Mineralogical controls on REE, Y, Th, U mobility during magmatic evolution and hydrothermal alteration (abst.): Terra Cognita, v. 5, p. 284-285. Authors at CREGU, BP 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

The slightly peraluminous leucogranitic apex of the Xihuashan tungsten district (Southern Jiangxi) presents four intrusions: γ_a, γ_b, γ_c, and γ_d, γ_e, emplaced during upper Jurassic (Yenshanian). These granites are affected by several alterations: early albitization, chloritization, greisening, hydrothermal quartz-leaching accompanied by sodic and potassic metasomatisms, secondary silicification.

Chemico-mineralogical diagrams allow to distinguish early albitization, without variation of quartz, from latter Na-K metasomatism, with an important loss of quartz.

During early albitization, L.REE and Th contents are strongly depleted while H.REE, Y and U clearly increase. The mobility of these elements is very weak during potassic metamsomatism. These geochemical variations can be closely correlated with mineralogical evolutions: destabilization of monazite and garnet, new crystallization of parisite, Y-parisite, Y-fluorite and betafite, chemical reequilibration of uranothorite and uraninite.

Fluid phases, rich in complexing anions (F^-, CO_3^{2-}) are involved in these mineral reactions. In potassic metasomatites, microthermometric studies evidenced three types of fluids:

- a fluid composed of an aqueous solution (76 to 88% moles) and a CO_2, CH_4, N_2 phase (2 to 8% moles; $d = 0.82$ g/cm^3);
- two aqueous fluids:
  . 6.6 to 7.3% eq. NaCl and Th = 200°C;
  . 1.4% eq. NaCl and Th = 175°C.

The relative importance of magmatic differentiation versus hydrothermal processes on REE, Y, Th and U variations is discussed. (Authors' abstract)

MARUEJOL, P. and CUNEY, M., 1985 Xihuashan tungsten-bearing granites (Jiangxi, China): Mineralogical controls on REE, Y, Th, U mobility during magmatic evolution and hydrothermal alteration (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 149.

The slightly peraluminous leucogranitic apex of the Xihuashan tungsten district (Southern Jiangxi) presents four intrusions: γ_a, γ_b, γ_c, and γ_d, γ_e, emplaced during upper Jurassic (Yenshanian). These granites are affected by several alterations: early albitization, chloritization, greisenization, and hydrothermal quartz-leaching accompanied by sodic and potassic metasomatism and secondary silicification.

Chemico-mineralogical diagrams permit distinction between early albitization, without variation of quartz, and latter Na-K metasomatism, with an important loss of quartz.

During early albitization, L·REE and Th contents are strongly depleted while H·REE, Y and U clearly increase. The mobility of these elements is very weak during potassic metasomatism. These geochemical variations can be closely correlated with mineralogical evolution: destabilization of monazite and garnet, new crystallizations of parisite, Y-parisite, Y-fluorite and betafite, and chemical reequilibration of uranothorite and uraninite.

Fluid phases, rich in complexing anions (F^-, CO_3^{2-}) are involved in these mineral reactions. In potassic metasomatites, microthermometric studies evidenced three types of fluids: 1) an aqueous solution (76 to 88 mole %) and a CO_2, CH_4, N_2 phase (2 to 8 mole %; $d = 0.82$ g/cm^3); 2) aqueous fluid with 6.6 to 7.3% eq. NaCl and Th = 200°C; and 3) aqueous fluid with 1.4% eq. NaCl and Th = 175°C. The relative importance of magmatic differentiation versus hydrothermal processes on REE, Y, Th and U variations is discussed. (Authors' abstract)

MARVIN, K.A., 1985, The relationship between time of migration of hydrocarbons and catagenic mineral-formation in the Paleozoic sub-salt sequence of the Southern Cis-Ural region based on thermobarogeochemical data (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 203-205 (in Russian; translation by D.A. Brown). Author at Saratov State Univ., Saratov, USSR.

In the Southern Cis-Ural region, the principal petroleum prospects are associated with the complex of Devonian, Carboniferous, and pre-Kungurian sub-salt deposits. In order to determine the time and T conditions of HC migration, samples of rocks were collected from the Artinskian, Sakmarian, and Asselian Stages of the Lower Permian sequence, and Middle and Lower Carboniferous material from core in a number of drill-holes, located in the central depression zone of the Cis-Uralian Trough. Inclusions in massive anhydrite and in calcite from veinlets in limestones and mudstones were conducted by G.A. Moskovskiy in the thermobarogeochemical laboratory at Saratov State University. The calcite veinlets are as a rule, very thin (1-2 and rarely 3-4 mm), with grains measuring 0.1-0.2, and rarely ≤0.6 mm, sometimes with traces of plastic deformation of the crystals. The massive anhydrite has a vari-grained texture with grains ≤0.4 mm in size.

It has been established that inclusions of two kinds are present in the anhydrite, two-phase (gas = 2-5 vol.%); and single-phase, essentially liquid (aqueous and, less frequently, oil, based on luminescence).

The calcite contains single-phase liquid, single-phase gas, and two-phase gas-liquid inclusions. The last consist mainly of aqueous solutions and rarely, oil.

Th showed that the catagenic calcite formed at 102-114°C, and in only two cases, were T of 142 and 182°C found, for samples from ~5000 m depth. Th of anhydrite were also close to those for calcite (90-110°C) and evidently correspond to its catagenic recrystallization. No direct correlation was found between Th and the depths of occurrence, apparently indicating that the catagenic inclusions formed at a similar topographic level [but now] occur at different depths.

Oil inclusions shows that migration of HCs took place at this time, but their scarcity suggests that this process was not very intense at the time of transformation of the catagenic mineral. A later HC migration has formed films of oil and bitumen in the micro-cracks, sutures, and intergranular spaces. These data indicate that filling of the traps with HCs took place mainly during the post-orogenic phase of development of the Southern Cis-Urals, when the structural plan of the area acquired features similar to those at present. (From the author's abstract)

MASHBURN, L.E. and CLOOS, Mark, 1985, Mineralized veins from Franciscan melange blocks and Cambria Slab trench slope basin sediments near San Simeon, California: A fluid inclusion study (abst): Geol. Soc. Am. Abst. with Programs, v. 17, p. 367. Authors at Dept. Geol. Sci., Univ. Texas, Austin, TX 78713.

Near San Simeon, California, mineralized veins are locally abundant in melange blocks surrounded by mud-matrix, in Cambria Slab slope basin sediments, and along Tertiary strike slip faults. Vein minerals along known Tertiary faults are dominantly calcite and laumontite. These veins are typically cataclastic and abundant within several m of the high-angle fault zones. Mineralized veins in the blocks of the melange contain predominantly quartz, calcite and laumontite. Aragonite is present in some veins from mafic blocks. Veins either crosscut blocks and melange matrix or are wholly within blocks. Generally, they are from mm to cm wide and lack preferred orientation or regular spacing. Mineralized veins within the slope basin sediments are predominantly calcite and laumontite, mm to cm wide and up to several m long. In both melange and basin settings, zoned, euhedral crystals of carbonate and quartz line cavities from mm to cm across.

Preliminary fluid inclusion studies show veins along Tertiary faults have Th between 70 and 125°C and NaCl(equiv.) salinities between 1 and 3 wt.%. Slope basin sandstones have temperatures between 110 and 130°C and salinities between 2 to 5 wt.%. In the melange, graywacke blocks have temperatures between 110 and 175°C, while both greenstones and blueschists have temperatures between 120 and 220°C. Blocks encased in melange record salinities from 2 to 6 wt.%.

Preliminary conclusions include: The low salinities of inclusions in veins along Tertiary faults suggest dilution by meteoric water. Some blocks of greenstone and blueschist were veined at depths of 10 km or more, while blocks of graywacke were only veined at shallower levels following partial lithification. The pore waters of the melange were diluted by clay mineral dehydration. Warm waters, probably derived from the underlying melange, may move into slope basin sediments. (Authors' abstract)

MASSOTH, G.J., BAKER, E.T., COWEN, J.P., ROE, K.K. and APPRIOU, P.Y., 1985, The geochemical diversity of Juan de Fuca Ridge hydrothermal plumes (abst.): EOS, v. 66, no. 46, p. 929.

MASUDA, Harue, SAKAI, Hitoshi, CHIBA, Hitoshi and TSURUMAKI, Michiji, 1985, Geochemical characteristics of Na-Ca-Cl-HCO_3 type waters in Arima and its vicinity in the western Kinki district, Japan: Geochem. J., v. 19, p. 149-162. First author at Dept. Geosci., Osaka City Univ., Sumiyoshi-ku, Osaka 558, Japan.

Na-Ca-Cl-(HCO_3) type waters of Cl content ranging from a few hundred mg/l to more than twice that of seawater widely distribute in the studied area. From the chemical and isotopic compositions and reservoir rock types, these waters are classifed into the Arima brines (Type I, Arima-type brine of Matsubaya et al., 1973), dilute carbonated waters from Paleozoic sedimentary rocks (Type II), and those from Cretaceous to Paleogene acidic igneous rocks (Type III). Arima brines are highly saline (Cl = 1000 ~ 36,000 mg/l) and are considered to be mixtures of a unique deep brine of $\delta D = -32‰$, $\delta^{18}O = +10‰$ and Cl = 54 g/l and bicarbonate-rich dilute waters of meteoric origin. From the chemical and isotopic data presented in this paper and in the light of the high $^3He/^4He$ ratios observed in gases of Arima brines (Sano and Wakita, 1985; Nagao et al., 1981), it is likely that the deep brine originates from deeply-lying magma underneath the Arima Spa or from sedimentary rocks during metamorphism induced by the magma.

Most waters of Types II and III are often carbonated waters of meteoric origin. Chemical compositions of these waters suggest that both of them are formed by interaction between CO_2-bearing meteoric water and wall rocks. Among the waters of these groups studied, only the Tojo water (Cl = 6,380 mg/l) exhibited clear evidence of contribution from Arima brines. Other waters have no such sign or are too dilute to find any relation with Arima brines. (Authors' abstract)

MATSUBAYA, Osamu, TAKENAKA, Teruo, YOSHIDA, Yutaka and ETCHU, Hiroshi, 1985, Hydrogen and oxygen isotope ratios of geothermal waters in the southern Hachimantai area: Rept. of the Research Inst. of Underground Resources, Mining College, Akita Univ., Akita, Japan, no. 50, p. 19-25 (in Japanese; English abstract).

Geothermal waters from the Matsukawa and Kakkonda geothermal plants, wells at Amihari-Motoyu, and Nyuto and Tazawako areas were studied isotopically. The geothermal waters from Mutsukawa, Kakkonda and Amihari-Motoyu have hydrogen isotope ratios similar to the local meteoric waters, [and] higher oxygen isotope ratios than the local meteoric waters. This relationship of hydrogen and oxygen isotope ratios, that is called "oxygen shift," means that these geothermal waters are meteoric waters [that have] undergone the oxygen isotope exchange with rocks at high temperature of underground. The oxygen shifts are 2 ~ 3‰ in Matsukawa and Kakkonda, and 7‰ in Amihari-Motoyu. This difference may be important to understand the process of water-rock interaction in this area.

The geothermal waters at Nyuto and Tazawako areas also show 2 ~ 3‰ oxygen shift. The steam from the Tazawako-cho well and the hot spring water from the Tsurunoyu are estimated to be vapor and liquid phases separated from a single geothermal water of NaCl type, though the hot water from the Tsurunoyu is diluted with shallow meteoric water. (Authors' abstract)

MATSUHISA, Y., MORISHITA, Y. and SATO, T., 1985, Oxygen and carbon isotope variations in gold-bearing hydrothermal veins in the Kushikino mining area, southern Kyushu, Japan: Econ. Geol., v. 80, p. 283-293. Authors at Geol. Survey Japan, 1-1-3 Yatabe-Higashi, Ibaraki-ken 305, Japan.

The Kushikino mine is located in the Tertiary gold mining areas of southern Kyushu, Japan. The ore deposits occur in andesitic volcanics as fissure-filling epithermal veins, consisting of gold- and silver-bearing quartz and calcite with minor amounts of adularia, sericite, and sulfides. Quartz and calcite are dominant throughout the mineralization. Three major stages of mineral deposition are recognized as follows; (I) first opening of fractures and deposition of translucent quartz, (II) repeated fracturing and the main stage of the Au-Ag mineralization with deposition of milky quartz and calcite, and (III) deposition of barren calcite.

Oxygen and carbon isotope compositions were determined for quartz and calcite. The wide range of the $\delta^{18}O$ values of the stage II minerals corresponds to a temperature decrease from 220° to 140°C. The isotopic data can be interpreted to indicate a mixing of deep hydrothermal fluid and low-temperature meteoric ground water, if the deep hydrothermal water was unexchanged or partially exchanged meteoric water with a limited range of $\delta^{18}O$ values (lower than -3% at 300°C). Incorporation of a large quantity of high $\delta^{18}O$ thermal waters is not plausible. The $\delta^{13}C$-$\delta^{18}O$ trend of calcite is interpreted to show a temperature decrease and a change in the carbon species of the fluid. Calcite crystallized in equilibrium with a fluid in which H_2CO_3 was dominant at temperatures higher than 140° or 150°C, whereas HCO_3^- was dominant at lower temperatures. This accords with inferences based on phase equilibria. The stage III calcite crystallized in a lower temperature range of HCO_3^--dominant field.

Judging from fluid inclusion data and mineral assemblages, changes in pressure or pH of the fluid were not so important in stage II. The quartz-calcite deposition and Au-Ag mineralization in stage II may have taken place as a result of rapid cooling of the fluid due to mixing. Mixing of two fluids, both of which were saturated with calcite but which had different temperatures, caused supersaturation of the calcite and, thus, deposition of it along with a temperature decrease. Deposition of a large quantity of calcite in stage III would be due to a pressure decrease caused by the opening of fractures at shallow depths. A subsequent decrease in pH of the fluid may have caused the kaolinite alteration near the surface. (From the authors' abstract)

MATSUO, Sadao, KUSAKABE, Minoru, NIWANO, Mariko, HIRANO, Tomio and OKI, Yasue, 1985, Origin of thermal waters from the Hakone geothermal system, Japan: Geochem. J., v. 19, p. 27-44. First author at Dept. Chem., Tokyo Inst. Tech., O-okayama, Meguro-ku, Tokyo 152, Japan.

Based on isotopic studies of S, O, C and H. (E.R.)

MATTER, Albert, BURLEY, S.D. and MULLIS, Josef, 1985, Quantitative constraints on the timing of reservoir diagenesis: Application of combined cathodoluminescence microscopy and fluid inclusion thermometry (abst.):

6th Annual Res. Conf., Gulf Coast Sec., Soc. Econ. Paleon. & Mineral. Foundation, Program & Abstracts, Dec. 1-4, 1985, Austin, Texas, p. 19-20. First author at Geol. Inst., Univ. Bern, Baltzerstrasse 1, 3012-Bern, Switzerland.

The development of models for burial-related diagenesis requires the absolute dating of individual diagenetic processes. For such models to be truly predictive within a petroleum prospective basin or hydrocarbon reservoir under production, both the extent and timing of diagenetic alteration need to be considered in relation to the structural development of the basin and the generation and migration of hydrocarbons. A combination of thin-section and cathodoluminescence microscopy enables the relative sequence of individual fluid inclusion generations to be related to the different phases of authigenic quartz.

Fluid-inclusion thermometry and barometry can then be applied to each generation. Such an approach has been used to record the evolution of migrating pore-fluids and hydrocarbons within reservoir sandstones of the North Sea. For example, in deeply buried Carboniferous sandstones from the Southern North Sea Basin, two phases of late quartz cement enclose three generations of fluid inclusions and are in turn cut by quartz-filled fractures containing a fourth generation of inclusions. Corrected Th suggest that extensive quartz cementation took place in these sandstones at temperatures between 85° and 95°C and corresponding burial depths of around 2.7 km. The observed sequence of fluid compositions represents a progressive change from a dilute aqueous pore fluid through a saline sodium chloride brine to a methane-rich fluid with higher hydrocarbons and, finally, to a dry, almost pure, methane gas. Comparison with the burial curve suggests gas entrapment took place at around 90 Ma.

The same approach applied to Upper Jurassic reservoir sandstones of the Outer Moray Firth [Tartan reservoir] reveals a different evolution of pore water compositions. Two distinct phases of late quartz authigenesis are recognized, each containing two fluid inclusion generations. Measured salinities in the first phase of quartz cement average 18.4 wt % (NaCl equiv.). A marked differentiation and lowering of salinities to an average of 11.7 in the downthrown block and 8.6 wt percent in the upthrown block is recorded for the second phase of quartz cement. This differentiation took place during latest Cretaceous-earliest Tertiary time.

The temperature of quartz precipitation is depth-related. Microthermometry indicates that the minimum temperature of precipitation of the first quartz generation was 70°C in the upthrown block and an average of 95°C in the downthrown block. The second generation of quartz cement was precipitated at minimum temperatures of 85°C and 105°C in the upthrown and downthrown blocks respectively. Barite precipitated shortly after the second phase of quartz at comparable temperatures but from ore fluids of a lower salinity. Subsequently, calcite cementation from a similar relatively low-salinity pore fluid occurred at a minimum temperature of 115°C. (From the authors' abstract)

MATTEY, D.P., MENZIES, M. and PILLINGER, C.T., 1985, Carbon isotopes in lithospheric peridotites and pyroxenites (abst.): Terra Cognita, v. 5, p. 147. Authors at Dept. Earth Sci., The Open Univ., Milton Keynes MK7 6AA, UK.

Chemical heterogeneity in lithospheric mantle reflects, at least in part, the passage of melts and fluids throughout time and there is evidence that CO_2 may be an important component associated with such mantle enrichment processes. Using stepped heating techniques and high-sensitivity mass spectrometry we are investigating the relationship between carbon isotopes, trace elements and radiogenic isotopes in a selection of mantle pyroxenes which contain CO_2-rich fluid inclusions.

Stepped heating identifies two principle species of carbon in the diopsides: isotopically light carbon released by combustion below 600°C, and a second isotopically distinct form of carbon released by either combustion or pyrolysis, usually at temperatures greater than 1000°C. The former species is interpreted as dominantly organic carbon, which exists as surficial contamination; whilst the latter species is believed to be indigenous CO_2, residing within the lattice, or as fluid inclusions.

Preliminary data for nodules from the Geronimo Volcanic Field, Arizona, show that light rare-earth element (LREE) depleted diopsides (Type 1A), which have Sr and Nd isotope ratios similar to mid-ocean ridge basalts (MORB), contain less than 3 ppm indigenous C, whereas LREE enriched diopsides (Type 1B), characterized by decoupled radiogenic isotope ratios, contain 4 to 29 ppm C. The isotopic composition ($\delta^{13}C$(PDB)) of CO_2 in Type 1A diopsides falls within the range for CO_2 in MORB (-2‰ to -8‰), whereas Type 1B diopsides contain CO_2 with $\delta^{13}C$ ranging from -20% to -31‰.

Available data from other localities suggest that Type 1A nodules are depleted in CO_2 that is isotopically similar to MORB, and Type 1B nodules are enriched in CO_2 which ranges in composition from +1‰ to -31‰. This range closely approaches the total isotopic variation of the sedimentary geochemical cycle and of diamonds. (Authors' abstract)

MAYEVSKIY, B.I., ZATSIKHA, B.V. and NOSIK, L.P., 1985, Hydrocarbon-bearing inclusions in hydrothermal minerals as a prospective indicator of petroleum occurrences in deep crustal zones (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 177-178 (in Russian; translation by D.A. Brown). Authors at IFING, Ivano-Frankovsk, USSR.

It is currently important to estimate the petroleum prospects of deep-seated crustal zones (>3-4 km). The present position of oil and gas pools does not reflect the true relationship between the composition of the hydrocarbons (HCs) and the PT conditions [and there is much controversy concerning the temperature limits for formation of various solid, liquid, and gaseous HCS]. ... In order to clarify the effect of T on the specific composition of the HCs, the authors have compiled a graph of more than 250 results of studying GLIs, both personal, and also taken from the literature (more than 40 references). Conservation of HCs, according to Th data, took place over a wide T range (50-750°C). As a result, the following relations between T and the specific HC composition have been revealed: oils (50-250°C) (mainly >100°C), kerites (170-400°C), anthracolites (150-600°C) (mainly >300°C), and graphite-coaly materials (300-600°C and more) (mainly >500°C). There is a wide range of gaseous HCs. Methane is a persistent component, occurring over a wide T range (70-750°C). Ethane and heavy HCs occur mainly at T = 70-450°C.

These studies suggest the existence of oil pools in the upper zone of the crust, where T ≤~220°C. As depth and temperature increase, both methanization and also polymerization of the oil HCs takes place, along with ordering of the structure of their asphalt-resin components with conversion to anthracolites at T >300°C, and later to graphite-coaly substances at T >400°C. T = 350-400°C will evidently be the limit of commercial gas-capacity, because significant dilution of the HC gases by non-HC components, formed as a result of metamorphism of the mineral portion of the rock, begins at these temperatures. (From the authors' abstract)

MAYSKIY, Yu.G., 1985, Planimetric analysis of systems of fluid inclusions in minerals and interpretation of its results (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 42-44 (in Russian). Author at Rostov State Univ., Rostov-on-Don, USSR.

The author presents a proposal characterizing inclusion distribution in crystals by use of the ratio of the linear dimension of inclusion d and the shortest distance between neighboring inclusions ℓ; the ratio is in two classes: <1 and 1 to 3. Synthetic quartz bears more inclusions characterized by ℓ:d ratio <3 than most of natural specimens. This method is proposed for determination of primary width of the healed fractures, mass of mineral precipitated in various stages of mineral formation, equilibrium or disequilibrium during mineral crystallization and for interpretation of decrepitation results [examples not given]. (A.K.)

MAZOR, Emanuel, 1985, Sampling of volcanic gases - The role of noble-gas measurements: a case study of Vulcano, south Italy: Chem. Geol., v. 49, p. 329-338.

Mc- All names starting with Mc- or Mac- are listed as though spelled Mac-

MEANS, J.L. and HUBBARD, N.J., 1985, The organic chemistry of deep ground waters from the Palo Duro Basin, Texas: Implications for radionuclide complexation, ground-water origin, and petroleum exploration: Office of Nuclear Waste Isolation Tech. Rept. BMI/ONWI-578, 83 pp. First author at Battelle Memorial Institute Columbus Laboratories, Columbus, OH.

This report describes the organic geochemistry of 11 ground-water samples from the Palo Duro Basin, Texas, and discusses the implications of their organic geochemical compositions in terms of radionuclide complexation, ground-water origin, and the petroleum potential of two candidate repository sites in Deaf Smith and Swisher Counties.

Short-chain aliphatic acid anions are the principal organic constituents present. Acetate predominates, with concentrations ranging from 3 to 225 mg/l. Propionate ranges from <1 to 23 mg/l. Traces of n-butyrate, isobutyrate, and n-valerate were also detected. The short-chain aliphatic acid anions are derived from Paleozoic, lipid-rich sedimentary organic matter. Mass balance calculations show that short-chain aliphatic acid anions account for nearly 100 percent of the total organic carbon content in most of the samples.

Stability constant data and simple chemical equilibria calculations suggest that short-chain aliphatic acids are relatively weak complexing agents. The extent of complexation of a typical actinide by selected inorganic ligands present in these brines (chloride, sulfate, and fluoride) is expected to far outweigh actinide complexation by the aliphatic acid anions.

Various lines of evidence suggest that some portion of the bromide concentrations in the brines is derived from the same source as the short-chain aliphatic acid anions, namely, Paleozoic sedimentary organic matter. This observation raises serious questions regarding the use of bromide as a conservative marker constituent for reconstructing the chemical history of subsurface brines, unless the total bromide concentrations can somehow be corrected for their organically derived components. When the postulated organic components are subtracted from total bromide concentrations, the origins of the Palo Duro brines, based on chloride versus bromide relationships, appear largely consistent with origins based on isotopic evidence.

The short-chain aliphatic acid anion content of the Palo Duro brines is postulated to have been much greater in the geologic past and is interpreted to have been reduced via slow thermal decarboxylation at relatively low subsurface temperatures. Aliphatic acid anions are but one of numerous petroleum proximity indicators, which consistently suggest a greater petroleum exploration potential of the area surrounding the Swisher County site than the region encompassing the candidate site in Deaf Smith County. Short-chain aliphatic acid anions appear to provide a useful petroleum exploration tool as long as the complex reactions that may diminish their concentrations in ground water are recognized. (Authors' abstract)

MEDEIROS NETO, F.A., 1985, Geological, geochemical and fluid inclusion studies of Cu-Zn sulfide deposit from 4E/Pojuca Orebody, Carjás District, Brazil: M. Sc. Thesis, CG-UFPa, 154 pp. (in Portuguese). Author at Travessa Lomas Valentinas, 2717 - Marco. 66.000 - Belém - Pará- Brazil.

The deposit of Fe-Cu-Zn sulfides of the Pojuca area lies within the Archean Salobo-Pojuca volcano-sedimentary sequence of the Amazon craton. In the area of the 4E orebody two sequences of orthoamphibolites were identified, separated by a clastic-chemical metasedimentary unit which retains primary depositional structures. This unit was interpreted as a facies of the banded iron formation which also hosts the stratiform Fe-Cu-Zn sulfide mineralization. The volcano-sedimentary sequence is overlain by a structurally concordant package of metasandstones and metasiltstones containing rock fragments which suggest a discordance between these and the underlying units. Hydrothermal veins, related to granitic bodies which occur in the area, cut the older metamorphic units, producing local remobilization of the stratiform sulfide and alteration/recrystallization of the pre-existing mineral assemblage.

Microthermometric studies of fluid inclusions in quartz crystals of the banded rocks which host the stratiform mineralization and in hydrothermal veins in which part of the stratiform sulfides were remobilized, show the fluids to be aqueous saline solutions of NaCl and lesser amounts of $CaCl_2$ and/or $MgCl_2$. Three-phase fluid inclusions dominate in the banded rocks and contain NaCl daughter crystals whose Th show a relative concordance with the estimated metamorphic conditions deduced from the mineral assemblages. However, in the same rocks, three-phase inclusions associated with two-phase fluid inclusions show Th equivalent to those of the fluid inclusions in the hydrothermal veins, confirming the extensive circulation of fluids which was responsible for the alteration of the pre-existing metamorphic assemblages. In the hydrothermal veins the inclusions are predominantly two-phase. Most are confined to fractures within individual grains and represent the fluid present during late stage healing of fractures, being related to the cooling of the granitic rocks which occur in the area. The small variation of Th for these fluids with variable densities[sic] supports a model of the circulation of aqueous fluids. The more saline aqueous inclusions, especially the three-phase group which occur either isolated or clustered in quartz grains of the oldest veins, and which show the highest Th, should represent the remains of magmatic fluids. In general, the fluid inclusions of the hydrothermal veins show a decrease in salinity corresponding to a drop in temperature from 510°C to 150°C.

The deposit of the Pojuca area shows characteristics similar to those of massive sulfide deposits of the volcanogenenic proximal exhalative type, and was probably formed in a deep submarine environment with transport of metals and sulfur by weakly acid hot brines. Precipitation was caused by mixture of the exhalative products with sea water and the chemical/mineralogical zoning is a result of the decrease in temperature and in oxygen fugacity. The cyclic zoning is related to fault movements and contemporaneous basic volcanism. (Author's abstract translated and shortened courtesy K. Fuzikawa)

MELKONYAN, R.L. and ROMANCHEV, B.P., 1985, Conditions of formation of some gabbro-granite assemblages of Armenia: Geokhimiya, 1985, no. 6, p. 808-820 (in Russian; English abstract).

P melt inclusions in minerals of plagiorhyolite-plagiogranite, gabbro-tonalite and gabbro-granodiorite formations show sequences of phase equilibria between liquidus and solidus indicating a general tendency of increase of the crystallization intervals along with simultaneous decrease of liquidus and solidus, from more basic rocks to acid ones. In quartz grains from volcanites of plagiorhyolite-plagiogranite formation high-T (1300 to 1330°C) melt inclusions of high-alumina basalts were observed. Phenomena hinting at immiscibility of melts at 870°C were revealed in plagiogranites. (From the authors' abstract)

MEL'NIKOV, F.P. and APOLLONOV, V.N., 1985, The mineral composition and inclusions in minerals from halite veinlets in dolerite (the Nepa deposit of potash salts) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 201 (in Russian; translation by D.A. Brown). Authors at Moscow State Univ., Moscow, USSR.

In a body of dolerites that break through Cambrian and Ordovician sedimentary rocks, drill-core from a depth of 800-850 m (at the level of occurrence of salt rocks of the Angara Group) has revealed veinlets, <3 cm thick, in which the predominant mineral is a water-clear coarse-grained halite. The walls of the veinlets are lined with micro-druses of acicular actinolite and phlogopite spherulites, and there are often crystals of apatite, pyrrhotite, pyrite, and magnetite. Large crystals (≤1 cm) of white calcite and pink anhydrite are usually not attached to the veinlet walls, but seemingly form accumulations floating in the halite. Accumulations of small (≤0.001 mm) grains of sylvite are very rarely found in the halite, solitary or developed along the cleavage planes of the latter. Along the contacts of the halite veinlets the country rocks show zones of alteration (serpentinization) of small thickness (from a few millimeters up to 1-2 cm).

Gas inclusions (≤0.1 mm) of various kinds have been found in the halite: solitary and cubic in shape; groups developed along low-angle boundaries; and confined to the dm [solid inclusion?] contacts in the halite. The calcite crystals display isolated three-phase inclusions, with a large gas phase and halite [dm?].

The undisturbed acicular actinolite crystals (≤2 cm long) penetrating monocrystalline halite, indicates the absence of repeated movement and slow flow of material in the vein after their formation. Arising from the mineral composition of the veinlets, the phase composition of the inclusions in halite and calcite, and the nature of the changes in the country rocks, it is suggested that the veinlets formed by injection of near-contact salt melt into a crush zone in an already solidified intrusive body. (Authors' abstract)

MERGENOV, B.M., KOZHAKHMETOV, Ye.M. and KURMANBAEV, Ye.A., 1985, Luminescence of melt inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 79-80 (in Russian). Authors at Inst. Geol. Sci. of Acad. Sci., Alma-Ata, Kazakhstan, USSR.

Since analyses of G released by heating of magmatic minerals contained hydrocarbons, one may suppose that hydrocarbon components are present in the filling of melt inclusions. Search for hydrocarbons by luminescence method was made in melt inclusions in quartz from Upper Permian volcanites of trachyliparite composition from N. Pribalkhash'ye. Melt inclusions are negative crystals 3 to 50 µm in size. Observations were performed with use of Reichert microscope "MeFe-2," illumination with lamp DRSh-250 + filter UFS-2, luminescence spectra were recorded with use of double monochromator DMR-2 and photomultiplier FEU-79. Luminescence in green color was observed on the walls of G bubble in melt inclusions (also after opening of the bubbles, proving the condensation of the luminescent substance on the bubble walls) and sometimes luminescence outlined the contour of whole inclusions. On the basis of similarity of the obtained spectra with spectra of the reference bitumens, the luminescent substance in melt inclusions was identified as bituminous. Slight shift of maximum of spectrum most probably is connected with variation of composition of hydrocarbons. (Authors' abstract; translated by A.K.)

MERGENOV, B.M., PARILOV, Yu.S., KOZHAKHMETOV, Ye.M. and MIKHALEVA, V.A., 1984, Mode of gas evolution and fluid composition of inclusions in quartz from volcanic rocks: Dokl. Akad. Nauk SSSR, v. 275, no. 6, p. 1488-1490 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 4, p. 176-178, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 225. (E.R.)

MERLIVAT, L., ANDRIE, C. and JEAN-BAPTISTE, P., 1985, Deuterium, oxygen 18, helium 3 and helium 4 content of hydrothermal vents on the East Pacific Rise at 13°N (abst.): Terra Cognita, v. 5, p. 191. Authors at Lab. Géoch. Iso., Dept. Physico-Chimie, CEN/Saclay, 91190 Gif-sur-Yvette, France.

The isotopic composition (D, ^{18}O, ^{3}He, ^{4}He) of three hydrothermal vents sampled in February 1984 on the East Pacific Rise at 13°N has been determined. The ^{3}He/^{4}He ratio is constant in the 3 waters and equal to $(1.05 \pm 0.01)10^{-5}$. From the amount of ^{3}He we calculate a lower bound for the heat removed by axial vents, equal to 1.310^{19} cal/yr i.e. 25% from the total heat loss from sea floor spreading.

The water-rock ratios (in mass) computed for deuterium are equal to 1.2 and 2.5 for two vents distant from only 900 meters. This shows a large variability of the hydrothermal circulation at a short distance. Based on helium 3 and deuterium data, we calculate that the fraction of the oceanic crust which is altered is at least equal to 18% or 46% according to the vent which is considered. (Authors' abstract)

METZ, M.C., BROOKINS, D.G., ROSENBERG, P.E. and ZARTMAN, R.E., 1985, Geology and geochemistry of the Snowbird deposit, Mineral County, Montana: Econ. Geol., v. 80, p. 394-409. First author at GeoTec Service, Inc., 14379 W. Ellsworth Ave., Golden, CO 80401.

The Snowbird deposit is a lenticular, rare earth- and fluorite-rich quartz-carbonate body with a pegmatitic texture, which consists of a peripheral quartz zone surrounding a core containing ferroan calcite, ankerite, fluorite, and quartz with minor parisite, xenotime, pyrite, and gersdorffite. The temperatures of formation based on oxygen isotope geothermometry, fluid inclusion studies, and other considerations are in the range of 400° to 500°C.

The Snowbird deposit is rich in Th and rare earth elements but is impoverished in U. Hydrothermal fluids probably responsible for the deposit initially contained mainly volatile constituents; the cation content was acquired largely by leaching of either Belt metasediments or pre-Belt schists and gneisses. Snowbird mineralization bears definite resemblances to the Th deposits of the Lemhi Pass area and to late, hydrothermal "carbonatite" dikes associated with the Iron Hill carbonatite. (From the authors' abstract)

MEYER, H.O.A., 1985, Genesis of diamond: a mantle saga: Am. Mineral., v. 70, p. 344-355. Author at Dept. Geosci., Purdue Univ., West Lafayette, IN 47907.

A model for the genesis of natural diamond is presented based on the physical, chemical and mineralogical properties and features of diamond. Optical studies suggest that individual diamonds have had complex growth histories in which growth and dissolution may have occurred. Growth was not always continuous nor did diamonds grow in necessarily similar chemical environments. Evidence for this is provided by variation in the nitrogen and trace element contents in diamonds as well as information from studies of the minerals included in diamond. Isotopic data suggest that diamonds formed from carbon whose sources varied isotopically. The possibility exists that some diamonds may be products of recycled subducted carbon, whereas others have formed from primoridal material either through magmatic or metasomatic processes. It is also likely that most diamonds formed in the Archaean or Proterozoic. The cognate host rocks for diamond in the mantle were several but can be broadly grouped into eclogitic and ultramafic (peridotitic); however in mineralogic and chemical detail these rocks are quite diverse. Although diamond is commonly found in kimberlite and in lamproite at the earth's surface, these two rocks are not genetically related to diamond formation. Instead they are the transporting vehicles in which diamond ascended rapidly from mantle depths to the crust. (Author's abstract)

MICHARD, Gil, 1985, Equilibria between minerals and geothermal solutions: Bull. Minéral., v. 108, p. 29-44 (in French; English abstact). Author at Lab. Géochimie des Eaux (Groupe du LA 196), Univ. Paris VII, 2, Place Jussieu, 75251 Paris Cedex 05, France.

Activities of elements estimated in geothermal solutions are compared with activities calculated from mineral equilibria. A fair agreement is observed for many elements. The influence of temperature is generally more important than the influence of the nature of mineral association. Redox equilibria were also investigated, showing that geothermal solutions are generally strongly reduced. (Author's abstract)

MILLER, G.H. and ROSSMAN, G.R., 1985, The natural occurrence of hydrogen in olivine (abst.): EOS, v. 66, p. 1135. First author at 170-25 Caltech, Pasadena, CA 91125.

Olivine single crystals from 12 locales were studied with polarized IR spectroscopy to characterize the abundance and speciation of H in naturally occurring olivines. H incorporated as OH was identified by the absorption of OH near 3700 cm^{-1}. Over 30 polarized OH absorption bands were identified between 3700 and 3300 cm^{-1}. These bands cannot be attributed to hydrous phases commonly associated with olivine. H in olivines of mantle origin spans the abundance range of 10 $H/10^6$ Si (San Carlos, AZ basalt) to 270 $H/10^6$ Si (S. Africa kimberlite). Samples from any given locality show minor variation in both total H abundance and relative band intensities and are consistent with published spectra of olivines from that locality. Olivines from any two localities do show significant differences in total H abundance and in relative band intensities. The complexity of the OH spectra and the variability between localities suggest that H site occupancy may be controlled by trace impurities, as in the case of quartz, and by the pressure-temperature history of the crystals.

Mantle olivines show considerable complexity and variability in OH spectra; this may reflect heterogeneous H abundance in the upper mantle, diffusive loss during transport, or both.

One sample of San Carlos olivine annealed at 800°C, $P(H_2O) = 8.9$ kb, was examined to determine if the hydrogen speciation of annealed samples is consistent with the speciation in natural samples. Thirteen bands from 3700 to 3450 cm^{-1} were seen, all of which occur in natural samples, but not all 13 in any single sample. Annealed samples used in rheologic studies may not adequately represent natural mantle olivine because of speciation differences. (Authors' abstract)

MILLERO, F.J., 1985, The physical chemistry of natural waters: Pure & Appl. Chem., v. 57, p. 1015-1024. Author at Rosensteil Sch. Marine & Atmos. Sci., Univ. Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA.

Ionic interactions have been shown to affect the thermodynamic and transport properties of natural waters as well as bio- and geochemical processes taking place in these waters. The ionic interaction models used to account for these interactions have been examined. Simple additivity models are used to estimate the density and sound speed of the mixtures of sea salts and seawater. The estimated values are shown to be in good agreement with the measured values. The ion pairing and specific interaction models are used to estimate the activity coefficients of ions in seawater and brines. The results are shown to be in good agreement with measured values. The estimated activity coefficients are shown to yield reliable values of the pK for the ionization of acids. (Author's abstract)

MILLERO, F.J. and CHEN, C.A., 1985, The speed of sound in mixtures of the major sea salts. A test of Young's rule for adiabatic PVT properties: J. Solution Chem., v. 14, no. 4, p. 301-310.

MILLERO, F.J., CONNAUGHTON, L.M., VINOKUROVA, Faina and CHETIRKIN, P.V., 1985, PVT properties of concentrated aqueous electrolytes. III. Volume changes for mixing the major sea salts at $I = 1.0$ and 3.0 at 25°C: J. Solution Chem., v. 14, no. 12, p. 837-851.

MILLERO, F.J. and LAMPREIA, M.I., 1985, The PVT properties of concentrated aqueous electrolytes. IV. Changes in the compressibilities of mixing the major sea salts at 25°C: J. Solution Chem., v. 14, no. 12, p. 853-864.

MIRONOVA, O.F. and ROSTOTSKAYA, N.M., 1985, Possibilities of the pyrochromatographic method in analysis of fluid inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 68-69 (in Russian). Authors at GEOKHI, Moscow, USSR.

With use of gas-chromatograph "TSVET-1000" with flame-ionization detector and pyrolysis for opening inclusions allow determination of hydrocarbons in inclusions in mineral sample 50-100 mg, however, the source of hydrocarbons is not always easy to determine (fluid or solid inclusions, gases themselves, or products of pyrolysis). For better understanding of nature of these gases, the authors recommend a series of analyses of gases, released during heating in T intervals followng one another. (A.K.)

MIRONOVA, O.F., SAVEL'EVA, N.I., IKORSKIY, S.V. and VASYUTA, Yu.V., 1985, Comparison of results of bulk analysis of fluid inclusions by various methods of release of gas phase (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 64-65 (in Russian). First author at GEOKHI, Moscow, USSR.

For gas chromatography analysis inclusions were opened by the following methods: 1) powdering at room T under inert gas, 2) crushing at Th and 3) decrepitation. Methods 1) and 2), with few exceptions showed good agreement, so that method 2) would be recommended only if H_2O is determined. For CO_2 determination any of the three methods was appropriate; the influence of carbonate contamination may be recognized by thermal analysis. Analyses performed for CH_4 with different gas release methods sometimes give similar results, but usually mechanical opening gives lower values than decrepitation due to analyzing only gas component, whereas decrepitation volatilizes also solid or liquid hydrocarbons. Thermal opening gives more complete information, but thermal analysis (DTA? - A.K.) should be combined with decrepitation. For correct interpretation the combination of methods is recommended. (A.K.)

MIRONOVA, O.F., SAVEL'EVA, N.I., IKORSKIY, S.V. and VASYNTA, Y.V., 1985, A comparison of results of bulk analysis of fluid inclusions with various methods of extraction of gas phase: Geokhimiya, 1985, no. 1, p. 111-117 (in Russian; English abstract).

The main carbon-bearing components (CO_2 and CH_4) were determined with various techniques of breaking open the inclusions: mechanical (attrition in atmosphere of inert gas at room temperature and crushing in vacuum at 200°C) and thermal ones. The most discrepancies were obtained for the determination of methane because the thermal method gives the total characteristics of gas component of fluid inclusions and non-volatile carbonaceous matter. Formation of new hydrocarbons may occur in any extraction procedure so the bulk gas analysis without detailed complex study does not give a quantitative characterization of the mineral-formation media. (Authors' abstract)

MOLLER, P., 1985a, Correlation of homogenization temperatures of multiphase liquid inclusions and Ga/Ge model temperatures in sphalerite-bearing deposits (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 94. Author at Hahn-Meitner-Inst. Kernforschung Berlin, Glienicker Str. 100, D-1000 Berlin 39, FRG.

It has been shown (Möller, P., in press: Development and application of the Ga/Ge geothermometer for sphalerite from sediment-hosted deposits. In: Monograph Series on Mineral Deposits: Geochemical aspects of ore formation in recent and fossil sedimentary environment No. 24) that the Ga/Ge ratio in sphalerite can be related to the temperature of the initial fluids from which the sphalerite grew after mixing with various amounts of different fluids. The extent of mixing of the two fluids can be qualitatively derived from Th (which represents the temperature after mixing of the fluids) and the Ga/Ge temperature which indicates the temperature of the initial host metal-bearing fluid. Thus different temperature information strongly indicates that mixing of fluids did occur. The study of fluid inclusions and temperature dependent trace element ratios in minerals could give further insight into the mechanism of ore formation. (Author's abstract)

MÖLLER, Peter, 1985b, Development and application of the Ga/Ge-geothermometer for sphalerite from sediment-hosted deposits: Mono. Ser. on Min. Deposits, v. 25, p. 15-30, Berlin-Stuttgart, Gebruder Borntraeger.
See previous abstract. (E.R.)

MONNIN, C., 1985, Apparent densities and molar volumes of binary solutions in the system Na-K-Ca-Mg-Cl-SO_4-H_2O (abst.): Bull. Mineral., v. 108, p. 92 (in French).

MONTANEZ, I.P. and READ, J.F., 1985, Unconformity related and deep burial diagenesis, Upper Knox carbonates, southern and central Appalachians (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 667.

MOODY, J.B., JENKINS, J.E. and MEYER, Dann, 1985, An experimental investigation of the albitization of plagioclase: Can. Mineral., v. 23, p. 583-596.

MOON, K.J., 1985, Fluid inclusion study of the Sangdong tungsten skarn deposits: J. Korean Inst. Mining Geol., v. 18, no. 3, p. 205-216 (in Korean; English abstract).

Fluid inclusion study reveals that the mineralogical zonal distribution of the Sangdong skarn orebody may be likely related to (homogenization) temperatures of fluids with time and space. Firstly limestone beds were replaced by hot boiling fluids ranging from 350 to 550°C, forming the pyroxene-garnet skarn, which was replaced by amphibole and quartz-mica skarns by non-boiling fluids at 300 to 500°C, which mainly penetrated the central part of the pyroxene-garnet skarn orebody.

Freezing tests identify presence of $CaCl_2$ and $MgCl_2$ as brines in the fluids besides NaCl and KCl that are shown as daughter minerals and show that two or more fluids may be involved in mineralization by showing a bimodal distribution of salinities. This study has contributed to find a new orebody and a granitic pluton as a source rock. (Author's abstract)

MOORE, E.L., ULMER, G.C. and GRANDSTAFF, D.E., 1985, Hydrothermal interaction of Columbia plateau basalt from the Umtanum flow (Washington, U.S.A.) with its coexisting groundwater: Chem. Geol., v. 49, p. 53-71. Authors at Dept. Geol., Temple Univ., Philadelphia, PA 19122, USA.

A series of experiments have been performed in which tholeiitic basalt from the Umtanum flow of the Columbia River plateau was reacted with the synthetic equivalent of groundwater with which it is in contact at a pressure of 300 bar, temperatures of 100°, 200° and 300°C, and water/rock mass ratios of between 5 and 50. Reaction products formed included: silica, illite, scapolite, wairakite, heulandite, K-feldspar and smectite. The solution composition from the experiments compare favorably with the compositions of some Icelandic geothermal fluids. (From the authors' abstract)

MORGAN, J.W., CZAMANSKE, G.K. and WANDLESS, G.A., 1985, Origin and evolution of the alkalic ultamafic rocks in the Coyote Peak diatreme, Humboldt County, California: Geochimica Cosmo. Acta, v. 49, p. 749-759. First author at U.S. Geol. Survey, Reston, VA 22092.

Depleted mantle residue was incongruently melted in the presence of H_2O and CO_2 at a total pressure >26 kb to yield ~0.5% of a Si-poor, Ca-rich melt. This melt then metasomatized depleted garnet-free harzburgite in the upper mantle at about 26 kb to produce a rock similar to phlogopite-bearing wehrlite. (From the authors' abstract)

MORI, Y.H., 1985, Classification of configurations of two-phase vapor/liquid bubbles in an immiscible liquid in relation to direct-contact evaporation and condensation processes: Int. J. Multiphase Flow, v. 11, no. 4, p. 571-576. Author at Dept. Mech. Engrg., Keio Univ., 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223, Japan.

A variety of configurations are possible, some of which are pertinent to fluid inclusion phenomena. (E.R.)

MOSKOVSKIY, G.A., 1985, Physicochemical conditions of Kungurian halogenesis in the Caspian syneclise (based on inclusions in halite) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 197-199 (in Russian; translation by D.A. Brown). Author at Saratov State Univ., Saratov, USSR.

The morphology, phase and chemical composition, gas-saturation, and Th of inclusions in halite from Kungurian salts in a number of areas in the Caspian syneclise and its surroundings (the El'ton and Gremyachinsk deposits of potash salts, and the salt-dome structures of Baskunchak, Kara-Tyube, Sagiz, and the Krasnokut sector in the northwest of the marginal zone, etc.), have been examined, using methods developed by O.I. Petrichenko (L'vov IGGGI AN USSR).

P inclusions in halite, formed during sedimentation, diagenesis, and catagenesis of the salts, differ significantly in morphology, and in chemical composition, gas-content, and Th. The chemical composition of inclusions in sedimentary halite form a zoned structure, based on the degree of evaporation of the brine in the saline basin. With a high degree of evaporation, dm sylvite, carnallite, and bischofite are present, along with high gas contents (0.3-2.2 cm^3/L). Inclusions in diagenetic halite usually do not show such zoning, may have higher concentrations (sometimes with different chemistry), and more gas (2.5-15 cm^3/L). Inclusions in catagenetic halite are also unzoned, usually two-phase (gas-liquid, and less commonly, solid-liquid), and sometimes are essentially gas (HC).

S inclusions in halite are mainly gas-liquid, and occur on the grain boundaries. They show variable G/L ratios, and liquid or gaseous HCs, from leakage.

Over 5000 analyses of individual inclusions in sedimentary and diagenetic halite have been made. The content of K, Mg, and SO_4 for inclusions in the initial phase of precipitation of halite has been determined (3-7; 15-30; and 5-20 g/L); for sylvite (35-40; 60-80; and 5-45 g/L); and for carnallite (28-30; 90-95; and 5-50 g/L). Leaching [natural?] of rock salt and K-Mg salts yielded smaller amounts of K, Mg, and SO_4 than during the initial phase of precipitation of halite (during leaching of rock salt) and an anomalously high K relative to Mg (20-30 and 15-25 g/L) during leaching of the K-Mg salts of chloride composition.

Th (>300 determinations) have been made. T of the brine during precipitation of halite was <40-70°C. The basin depth has been estimated on the basis of an empirical formula, suggested by the author, according to the ratio of gas content in inclusions in sedimentary halite and P in the diagenetic form (~100 determinations). During the phase of halite precipitation, the depth of the basin was 30-90 m, and during the precipitation of the potash salts, it was <15 m.

These studies have enabled the author to estimate the prospects for potash and magnesian salts in a number of sections in the Gremyachinsk deposit of potash salts and in the Krasnokut sector in the northwest of the marginal zone of the syneclise. (Author's abstract)

MOSKOVSKIY, G.A. and GONCHARENKO, O.P., 1985, A joint interpretation of the results of determining the macro- and micro-components in solutions from inclusions in minerals of halide rocks and in the rocks themselves (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 192-193 (in Russian; translation by D.A. Brown). Authors at Saratov State Univ., Saratov, USSR.

The amounts of bromine and chlorine in rock salt and in K-Mg salts and the chemical composition of brine in inclusions in primary-sedimentary halite from halide sediments of the Iren Horizon of the Kungurian Stage in the Caspian Syneclise has been studied in detail in the Krasnokut sector in the northwest of the marginal zone, and the Safronovsk sector in the south of the Volga Homocline (the Gremyachinsk deposit of potash salts), and superficially, in a number of other sectors in the surroundings of the syneclise.

In the search for K-Mg salts, the authors, in conjunction with the Dept. of Geochem. at Moscow State Univ. (Rumyantseva & Zherebtsova, 1983), have developed a procedure for Br and Cl in individual liquid inclusions in halite. The amount of Br and Cl and the value of the Br/Cl ratio have been determined in inclusions in a diagenetic halite from the Dolina and Yeruslansk rhythm-members in the Krasnokut sector of the marginal zone of the syneclise. Ultra-microchemical analyses were also made of K, Mg, SO_4, and Ca of preservation of the primary-sedimentary structure of the halite, the results of studying the compositions and determining the Br/Cl ratio have proved equally informative.

These methods have established the boundaries of the phases of halogenesis, have clarified the geochemical anomalies corresponding to the lateral continuation of the potash layer (in the Antipovsk rhythm-member of the Gremyachinsk deposit and a number of other halide sections), and have even permitted a stratigraphic correlation (for the El'ton, Baskunchak, and Krasnokut sectors).

In the Gremyachinsk deposit, widespread diagenetic processes, cause the chemistry of the solutions to be markedly different from that in the sedimentary processes.

The Br/Cl ratio of liquid inclusions in diagenetic halite of the Dolina and Yeruslansk rhythm-members has a significant spread compared with experiments on the evaporation of sea-water by M.G. Valyashko, et al. $(Br.10^{-3}/Cl)$* from 3.3 to 11.1, as against 3.5-20 at the beginning of the halite phase on evaporation of modern sea-water. This suggests that a significant part of the diagenetic halite crystallized here in the presence of solutions from leaching the sedimentary halite and the K-Mg chloride salts.

The joint interpretation of the results of determining the amounts of Br, Cl, K, Mg, Ca, and SO_4 ions in inclusions of minerals of halogenic rocks and in the rocks themselves, has enabled the authors more completely to define the conditions of halogenesis in the region. The results of inclusion analyses suggest a major role for migrating brines in the formation of the potash salts in the Gremyachinsk deposit, the brines having migrated from the western part of the Caspian Syneclise, where their preliminary evaporation took place, and it is recommended that a search be made for K and Mg salts [in that area?]. (From the authors' abstract)

*[Sic; presumably $(Br.10^3)/Cl$ is meant.]

MUENOW, D.W. and GOODING, J.L., 1985, "Martian" volatiles in shergottite EETA79001: Possible significance of secondary minerals (abst.): Lunar and Planetary Sci. XVI, p. 593-594.

MUIR, M.D., DONNELLY, T.H., WILKINS, R.W.T. and ARMSTRONG, K.J., 1985, Stable isotope, petrological, and fluid inclusion studies of minor mineral deposits from the McArthur Basin: implications for the genesis of some sediment-hosted base metal mineralization from the Northern Territory: Australian J. Earth Sci., v. 32, p. 239-260. First author at CRA Explor. Pty. Ltd., PO. Box 656, Fyshwick, ACT 2609, Australia.

The geology, stable isotopes and fluid inclusions from mineralized and unmineralized Middle Proterozoic sequences of the McArthur Basin, Northern Territory, have been studied at Eastern Creek, Bulman Mines, Beetle Springs and other localities in the McArthur Basin where disseminated sulphides in unmineralized black shales were available from drill core. At Eastern Creek, galena and minor chalcopyrite (δ^{34}S +3.6 to +11.2‰) occur in an evaporitic sedimentary sequence. Barite (δ^{34}S +18.4 to +24.7‰) also occurs, and saline brines are trapped along healed fractures in the barite. Pressure-corrected Tt in the barite (95-138°C), and in vein dolomite (158-168°C) agree with T estimates from the degree of maturation of the sedimentary organic matter. The δ^{18}O and δ^{13}C($\sum$CO2) values of the mineralizing fluid were calculated to be +3.5 to +4.5‰ and -2.7‰, respectively. Sedimentary dolomite has restricted δ^{13}C and δ^{18}O ranges, within the reported ranges for nonmineralized Middle Proterozoic dolomite. An ore formation model developed for Eastern Creek, in which a basinal fluid at about 200°C carrying base metals and sulphide was released from underlying sediments during local fault movement, may be applicable to a number of other depostis. The mineralization deposited from these fluids occurs only below the pre-Roper Group unconformity, implying that it may be older than the basal Roper Group. The δ^{34}S values of iron sulphides in fine grained black dolostones (not associated with mineral deposits) from the McArthur Basin were assessed in the light of the values found for sulphides in modern organic-rich sedimentary environments. The data so obtained suggest that the considerable concentration of iron sulphide in the mineral deposits formed, at least in part, from heated basinal waters and that disseminated iron sulphides remote from mineralization also formed from a similar source. (Authors' abstract)

MÜLLER, E., 1985, The migration of gas-filled brine inclusions in rock salt under a temperature gradient: Cryst. Res. Technol., v. 20, no. 2, p. 521-526. Author at Nuclear Safety & Radiation Protection Board of GDR, Berlin.

In natural halite crystals two sorts of inclusions will move if there exists a temperature gradient. The direction of moving brine inclusions is oriented towards the heat source.

Brine inclusions which additionally contain more than 10% gas move towards the cold end of a specimen. This model is well known but detailed information about the migration mechanism of these so-called Sorby inclusions have been lacking in literature so far.

In this paper it will be demonstrated that Sorby inclusions having a diameter of up to 20 micrometers can move undisturbed through the crystal. Sorby inclusions with a diameter of more than 20 micrometers are fixed and form droplets with their tips directed towards the cold side of the specimen. Later when the tips have grown the inclusions will emit a new daughter inclusion which can move through the crystal. The velocity of migration depends on the generation of daughters.

Extended kinds of Sorby inclusions are stable for a long time. However, these can decay into many individuals which will move through the crystal like the others. (Author's abstract)

MÜLLER, E., 1985, The transportation of brine inclusions in rock salt in a temperature field of a heat source: Cryst. Res. Technol., v. 20, no. 5, p. 677-682. Author at Staatliches Amt für Atmos. und Strahlenschutz der DDR, Waldowallee 117, Abt. Information, DDR-1157, Berlin, FRG.

There are three kinds of brine inclusions in a natural crystal of halite, as follows: a) inclusions totally filled with brine; b) inclusions partially filled with brine and gas (SORBY inclusions) and c) inclusions totally filled with gas. Type a) and b) migrate in the crystal under the influence of a temperature gradient. Type c) inclusions do not move.

This paper deals with the question whether the migration causes tracks in the crystal or not.

In general, no tracks are caused directly by the motion of inclusions. However, there are some phenomena which can be explained as tracks. The reasons of these phenomena are examined and described. (Author's abstract)

MÜLLER, E. and ZSCHÄTSCH, B., 1985, Migration of brine inclusions through grain boundaries in rock salt: Cryst. Res. Technol., v. 20, no. 1, p. K1-K3. Author at Nuclear Safety & Radiation Protection Board of GDR, Berlin.

Grain boundaries are no obstacle. (E.R.)

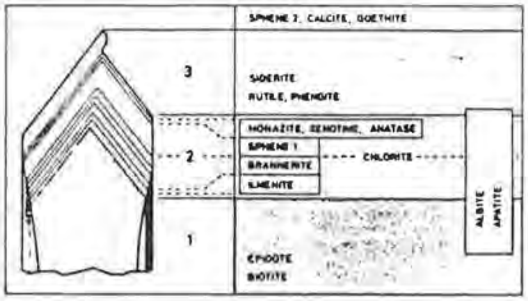
MULLIS, Josef, 1985, Control of mineral succession in Alpine fissures by H_2O- and CO_2-rich fluids (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 96-97. Author at Inst. Mineral. and Petrogr., Freiburg, Switzerland.

During the growth of cleft minerals solids are trapped within the crystals as well as fluids. They consist of rock fragments and other already formed minerals. Owing to tectonic activity such fragments are sheared off the cleft walls and fall upon minerals which may be growing below. There they form thin deposits, which may be overgrown by the host crystal. If the equilibrium of the minerals with the coexisting fluid is suddenly changed by tectonic events or by fluid migration etc., a part of the mineral paragenesis may be dissolved and reprecipitated as new minerals under the new equilibrium conditions. As fissure quartz is very rarely dissolved under retrograde conditions, the solid inclusions often remain the only witnesses of the earlier paragenesis. Together with the fluid inclusions, they are used to reconstruct the physico-chemical conditions existing during crystallization of the different types of paragenesis throughout the history of the cleft.

The interaction of fluid evolution and mineral succession has been investigated on more than 50 Alpine fissures. Fissure minerals form during retrograde metamorphic conditions, starting with scapolite (amphibolite facies) and finishing with the formation of zeolites (lowest metamorphic conditions). Within the amphibolite facies, the fluid composition is rich in CO_2, whereas in the greenschist facies and in the high grade anchizone, H_2O predominates. Owing to tectonic movements, CO_2 often migrates into the water-rich clefts, and in consequence minerals like epidote, ilmenite, sphene, adularia and chlorite become unstable. They dissolve, and in the CO_2-enriched fluid, a new mineral paragenesis crystallizes: rutile, white mica and ankerite. The mineral reactions can be deduced approximately as follows:

1. Sphene + CO_2 = Calcite + Rutile + Quartz
2. Ilmenite + CO_2 = Siderite + Rutile
3. Epidote + K^+ + $1/4Fe^{++}$ + H_2O + $2CO_2$ = Phengite + 2 Calcite + $1/4Fe^{+++}$ + H^+[sic]
4. Chlorite + K^+ + $3CO_2$ = Phengite + 3 Siderite + Mg^{++} + $3H_2O$[sic]

5. 3 Adularia + $2H^+$ = White mica + $6SiO_2$ + $2K^+$. (Author's abstract)



Generation	H_2O	CO_2	NaCl
1	97.1	0.7	2.2
2 früh	96.7	0.7	2.6
3 früh	93.8	3.3	2.9

Interaction of quartz growth and crystallization of fissure minerals with the fluid evolution during retrograde metamorphic conditions, demonstrated by an example of Alpine fissure from Zinggenstock (Aar Massif).

MULLIS, Josef, DUBESSY, Jean and POTY, Bernard, 1985, Evolution of pressure, temperature and fluid composition in Alpine fissures during mid-Tertiary metamorphism of the central Alps (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 98-99. First author at Inst. Mineral. and Petrogr., 1700 Freiburg, Switzerland.

Tectonic movements often lead to the fracturing of minerals growing on the walls of Alpine fissures. If such minerals recrystallize, fluids are trapped as witnesses of the tectonic history.

The influence of tectonic movements upon fluid evolution will be discussed with several examples.

1) Val d'Illiez (Helvetic zone). Pressure drops of several hundreds of bars are enough to cause an unmixing within the system H_2O-CH_4 at ~260°C. The initial fluid was in fact situated near the two-phase-field.

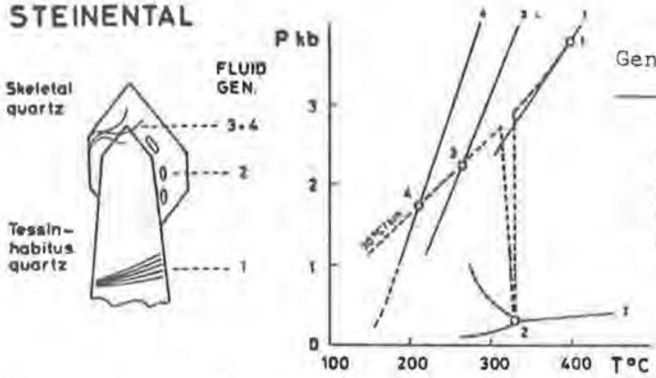
2) Amsteg, Amethystkehle, Val Giuv (Aar Massif). In these clefts an important enrichment of CO_2 in the paleofluids is associated with pressure drops. The P-V-T-X conditions show that there was no unmixing in the cavity. Furthermore, the lack of CO_2 within the surrounding rocks suggests a migration of fluids from metasediments situated at greater depths. This implies that the Aar Massif should correspond to a nappe system including or covering metasediments.

3) Steinental, Lago Cadagno, Camperio (Gotthard Massif and Penninic domain). The fluids characterized by an important enrichment in CO_2 have undergone a pressure drop of about 2 kbars. The P-V-T-X conditions of the fluids as well as the presence of CO_2 within the surrounding rock prove that the pressure decrease caused an intracavity unmixing of the initial fluid.

These few examples typical of Alpine fissures with gas enrichment show that tectonic movements causing a pressure drop may lead to unmixing with the fluid phase and/or can be an important driving force for fluid migration.

Along the north-south profile across the Swiss Alps, the evolution of the P-T conditions of fluid trapping can be compared to the tectonic history of this Geotraverse. It can be shown that during early Miocene times an important uplift and erosion must have occurred in the southern part of the Penninic nappes, while for the Gotthard and the Aar Massifs crustal thickening must be proposed. (Authors' abstract)

Continued next page.



Generation	H_2O	CO_2	NaCl
1	78.7	20.1	1.2
2	68.6	31.4	?
3	98.5	0.0	1.5
4	99.6	0.0	0.4

Interaction of tectonic activity, pressure drop, fluid unmixing and quartz growth (skeletal quartz), demonstrated by an example of Alpine fissure from Steinental (Penninic domain).

MULLIS, J. and STALDER, H.A., 1985, Fluid inclusions in rockforming and fissure quartz from cores out of two NAGRA-boreholes in north-Switzerland (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 100. First author at Inst. Mineral. and Petrogr., CH-1700 Freiburg, Switzerland.

NAGRA is the "National Cooperative for the Storage of Radioactive Waste." With the execution of a drilling project starting in 1982, NAGRA tests candidate sites in north-Switzerland for burial of high-level wastes. The first drilled hole is situated near Boettstein, AG. The 1501-m hole penetrated, from bottom to top, 1186 m granite (= Boettstein-Granite), 298 m Triassic sedimentary beds and 17 m gravels. The second drilled hole is situated near Weiach, ZH. The 2448 m cored hole penetrated, from bottom to top, 462 m gneiss (basement), 570 m upper Carboniferous schists, 461 m Permian beds (included evaporitic layers), 285 m Triassic beds etc.

Fluid inclusion studies (mainly microthermometry) were made on Boettstein cores, in rockforming and fissure quartz out of the granite; and on Weiach cores, in rockforming and fissure quartz out of aplite and hydrothermally altered gneiss from the basement, as well as in detrital quartz from Permo-Carboniferous sediments.

Two completely different fluids were found: relatively salt-poor aqueous solutions with Th between 380° and 100°C, and salt-rich solutions with Th between 105 and 25°C and Tm between -17 and -26°C resp. -9 and -12°C. Boiling phenomena were systematically detected for the first fluid series. Local developments of the ancient fluids are obvious. Age relations could be found in the Weiach specimens: The salt-poor fluids are older, pre-Stephanian; the salt-rich solutions are younger, post-Stephanian, probably related to the Permian evaporites. It is assumed that it is the same for the Boettstein fluids. One can correlate the two kinds of fluids with two (otherwise established) hydrothermal (alteration) phases. (Authors' abstract)

MUNIZ, P.F., 1985, Precious metal vein deposits of the Buffalo Hump district, west-central Idaho: Masters thesis, Univ. Wisconsin, Madison, WI, 84 pp.

Indexed under fluid inclusions.

MUNKSGAARD, N.C. and ZECK, H.P., 1985, Oxygen isotope systematics indicating large-scale circulation of fluids in granitic rocks from southwest Sweden: Chem. Geol., v. 51, p. 239-246. Authors at Geol. Inst., Copenhagen Univ., 1350 Copenhagen K, Denmark.

In the Precambrian basement of SW Sweden two formations of granitic rocks have been strongly recrystallized but have preserved their granitic texture. Most magmatic crystals have been replaced by greenschist-facies mineral assemblages. $\delta^{18}O$ whole-rock values for the granitic rocks vary from +1.7‰ to +8.2‰ (relative to SMOW) and extend below the normal range for granitic rocks (+6 to +10‰). Quartz-K-feldspar pairs show $^{18}O/^{16}O$ fractionations of +5.4‰ and +7.8‰, indicating disturbance of magmatic equilibrium fractionations. It is concluded that the O-isotope redistribution took place during the pervasive recrystallization of the rocks, under the influence of a large-scale flux of water (partly) of meteoric origin, probably in a convective hydrothermal system set up by the intrusion of the granites themselves. Estimation of pre-alteration $\delta^{18}O$ whole-rock values for one of the granitic units suggests a partly S-type origin. (Authors' abstract)

MURALI, A.V., ZOLENSKY, M.E., SOMMER, M. and BLANCHARD, D.P., 1985, Impactite and tektite glasses from Lonar crater, India (abst.): EOS, v. 66, no. 46, p. 948. First author at SN2, NRC/Johnson Space Center, Houston, TX 77058.

Lonar crater (19°58'N, 76°31'E) is a young meteorite impact crater in Deccan basalts, Buldana Dt., Mahrashtra State, India. Petrographic and chemical studies of the impactites from this crater have clearly indicated that these heterogenous glasses are impact melt products of local tholeiitic basalts.

Apart from these impactites, dense black glasses with distinct aerodynamic features and flow characters, are also reported within 1 km of the crater rim. Systematic petrographic and chemical (microprobe, instrumental neutron activation analysis and laser decrepitation and mass spectrometric volatile analysis) studies have been carried out on these glasses for the firt time. Two impact glasses, five unshocked basalt flow samples from the area, and the Georgia tektite (DGA-1) have also been included in the study for comparison. The study revealed that a) these dense glasses are very homogenous (petrographically and chemically), show occasional schlieren and strained[sic] birefringence, b) circular and/or elliptical vesicles are present in some of these glasses, aligned along the flow direction, c) these glasses have restricted chemical composition except in Na_2O which varies widely (1.4-6.9%), and have characteristically high SiO_2 contents (64%-67%), as against ~50% SiO_2 of impactites and Deccan basalts, d) they have very low water content (0.095%) and high CO_2/H_2O ratios (~0.15) comparable to Georgia tektite (H_2O: 0.09%; CO_2/H_2O: 0.20) while local basalts contain an order of magnitude lower (0.009) CO_2/H_2O ratios, and e) they are depleted in their overall REE abundances by 65.50% compared to those of Lonar basalts and impactites, although their relative REE patterns are strikingly similar. Local intertrappean beds and the precrater soil compositions need to be evaluated to understand the formation of these high silica, homogenous (tektite) glasses at Lonar crater. (Authors' abstract) [References cited have been omitted by editor.]

MUROWCHICK, J.B., NESBITT, B.E. and MUEHLENBACHS, K., 1985, Multiple origins of Canadian Cordilleran gold deposits: Geochemical characteristics (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 672. Authors at Dept. Geol., Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

Two types of lode Au mineralization (Mother Lode and Epithermal) can be recognized in the Canadian Cordillera by geochemical characteristics. The Coquihalla Au belt, a typical ML district, has steeply-dipping Q-cc-ab-Au veins. Host rocks are greywackes, slates, and greenstones in fault contact with a serpentinite body.

Isotopic analyses: Q-cc and antigorite-mt pairs give temps. around 250°C. $\delta^{18}O$(SMOW) are exceptionally high: vein Q = 16 to 18‰ (the lower values are near the serpentinite and mineralized zones), antigorite = 7.4 to 9.5‰ (the higher values are near the serpentinite-greywacke contact), and cc = 14 to 18‰ with $\delta^{13}C$(PDB) = -2.9 to -6.9‰. δD are low: -111 to -142 for the serpentines and -84 to -100 for fluid inclusion waters extracted by crushing vein Q. These fluids have low salinity and contain CO_2. The $\delta^{18}O$ for the ore fluid is about 8‰ and was also the serpentinizing fluid. The δD suggest that the fluid was dominantly meteoric, but evolved by reaction with the metasediments during deep circulation.

The typical ML assemblage is Q-cc-ab with aspy, py, po, Au, ±Au tellurides ± scheelite; Au/Ag = 4 to 7 in this belt. Other ML deposits in BC show similar isotopic and mineralogic traits.

Epithermal deposits in the Canadian Cordillera are comparable to well-studied US examples: their fluids were shallow-circulated meteoric waters ($\delta^{18}O$ = -14 to -7), $\delta^{18}O$ = -5 to +2, T = 200-300°C, Au/Ag<1, and have Q, chalcedony, cc, hematite, adularia, barite, py, cpy, Ag_2S, Au, electrum and anomalous Hg, As, and Tl contents.

The association of Hg and Sb occurrences near many B.C. ML deposits suggests that these may be the epithermal expression of deeper ML mineralization. (Authors' abstract)

MURPHY, M.T. and BROOKINS, D.G., 1985, Trace-element behavior within a fossil hydrothermal zone; strontium-isotope data (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 258.

MYAZ', N.I., SIMKIV, Zh.A. and YAROVAYA, T.F., L985, Solubility of minerals and water leachates (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 54-55 (in Russian). Authors at L'vov State Univ., L'vov, Ukraine.

On the basis of the nine subsequent water leachates made for quartz and sulfide samples it was found that the "solubility background" for quartz consists essentially of hydrosilicate ions, plus subordinate HCO_3, Cl and Ca; for sulfides (sphalerite, galena, cinnabar) - essentially of Cl. Na, K, Mg, Sr and Fe in the third and following leachates rarely exceed 0.1 mg per 250 ml of leachate. Solubility of minerals is the individual feature of each sample and should be determined for any of them. Triple water leachate is sufficient for routine work. (A.K.)

NAESER, C.W. and CUNNINGHAM, C.G., 1985, Fission-track dating applied to mineral exploration (abst.): U.S. Geol. Survey Circular 949, p. 33-34.

The partial to total resetting of fission-track ages of apatite and zircon in country rock around a mineralized area can be used to (1) locate a paleothermal anomaly, (2) determine the age of a paleothermal anomaly that may coincide with a mineralizing event, and (3) determine the direction toward the heat source. (From the authors' abstract)

NAI-YONG, Tàng and PLUMTREE, Alan, 1985, Nucleation of cavities due to vacancy supersaturation: Z. Metallkde., v. 76, no. 1, p. 46-53. First author at Dept. Mech. Engrg., Qinghua Univ., Beijing, China.

Creep strain generates excess vacancies thereby inducing vacancy supersaturation. The degree of supersaturation is enhanced due to localized deformation in the vicinity of grain boundaries and, more importantly, some grain boundaries failing to act as perfect sinks for vacancies. It is shown that the high degree of vacancy supersaturation generated in power-law creep provides enough driving force for cavity nucleation via a vacancy aggregation mechanism. (Authors' abstract)

NAKASHIMA, Kazuo, WATANABE, Makoto and SOEDA, Akira, 1985, X-ray and microprobe analyses of wolframite series from the Kaneuchi mine, Kyoto Prefecture, Japan: J. Japan. Assoc. Min., Petr., Econ. Geol., v. 80, p. 321-326. First author at Dept. Earth Sci., Faculty of Sci., Yamagata Univ. Yamagata 990, Japan.

Quotes unpublished data (p. 333-334) on Th values. (E.R.)

NAST, H.J., 1985, The geology and petrochemistry of the Sisson Brook W-Cu-Mo deposit, New Brunswick: Masters thesis, McGill Univ., Montreal, PQ, Canada, 208 pp.

Indexed under fluid inclusions.

NAUMKO, I.M., 1985, Formation of primary inclusions of mineral-forming media during repulsion, joint growth and trapping of solid particles by growing topaz crystals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 13-14 (in Russian). Author at Inst. Geol. & Geochem. of Mineral Fuels of Acad. Sci. of Ukrainian SSR, L'vov, Naukova Str. 3a, Ukraine.

The above types of inclusions were first found in chamber (i.e., "zanorysh") type pegmatites in Volyn (Korosten' pluton) in topaz crystals from zones of leaching and recrystallization in one pegmatite body in the center of the Volodarsk-Volynskiy field.

Solid inclusions are rhomb-shape anisotropic crystals of low interference colors (first order) and refractive indices lower than topaz (albite?). Their distribution shows that chips of this mineral appeared on the surface of growing crystal many times. These particles are <45 µm.

Above and under these solid inclusions the cavities are observed, having an elongated, tubular habit. They occur perpendicular to the topaz cleavage, accordingly to elongation of its crystal; length reaches 170 µm. The described cavities filled with parent solution, are one of the types of P inclusions of mineral-forming medium in topaz.

Types of P inclusions of mineral-forming fluids include:

1. Complex CO_2 inclusions: LH_2O:LCO_2:G are in ratios either 60:20:20 or 25:35:40. In the first variety LCO_2+G homogenize in LCO_2, next dissolving in LH_2O, in the second one - all homogenizations are in G. P inclusions (LH_2O+LCO_2+G) in the same part of topaz trapped by growth pyramid of faces $\{00\bar{1}\}$ homogenize like the second variety.

2. Essentially G inclusions (G up to 90-95%).

Similar families of inclusions formed during repulsion and trapping of solid particles were described by V.G. Feklichev (1964) in beryls from Asia, M.M. Slivko (1966) in tourmalines from the Urals and Siberia and by K. Lkhamsuren (1969) in topazes from Mongolia. Inclusion fillings may form during boiling of mineral-forming fluid. (Author's abstract translated by A.K.)

NAUMOV, G.B., MIRONOVA, O.F., SAVEL'EVA, N.I. and DANILOVA, T.V., 1985, Uranium concentration in mineral-forming fluid (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 57 (in Russian). Authors at Inst. Geochem. & Anal. Chem., Moscow, USSR.

In quartz and calcite samples the amount of water and uranium was determined in fluid inclusions after decrepitation[sic, A.K.]. Water was determined in vacuum set with liquid manometer. Uranium was washed from the decrepitated sample and its concentration was determined in solution by a laser-luminescence method. High U concentrations were found in minerals of ore stage (tens and hundreds mg per ℓ); pre-ore solutions and those in minerals other than ore mineralization were low in U (few mg per ℓ). [See abstract by same authors in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 237, 1984.] (A.K.)

NAUMOV, V.B. and IVANOVA, G.F., 1984, Geochemical criteria for a genetic relation between rare-metal mineralization and acid magmatism: Geokhimiya, 1984, no. 6, p. 791-804 (in Russian; translated in Geochem. Int'l., v. 21, no. 6, p. 1-13, 1984 (pub. 1985)).

See Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 238-239. (E.R.)

NAUMOV, V.B. and KOVALENKO, V.I., 1985, A description of the principal volatile components in magmatic and metamorphic processes based on a study of inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 119-121 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

The authors have obtained personal and literature data on the most common volatile components in melt and fluid inclusions from the deep crustal zones and the upper mantle. About 100 such works have been published and almost 300 rock samples have been examined. All the available results have been entered on a P-T diagram for the fluid (P = 0-15 kbar, T = 500-1500°C), yielding the following conclusions. (Coordination of the P values has been achieved using Yu.P. Mel'nik's tabular data based on gas properties.)

1. A wide field of crystallization for acid melts (≥1250°C to 550°C) is unusual. The basic and less common ultramafic melts have higher T (1500-1000°C). The maximum pressures of the deep-seated fluids are 11-13 kbar for CO_2 gas and N_2, whereas for water, they are half that amount (5.5-6 kbar).

2. CO_2 is typical of the basic melts, and H_2O in the acid ones. On the whole, the basaltic magmas (including those of the oceanic and continental rifts, and the intra-plate environments) are virtually without water. Small amounts of water are present only in island-arc magmas. The principal volatile in the acid magmas is water, the concentration of which varies from <0.1 ≤ 14 wt %. In acid magmas as T decreases, Pf rises (from 0.1 to 6 kbar) along the granite plus water solidus. In strongly differentiated acid magmas, F, B, and rare elements, along with water, begin to play a significant role, so that low-temperature (≥550°C) and very water-rich melts of Li-F granites, ongonites, and rare-metal alkali-granites, are formed.

3. At P = 6-13 kbar, and T = 500-1100°C, the deep-seated fluids consist of CO_2, CH_4, and N_2, with no water. Under these conditions, magmatic melts have also not been identified, only metamorphic rocks. It is clear that at D >20-22 km, water is virtually absent from the fluid. This conclusion is supported by studies of fluid inclusions in the Kola super-deep drill-hole (water decreases and disappears in depth and with increase in metamorphic grade).

4. From syngenetic melt and fluid inclusions, it is evident that on degassing of natural basalt magmas, CO_2 is released, and for the granites, water.

5. The main component of fluids from ultramafic nodules in alkaline basalts and kimberlites is CO_2, and sometimes along with ≤8-12 mole % CO (Raman-spectroscopy data), N_2, or a small amount of sulfurous gases. (From the authors' abstract)

NAUMOV, V.B., KOVALENKO, V.I., CLOCCHIATTI, R. and SOLOVOVA, I.P., 1984, Crystallization parameters and phase compositions for melt inclusions in ongorhyolite quartz: Geokhimiya, 1984, no. 4, p. 451-464 (in Russian; translated in Geochem. Int'l., v. 21, no. 4, p. 19-32, 1984 (pub. 1985)).

See Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 239. (E.R.)

NECHAEV, Ye.A., 1984, The effects of solution composition on the adsorption of gold (III) complexes on hematite: Geokhimiya, no. 4, p. 527-533 (in Russian, English abstract; translated in Geochem. Int'l., v. 21, no. 4, p. 87-93, 1985).

NEGGA, H.S., SHEPPARD, S.M.F., ROSENBAUM, J.R., HOLLIGER, P. and CUNEY, M., 1985, Origin of uranium mineralizing fluids in the La Lauzière massif (western Alps, France) determined from C, O, H isotopic and fluid inclusions data (abst.): Terra Cognita, v. 5, p. 150. Authors at CREGU, BP 23, 54501 Vandoeuvre-les-Nancy Cedex, France.

In the La Lauziere metamorphic and granitic complex (Belledonne external crystalline massif) the main uranium mineralizations are commonly associated with carbonate veins, lenses or breccias. Dolomite or ankerite are deposited before pitchblende whereas calcite is contemporaneous. Late Alpine calcite veins are also locally present.

The fluids associated with each carbonate phase are mainly aqueous and have been trapped at different conditions regarding P (dolomite or ankerite >1.5 Kb; calcite <1.5 Kb), T (dolomite or ankerite >350°C, calcite 300-350°C) and fluid composition (decreasing salinity from dolomite to calcite). The very low $\delta^{13}C$ value (-10 to -14‰ PDB) of the carbonates indicates an organic origin for the carbon. $\delta^{18}O$ of the carbonates and δD of the aqueous fluids implicates mixing of metamorphic and meteoric fluids. The meteoric contribution increases during the infilling of the veinlets whereas the salinity decreases (20 to 9 wt % equivalent NaCl). The mixing phenomena may be interpreted in a context of uplifting which attains several hundred of meters. The increase of homogenization temperature observed in the fluid inclusions is also coherent with this model.

The main uranium mineralizations are Hercynian (upper intercept of the discordia at 280 ± 4 M.a.) and appears when the meteoric contribution of the fluid is the most important. Alpine calcite presents distinct isotopic characteristics. (Authors' abstract)

NELSON, C.E. and GILES, D.L., 1985, Hydrothermal eruption mechanisms and hot spring gold deposits: Econ. Geol., v. 80, p. 1633-1639. Authors at Cimarron Explor., Inc., 66 S. Van Gordon, Suite 140, Lakewood, CO 80228.

Episodes of gold mineralization in the shallow hot spring environment are related in time to hydrothermal eruption events and in space to the resulting vent breccias and peripheral stockwork zones. It is proposed that large but short-lived overpressures in a geothermal reservoir, probably triggered by sudden magmatic heat fluxes, induce hydraulic fracturing which then evolves into hydrothermal eruptions if driven through to the surface. The maximum available energy in hot, shallow reservoirs appears easily sufficient to drive such eruptions, particularly if CO_2-rich fluids are involved. In mineralized systems, gold-bearing fluids are subsequently channeled into the outflow conduit where they flood the permeable vent breccia and peripheral stockwork. Gold is lifted into this hot spring environment above a boiling level that is elevated by high flow rates to within several hundred meters of the surface and is precipitated with abundant quartz, pyrite, and adularia, along with a distinctive and steeply zoned trace element suite. These sequential events probably occur as a continuum, which if repeated cyclically in a single vent zone, can result in ore-grade mineralization. (Authors' abstract)

NERONSKI, G.I. and LEVITSKI, Y.T., 1985, Structural position of fluid inclusions in native gold (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 40-41 (in Russian; translation by I. Kulikov). Authors at Amur KNII DVNTs of AN SSSR, Blagoveshtensk, USSR.

The presence of vapor-liquid inclusions in native gold have been known since 1954, when L.A. Nikelayeva described small knobs of swelling on grains of placer gold. In 1962 A.E. Gapon produced such knobs artificially by dry heating of gold grains; and in 1973 N.V. Petrovskaya and coauthors determined the composition of larger individual inclusions. In recent years many works appeared on vacuum decrepitation of gold and on inclusion compositions, in which the possibility of use of gold decrepitation for solving of some gold ore genesis problems was shown.

For interpretation of decrepitation results and of inclusion composition in gold it is important to know also the nature of inclusions (primary or secondary). For transparent minerals these issues were studied in detail by N.P. Yermakov (1972).

For solving of the problem of structural position of vapor-liquid inclusions in native gold we used the visual-photographic method which was developed earlier (Neronski and Levitski, 1982 [see Fluid Inclusion Research--Proceedings of COFFI, v. 15, 1982, p. 174-175, and v. 13, 1980, p. 173]). The observation was made in the process of heating of a polished section or ideally smooth induction surface of a gold grain; this permits observing smaller knobs of swelling, in addition to the bigger ones. Before visual decrepitation the polished section was etched and photographed. After decrepitation it was rephotographed, thus determining the position of inclusions with regard to the primary structure of the grain.

Inclusions in polycrystal gold aggregates, observed in such a way, often had significant dimensions (up to 3 mm), and more often they were located at the edges of the grains; smaller inclusions were found to be inside the grains, but they are more rare. Inclusions at the faces are thought to be primary ones. Secondary inclusions were not determined. (From the authors' abstract)

NEWMAN, S., STOLPER, E. and EPSTEIN, S., 1985, Variations in hydrogen isotopic ratios of obsidians erupted 1400 A.D. at Mono Craters, California (abst.): EOS, v. 66, no. 18, p. 391.

NEWTON, R.C., 1985, Temperature, pressure and metamorphic fluid regimes in the amphibolite facies to granulite facies transition zones, in A.C. Tobi and J.L.R. Touret, eds., The Deep Proterozoic Crust in the North Atlantic Provinces: D. Reidel Publ. Co., p. 75-104.

See following item, as well as Newton, 1984, and Newton et. al., 1984, in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 242-243. (E.R.)

NEWTON, R.C. and HANSEN, E.C., 1983, The origin of Proterozoic and late Archean charnockites - evidence from field relations and experimental petrology: Geol. Soc. Am. Memoir 161, p. 167-178. Authors at Dept.

Geophys. Sci., The Univ. Chicago, Chicago, IL 60637.

The definitive characteristics of most Archean and Proterozoic charnockites have resulted from granulite-facies metamorphism in the presence of CO_2-rich, H_2O-poor fluids. Chemical analyses, experimental petrology, fluid inclusion studies, and field relations in the Archean amphibolite-facies to granulite-facies transition region of southern India show that charnockitic metamorphism of gray gneiss may be either virtually isochemical or profoundly metasomatic. K-metasomatism and anatexis commonly attend charnockitic metamorphism, as H_2O-rich fluids were driven upwards ahead of a wave of hot CO_2. Dehydration and depletion of incompatible elements, especially Rb and U, followed migmatite formation. It is not yet clear whether the observed depletions can be entirely accounted for by leaching by a vapor phase or whether escape of anatectic melt is required to produce the most intense depletions. (From the authors' abstract)

NGUYEN TRUNG, C. and POTY, B., 1985, Experimental study of the stoichiometry and the solubility of $UO_2(c)$ in aqueous solutions (H_2O with dissolved CO_2, LiOH, NaOH) from 100 to 350°C, at saturation vapor pressure, and at the hematite-magnetite or nickel-nickel oxide buffers (abst.): Bull. Minéral., v. 108, p. 93 (in French).

NGUYEN-TRUNG, Chinh and POTY, Bernard, 1985, Stoichiometry and solubility of uranium (IV) oxide in aqueous solutions (H_2O, LiOH, NaOH) (abst.): Int'l. Meeting on Concentration Mechanisms of Uranium in Geological Environments, Nancy, France, 2-5 Oct., 1985, Program & Abst., p. 163-165.

NICHOLLS, J. and CRAWFORD, M.L., 1985, Fortran programs for calculation of fluid properties from microthermometric data on fluid inclusions: Computers & Geosci., v. 11, no. 5, p. 619-645. First author at Dept. Geol. & Geophys., Univ. Calgary, Calgary, Alberta, Canada T2N 1N4.

Four FORTRAN programs for the calculation of fluid properties from observational data on fluid inclusions are described along with instructions for their implementation. The primary data from fluid inclusion studies are phase identifications, phase transition temperatures, and estimates of relative phase volumes. From these data the programs calculate densities, compositions and isochores for H_2O, CO_2, H_2O-CO_2, H_2O-NaCl and H_2O-CO_2-NaCl mixtures. (Authors' abstract)

NICOLAYSEN, L.O., 1985, Renewed ferment in the earth sciences - especially about power supplies for the core, for the mantle and for crises in the faunal record: S. African J. Sci., v. 81, p. 120-132. Author at Bernard Price Inst. Geophys. Res., Univ. Witwatersrand, Johannesburg 2001, S. Africa.

Includes discussion of the possible roles of CO_2-rich fluids in core and mantle processes. (E.R.)

NICOLLET, Christian, 1985, The banded cordierite and garnet-bearing gneisses from Ihosy: A geothermo-barometric tracer in southern Madagascar: Precambrian Res., v. 28, p. 175-185 (in French; English abstract). Author at Centre Univ. Régional de Tuléar (Madagascar) et Lab. Pétrol. des Zones Profondes, U.S.T.L. 34060, Montpellier, France.

Garnet-plagioclase, garnet-cordierite and garnet-biotite geothermo- and geobarometers allow the estimation of the conditions of [the] migmatization ($T > 700°C$, PT = 5-5.5 kbar, PH_2O = 0.3-0.4 PT). (From the author's abstract)

NIEMANN, J.C. and READ, J.F., 1985, Recognition of unconformity-sourced aquifer cements and later burial cements, Mississippian Newman Limestone, Kentucky (abst.): Am. Assoc. Petrol. Geol. Bull., v. 69, no. 2, p. 293. Authors at Virginia Polytech. Inst. and State Univ., Blacksburg, VA.

The Mississippian Newman Limestone in eastern Kentucky contains aquifer-related cements and deeper burial cements. These cements were differentiated by trace elements, cathodoluminescence, staining, and fluid inclusions. Aquifer cements are nonferroan and show a nonluminescent to dull to nonluminescent to bright cathodoluminescent zonation. They fill leached ooid and fossil molds, indicating that pore waters were initially undersaturated with calcium carbonate. Within a regional paleoaquifer, early nonluminescent cement (34 ppm Mn, 33 ppm Fe average) precipitated from oxidizing waters that later became reducing to form dull cement (average 181 ppm Mn, 565 ppm Fe). A second nonluminescent cement was formed following later recharge. Aquifer stagnation, prior to or during burial, was accompanied by bright cementation (2,139 ppm Mn, 252 ppm Fe average). Waters were sourced from post-Newman unconformities. Aquifer cement, which decreases away from recharge areas, was determined by initially staining for late-burial calcite; image analysis was then used to determine the amount of early cement by subtracting late-burial cement from total cement. Later, iron-rich burial cements (778 ppm Mn, 4,295 ppm Fe average) filled the following pore space: (1) remnant intergranular, (2) fractures in compacted skeletal grains, (3) cavities caused by spalling ooid cortices and early cement rims, and (4) tectonic fractures, which are lined with saddle dolomite and pyrite. Secondary fluid inclusions suggest that late-stage fluids were chemically complex brines with temperatures and ranged from 50°C to 160°C and averaged 100°C. These techniques may help to evaluate porosity loss by shallow cementation in paleoaquifers (potential pore plugging prior to hydrocarbon migration) vs. cementation by deeper burial processes. (Authors' abstract)

NIKOGOSYAN, I.K, SOBOLEV, A.V. and KONONKOVA, N.N., 1985, Petrology of the oceanites of Reunion, Indian Ocean, based on magmatic inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 138-139 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

The oceanites are the most magnesian and olivine-phenocryst-enriched lavas of the subalkaline series of the oceanic islands, and may be regarded as possible manifestations of the original melt of these series. This paper attempts to determine the composition and conditions of crystallization of the original oceanite melt from two volcanic centers on Reunion Island (Piton des Neiges - 50,000 years; Piton de la Fournes - present-day), through a study of the magmatic inclusions in phenocrysts.

The paragenesis of the phenocrysts in these rocks consists of ol (Fo = 85-87% Piton des Neiges; Fo = 82-85% Piton de la Fournes) and crsp of variable composition. Optical studies on the ol have identified P melt inclusions [with?] crsp and cpx (Piton des Neiges), syngenetic fluid inclusions, and also combined inclusions of these phases in varying ratios. The Tt of ol, determined by Th is 1340-1190°C. In this case, there is a firm correlation ($r = 0.91$) between Th of the melt inclusions and the Mg content of the enclosing ol, indicating fractional crystallization.

According to cryometric and spectometric data on [opened] fluid inclusions, the composition of the fluid evolved during the process of crystallization from CO_2 to CO_2-H_2O ($P(H_2O)/P(CO_2) = 3/5$) in the P range of 1-0.5 kbar.

Homogenized melt inclusions to have a picrite composition, which evolved to the typical subalkaline basalts of Reunion Island. The compositions of syngenetic crsp and melts established $f(O_2)$ as intermediate between the Ni-NiO and quartz-magnetite-fayalite buffers.

Significant differences have been identified in the Tf and the degree of fractionation of the melts, which formed the oceanites in the two centers. (From the authors' abstract)

NIKOL'SKAYA, L.V. and SKROPYSHEV, A.V., 1985, Studies of the possibility of removal of gas-liquid inclusions from crystals of Iceland spar of the Siberian Platform (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 44-45 (in Russian). Authors at Leningrad Geol. Inst., Leningrad, USSR.

Inclusions in Iceland spar had Th 40-200°C (mostly up to 100°C), filling degree about 0.9, overheating that did not cause opening of inclusions was 100-120°C above Th. Inclusion solutions are of Cl-Ca-Na and Cl-HCO_3-Ca-Na types. In autoclave it is possible to achieve the speed of inclusion migration in calcite crystal in range of 0.1 angstrom per 24 hours, so slow migration is caused by weak solubility of $CaCO_3$ in inclusion solution, whereas use of NH_4Cl solution for synthesis of calcite crystals results in growth rate up to 10^{-7} cm per sec.[sic] (A.K.)

NIKOL'SKIY, N.S., 1984, P-t-fO_2 conditions for stability of phlogopite in the presence of hydrogen, oxygen and carbon-containing fluids and their effect on petrogenesis: Dokl. Akad. Nauk SSSR, 1984, no. 4, p. 962-966 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., v. 275, p. 89-93, 1985).

NIKOL'SKIY, N.S., 1985, Thermodynamic parameters of the formation of apatite based on gas-chromatography and thermobarometric data (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 160-162 (in Russian; translation by D.A. Brown). Author at Far Eastern Geol. Inst. of Far Eastern Sci. Center of Acad. Sci. USSR, Valdivostok, USSR.

The degree of reliability in making a quantitative estimate of the physicochemical conditions of formation of minerals is significantly enhanced if determination of the parameters is undertaken by several methods. This is discussed through a study of apatites from alkaline magmatic rocks, for which there are determinations of the composition of the gas phase, occluded by crystals, and the results of thermobarometic studies.

The gas phase was separated by stepped heating (200°C intervals) of crushed samples of apatite in a vacuum, and analyzed by gas chromatograph (Karzhavin et al., 1975). Two T ranges have been identified (400-600 and 800-1000°C) for maximum gas release, which in the present author's view, correspond to the rupture of large GLIs and the extraction of gases from defects and inter-molecular layers in the crystal lattice. Calculation of the equilibrium parameters of the gas phases was achieved through the present author's procedure (Nikol'skiy, 1981). Results of the computations are given in the Table, which also provides data from a thermobarometric study of inclusions in the apatites (Valyashko and Kogarko, 1966; Kogarko, 1977; Krasnova and Yakovleva, 1978).

A comparison of the Tf of the apatites, obtained by various methods, demonstrates that in some cases, their partial or complete coincidence is recorded (Table, Sample 2, 4, and 5), but sometimes the calculated values are greater than the Th (Samples 1 and 3). An analysis of all the data indicates that the calculated T values are more correct: 1100-1150°C for early-generation apatite (Sample 1), 830-990°C for apatite of the relatively larger generation (Sample 2), and 600-650°C for apatite from the alkaline pegmatite (Sample 3).

Anomalously low values for the calculated P (Samples 3 and 4) may have resulted from various causes (deviation of the gas phase from the equilibrium state, absence of determinations of some components of the fluid, especially those such as N_2 and the inert gases, and the crystallization of apatites in open cavities). But on the other hand, the barometric determinations evidently give overestimates. In the author's view, the fluid pressure did not exceed 100-200 bars.

It is believed (Kogarko, 1977) that $f(O_2)$ during the formation of the nepheline syenites corresponded to the field bounded by the quartz-magnetite-fayalite and nickel-bunsenite equilibrium curves. But, in fact, $f(O_2)$ and the fluid phase of the apatites lay mainly on the level of the iron stability field, below the quartz-iron-fayalite equilibrium curve (Table, Samples 1-4), and less frequently, corresponded to the stability field of fayalite with magnetite (Sample 5). (Author's abstract)

Table

Sample No.	Heating range, °C	Calculated data			Thermobarometric determinations	
		t, °C	P, bars	$-\log f(O_2)$ (bars)	Th, °C	P, atm.
1	400-1000	1095	30	15.114	740-850	890-1080
	600-1000	1145	25	14.352	270-280	
2	400- 600	570	0.22	26.640	740-850	the same
	800-1000	990	30	16.172		
	600-1000	830	3	19.623		
3	800-1000	645	0.06	24.800	270-340	570- 690
	600-1000	605	0.04	25.936	115-120	
4	400- 600	375	0.002	36.255	750-880	890-1080
	800-1000	870	0.73	19.048	360-380	
	600-1000	750	0.34	21.726		
5	800-1000	585	12	23.755	560-800	
	600-1000	570	8	24.388	350-490	

Legend:
Apatites: 1) from patchy area; 2) from lensoid-banded area in apatite-nepheline rocks, Yukspor, Khibiny, Kola Peninsula; 3) from alkaline pegmatite, Lovozero, Kola Peninsula; 4) from pegmatoid in rischorrites, Poachvlumchorr, Khibiny, Kola Peninsula; 5) from phlogopite-diopside-forsterite rock, Kovdor, Kola Peninsula.

NISHIOKA, G.K., KELLY, W.C., LOHMANN, K.C. and RYE, R.O., 1985, Stable isotope geochemistry and P-T-X conditions of late vein mineralization at White Pine, Michigan (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 678. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Numerous calcite veins crosscutting the main cupriferous ore zone at White Pine shed light on the late Precambrian, post-ore history of the district. Vein fluids (Na-Ca-Cl brines; 0-28% NaCl) migrated through enclosing redbed sequences and infiltrated the mineralized Nonesuch Shale, there leaching pre-existing copper (Carpenter, 1968). Based on isotopic analysis of calcites and fluid inclusion extracts, typical vein waters were evolved meteoric fluids initially sourced at high elevations (δD-H_2O = -56 to -76‰; $\delta^{18}O$-(H_2O)SMOW = -10 to -1‰ [calculated]) which presumably derived their salts by dissolution of evaporites in sediments of Oronto Group.

The carbon isotopic composition of these vein calcites typically ranges from -10 to -6‰ $\delta^{13}C$ PDB with rare calcite cement zones possessing anomalously depleted values (-31‰). Such depleted values indicate a significant contribution of carbon derived from the oxidation of organic matter (presumably the Nonesuch Oil), a process which may also account for the anomalously light δD (-93‰) composition of some inclusion waters.

Integration of several types of evidence (fluid inclusion isochores, Cu_2S polymorphs, hydrocarbon maturation temperatures) indicates vein fluid temperatures were between 50-93°C, and at times during calcite precipitation, total hydrostatic pressures were certainly below 400 bars and probably below 200 bars. These pressures require erosional removal of the entire Jacobsville Sandstone and a substantial part of the Freda Sandstone before the vein mineralization came to a close in late Precambrian time. (Authors' abstract)

NIVIN, V.A., 1985, Composition and distribution of gas phase in the rocks of the Lovozero mineral deposit: Geologiia Rudnykh Mestorozhdenii, v. 27, no. 3, p. 79-83 (in Russian).

Includes 8 analyses for H_2, CH_4, C_2H_6, He and cm^3/kg. H_2 and CH_4 comprise ~90% of total gas. (E.R.)

NORDSTROM, D.K., 1985, Evidence for fluid inclusion leakage and water-rock interactions in the deep groundwaters of the Stripa granite, Sweden (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A44. Author at U.S. Geol. Survey, MS-421, 345 Middlefield Road, Menlo Park, CA 94025, USA.

The internationally sponsored research program for radioactive waste management, known as the Stripa Project, has accumulated 7 years of hydrogeochemical data to depths of 1200 meters in a Proterozoic granite in central Sweden. The Cl concentrations increase irregularly with depth up to 700 mg/L and correlate strongly with Na and Ca. Anomalously high Ca/Mg, Br/Cl and I/Cl ratios suggest an unusual origin of the groundwater salinity not related to low-temperature processes. Stripa granite leachates give Br/Cl and I/Cl ratios nearly identical to the groundwater, indicating the leakage of fluid inclusions. Measurements of size, number per cm^3 and salinity of fluid inclusions demonstrate that there is more than sufficient fluid-inclusion salt to produce the observed salinity. For a porosity of 1%, only a few percent of the fluid inclusions need to mix with the groundwater to achieve 700 mg/L Cl. Micropore salinities were measured and found to be intermediate between the fluid-inclusion salinity and the groundwater salinity, demonstrating that fluid inclusions in the rock matrix can mix with the groundwater in the microcavities. Carbonate alkalinity, pH and F, K, Mg and Ba do not correlate with Cl; these constituents probably participate in precipitation/dissolution of minerals such as calcite, fluorite and barite as shown by WATEQ calculations. These results indicate that groundwaters in crystalline rock can acquire salt components from the crystalline bedrock itself and that the groundwater can be of different origin and age than the dissolved salts. (Author's abstract)

NORDSTROM, D.K. and 6 others, 1985, Hydrogeological and hydrogeochemical investigations in boreholes - Final report of the phase I geochemical investigations of the Stripa groundwaters: Stripa Project Rept. 85-06, Stockholm, Sweden, Swedish Nuclear Fuel & Waste Management Co., 253 pp. First author at U.S. Geol. Survey, USA.

A very thorough study of the nature and origin of these waters in granite, including a section on the possible derivation of the solutes from opening of fluid inclusions. Many samples of rock were crushed and leached 6 times, with analyses of leachates for Cl, Br, I, F, and SO_4. Studies of the waters and fracture-lining calcite, etc., involved C, O, S and H isotopes, radioelements, atmospheric and radiogenic gases, etc. (E.R.)

NORMAN, D.I., 1985, Applications of fluid inclusion gas analytical data to the study of hydrothermal ore deposits (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 102-103. Author at Min.-Geo. Museum, Sars Gate 1, Oslo 5, Norway.

A quadrupole mass spectrometer attached to a glass, high-vacuum extraction line is used to analyze gases in water, minerals, glasses, and fluid inclusions. Twenty-one gases are measured by splitting the volatiles into 3 or 4 fractions, measuring gas by pressure measurement and gas ratios by mass spectrometer, and determining water by either weighing or pressure measurement. Gas-water ratios are determined with an accuracy of 5% or less, however accuracy of fluid inclusion gas measurements is lower because of the extraction process. The preferred method of volatile extraction is thermal decrepitation, however this results in some decrepitation of organic compounds.

Based on several hundred analyses, compositions of inclusion gases from hydrothermal ore deposits are divided into 3 groups: CO_2, CO_2-S, and CO_2-N_2-C_nH_n. Inclusion fluids from Mn-Fe-W oxide deposits have CO_2 as the principal gas. Deposits of fluids from magmas such as the porphyry-type have mainly CO_2 and sulfur species gases in fluid inclusions. CO_2, N_2, and organic compounds up to C_6, in roughly equal amounts, have been measured in ten epithermal Au-Ag deposits, a Mississippi Valley-type deposit, and the Bunker Hill deposit, ID, as well as evaporite minerals from the western US Permian basin.

Hydrogen sulfide typically occurs in concentrations of 10^{-2} to 10^{-4} mole % in fluid inclusions from hydrothermal sulfide deposits, but concentrations >1% have been detected in one Au deposit and in the Questa, NM Mo-porphyry deposit.

Calculations of $f(O_2)$, $f(S_2)$, and $f(CO_2)$ based on analysis of H_2, H_2S, and CO_2 are in agreement with the mineralogy of all deposits studied. This has proven a most useful method in understanding changes in mineralogy with time in several ore deposits. The pH of ore solutions is calculated when Ca concentrations are known or can be estimated and in general are 1 to 2 pH units less than neutral and agree with pH calculated from alteration mineral assemblages.

Calculation of the fugacity of all volatiles indicates the minimum pressure of fluid trapping. When fluids are boiling, a gas-pressure correction is calculated and added to the pressure estimated for a boiling, gas-free brine.

Organic compounds similar to those reported in oil field brines occur in the CO_2-N_2-C_nH_n-type inclusion fluids suggesting the N_2 and organics have a biologic origin. The occurrence of this type fluid in a variety of ore deposit types suggests the interaction of hydrothermal fluids with organic-bearing sediments is important in the genesis of Au- and sulfide-depositing fluids. Boiling of these fluids is primarily N_2 effervescence. In a given deposit, ore-depositing solutions are indicated to have a greater percentage of lighter organic compounds than non-ore-depositing solutions. (Author's abstract)

NORMAN, D.I. and SAWKINS, F.J., 1985, The Tribag breccia pipes: Precambrian Cu-Mo deposits, Batchawana Bay, Ontario: Econ. Geol., v. 80, p. 1593-1621. First author at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

The pipes contain mainly angular fragments of the surrounding metavolcanic and granitic country rocks and exhibit sharp contacts. Hydrothermal alteration within the pipes is restricted to the vicinity of fractures and orebodies but becomes more pervasive downward. Mineralization of the pipes can be divided into four periods, each marked by somewhat distinctive mineral assemblages and ore fluid characteristics. Period 1 resulted in formation of disseminated chalcopyrite-molybdenite sulfides associated with magnetite, pyrite, epidote, and quartz. Fluid temperatures were up to 469°C and salinities ranged up to 48.5 equiv. wt % NaCl. Period 2 resulted in deposition of coarsely crystalline quartz and carbonates in the breccia matrices accompanied by lesser amounts of zeolites, pyrite, and chalcopyrite. Fluid temperatures were ~420° to 330°C and salinities ranged from 12 to 1.5 equiv. wt % NaCl. Period 3 and 4 mineralization resulted in deposition of orebodies in fracture-controlled sites. Principal sulfides in period 3 ores are chalcopyrite and pyrite; these sulfides are massive in character and were deposited from fluids ranging from ~412° to 291°C and 14 to 5 equiv. wt % NaCl salinity. Period 4 ores have a mineralogy similar to that of period 3 but, in addition, contain sphalerite and galena, are of a disseminated nature, and were deposited from fluids of ~363° to ~250°C and of 17 to 6 equiv. wt % NaCl salinity. Estimates of pressure during the entire mineralization episode range from about 248 to 550 bars, with pressure up to 1 kb at times during period 1. These estimates suggest a regime that mostly fluctuated between hydrostatic and lithostatic conditions at a depth close to 2,500 m, but during period 1, pressures attained nearly twice lithostatic pressure.

Analyses of the fluids in inclusions indicate mineralizing waters of two types: period 1, 3, and 4 waters were Ca-Na brines, some of which contained copper in concentrations of thousands of ppm; period 2 fluids were Na-Ca brines containing about 90 ppm Cu. Analysis of fluid inclusion gases detected CO_2, H_2, H_2S, He, and Ar. From these data and thermodynamic considerations it can be demonstrated that H_2S concentrations decreased through the paragenesis, the fO_2 varied from below to above H_2S-HSO_4^- equilibria in period 1, 2, and 3 solutions which boiled, and the pH remained between 4.2 to 5.1. Limited stable isotope measurements suggest fluids of primarily magmatic origin. (From the authors' abstract)

NORMAN, D.I., TING, Wupoa, PUTNAM, B.R., III and SMITH, R.W., 1985, Mineralization of the Hansonburg Mississippi-Valley type deposit, New Mexico. Insight from composition of gases in fluid inclusions: The Can. Mineralogist, v. 23, p. 353-368. First author at New Mexico Inst. Mining & Tech., Socorro, NM 87801, USA.

Inclusion volatiles were determined in splits of samples from the Hansonburg Mississippi-Valley type of deposit (New Mexico) previously studied by microthermometry and fluid-inclusion microchemical analysis. The principal volatile is H_2O; the principal gases are CO_2, C_nH_n and N_2, which account for about 1 mole% of inclusion volatiles, except for one sample, in which 24 mole% gases were measured. H_2S was only detected in samples from early in the paragenetic sequence, when major sulfide deposition occurred. Organic compounds are C_1-C_6 species similar to those reported in oil-field brines. Calculated gas-fugacities indicate that mineralization occurred at a pressure of about 150 to 200 bars and suggest a possible but limited unmixing of solutions; the vapor phase that developed was principally N_2. Calculated pH values range from 4.3 to 5.1 and indicate little change in pH during mineralization. Calculated values $f(O_2)$ and $f(S_2)$ indicate that the ore solutions became less reducing during mineralization. Solutions were supersaturated with galena if lead was transported as a chloride complex. The data are not incompatible with a single ore-solution that transported both Pb and reduced sulfur. Ore fluids are postulated to have originated in a Rio Grande rift basin, migrated to the basin margin, and then into undisturbed carbonate along fractures. Mineral deposition occurred principally in response to the cooling of solutions. (Authors' abstract)

NORTH, R.M. and McLEMORE, V.T., 1985, Geology and mineralization of the El Cuervo Butte barite-fluorite-galena deposit in southern Santa Fe County, New Mexico: New Mexico Geol. Soc. Guidebook, 36th Field Conf., Santa Rosa, p. 301-305. Authors at New Mexico Bureau of Mines & Min. Resources, Socorro, NM 87801.

Fluorite showed Th 95-186°C (most 110-139°C), and salinity of 6.4-15.4 wt.% (most 12.3-14.3). The deposit shows similarities to the Hansonburg district, New Mexico. (E.R.)

NORTON, D.R. and FRIEDMAN, Irving, 1985, Chloride flux out of Yellowstone National Park: J. Volcanol. & Geotherm. Res., v. 26, p. 231-250.

NOSIK, L.P. and NOSIK, V.L., 1985, Hydrocarbons and diffusion of carbon and hydrogen in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 180-182 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. Ore Deposits Petrogr., Mineral. & Geochem. Acad. Sci. USSR (IGEM AN SSSR), Moscow, USSR.

The coefficients of diffusion* of carbon (and hydrogen) in iron, with rise in T trends asymptotically towards a limiting value, and their ratio, towards unity (Table 1), and other minerals have similar patterns.

At low Ts, as a consequence of the larger average depth of penetration of hydrogen than carbon (Table 2), a marked change may occur in the redox properties of the mineral-forming medium, whereas at high T, transport of fluids in atomic form through the rocks may be achieved, without changes in their composition.

An increase in equilibrium concentration of vacancies in minerals with rise in T (Table 3) will lead to an increase in solubility of C, H, and other elements, and during its subsequent fall, to a decrease in their solubility and the release of C_2, C_nH_m, H_2Fe_3C, and other compounds.

The minerals, ores, and rocks contain carbon in the vacuoles, pores, and structural defects, in the form of CO_2, CO_3^{2-}, and C which is released in the form of CO_2 as the samples are heated. During the formation of different kinds of C, the resulting isotope effect between them may change from kinetic (Table 3[sic; 4?]) to thermodynamic (Table 5) values.

Heating of samples (<0.1 mm fractions) from 0 to 1100°C causes the appearance of HCs at T = 500-960°C, which may either be formed by the catalytic properties of the crystal surfaces during the influx of atoms of C and H as a result of their diffusion, or their release from structural defects of submicroscopic area. The results in Tables 1 and 2 do not contradict the formation of HCs; according to these tables, C and H in a sample heated to 900°C for 1 hour, are in a state to pass onto a crystal surface from a depth of 0.1 mm.

The decrease in the amount of HCs in the 960°C field has been controlled both by an increase in the number of defects in the structure (Table 3), as a result of which the solubility of the gases in the crystal is increased, and also by renewed dissociation of the HCs that had formed.

The large isotope effects between CO_2 and C_{at}, CO_3^{2-} and C_{at}, and the small negative isotope effects between CH_4 and C_{at} in the minerals, ores,

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*[Equation given not clear in original; Ed.]

and rocks, also points to the formation of CH_4 during the process of diffusion of C and H atoms in them.

TABLES

1. Diffusion constants for C and H at various Ts.
2. Diffusion distance for C and H at 500 and 900°C for 1 min. to 1 year.
3. Concentration of vacancies at various Ts.
4. Values of α for various reactions at various Ts (kinetic).
4. Values of α for various reactions at various Ts (thermodynamic).

(From the authors' abstract)

NUTI, Sergio, 1985, Significance of the isotopic compositions in the fluid of Pozzuoli Solfatara (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

NYGAARD, D.D., SCHLEICHER, R.G. and LEIGHTY, D.A., 1985, Determination of halides by ICP emission spectrometry: Am. Laboratory, v. 17, no. 6, p. 59-62.

Gives procedures for determination of F, Cl, and Br. (E.R.)

OAKES, C.S., 1985, Strong salinity gradients in the northeastern part of the Salton Sea geothermal field, CA: A fluid inclusion & brine chemistry study (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 679. Author at Dept. Earth Sci. & Inst. Geophys. & Plan. Physics, Univ. California, Riverside, CA 92521.

Geothermal wells in the northeastern Salton Sea geothermal field produce concentrated Na-Ca-K-Cl brines. Maximum dissolved constituents do not exceed 260,000 ppm (corrected for steam loss).

Fluid inclusion homogenization temperatures from cuttings of vein calcite and quartz are in close agreement with temperature logs and indicate maximum reservoir temperatures between 290° and 310°C at 3140 to 3565 m. Melting temperatures of inclusion fluids indicate the trapping of both low salinity (10,000-100,000 ppm NaCl equivalent) and high salinity vein-forming solutions. The high salinity inclusion fluids appear similar to the produced reservoir fluids in their total dissolved solids, while both high salinity and low salinity inclusions imply temperatures similar to that of the reservoir. The low salinity inclusions occur over broad intervals above and below the much less vertically extensive high salinity inclusion fluids.

Although the presence of interstratified high salinity and low salinity brines should be gravitationally unstable, flow tests of one well, at varying well head pressures, produced two brines of distinctly different compositions. Consequently, the persistence of two different brines requires severe impedance of vertical permeability.

Stratification of brines in this geothermal system carries significant implications for the formation models of some epithermal ore deposits by mixing of fluids of different salinity, pH, fO_2, fS_2, temperature, etc. Additionally, there are very strong economic advantages to the possible production of hot, dilute brines rather than the currently produced highly saline brines. (Author's abstract)

OESCHGER, H., STAUFFER, B., FINKEL, R. and LANGWAY, C.C., Jr., 1985, Variations of the CO_2 concentration of occluded air and of anions and dust in polar ice cores, in E.T. Sundquist and W.S. Broecker, eds., The carbon cycle and atmospheric CO_2: Natural variations Archean to present: Am. Geophys. Union Geophysical Monograph 32, p. 132-142. First author at Phys. Inst., Univ. Bern, Switzerland.

Analysis of impurities entrapped in natural ice is the most promising method for reconstructing the history of atmospheric composition before the period of direct measurement and offers the possibility of extending the record to at least 100,000 years B.P. We report here the present state of work in this field, with special emphasis on atmospheric CO_2 concentration. After discussing the mechanism by which atmospheric gases are entrapped in ice, we report CO_2 concentrations in ice core samples, up to 100,000 years old, from deep drilling projects in Greenland and the Antarctic. Results from ice deposited during the last 2000 years allow us to estimate the preindustrial atmospheric CO_2 level, an important boundary condition for modelling the anthropogenic CO_2 increase. Using older samples from a deep ice core drilled at Dye 3, Greenland, we show that the CO_2 concentration was 180 to 200 ppmv at the end of the Wisconsin and increased during the transition to the Holocene to values in the 260 to 300 ppmv range. Detailed CO_2 measurements on sections of the Wisconsin part of the Dye 3 core which, based on $\delta^{18}O$, were deposited during times of significant climatic variation, show that the $\delta^{18}O$ variations were accompanied by simultaneous correlated rapid CO_2 variations. Other parameters, including micro-particle concentration and Cl^-, NO_3^- and SO_4^{2-} concentrations also showed significant variations which correlate with the measured $\delta^{18}O$ shifts. (Authors' abstract)

OGLOBLINA, A.I., RUDENKO, A.P., KULAKOVA, I.I., FLOROVSKAYA, V.N., RAMENSKAYA, M.Ye. and BOTKUNOV, A.I., 1983, Composition of polycyclic aromatics in kimberlite: Dokl. Akad. Nauk SSSR, v. 272, no. 4, p. 964-967 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 272, p. 199-202, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 192-193, 1983. (E.R.)

O'HEARN, T.C. and MOORE, C.H., 1985, Fluid inclusion study of diagenetic mineral phases, Upper Jurassic Smackover Formation, southwest Arkansas and northeast Texas (abst.): AAPG Bull., v. 69, no. 2, p. 294. First author at Texaco U.S.A., New Orleans, LA.

Th and final melting temperature data from primary and secondary two-phase fluid inclusions within carbonate and sulfate mineral phases reflect the physical reequilibration of pre-burial calcites and the precipitation of late diagenetic mineral phases during the burial of the upper Smackover (Upper Jurassic, Oxfordian) lime-grainstones in southwestern Arkansas and northeastern Texas. Th range from 83.0°C to 153.8°C (uncorrected for excess ambient formation pressures at time of trapping). Final melting points [ice?] range from -33.4°C to -13.5°C.

Statistically distinct temperature populations reveal the reequilibration of pre-burial bladed calcite cements and parallel the subsequent paragenesis during burial of nonfabric-selective dolomite, zoned equant mosaic calcite, anhydrite, celestite, unzoned poikilitic calcite cement, and baroque dolomite cement under conditions of increasing temperatures and salinity.

Reequilibration/precipitation began after a minimum depth of burial in the range of 0.95 to 1.75 km. Reequilibration/precipitation resulted, in part, in response to the original connate meteoric to marine pore water system being mixed with, and subsequently replaced by, basinal brines that migrated into the upper Smackover grainstones from the Louann Salt.

Melting temperature data indicate that fluids trapped within the two-phase fluid inclusions are highly saline, varying from 17 to 27 wt. % NaCl. Melting temperature data also indicate that the fluids are $CaCl_2$-rich brines with NaCl and probably $MgCl_2$ and $FeCl_2$ as additional chloride components. (Authors' abstract)

OHMOTO, Hiroshi, 1985, Thermodynamic and kinetic evaluation of the causes of metal-ratio regularities in low temperature hydrothermal deposits (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 680. Author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Ratios of Fe, Cu, Zn, Pb, Au, Ag and other metals in hydrothermal deposits depend largely on three parameters: (1) the concentrations of these metals in the hydrothermal fluids; (2) the concentrations of H_2 and H_2S in the fluids; and (3) the kinetics of reactions among H_2, O_2, H_2O, H_2S, SO_4^{2-}, CO_2, CH_4, and metal species during depositional processes. Parameters 1, 2 and 3 are mutually dependent, and 1 and 2 are controlled largely by the dominant rock type and thermal history of hydrothermal systems. Parameter 3 can be inferred from chemical and isotopic data of various natural systems (e.g., geothermal fluids) and of laboratory experimental systems.

Hydrothermal fluids which evolved in rocks with abundant pyrite and organic matter (i.e., shales) will attain $>10^{-10}$ m of H_2 and $\geq 10^{-5}$ m each of H_2S and Σmetals at $T > 100°C$, with the concentration relation: $H_2S \geq \Sigma Zn \geq \Sigma Pb \geq \Sigma Fe > \Sigma Cu$. The calculated values are in good agreement with values observed in many geothermal fluids, oil-field brines and fluid inclusions. Mixing of such fluids with seawater or meteoric water at depositional sites and where only partial reactions take place between the oxidized and reduced fluid species will produce the ores characteristic of the Mississippi Valley-type and shale-hosted massive sulfide deposits (e.g., major sphalerite and galena, minor pyrite, and rare chalcopyrite and gold).

Hydrothermal fluids developed in hematite-bearing rocks, in contrast, will contain less than 10^{-6} m of H_2 and 10^{-5} m of H_2S if $T \leq 200°C$, but may transport more than 10^{-5} m each of ΣCu, ΣZn and ΣPb. Reactions of such fluids with diagenetic pyrite and/or organic matter at the depositional sites produce the ores characteristic of the red-bed associated Cu-U-Co deposits (i.e., poor in Zn and Cu dominantly as chalcocite). (Author's abstract)

OHNENSTETTER, M., DUBOIS, M. and CHAROY, B., 1985, Hydrothermal activity in ophiolites: A case study from late-stage plutonic differentiates of Cyprus and Oman (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 169.

In the Oman and Cyprus ophiolites, information on heat transfer at the boundary layer between the magma chamber and the circulating hydrothermal water were deduced from studies of magmatic and metamorphic assemblages and from the nature of inclusions. Crystallization of gabbro, diorite and granophyre in successive telescoped magmatic intrusions show the transition from conditions of equilibrium crystallization in gabbro to nearly pure fractional crystallization in diorite and granophyre.

Four types of fluid inclusion in quartz are defined in particular from the Cyprus samples: 1) one-phase liquid inclusions: type L; 2) two-phase liquid + vapor inclusions with two subtypes: type 2 L with volume liquid/volume total >0.8; type 2 V with volume liquid/volume total <0.8; 3) three-phase liquid + vapor + an isotropic solid phase assumed to be halite: L + V + S; 4) multiphase inclusions: L + V + S with numerous isotropic or anisotropic solids: carbonates, hematite, ilmenite, magnetite, epidote, muscovite, plagioclase, potassic feldspar, quartz, amphibole, pyrite, NaCl, $FeCl_2$ and episodically KCl and $(Ca, Fe)Cl_2$. Microthermometric measurements led to the distribution of two types of fluid having distinct characteristics and salinities: 1) A low to intermediate salinity fluid comparable to seawater, with a wide range of Th (170-450°). During adiabatic ascent, a hot supercritical fluid must have intersected the boiling curve. Trapping of fluid near critical conditions followed. 2) A high salinity fluid (30 wt.% eq. NaCl) which projects on both sides of the three-phase (L + V + S) univariant curve on a T-X diagram. The freezing temperatures of the liquid phase indicate that other cations than Na are present. Temperatures of melting (200°-400°) and of homogenization (110°-490°) are in the same range despite the persistence of some solids after homogenization. These facts are in agreement with heterogeneous trapping and thus constitute good evidence for an origin by fluid immiscibility.

In all the studied samples, Th increases from cumulate gabbro to diorite and granophyre and may indicate the role of the late stage intrusions in supplying heat to the hydrothermal system. Rapid and episodic crystallization of large volumes of magma in the final stage of evolution of the main magma chamber may be related to the formation of large sulfide deposits. Comparison of the chronology of the distinct cumulate sequence with that of the associated cogenetic lavas may help to explain the stratigraphic position of the main sulfide deposits. (Authors' abstract)

OLADE, M.A. and MORTON, R.D., 1985, Origin of lead-zinc mineralization in the southern Benue Trough, Nigeria - Fluid inclusion and trace element studies: Mineral. Deposita, v. 20, p. 76-80. First author at Dept. Geol., Univ. Ibadan, Nigeria.

The epigenetic Pb-Zn deposits of the southern Benue Valley (Nigeria) are localized within Cretaceous sediments of an intracontinental rift basin. Fluid inclusion studies of vein minerals from the Abakaliki and Ishiagu orebodies show that sphalerite and quartz were deposited at relatively low temperatures (102-175°C), with ore-fluid salinity mostly in the range of 17-25 equiv. wt% NaCl. Trace-element contents of sphalerite and galena are also consistent with the low temperature of formation and epigenetic origin.

On the basis of the geotectonic setting, the mode of occurrence and fluid-inclusion characteristics, mineralization is attributed to connate brines set into motion by a high geothermal gradient accompanying continental rifting. Mineral deposition was caused principally by rapid cooling due either to reaction with wall rocks or mixing with meteoric or descending water of low salinity. (Authors' abstract)

OLEINIKOV, B.V., PANKOV. V.I., PLAKSENKO, A.N. and OKRUGIN, A.V., 1985, Inclusions in moissanite from platform basic rocks: Dokl. Akad. Nauk SSSR, v. 283, no. 5, p. 1269-1273 (in Russian).

Grains of alpha- SiCII (6H) up to 1 mm from artificial (i.e., man made) concentrates from several mafic rocks contain inclusions of silicon, graphite, silicide, and glassy(?) silicate. The silicon and graphite each occur as rounded inclusions. The silicides, silicates, and a probable carbonaceous substance are associated, all filling fractures in the moissanite grains. Probe data show three silicides, with formulas roughly corresponding to Fe_2Si_5, $FeSi_2$, and $FeTiSi_2$. The silicate compositions are somewhat variable but typically have 80% SiO_2, 10% Al_2O_3, 4% K_2O, and 1% Na_2O. The substance decomposes in the electron beam, suggesting it is a glass. (Abstract courtesy D. Milton)

OLSEN, S.N., 1985, The composition and role of the fluid in migmatization of the Front Range rocks: A fluid inclusion study (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 681. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218.

The abundance and average density of early CO_2 inclusions in the leucosome of 1,700 m.y. Front Range migmatites are greater than in its paleosome or selvage, suggesting that these inclusions are related to the migmatization process. If the CO_2 fluid formed from an H_2O-CO_2 fluid by partitioning of H_2O into a partial melt, there should be some early H_2O inclusions: H_2O must be released as the melt crystallizes. As found in migmatites from other areas, most aqueous inclusions in these rocks are obviously younger than the early CO_2 ones. Early H_2O-rich fluid may still be preserved, at least in three ways: (1) in rare, isolated or clustered inclusions within quartz inclusions in feldspar; (2) as inclusions in microcline porphyroblasts; (3) in hydrous alteration products of feldspar. (1) contain dilute fluids, 1 to 6 wt.% NaCl equiv. A rough correlation between Th and Tm of the aqueous inclusions in general for these rocks and textural evidence also suggest that the early fluid was dilute. The densities of type (1) and the early CO_2 inclusions found in the quartz inclusions in feldspar (but not with type 1 inclusions) are appropriate for the P-T conditions of migmatization. These early inclusions must have been preserved because of "protected" environment. Inclusions (2), found to contain H_2O (and CO_2) by infrared analyses (A. Hofmeister, 1985), must be early because they are absent from recrystallized grains. (2) and (3) are much more common in the leucosome than in the other zones indicating that they are related to migmatization process. The distribution of early CO_2 inclusions suggests that fluid concentration in the leucosome occurred before melting and was a cause, not a result, of melting. A simple extraction of melt from the selvage or diffusion of H_2O from the paleosome to the melt in the leucosome would have enriched the selvage or paleosome in CO_2. (Author's abstract)

O'NEIL, J.R. and TAYLOR, B.E., 1985, Degassing of Obsidian Dome magma: hydrogen and oxygen isotope studies in the Inyo dome chain, Long Valley area, California (abst.): EOS, v. 66, no. 18, p. 387.

O'NIONS, R.K. and OXBURGH, E.R., 1985, Fluids of deep-derivation in the continental lithosphere (abst.): NERC 3rd Deep Geology Workshop Programme and Absts., Univ. Durham, 3-4 Jan., 1985 (unpaginated). Authors at Univ. Cambridge.

Primordial ^3He and other rare gas isotopes may be used to identify fluids derived from sub-lithospheric depths both at the surface in association with hydrocarbon accumulation and groundwaters and trapped in association with other fluids within the lithosphere.

The relationship between continental heat production and heat flow and the presence and recognition of "deep-source" volatiles is discussed with reference to observation of the distribution of ^3He within the crust of Western Europe and elsewhere. (Authors' abstract)

O'REILLY, Suzanne, 1984, The mantle environment, in J.E. Glover and P.G. Harris, eds., Kimberlite occurrence and origin: Publs. Geol. Dept. & Univ. Extension, Univ. West Australia, no. 8, p. 63-102 Author at Macquarie Univ., Sch. Earth Sci., North Ryde, N.S.W., Australia.

A thorough review of ultramafic xenoliths and their petrologic significance, particularly with respect to mantle volatiles. (E.R.)

ORUŽINSKÝ, Viliam and HURAI, Vratislav, 1985, Fluid inclusions in secondary quartzites of Banská Stiavnica stratovolcano: Mineralia slov., v. 17, no. 5, p. 415-424 (in Czechoslovakian; English abstract). First author at Geol. ústav SAV, oddelenie nerastných surovin Vajanského 13, 851 01 Banská Bystrica.

Low-saline solutions (below 2.7 wt. % NaCl eq.) containing NaCl, KCl and rare carbon dioxide have been found to occur within fluid inclusions of the so-called secondary quartzites from Cenozoic Banská Stiavnica volcanic structure. Characterization of fluid inclusions suggest a dynamic liquid- and/or vapor-dominated environment with thermodynamic conditions varying between 166-270°C and 6-55 bars, respectively. Temperatures and pressures estimated as well as composition of fluids contrast with conceptions about either synsedimentary origin or action of low-to-medium thermal solfataras. (Authors' abstract)

OSIF, T.L., 1985, The effects of salt, gas, temperature, and pressure on the compressibility and formation volume factor of water, in Dorfman, M.H. and Morton, R.A., eds., 1985, Geopressured-Geothermal Energy, Proc. 6th U.S. Gulf Coast Conf.: New York, Pergamon Press, p. 115-124. Author at Inst. Gas Tech., 3423 South State Street, Chicago, IL 60616.

Compressibilities and formation volume factors of water-sodium chloride-gas systems were measured as a function of temperature (200° to 270°F), pressure (up to 20,000 psi), and composition (up to 34.5 SCF gas/bbl and up to 200 g sodium chloride/L). Plots of the reciprocal of compressibility vs. pressure are linear for water and brines. The slopes of these plots are all the same but the intercept are linearly dependent on the temperature and salinity. Dissolved gas has no effect on these compressibilities at GWR's of 13 SCF/bbl. Even at GWR's of 34.5 SCF/bbl, dissolved gas probably has no effect, but certainly causes no more than a 5% increase in the compressibility of brine. Dissolved gas does not have an effect on formation volume factors. (Author's abstract)

OSTAPENKO, N.S., LEVITSKIY, Yu.T. and SHAKHRAY, S.A., 1985, Contribution to the evaluation of decrepitation temperatures of minerals by thermovacuum decrepitograms (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 81-83 (in Russian). Authors at Amur Complex Sci.-Research Inst. of Far-East Sci. Center Acad. Sci., Blagoveshchensk, USSR.

The authors, after discussion of possible factors affecting thermovacuum decrepigrams, conclude that correct interval of Td is that indicated by "main ascending branch of decrepigrams;" since "it is an integral (cumulative) record of gas release from huge amount of P and PS inclusions trapped during mineral growth." Average Td is found as the half-height of the whole peak. (A.K.)

O'SULLIVAN, M.J., BODVARSSON, G.S., PRUESS, K. and BLAKELEY, M.R., 1985, Fluid and heat flow in gas-rich geothermal reservoirs: Soc. Petrol. Engrs. J., v. 25, no. 2, p. 215-226. First author at Univ. Auckland, New Zealand.

Numerical simulation techniques are used to study the effects of noncondensable gases (CO_2) on geothermal reservoir behavior in the natural state and during exploitation. It is shown that the presence of CO_2 has a large effect on the thermodynamic conditions of a reservoir in the natural state, especially on temperature distributions and phase compositions. The gas will expand two-phase zones and increase gas saturations to enable flow of CO_2 through the system. During exploitation, the early pressure drop primarily results from "degassing" of the system. This process can cause a very rapid initial pressure drop, on the order of megapascals, depending on the initial partial pressure of CO_2. The flowing gas content from wells can provide information on in-place gas saturations and relative permeability curves that apply at a given geothermal resource. Site-specific studies are made for the gas-rich, two-phase reservoir at the Ohaaki geothermal field in New Zealand. A simple lumped-parameter model and a vertical column model are applied to the field data. The results obtained agree well with the natural thermodynamic state of the Ohaaki field (pressure and temperature profiles) and a partial pressure of 1.5 to 2.5 MPa [217 to 363 psi] is calculated in the primary reservoirs. The models also agree reasonably well with field data obtained during exploitation of the field. The treatment of thermophysical properties of H_2O/CO_2 mixtures for different phase compositions is summarized. (Authors' abstract)

Includes new formulations for the calculation of some of the gas properties. (E.R.)

OZIMA, M., ZASHU, S., MATTEY, D.P. and PILLINGER, C.T., 1985, Helium, argon and carbon isotopic compositions in diamonds and their implications in mantle evolution: Geochem. J., v. 19, p. 127-134. First author at Geophys. Inst., Univ. Tokyo, Tokyo 113, Japan.

Helium and argon isotopic data of diamonds suggest that the mantle where diamonds crystallized has remained almost a closed system for most of the Earth's history. The $^3He/^4He-^3He$ evolution diagram implies that at least two diamonds studied are nearly as old as the Earth. Carbon isotopic compositions of the stones studied varied from -3.3 to -39.7‰, while older diamonds show less deviation from the generally considered average $\delta^{13}C$ for diamonds. (Authors' abstract)

PAGEL, M., GEORGE, E., WALGENWITZ, F. and DUBESSY, J., 1985, Evaluation of constraints imposed by fluid inclusions on the modeling of sedimentary basins (abst.): Bull. Minéral., v. 108, p. 93 (in French, translated by C. Eastoe).

Fluid inclusions contain valuable information for studies of the thermal and chemical regimes of sedimentary basins. Possible constraints are discussed in a theoretical framework, and starting from natural examples, in particular oilfield basins (North Sea, Angola, Gabon). The main problems discussed are: 1. Variation of fluid chemistry and density during diagenesis. 2. Regional variations of chemical and thermal gradients in space and time. 3. Relationships between tectonics and fluid migration. 4. Convection or conduction: demonstration of local hydrothermal activity, or of large-scale migration of hot fluids. Flow directions in a basin. 5. Relative timing of hydrocarbon migration, or dating of the migration if the data are combined with fission-track analysis or radiogenic isotope methods. 6. Duration of the thermal episode, from a combination of fluid inclusions and fission-track techniques. 7. Importance of chemical sediments (halite, gypsum) in recording fluid history. (Authors' abstract)

PAGEL, M. and POTY, B., 1984, The evolution of composition temperature and pressure of sedimentary fluids over time: A fluid inclusion reconstruction, in Thermal Phenomena in Sedimentary Basins, B. Durand, ed.: Int'l. Colloquium, Bordeau, June 7-10, 1983, Collection Colloques et Seminaries 41, Editions Technip, Paris, 1984, p. 71-88.

See abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 253-254, 1984. (E.R.)

PAGEL, M. and SVAB, M., 1985, Petrographic and geochemial variations within the Carswell structure metamorphic core and their implications with respect to uranium mineralization: Geol. Assoc. Canada Special Paper 29, 1985,

p. 55-70. First author at Centre de Recherches sur la Géol. de l'Uranium, B.P. 23, 54501 Vandoeuvre-lés-Nancy Cédex, France.

Two major lithologic units have been recognized in the Carswell structure metamorphic core. The Earl River complex, composed of mixed feldspathic gneisses and mafic gneisses, is overlain by aluminous Peter River gneisses. Granitoids and pegmatoids are ubiquitous in both rock units and are, to a great extent, the result of in-situ anatexis of the metasedimentary gneisses. These gneisses are interpreted to be a normal detrital succession of arkoses and greywackes at the base, forming the Earl River complex, and shales at the top which make up the Peter River gneisses. Metamorphism reached granulite facies in the presence of fluids rich in carbon dioxide, methane, and nitrogen. Compared with other granulite facies terrains, the basement is relatively rich in uranium and thorium. The metamorphic core has undergone at least six alteration phases: retrograde metamorphism, surface weathering, alteration related to diagenesis in the overlying Athabasca Group, alteration related to the episode of the main uranium deposition, alteration associated with the formation of the Carswell structure, and finally alteration associated with a later episode of uranium deposition and remobilization. The main mineralizing phase is associated with the circulation of brines and is accompanied by the formation of aluminous and magnesian chlorite, magnesian chlorite, illite, and alkali poor Mg-tourmalines. (Authors' abstract)

Fluid inclusions were observed and studied from three areas: Rare inclusions were found in quartz, formed prior to uranium oxides; in quartz-uranium oxides-dravite veins and in quartz-uranium oxide veinlets from the OP and Dominique-Peter deposits respectively. They are either two-phase (V + L) or three-phase (V + L + halite(?)) and have Th up to 300°C with salinities from dilute to "super-saturated" brines. Leaching after crushing indicates the K/Na ratio is very low (~0.0085). Quartz from altered aluminous gneiss from the D deposit has abundant two-phase inclusions that contain a hexagonal reddish material (hematite?). They have Tm-ice from -11.7° to -47.4°C and a maximum Th of 172°C. (Abstract by H.E. Belkin)

PAGEL, M., WHEATLEY, K. and EY, F., 1985, The origin of the Carswell circular structure, in The Carswell Structure Uranium Deposit, Saskatchewan, R. Lainé, D. Alonso and M. Svab., eds.: Geol. Assoc. Canada Special Paper 29, p. 213-223. First author at Centre de Recherches sur la Geol. de l'Uranium, B.P. 23-54501 Vandoeuvre les Nancy Cedex, France.

Includes a brief discussion of the results of earlier (1975) studies of the fluid inclusions at Carswell. (E.R.)

PAN, Pujing and SUSAK, N.J., 1985, A spectrophotometric study of cobalt (II) chloride complexes in aqueous solutions: Ligand-field bands and octahedral-tetrahedral coordination equilibria in solutions up to 5m NaCl and 90°C (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A46.

PANINA, L.I., 1985, Physicochemical conditions for the formation of rocks in intrusives of an alkaline ultrabasite formation: Geol. i Geofizika, v. 26, no. 1, p. 39-50 (in Russian, translated in Soviet Geol. & Geophysics, v. 26, no. 1, p. 36-44). Author at Acad. Sci. USSR, Sib. Div., Inst. Geol. & Geophysics, Novosibirsk, USSR.

It has been established by methods of thermobarochemistry that in massifs of an alkaline-ultrabasic formation all the rocks, including those of metasomatic appearance, crystallized from magmatic melt. The melt was initially at high temperature (above 1450°C), and olivine, pyroxene, and melilite crystallized from it. Upon cooling, beginning at 1100°C, the melt was enriched with water and salts and was gradually transformed into lower-melting silicate and saline melt-solutions. Residual products of differentiation of the original melt, saline melt-solutions, can be considered due to carbonatite magma with which crystallization of carbonate minerals of carbonatites is related. It has been established that the like-named continuous minerals, entering the composition of various rocks of the complex, crystallized at similar temperatures, in the same sequence, from a mineralizing medium of similar chemical composition. It is concluded that the entire diversity of rocks of the complex formed from the same original magma during its differentiation as a result of the different combination of rock-forming minerals, which were successively separated from the magma by gravity. (Author's abstract)

PANINA, L.I., PROSHENKIN, I.Ye., USOL'TSEVA, L.M., BULGAKOVA, Ye.N. and MOTORINA, I.V., 1985, Physicochemical conditions of formation of the Khanin apatite deposit (Aldan shield) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 159-160 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. & Geophys. Siber. Div. Acad. Sci. USSR, Novosibirsk, USSR.

The Khanin Massif, from the nature of its rocks, may be regarded as ultramafic. It consists mainly of pyroxenites, enriched in varying degree in apatite, biotite, ore minerals, and K-feldspar. Owing to the wide variation in the amounts of minerals, the composition of the pyroxenites may vary in local sectors as far as shonkinites, pyroxene syenites, and slyudites; monomineralic apatite segregations have sometimes been noted. The pyroxenites of the Khanin Massif, as compared with typical ultramafic rocks, have an anomalously high content of alkalis, Sr, Ba, Ti, Fe, S, and P, and decreased amounts of Cr.

Melt inclusions have been found in py, ap, and K-feldspar. They occur ubiquitously in the py, in individual grains in the ap, and occasionally in the K-feldspar.

In the py, the P inclusions are usually crystallized, and sometimes platelets of a dark mica, ore material, and a gas phase, are distinguishable in them. They are very rarely glassy. During heating, they often explode or homogenize into a melt at 1245-1310°C. The composition of the glass inclusions (wt %, by microprobe): SiO_2, 42.82; TiO_2, 1.11; Al_2O_3, 9.37; FeO, 18.07; MnO, 0.28; MgO, 9.67; CaO, 12.20; Na_2O, 2.03; K_2O, 1.30; F, 0.34. It is significantly different from the composition of the rock examined (a biotite pyroxenite) and is closest to the average composition of the shonkinites, but lower in Si, Ca, and K and higher in Fe and Mg.

Two kinds of P glassy inclusions hve been found in the apatite: brown rounded forms and prismatic light-colored forms. Their Th into a melt occurs at 1250-1290°C. The component of brown inclusions has been analyzed on a microprobe prior to heating and after homogenization (Table).

The larger amounts of CaO and P_2O_5 in the homogenized inclusions may be explained by melting of apatite, deposited on the vacuole walls.

The inclusions in K-feldspar are partially crystallized, and their Th into melt occurs at 1200-1260°C.

The formation of the rocks and the apatite mineralization in the Khanin Massif took place from a magmatic melt. Separation of apatite was achieved during one of the early phases of crystallization. During crystallization, the composition of the melt approximated to that of the alkaline gabbroids. (Authors' abstract) Continued next page.

Table

	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	F
Unheated inclusions	33.26	0,78	14.25	10.50	0.31	0.84	12.71	0.09	0.05	1.68	--
Content after homogenization	31.07	0,67	14.29	12.53	0.26	0.76	21.32	0.18	0.08	6.33	0.28

PANOV, B.S., BAGATAYEV, R.M., MEDVEDEV, V.E. and SOSKIN, L.Ya., 1985, Thermobarogeochemical peculiarities of quartz from the deep-seated horizons of the Nikitovka ore field (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 85-86 (in Russian; translation by D.A. Brown). Authors at Donetsk Polytech. Inst., Donetsk, USSR.

We have examined the conditions of formation of crystals and vein segregations of quartz from the deep horizons (330-450 m) of the No. 2-bis shaft in the Nikitovka ore field. Here, infilling veins are exposed with a thickness of from 1-2 to 50-60 cm, plus swells of ≥1 m, transverse and diagonal to the strike of the surrounding sandstone strata. The veins are quartz, and less frequently carbonate-quartz with antimonite, cinnabar, and frequently a trace of dickite. In the vein swellings, there are slit-like cavities, filled with intergrown crystals of quartz, antimonite, and cinnabar. The short columnar quartz crystals are usually <6 mm, and larger crystals (up to 45 x 25 mm) are rare.

The quartz crystals have abundant P and S fluid inclusions. The P inclusions frequently outline growth zones. The inclusions in these zones have an irregular, branched shape, and are often isolated. Sometimes they have enclosed small flaky accumulations of a clay mineral with relatively high birefringence. Bundles of subparallel tubular P inclusions occur perpendicular to the rhombohedron and extending out from the center of the crystal. These have usually leaked along cracks or have been refilled with later solutions. Unaffected P inclusions in the inner, earliest parts of the quartz crystals on the 330-m horizon (Vein II-bis) are 148-152°C, whereas on the 390-m horizon (Vein 13), they reach values of 151-162°C, giving an indication of a vertical temperature zonation within the ore field. In the late zones of quartz growth in Vein 13, Th = 138-150°C. Abundant late secondary inclusions have Th ≤105°C.

Hydrous extracts show Na and Ca > K and Mg. Maximum values (mmole/kg) are 0.51, 0.17, 0.05, and 0.03, respectively. A trace of lithium (0.003-0.004 mmol/kg) is always found. HCO_3 (0.53 mmole/kg) is 3-5 times greater than the total of Cl, F and SO_4. The extracts are weakly alkaline (pH = 7.90-8.25).

Cryometry shows the predominance of alkali chlorides[sic] and bicarbonates. From Tm ice, the solutions have 4.0-6.4 wt% NaCl equiv.

Mass-spectrometry (done at IGGGI AN Ukr. SSR) of quartz: ≤91.30 vol% CO_2, ≤6.20% N_2, ≤5.30% CH_4, and ≤1.82% C_2H_6. The large amount of CO_2 is supported by cryometric studies. In spite of the absence of liquid CO_2 even during intense cooling, crystals of gaseous hydrates do form regularly, up to 5 vol%.

The salt and gas composition of the inclusions indicate a significant similarity between the antimony-mercury mineralization of Nikitovka and other antimony-mercury deposits. (From the authors' abstract)

PANOV, B.S., KUPENKO, V.I. and RYADNIN, V.A., 1985, The temperature and isotopic-geochemical peculiarities of the ore mineralization of the southwestern part of the Donets Basin (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 87-88 (in Russian; translation by D.A. Brown). Authors at Donetsk Polytech. Inst., Donetsk, USSR.

We have carried out an interdisciplinary study of the isotope-geochemical and thermobaric conditions of formation of recently discovered hydrothermal mineralization in the southwestern part of the Donets Basin. The Chelyuskintsev and Krasnaya Zezda shaft fields in the SW Donetsk show low-temperature polymetallic and mercury mineralization. Paragenesis includes sphalerite, pyrite, galena, millerite, and cinnabar plus calcite, ankerite, barites, dickite, and quartz.

P gas-liquid inclusions, ≤0.03 mm, located in the zones of carbonate-crystal growth, are characterized by an irregular, and less commonly rhombohedral shape with stepped surfaces. Th = 80-53°C for calcite of the mercury paragenesis, whereas calcite and ankerite of the polymetallic ore-shows vary widely, along with variations in $\delta^{13}C$ and $\delta^{18}O$. For carbon, most of the analyses (10) range from -5.9 to +4.3‰ (PDB), four analyses range from +9.0 to +15.1‰, and for other analyses the spread increased to -13.7 to +25.4‰. The carbonates are concentrated markedly around $\delta^{18}O$ = +22.0‰ (SMOW), plus some ligher ones, down to +4.5‰ (one analysis). Starting with the temperatures of mineral-formation, the oxygen-isotope composition of the calcite, and the isotope equilibrium constant in the water-calcite system, we calculated the isotope composition. The calculated mineral-forming solutions, using O'Neil & Clayton's formula and [inclusion] temperatures, range from 0 to -5‰ (SMOW), but in individual cases they reach -10 and -17‰.

A comparison between these data and those in the literature on the oxygen isotope composition of various waters (Taylor, 1977, etc.) suggests participation of both connate seawater ($\delta^{18}O$ = 0‰) and meteoric water ($\delta^{18}O$ = -8.6 to -10.9‰) in the formation of the calcite. In addition, some heavier water, having a deep-seated origin, was involved in mineral formation.

A comparison between the calculated composition of the hydrothermal solutions and [the low values of] $\delta^{13}C$ of the corresponding calcite shows that it formed from a "lighter water." The $\delta^{18}O$ of the carbonates, formed from solutions similar to oceanic water, with some deep-seated component; [they] are characterized, as a rule, by positive $\delta^{13}C$ values[sic]. In this case, calcite enriched in ^{13}C shows increased amounts of mercury, which was, in all probability, associated with solutions least augmented by meteoric waters.

The sulfur-isotope composition of the pyrites, associated with cinnabar and calcite, and also sphalerite, varies widely (from -9.88 to 26.25‰). Fractionation of the sulfur isotopes has been controlled by those same physicochemical parameters, in particular pH and fO_2, as in the case of the carbon isotopes. In this respect, the large range of changes in the $\delta^{34}S$ values, as in the case of $\delta^{13}C$, may be explained by mixing of formation and surface waters.

The data obtained point to marked differences in the processes of ore-formation of the well-known mercury and polymetallic deposits in the Donbass at Nikitovka and Nagol'nyy Kryazh, from those of the mineralization of the southwestern part of this region. (From the authors' abstract)

PANSZE, A.J., 1985, Applied geochemistry of epithermal silver systems (abst.): Geol. Ass. Canada, Cord. Sec., Symp. Silver '85, Vanc., B.C., p. 10-11. Author at Cruson & Pansze, Geologists, Golden, CO.

Physical-chemical processes that form silver deposits also produce geologic field criteria that are important guides to ore. Nature of the ore fluid, metal-transport chemistry, and depositional processes control localization, mineralogy, and zoning of silver, associated minerals, and alteration.

Silver-bearing hydrothermal solutions are of near-neutral pH, low salinity, and low to moderate temperatures (100-350°C). Most silver is transported as sulfide and chloride complexes. Processes which deposit silver are changes in pressure, temperature, pH, and oxidation state. Boiling of the ore fluid deposits silver in some, but not all, systems.

Selected ore, gangue, and alteration minerals provide clues to possible ore mineralization when interpreted in the context of geochemical proceses. Surface anomalies of Bi, Pb, Sb, and other less mobile metals can indicate a leached silver system. Some As-Sb-Hg minerals are clues to subsurface unoxidized silver. Amethyst, hematite, jasperoid, and adularia gangues are manifestations of potential ore precipitating processes. Zeolites, epidote, potassium enrichment, alunite/kaolinite, and sericite alteration are environment-specific products of hydrothermal action which often deposits silver. Subtle characteristics of silicification can be evidence of ore-forming events and position within an epithermal system. Slight variations in geochemical parameters, such as pH or CO_2 content, can affect important changes in geologic characteristics of a system. Understanding and applying practical geochemical principles provides field geologists with additional evidence of potential silver mineralization. (Author's abstract)

PARILOV, Yu.S and MIKHALEVA, V.A., 1985, Temperature, composition, and properties of fluids that formed ores in Dzhezkazgan [USSR]: Vestn. Akad. Nauk Kaz. SSR 1985, no. 10, p. 59-66 (in Russian).

Ore formation of Dzhezkazgan involved hydrothermal-metasomatic high-temperature, sedimentary, exhalation-sedimentary, infiltration-hydrothermal, vadose-hydrothermal, and hydrogenic-epigenetic processes. A study of the gas-liquid inclusions in quartz and other minerals indicated that most of the sulfide ores of the Dzhezkazgan deposit formed at high temperatures (600-400°, based on vacuum decrepitation); this suggests epigenetic ore genesis. The formation temperature (T) of sulfide veins was higher than the T of ore mineralization in sandstones. Ores of stage 1 and 2 in sandstones and high-temperature sulfide veins were derived from metal-rich fluids with a high content of CO_2. (C.A. 104: 53782d)

PARK, H.-I., 1983, Ore and fluid inclusions of the Tongyeong gold-silver deposits: J. of the Korean Inst. of Mining Geol., v. 16, no. 4, p. 245-251 (in Korean; English abstract).

The Tongyeong gold-silver deposit is located in Chungmu City, at the southern end of Korean peninsula. The ore deposit is an epithermal gold-silver vein emplaced in late Cretaceous andesite, andesitic pyroclastics and quartz porphyry. The ore is composed of pyrite, chalcopyrite, sphalerite, galena, electrum, argentian tetrahedrite, Cu-Ag-sulfides, quartz and rhodochrosite. Th of fluid inclusions in quartz ranges from 134 to 223°C and salinity ranges from 1.2 to 3.8 weight % equivalent to NaCl. (Author's abstract)

PARK, H.-I., CHOI, S.W., CHANG, H.W. and LEE, M.S., 1983, Genesis of the copper deposits in Goseong district, Gyeongnam area: J. of the Korean Inst. of Mining Geol., v. 16, no. 3, p. 135-147 (in Korean; English abstract).

The copper deposits in Goseong district, Gyeongnam area are fissure filled copper veins emplaced in the Cretaceous Goseong formation and andesitic rocks. Occurrence of ore veins and mineral paragenesis suggest a division of the hydrothermal mineralization into three stages: I, arsenopyrite, pyrite, quartz, chlorite and epidote; II, pyrite, chalcopyrite, galena, sphalerite, electrum, pyargyrite, tetrahedrite, silver sulfosalt minerals, quartz, chlorite, sericite and minor calcite; III, barren calcite veins.

Filling temperature of fluid inclusions in quartz of stage II, range from 260 to 360°C and salinities from 6.2 to 13.6 weight percent NaCl equivalent. (Authors' abstract)

PARK, H.-I., CHOI, S.-W., CHANG, H.W. and CHAE, D.-H., 1985, Copper mineralization at Haman-Gunbuk mining district, Kyeongnam area: J. Korean Inst. Mining Geol., v. 18, no. 2, p. 107-124 (in Korean; English abstract).

More than fifty copper veins are emplaced around late Cretaceous granitoid stocks in Haman-Gunbuk district, southernmost part of Korea. These veins cut both late Cretaceous granitoids and hornfels of Jindong formation which is intruded by the granitoids. The paragenesis of veins is nearly the same, consisting of (1) an early vein stage in which most iron oxide minerals, tourmaline and other silicate minerals were deposited, (2) calcite and quartz with base-metal sulfides and (3) late veinlets of barren calcite.

Fluid inclusion studies reveal highly systematic trends of salinity and temperature during mineralization. Ore fluids of early vein stage were complex NaCl-KCl-rich brines. Salinities of polyphase inclusions in quartz and scapolite in this stage reached 72 wt.% and gradually decreased to 10.5 wt.% in closing stage. Th of inclusions in the beginning of this stage were up to 490°C and then declined steadily to 290°C in the late stage. Salinities of fluid inclusions in quartz and calcite of base-metal sulfide stage were 37.4 ~ 5.7 wt.% and Th range from 373°C to 170°C. Intermittent boiling of early vein fluid is indicated by fluid inclusions in quartz. Potassic alteration of granodiorite adjacent to early vein seems to be related to early saline vein fluid.

Fluid inclusion data of base-metal sulfide stage of this area reveal nearly the same range as those of Koseong copper mining district about 30 km apart from this area. (Authors' abstract)

PARK, H.-I., CHOI, S.-W. and KIM, D.-L., 1985, Fluid inclusions of Daehwa and Donsan tungsten-molybdenum deposits: J. Korean Inst. Mining Geol., v. 18, no. 3, p. 225-237 (in Korean; English abstract).

Mineralization of Daehwa and Donsan W-Mo deposits can be divided into three distinct depositional stages on the basis of mineral paragenesis and fluid inclusion studies: I. oxides and silicates; II. base-metal sulfides and sulfosalts with carbonates; stage III, barren calcite and fluorite. Tungsten, molybdenum and tin mineralization occurred in stage I.

Fluid inclusion studies reveal that ore fluids of stage I were homogeneous H_2O-CO_2 fluids containing 3.5 ~ 14.6 mol % CO_2. Minimum temperature and pressure of stage I ore fluids were 240°C and 500 bars respectively. Salinities of aqueous type I inclusions in minerals of stage I range from 3.7 to 7.6 wt. % equiv. NaCl, whereas those of CO_2-containing type III inclusions range from 0.3 to 4.4 wt. %. Temperatures of stage II ore fluids range from 200 to 305°C on the whole and salinities were in the range of 3.2 ~ 7.2 wt. %. Th of fluid inclusions in calcite and fluorite of stage III range from 114 to 186°C and salinities were in the range of 0.9 ~ 4.3 wt. %.

Sulfur fugacities during stage II deduced from mineral assemblages and temperature data from fluid inclusions declined from earlier to later, in the range of $10^{-11} \sim 10^{-18}$ atm. Fluid inclusion evidence suggest that the dominance of CO_2 in ore fluid during W-Mo mineralization is the characteristic feature of Cretaceous W-Mo deposits of central district of Korea compared to those of Kyeongsang basin district. (Authors' abstract)

PARK, H.-I., LEE, S.M., LEE, M.S. and KIM, S.J., 1981, A study on the genesis of the metallic ore deposits in Hwanggangri region: J. Korean Inst. Mining Geol., v. 17, no. 3, p. 201-222 (in Korean; English abstract).

The upper Cretaceous granites associated with the mineralization contain anomalously high fluorine content (900 ppm avg.), in comparison with 340 ppm for the overall Cretaceous granites in Korea.

Most of the mineral deposits in the region are fissure-filling with a general trend of N-S system. A zonal distribution of the mineral deposits, such as tungsten-molybdenum-tin, copper-lead-zinc-bismuth and manganese are distributed from the margin of the granite body to the sedimentary rocks.

A telescopic feature of the same order in a vertical section within an ore vein is also recognized. The paragenetic sequence is also compatible with the order of mineral zoning.

Nature of the ore-fluid shows a high content of CO_2 and the salinity ranges from 3.0 to 11.5 wt.% NaCl equiv. during major ore formation, whereas there is practically no CO_2 and a low salinity of $0.4 \sim 1.5$ wt.% in the latest stage. The temperature of the major ore formation ranges from 235° to 370° whereas that of the latest is 145°C. Manganese oxide ores formed from sulfide-bearing rhodochrosite veins at near surface environment. (From the authors' abstract)

PARK, H.-I., MOON, S.H. and BEA, Y.B., 1985, Mineral paragenesis and fluid inclusions of the Dongbo tungsten-molybdenum deposits: J. Korean Inst. Mining Geol., v. 18, no. 4, p. 331-342 (in Korean; English abstract).

The Dongbo tungsten-molybdenum deposits are fissure-filling veins emplaced in granites of late Cretaceous age. Integrated field, mineralogic and fluid inclusion studies were undertaken to illuminate the character and origin of the ore deposits.

Mineral paragenesis is complicated by repeated fracturing, but four distinct depositional stages can be recognized: (I) tungsten-molybdenum minerals-quartz-chlorite, (II) iron-oxide and sulfides-quartz, (III) iron-oxide-base metal sulfides-sulfosalts-quartz-carbonates, (IV) barren rhodochrosite-zeolite.

Fluid inclusion studies were carried out for stage I quartz and stage III quartz, sphalerite and calcite. Fluid inclusion studies reveals highly systematic trends of Th and salinity throughout the mineralization. Ore fluids during stage I were complex, NaCl-rich brine and salinity reached values as high as 34.4 wt.% equiv. NaCl, but the later ore fluids were more dilute and reached to 9.7 wt.% equiv. NaCl during stage III. Intermittent boiling of ore fluid during stage I is indicated by the fluid inclusions in stage I quartz. Depositional temperatures and pressures during stage I range from 520°C to 265°C and from 600 to 400 bars. Th of the stage III quartz, sphalerite and calcite range from 305°C to 190°C.

Fluid inclusion data from the Dongbo mine are nearly similar to those from other hydrothermal tungsten deposits in the Kyeongsang basin. Depositional temperature and salinity of ore fluids during precipitation of tungsten-molybdenum minerals in Dongbo mine were much higher, but CO_2 contents were much lower than those from hydrothermal tungsten-molybdenum deposits of late Cretaceous plutonic association in central parts of Korean peninsula. (Author's abstract)

PARK, K.H. and PARK, H.I., 1980, On the genesis of Ulsan iron-tungsten deposits: J. of the Korean Inst. of Mining Geol., v. 13, no. 2, p. 104-116 (in Korean; English abstract).

The Ulsan mine is one of the largest contact metasomatic magnetite and scheelite deposits in the southeastern part of Korea. Mineralization at the Ulsan mine is localized along the contact between upper Cretaceous quartz latite-andesite and limestones of unknown age which were intruded by 58 m.y.-old biotite-horndlende granite.

General zonal sequence of skarn toward crystalline limestone from limestone-volanics contact is grandite, grandite-salite and salite zones. On the other hand skarns of volcanic origin exhibit the following zonal sequences toward hornfels from boundary with limestone: garnet, garnet-epidote, and epidote. Compositions of garnets and clinopyroxenes are determined by the X-ray diffraction and reflective indices. Local brecciation of these early skarns was followed by formation of the later skarn as zoned patches, breccia fillings and cross-cutting veins. Paragenetic sequence of late skarn minerals which is exhibited in the zoned patches and veins in an overlapping progression with time from andradite through hedenbergite or actinolite, quartz to calcite deposition.

Magnetite metallization followed early formed skarns and pyrite pyrrhotite, sphalerite, galena, tennantite, scheelite and arsenopyrite were deposited simultaneously with hedenbergite, quartz and calcite of late skarn. Filling temperatures of fluid inclusions in calcites range from 160° to 280°C. (Authors' abstract)

PARKISON, G.A., EMANUEL, K.M., WRONKIEWICZ, D.J. and NORMAN, D.I., 1985, Geology of the Cochiti mining district, Sandoval County, New Mexico (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 54. First author at NICOR Min. Ventures, Inc., Albuquerque, NM.

The Cochiti or Bland mining district is located about fifty miles north of Albuquerque on the southeast flank of the Jemez Mountains. The majority of mining activity was conducted from 1897 to 1903 an again from 1914 to 1916. A total of at least 185,000 tons of ore grading .20 oz/t gold and 4.0 oz/t silver has been produced.

Mid- to late Miocene andesitic volcanic and felsic hypabyssal intrusive rocks underlie the area. Ths sequence of rocks may reflect the early evolution of the adjacent Valles-Toledo caldera complex. Numerous north-south-trending, steeply dipping faults and fractures cut all rock types and may be related to extensional tectonism of the Rio Grande rift.

Veins and stockwork zones are generally associated with these north-south-trending structures and are composed primarily of sugary to chalcedonic quartz with only minor calcite. Multiple periods of vien filling and brecciation can be demonstrated. At least thirteen separate vein systems have been mapped, some extending for over two miles along strike. Veins locally exceed sixty feet and typically are at least ten feet in width. Ore shoots are localized at flexures and dilatant zones along veins, and ore grades generally increase with vein width. Vein sulfides are quite sparse and are primarily pyrite, gold, electrum, argentite, ruby silver, and minor base-metal sulfides. Alteration zoning towards veins grades from regional propylitization through advanced argillic to silicification.

Fluid-inclusion data suggest that precious-metal deposition occurred at or above the zone of boiling, typically at temperatures between 240 and 315°C, from dilute hydrothermal fluids with greater than 1% H_2S. Mineralization occurred between about 6.5 and 1.5 m.y. (Authors' abstract)

PARNELL, John and SWAINBANK, Ian, 1985, Galena mineralization in the Orcadian Basin, Scotland: Geological and isotopic evidence for sources of lead: Mineral. Deposita, v. 20, p. 50-56. First author at Dept. Geol., Queen's Univ., Belfast BT7 1NN, UK.

One-phase inclusions were found in sphalerite from algal breccias (p. 52). (E.R.)

PASCAL, M.L. and ROUX, J., 1985, K-Na exchange equilibria between muscovite-paragonite solid solution and hydrothermal chloride solutions: Min. Mag., v. 49, p. 515-521.

PASSCHIER, C.W., 1985, Water-deficient mylonite zones - An example from the Pyrennes: Lithos, v. 18, p. 115-127. Author at Inst. Aardwetenschappen, Budapestlaan 4, 3508 TA Utrecht, The Netherlands.

Some mylonite zones which operate at retrograde conditions in metamorphic rocks have a low water content of the metamorphic fluid, resulting in an incomplete reequilibration of the mineral assemblages. Recognition of such zones is important for a correct assessment of P-T conditions of deformation, especially where these data are used for reconstructing paleogeometry of exhumed normal fault and thrust zones. An example of a water-deficient mylonite zone from the Pyrenees is characterized by incomplete breakdown of sillimanite + orthoclase in the stability field of muscovite + quartz, pure CO_2 fluid inclusions, limited postkinematic grain growth and high differential stresses during the deformation as indicated by recrystallized quartz grain size. (Author's abstract)

PASTERIS, J.D., KUEHN, C.A. and BODNAR, R.J., 1984, Applications of the laser Raman microprobe U-1000 to hydrothermal ore deposits: examples from Carlin (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 619. First author at Dept. Earth & Planet. Sci., Washington Univ., Box 1169, St. Louis, MO 63130.

The laser Raman microprobe (LRM) has been used in the study of fluid inclusions to identify polyatomic gases in metamorphic and igneous rocks, complex ions in aqueous solutions, and daughter crystals in various hosts (e.g., Rosasco & Roedder 1979, Dhamelincourt et al. 1979). Non-electrolyte components of hydrothermal fluid inclusions can be analyzed (in some cases, only) by LRM. The technique permits pinpoint analysis of individual fluid and solid inclusions as well as the separate phases within them. Fluid inclusions in quartz and calcite from several types of samples from the Carlin (Nevada) disseminated gold deposit have been studied petrographically and by microthermometry (MCT) and Raman spectroscopy. The LRM was used to scan for CO_2, CO, N_2, H_2S, $CH_4 \pm H_2O$. MCT and LRM analysis revealed, in addition to aqueous brines, 3-phase inclusions of brine with different amounts of CO_2 and 1-phase liquid inclusions of pure CH_4. Very minor H_2S was detected in 2 inclusions. These gases <u>may</u> have affected ore deposition; their identification also is necessary for pressure estimations derived from Th. The LRM provides more than compositional data. For instance, the exact spectral position and shape of the CH_4 peak indicate the internal pressure in inclusions, even those too small (<3 μm) to be analyzed by MCT. The LRM also was used to structurally characterize carbonaceous material in the jasperoid host rock at Carlin (disordered graphite, in part) and to distinguish between the TiO_2 polymorphs anatase and brookite (both present) in hydrothermal quartz deposits at Magnet Cove. Such information provides further constraints on the formation conditions of the deposits. (Authors' abstract)

PASTERIS, J.D., SEITZ, J.C. and WOPENKA, Brigitte, 1985, Compositional interpretation of synthetic carbon-oxygen-hydrogen fluid inclusions by micro-Raman analysis and microthermometry: Microbeam Anal., 1985, Proc. 20th Ann. Conf., p. 25-28.

Both microthermometry and laser Raman microprobe were used in a study of synthetic fluid inclusions in quartz (Sterner and Bodnar, 1984, Fluid Inclusion Research, v. 17, p. 331-332). Quantification of the Raman analyses was attempted using relative normalized differential Raman scattering cross sections (RNDRS) and peak areas. However, the available RNDRS data are inexact, refer to gases at 1 atm (not liquids), and apply to a different scattering geometry than the instrument used. The comparison of the two analytical procedures showed that each method pointed out a weak assumption in the other, and hence should be used complementarily. (E.R.)

PATIL, R.R. and SINGH, R.P., 1985, Fluid inclusion studies of vein quartz from sulphide mineralization around Bamsu, Chamoli district, Uttar Pradesh, Garhwal Himalaya: Indian J. Earth Sci., v. 12, p. 72-79. Authors at Wadia Inst. Himalayan Geol., Dehra Dun-248001, India.

The sulphide mineralization from Bamsu-Chandrapuri area is studied for its fluid inclusion geothermometry. The transparent gangue quartz, intimately associated with mineralization is used for Th studies. Primary inclusions from the gangue quartz indicate invariable presence of liquid carbon dioxide, while those observed in host-rock away from the vein and those observed in the later secondary veins were found to contain mainly water. On the basis of variation in their composition, density, and Th, the inclusions are classified into four types. The thermometric observations indicate that the mineralizing fluid attained high temperature above 350°C in the initial stage while in the waning stage they cooled to 190°C. (Authors' abstract)

PATTRICK, R.A.D., 1985, Pb-Zn and minor U mineralization at Tyndrum, Scotland: Min. Mag., v. 49, p. 671-681. Author at Dept. Geol., Univ. Manchester, Manchester M13 9PL.

The Tyndrum Pb-Zn mineralization occurs as veins and vein breccias in NE-SW trending fractures associated with the Tyndrum-Glen-Fyne fault. The major minerals are quartz, galena, and sphalerite with minor chalcopyrite and barite. Tetrahedrite (sometimes silver- and cadmium-rich), pyrargyrite, marcasite, and pyrite occur as small inclusions (<100 μm) in the galena-rich veins. Sphalerite formed early in the depositional sequence, mainly in breccias, with increasing amounts of galena and chalcopyrite deposited in the later vein stages of mineralization. Uraniferous veins post-date the main Pb-Zn mineralization and contain uraninite, calcite, barite, galena, sphalerite, chalcopyrite, argentite, chalcocite, tetrahedrite, and safflorite.

Fluid inclusion studies reveal that the mineralizing solutions contained ~20 wt.% equiv. NaCl + KCl, had an Na/K ratio of 3:1 and were boiling during mineral precipitation.

The Tyndrum fault controlled the upward flow of the hydrothermal solutions and its intersection with fractures in quartzites favored the siting of the veins. The depositional sequences is explained by an increase in temperature during the mineralizing episode. The uraniferous veins may be a late oxidized stage of the main Pb-Zn mineralization. (Author's abstract)

PAVLOV, D.I., ILUPIN, I.P. and GORBACHEVA, S.A., 1985, Buried brines of Siberian platform as a possible factor of transformation of primary kimberlitic composition: Izv. Akad. Nauk SSSR, Ser. Geologicheskaia, 1985, no. 3, p. 44-53 (in Russian; translated in Int'l. Geol. Rev., v. 27, p. 600-610, 1985).

PAYETTE, Christine and MARTIN, R.F., 1985, Carboniferous glass in quartz-feldspar porphyry, Harvey Station, New Brunswick (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A47. Authors at Dept. Geol. Sci., McGill Univ., Montreal, Quebec, H3A 2A7, Canada.

The quartz-feldspar porphyry at Harvey Station, New Brunswick, associated with ignimbritic and other tuffaceous rhyolitic material, is found to contain glass that has remained intact since the porphyry was emplaced in Carboniferous times. The glass is found trapped and isolated in the quartz phenocrysts, which are paramorphic after β-quartz; the inclusions vary from spherical to faceted "negative crystals," averaging 30 to 50 μm across. The matrix to the phenocrysts has been devitrified, and then enriched in Si. The glass may contain accidentally trapped crystals that were on the liquidus, whose composition, size and habit preclude growth after entrapment: magnetite, hedenbergite and britholite (a rare earths (55 wt.%) silicate with an apatite structure) have been identified. Some inclusions near fractures in the quartz are devitrified. The glass is less siliceous (71% SiO_2) and more aluminous (15% Al_2O_3) than the whole-rock (80 and 11% respectively). Comparison of the composition of the melt (quenched as glass) and the bulk rock provides a firm handle on the metasomatic adjustments that have occurred as the plugs of porphyry cooled. (Authors' abstract)

PÊCHER, A., 1985, Fluid inclusion barothermometry in the higher Himalaya metamorphics: Retromorphism and density reequilibration: Himalayan Geol., in press. Paper presented at the "Fluid Inclusions" Seminar, Dehra-Dun, India, October 1984.

In the crystalline terrains of the higher Himalayas, one can see numerous syn-tectonic quartz exudation lenses. The lenses are rich in fluid inclusions, including a sample from Western Kumaon studied by Sauniac and Touret (1976) and numerous samples from Central Nepal studied by Leroy and others (1976), Pêcher (1979) and France-Lanord (1984). Pêcher has re-interpreted the results of these authors in light of new data available on the system $H_2O + CO_2$ (+ salt). These new interpretations confirm a CO_2-zonation parallel to the metamorphic zonation.

In addition, although the lenses are syn-metamorphic, the density of the inclusions corresponds to different P-T conditions (lower pressure) than those anticipated for the metamorphism. The author interprets these data to indicate the presence of secondary inclusions (as well as some inclusions that have reequilibrated) related to late-stage, retrograde low pressure-high temperature metamorphism. (Author's abstract, translated by M. Logsdon)

PECHER, Arnaud, LESPINASSE, Marc and LEROY, Jacques, 1985, Relations between fluid inclusion trails and regional stress field: a tool for fluid chronology. An example of an intragranitic uranium ore deposit (northwest Massif Central, France): Lithos, v. 18, p. 229-237. First author at Lab. de Géol. Structurale, École des Mines, Parc de Saurupt, 54042 Nancy Cedex, France.

Episyenites within the uranium ore-bearing Le Bernardan granite (northwest French Massif Central) were formed through the dissolution of quartz by hydrothermal solutions. These solutions may now be found fossilized as fluid inclusions (F.I.). The F.I. form rectilinear trails along microcracks which trapped the percolating fluids. Simultaneous study of the orientations of the trails and the chemistry of the inclusions shows that:

(1) the trails may be grouped according to direction, each related to successive regional stress fields;

(2) the fluids of each group are compositionally distinct, marking different stages of the hydrothermal event.

This example shows that the geometric relations between secondary F.I. trails and regional stress fields may be used to establish the chronology of both during a region's geological evolution. (Authors' abstract)

PENG, Ligui, 1985, The characteristics of ferromagnesian ultrabasic rocks and the study of silicate melt inclusions from Mayil mountain area of Xinjiang, China: Bull. Xi'an Inst. Geol. Min. Res., Chinese Acad. Geol. Sci., 1985, no. 11, p. 9-14 (in Chinese; English abstract).

Ferromagnesian ultrabasic rocks in this area are clinopyroxene-bearing peridotites and olivine-bearing clinopyroxenites, consisting of olivine ($Fo_{82.3-83.5}$) and diopside ($En_{46.2-46.7}Fs_{6.3-7.3}Wo_{46-46.5}$). The M/F [Mg/Fe?] ratio is 3.5-5.8.

The discovery of totally crystallized primary silicate melt inclusions in the rock-forming minerals, i.e., olivine and diopside, proves that these rocks are magmatic. Th of totally crystallized silicate melt inclusions in diopside vary between 1200 and 1250°C. The uniformity of types and chemical compositions of major rock-forming minerals and their similarity to the daughter minerals in melt inclusions show that the rocks have been formed under relatively stable conditions with slow decompression and cooling. After they formed, the rocks underwent mechanical and plastic deformation [but] the original textures are still well preserved. (Author's abstract)

PETRICHENKO, O.I. and KOVALEVICH, V.M., 1985, Problems of application of thermobarogeochemical methods in studying sedimentary rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 189-190 (in Russian; translation by D.A. Brown). Authors at IGGGI Acad. Sci. Ukrainian SSR, L'vov, USSR.

Chemical analyses of P liquid inclusions in halite show a regular change in the composition of saline basins during Phanerozoic time, and data allow us to assess the chemical composition of the World Ocean, beginning in the Cambrian. Inclusions in minerals from sedimentary rocks have provided: 1) the time of formation and the forms of migration of HCs in certain oil-gas deposits in the Ukraine; 2) additional information on the nature of the $CaCl_2$ brines in sediments; 3) the principal of physicochemical parameters of fluids during formation and diagenesis of rock salt, potash salts, sulfur ores; 4) criteria for exploration for potash-salt deposits, predicting their chemical and mineral composition, and classifying them.

These methods should be extended to the study of phosphorite and coal-bearing deposits, manganese and ferromanganese deposits, cherty sediments, weathering crusts, etc., although most are too fine-grained, opaque, or have not actually formed under sedimentary conditions. Authigenic minerals provide an important exception. (From the authors' abstract)

PETROV, P., 1981, Fissure-type and anomalous fluid inclusions in quartz from some lead-zinc ore deposits of the Madan ore field and in the Madzharovo ore deposit: God. Sofii. Univ. 'Kliment Okhridski,' Geol.-Geogr. Fak. 1981, publ. 1985, v. 75, no. 1, p. 97-141 (in Bulgarian).

A detailed microscopic study is made of the main morphol. types of fluid inclusions in clear quartz from the productive mineral parageneses of polymetallic ore deposits. The various morphologies are the result of polyvariant crack formation. Depending on the rate of crack regeneration, inclusions with varying proportions of liquid and gas phases, are formed inside the cracks. (C.A. 104: 92231t)

PETROV, P.P., 1985a. Fluid inclusions in natural hydrothermal quartz genetically connected with cracks: Comptes Rendus de l'Acad. Bulgare Sci., v. 38, no. 2, p. 215-218 (in English).

Care is needed in evaluating fluid inclusion data from secondary inclusions. (E.R.)

PETROV, Paraskev, 1985b. Fissure and abnormal fluid inclusions in quartz from some lead-zinc deposits in the Madan ore district and in the Madjarovo deposit: Annuaire de L'Univ. Sofia, "Kliment Ohridski" Fac. de Geol. & Geog., v. 75, no. 1, p. 97-110 plus 16 plates, 1981 (pub. 1985) (in Russian; English summary).

The paper presents a study of the fluid inclusions in quartz accompanying the Tertiary polymetallic ores in the Madan ore district and in the Madjarovo deposit, situated in the Rhodope Mountains (South Bulgaria). The deposits are of the vein type, and some of them in the Madan district are metasomatic formations (in marbles). The primary structure of the mineral association is preserved in a number of sections of the veins and metasomatic bodies. A typical feature of the quartz formed together with the productive polymetallic paragenesis is its transparency.

The detailed microscopic examinations show that the inclusions of mineral-forming fluids in the clear quartz are always associated with cracks. Depending mostly on the orientation and size of the cracks, the inclusions show various morphological peculiarities determined by the mechanism and rate of their growth during the healing of the cracks.

Two- and three-dimensional inclusions of varying degree of perfection of their vacuoles have been observed. The three-dimensional inclusions are better formed. The dependence between the degree of face development of the vacuoles and their visual association with cracks is demonstrated. This association is almost undetectable in the perfect crystals.

The processes of transformation of the cracks and the associated inclusions lead to various phase relationships inside them depending on the rate of regeneration. The numerous factors causing crack formation in quartz provide also a large number of possible mechanisms for their regeneration and formation of inclusions which show, therefore, noncomparable temperatures of homogenization. The primary sectorial inclusions found in the milky quartz and at the boundary between the clear and the milky quartz provide a possibility to compare them with the crack inclusions and to find a well-grounded approach to the latter's study. (Author's abstract)

PHILPOTTS, J., KANE, J., KIRSCHENBAUM, H., JOHNSON, R., ARUSCAVAGE, P., RAIT, N., BROWN, F., DORRZAPF, A., SKEEN, C., BROWN, Z., CRANDEL, W., FLEMING, S. and McCLAIN, R., 1985, Chemical composition of massive sulfides and hydrothermal fluids from the southern Juan de Fuca Ridge (abst.): EOS, v. 66, no. 46, p. 926.

PICHAVANT, M. and RAMBOZ, C., 1985, Liquidus phase relationships in the system Qz-Ab-Or-B_2O_3-H_2 under H_2O-undersaturated conditions and the effect of H_2O on phase relations in the haplogranite system (abst.): Terra Cognita, v. 5, p. 230 (in French).

The authors determined the phase relations for a portion of the system Az-Ab-Or-B_2O_3-H_2 (B_2O_3 = 4.5 wt %) at 1 kb under water-undersaturated conditions. Comparison of these data to those for water-saturated conditions allows a measure of the effect of water concentration on phase relations in silicate liquids at constant pressure. The initial solids were 4 anhydrous glasses, chosen because under saturated conditions their compositions were close to the cotectic curve. Fluids were H_2O-CO_2 mixtures obtained from reaction of water and $Ag_2C_2O_4$. The composition of the fluid phase under experimental conditions was determined from the global composition of fluid inclusions trapped in the glasses (approx. 35 mol% H_2O; 62 mol% CO_2; 3 mol% CH_4). Based on a mass balance betweeen glass and fluid before and after the experiment, the water content of the silicate liquid was between 2.4 and 3.2 wt %, as compared to a value of 6.5 wt % for a water-saturated fluid. The liquidus temperature was strongly elevated and the cotectic curve slightly displaced toward the Ab-Or join. The minimum composition was displaced to the Qz-Or side (Qz_{31}-$Ab_{34}Or_{35}$) in comparison to the saturated case (Qz_{31}-Ab_{46}-Or_{23}). Based on these results it seems likely that a decrease in the concentration water in the silicate liquid leads to an increase in a_{Or} relative to a_{Ab}. (Authors' abstract, translated by M. Logsdon)

PICHAVANT, Michel and RAMBOZ, Claire, 1985, First experimental determination of the phase relations in the haplogranite system under H_2O-undersaturated conditions: C.R. Acad. Sci. Paris, v. 301, Ser. II, no. 9, p. 607-610 (in French; English abstract).

Phase relations have been determined in the system Qz-Ab-Or-B_2O_3-H_2O (B_2O_3 = 4.5 wt% in the melt) under H_2O-undersaturated conditions at 1 kbar. The results, compared with the data obtained previously with excess H_2O in the same system and at the same pressure allow [us] to determine the effect of the melt H_2O content at constant pressure on the phase relations in the haplogranite system. The data suggest some type of association between H_2O and the albite-forming components in the melt. (Authors' abstract)

PICKTHORN, W.J., GOLDFARB, R.J. and LEACH, D.L., 1985, Reconnaissance oxygen isotope study of gold-bearing quartz veins within metasedimentary rocks of Valdez Group, Alaska (abst.): AAPF-SEPM-SEG Pacific Sections, Ann. Mtg., Alaskan & West Coast geol, energy, & mineral resources, Anchorage, AK, May 22-24, 1985, AAPG Bull., v. 69, no. 4, p. 675-676. First author at U.S. Geol. Survey, Menlo Park, CA.

Petrographic and fluid inclusion data suggest T of approximately 325°C for formation of the mineralized quartz veins. Calculated $\delta^{18}O$ values for fluids in equilibrium with the veins range from +8 to +12‰. A quartz separate from an altered quartz diorite intrusion at the Rough Tough mine in the Port Valdez district has a $\delta^{18}O$ value of +14.0‰; fluid in equilibrium with the intrusive at a reasonable T for its emplacement would have had a $\delta^{18}O$ value of approximately +12‰. These data suggest that the mineralized quartz veins formed from fluids derived from the Valdez Group during metamorphic dewatering. (From the authors' abstract)

PIERRET, R.F. and LeGUERN, F., 1985, Etna 1983: The sulfur chemistry in the plume: The SO_2/H_2S ratio (abst.): IAVCEI 1985 Scientific Assembly Abstracts (unpaginated).

PITZER, K.S. and PHUTELA, R.C., 1985, Thermodynamics of high-temperature brines: U.S. Dept. Energy, DOE Contract No. DE-AC03-76SF00098, Annual Rpt. 1984, Earth Sci. Div., Lawrence Berkeley Lab., Univ. California, Berkeley, CA, p. 10-13.

Activity coefficients at various temperatures for Na_2SO_4 in Na_2SO_4-NaCl brines are given. (E.R.)

PLATONOVA, E.L., 1985, Preliminary data on the vertical paleotemperature field of the Beregovo polymetallic mineralization in Transcarpathia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 90 (in Russian; translation by D.A. Brown). Author at IGGGI AN Ukr. SSR, L'vov, USSR.

In the Beregovo Hills, a number of drill-holes have reached the pre-Neogene basement at depths of 930, 750, and 600-650 m. The basement rocks consist of spilites, diabases, and diabase porphyrites, interstratified with chert-carbonate rocks and jasper. Starting with Th of fluid inclusions in vein quartz from the basement rocks, accepted as minimal temperatures of the mineral-forming solutions, we may conclude that the surface temperatures were uneven. The 250°C paleoisotherm corresponds to a depth of 930 m (DH 951) and 650 m (H952). Beginning at a depth of 350-300 m, the paleotemperature field has remained stable. In almost all the drill-holes at this level, Th for inclusions in quartz is 200°C.

The vertical paleotemperature gradient has been established on the basis of inclusions in quartz of a single generation, selected from different drill-holes in Ore Zone VI. The results obtained indicate the complex configuration of the paleotemperature field in the ore body examined. The amplitude of spread of the limbs of the ore body is emphasized by thermometry data for inclusions in quartz and is 50-80 m. This has been clearly noted in DH 1260, where the 200°C isotherm reaches the -110-m level, and in DH 980, this same isotherm occurs at about the -190-m level. The amplitude of spread must be taken into account when forecasting mineralization in depth, that is, during determination of the vertical range of mineralization. From the paleotemperatures, we may calculate the spread of mineralization, knowing the optimal temperatures of formation of the polymetallic ores. Within the Beregovo Hills area, polymetallic mineralization occurred at 240-180°C. A temperature of 160°C has been obtained on the present erosion level. It has also been established that cooling of the ore-bearing solutions, dependent on the measure of their upward advance, as 8°C per 100 m. We calculate that the vertical spread of the mineralization in a given sector was 750 m. (Author's abstract)

PLUMLEE G.S. and HAYBA, D.O., 1985, Solubility-temperature-salinity diagrams as a means for interpreting fluid-inclusion/mineral-zoning data from the Creede district, Colorado (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 691. Authors at U.S. Geol. Survey, MS 959, National Center, Reston, VA 22092.

Boiling and fluid mixing, which are widely regarded as effective ore-deposition mechanisms, can be differentiated by plotting fluid-inclusion data on temperature (enthalpy)-salinity diagrams. Solubilities of ore and gangue minerals can also be contoured on these diagrams to evaluate the relative chemical effects of mixing and boiling, and thereby reconcile ore-deposition models based on fluid-inclusion data with mineral-zoning patterns. For example, fluid-inclusion data from epithermal vein mineralization at Creede indicate the progressive mixing (from north to south) of metal-bearing brines with overlying ground water (Hayba, 1984, GSA Abs., v. 16, p. 534). Along this mixing path, solubility contours for sphalerite indicate a change of several orders of magnitude, consistent with the abundant sphalerite found in the northern veins. Temperatures and salinities are as high as 285°C and 11.5 wt% NaCl eq. in these sulfide-rich northern veins, but as low as 160-200°C and 2-7 wt% NaCl eq. in the barite-rich southern veins. Solubility-temperature-salinity (STS) diagrams show barite solubility changes relatively little at high temperatures and salinities, but drops significantly only at salinities below ~6 wt% NaCl eq. (pH changes above pH ~5 have no effect in sulfate-rich solutions). Fluid mixing was the depositional mechanism for barite because most mixing paths (decreasing temperature and salinity) cross solubility contours while boiling paths are parallel to them. Thus hot, saline fluids originating in the northern parts of the district deposited mainly sphalerite and galena, but only after significant cooling and dilution did they deposit the large quantities of barite seen in the southern parts of the district. STS diagrams are thus useful for visualizing chemical influences on mineral-zoning patterns and relating mineral solubilities to fluid-inclusion data. (Authors' abstract)

PODGORNYKH, N.M., 1985, Thermometry of ancient rhyolitic porphyries of Mongolia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 147-148 (in Russian; translation by D.A. Brown). Author at Inst. Geol. & Geophys. Siber. Div. Acad. Sci. USSR, Novosibirsk, USSR.

Results are presented of a thermometric study of ancient (late Riphean) spherulitic rhyolite porphyries of the Dzabhan Group from the area of the Hasagtu-Hairhan-Ula high-mountain massif, located in the Tsaganolom tectonic zone of Mongolia.

Th of the GLIs in quartz into the liquid phase = 120°C. Th of the discrete (probably P) inclusions, both finely crystallized, and also glassy, into melt = 1230-990°C. In this case, both a direct (decrease in Th from the center to the periphery of the grain) and the inverse temperature zonation has been recorded.

Chemical analysis of the homogenized inclusions, spheruloids, and the glassy groundmass has shown differences in their content of alkalies, the proportion of which increases in the glass from homogeneous inclusions. It is concluded that the porphyritic rhyolites formed in a subaerial environment, and may have been subjected to a very low grade of metamorphism, if at all. The latter conclusion may be used for paleogeographic, paleotectonic, and other reconstructions in the area under discussion. (From the author's abstract)

PODOSEK, F.A., ed., 1985, Terrestrial noble gases, Special issue: Chem. Geol., v. 52, no. 1, 125 pp.

Consists of 9 papers on various aspects of noble gases, their occurrence, abundance, and isotopes. (E.R.)

PODVYSOTSKII, V.T., 1985, Serpentine-carbonate mineralization in kimberlites: Zap Vses. Mineral. O-va, v. 114, no. 2, p. 234-247 (in Russian).

POHL, D.C., 1985, Experimental hydrothermal geochemistry: Basalt glass-seawater reactions: Ph.D. dissertation, Stanford Univ., CA.

POLLASTRO, R.M. and BARKER, C.E., 1984, Comparative measures of paleotemperature: An eample from clay-mineral, vitrinite reflectance, and fluid inclusion studies, Pinedale anticline, northern Green River Basin, Wyoming (abst.): Abstracts, First Ann. Meeting, Soc. Econ. Paleontologist and Mineralogists,p. 65-66. Authors at U.S. Geol. Survey, Denver, CO 80225.

See similar title Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 266, 1984. (E.R.)

POLLOCK, J.M. and CUMMINGS, M.L., 1985a Structural controls of mineralization and alteration, Ruth Mine, North Santiam mining area, Oregon (abst): Geol. Soc. Am. Abst. with Programs, v. 17, p. 401. Authors at Dept. Geol., Portland State Univ., Portland, OR 97207.

The Ruth Mine and associated base-metal veins are located on the eastern margin of a small porphyry copper system in the North Santiam mining area in the Cascade Range of Oregon. The veins are hosted in middle Tertiary andesite flows, tuffs, tuff breccias, and laharic breccias of the Western Cascade group. NW-trending dikes of equigranular and porphyritic diorite crop out in the area of the mine. Leucocratic quartz-feldspar porphyry intrusions (dacites) occur as irregularly shaped bodies.

Propylitic alteration characterized by replacement of primary mafic phases by chlorite and/or epidote, feldspars by epidote and/or carbonate, and disseminated pyrite is widespread but is non-uniform in distribution. Sphalerite, galena, pyrite, and chalcopyrite mineralization in open-space quartz veins is controlled along N30-40°W faults, along the contacts of diorite and dacite intrusions, and within crackle breccias in the dacite. This mainstage mineralization is accompanied by quartz-sericite alteration of wall rocks. Fluid inclusions from quartz exhibit salinities less than 5% and Th from 220-295°C. Calcite occurs within open spaces in mineralized quartz veins, in barren cross-cutting veins and as cements in breccias of mineralized quartz vein materials. Argillic alteration, including partial to complete kaolinization of hanging wall breccias along mainstage veins is accompanied by fine-grained gypsum. Brecciation of vein materials prior to development of clays is common.

Propylitic alteration is related to porphyry copper mineralization west of the mine. Mainstage mineralization in the Ruth Mine appears to have occurred later, either during late cooling of intrusions or during uplift of the Western Cascades. Argillic alteration with associated sulfates suggests the subsequent development of acid-sulfate hot springs similar to modern hot springs of the area. These springs predate formation of the Cascade Graben. (Authors' abstract)

POLLOCK, J.M. and CUMMINGS, M.L., 1985b, North Santiam mining ara, western Cascades - relations between alteration and volcanic stratigraphy: Discussion and field trip guide: Oregon Geol., v. 47, no. 12, p. 139-145. Authors at Dept. Geol., Portland State Univ., P.O. Box 751, Portland, OR 97207.

Tm ice range from -0.6 to -3.8, and Th from 204 to 299°C, in quartz from quartz-calcite veins, one with ore mineral. Barren quartz-epidote veins show Th 245-310 and <2 wt.% NaCl equiv. (E.R.)

POLYAK, B.G., PRASOLOV, E.M., CERMAK, V. and VERKHOVSKIY, A.B., 1985, Isotopic composition of noble gases in geothermal fluids of the Krusné Hory Mts., Czechoslovakia, and the nature of the local geothermal anomaly: Geochimica Cosmo. Acta, v. 49, p. 695-699. First author at Geol. Inst., USSR Acad. Sci., Moscow, USSR.

The contents and isotopic composition of all noble gases in the fluids from two localities (Karlovy Vary and Frantiskovy Lazne) in Western Czechoslovaki are given. The data show: (1) atmospheric Ne, Ar, Kr and Xe, which indicates meteoric recharge; (2) excess He, attributed to radiogenic contributions; (3) a small excess of Ne, but the data shed no light on its origin. Even though there is no evidence of any juvenile component in these mineral waters, part of the dissolved He is believed to be of deep (mantle) origin.

Correlation between the ratio $^3He/^4He$ and heat flow has been reported in the literature: our data enabled a direct test of this relationship and proved its fairly good validity. The combined interpretation of the heat flow and isotopic composition shows that the local heat flow anomaly in the Krusne Hory graben is of deep origin and was produced by the mass outflow which occurred during the Alpine activation of the Bohemian Massif. (Authors' abstract)

POLYAKOV, A.I., TURKOV, V.A., MURAVYEVA, N.S., NESMEYANOVA, L.I., IGNATENKO, K.I., 1985, Physico-chemical conditions of processes of generation and evolution of basalt magmas of the Baykal rift zone: Geokhimiya, 1985, no. 1, p. 41-58 (in Russian; English abstract).

Under study was chemical composition of ultramafic inclusions, megacrysts, phenocrysts and primary melt inclusions in minerals of volcanic rocks of the Baykal rift zone. Based on the data on geothermometers, geobarometers, experiments on Th of melt inclusions and inclusions with highly-compressed CO_2 the information on P-T conditions of generation and differentiation of basalt magmas was obtained. The geotherm for the Baykal rift was deduced. It is close to the geotherm of oceanic areas. Generation of initial basalt magmas takes place within the upper mantle in the upper part of the garnet peridotite facies at the depth of 60 to 80 km, 1200 to 1300°C and water content ~0.1%. As the result of abyssal crystallization of basalt magmas the megacrysts of olivine, clino- and orthopyroxenes, kersutite, plagioclase, chromium-free spinel and other minerals are formed under P = 13-18 kbar, T = 900-1200°C and high water content. Phenocrysts in the trachyte-basalt series crystallized under P = 2-5 kbar and T = 1260-830°C from dry melts. (From the authors' abstract)

POMÂRLEANU, Vasile and NEAGU, E.-A., 1985, Significance of fluid inclusions in determining the temperature gradients and their application to metallogenesis (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 104. First author at Inst. Geol. and Geophysics, Str. Caransebes 1, 178344 Bucharest, Romania.

The temperature gradients of ore solutions have been stated by taking into account Th of fluid inclusions reported from 650 quartz and sphalerite samples collected from the gold-silver-bearing and base metal hydrothermal ore deposits in the Baia Mare metallogenetic province.

Normal temperature gradients have been reported which point to the increase of temperature with the increase of depth and reverse gradients which point to the decrease of temperature to the deep levels.

The normal temperature gradients for the whole metallogenetic province vary between 5°C/100 m and 360°C/100 m.

The highly dipping veins (e.g., 80°-90°N, the main vein at Baia Sprie) show temperature gradients of 19-35°C/100 m, while the low dipping ones (e.g., 40°-50°N, the vein Sofia at Nistru) exhibit gradients of 60°C/100 m.

To normal temperature gradients (e.g., the sphalerite in the Cavnic deposit - 12.5°C/100 m) correspond normal concentration gradients of manganese in this mineral (0.023% Mn/100 m).

The chloritization areas around the veins with low dip show a small areal distribution (10-40 m in the case of the vein Sofia, Nistru ore deposit) of small gradients (60°C/100 m) and a large areal distribution (60-170 m in the case of the main vein at Baia Sprie) of high gradients (22-35°C/100 m).

The temperature gradients show that the solutions, on their way from the source to the surface, cooled by irreversible adiabatic expansion and by mixing with ground waters. (Authors' abstract)

POPIVNYAK, I.V., SHEVCHUK, V.V., ZHOVTULYA, B.D. and MAKHORKIN, I.O., 1985, The problem of the informative nature of 'anomalous' melt inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 115-117 (in Russian;

translation by D.A. Brown). Authors at L'vov State Univ., L'vov, USSR.

Halos of small secondary inclusions of gas, glass, ± dms formed in cracks surrounding solid (or fluid) inclusions in xenoliths and xenocrysts from kimberlites are described. Differences in coefficients of expansion are responsible [for cracks around solid inclusions]. Some S inclusions have Tm dms 780-850°C. The crumbling of the material from many such cracks may result in increased porosity and significant concentration of volatile components such as H_2, He, N_2, etc. (Abbreviated by E.R. from the authors' abstract)

PORCELLI, D.R. and O'NIONS, R.K., 1985, Fluid interactions in lithospheric mantle (abst.): Terra Cognita, v. 5, p. 200. Authors at Dept. Earth Sci., Univ. Cambridge, Cambridge, UK.

The introduction of enriched fluids in LIL elements into lithospheric mantle peridotite, which is often depleted in major elements, is a well-documented phenomenon. CO_2-rich fluids are often invoked for this metasomatism, but the detailed relationships between these features and the frequently present CO_2 fluid inclusions in mantle xenoliths are unclear. Whereas Sr and Nd isotopes can provide evidence for the transport of LIL elements and their interaction in the lithosphere, rare gas isotopes provide a tracer for the volatile species involved.

The $^3He/^4He$ ratios (R) of recently erupted ultramafic xenoliths from E. Africa, S.E. Australia, the Massif Central in France, and S. Yemen have been determined, and compared to the atmospheric ratio (R_A) have whole-rock values from 6 to 9 x R_A. This is a much more restricted range than previously recorded for other samples where radiogenic addition and diffusive losses may have been important. In marked contrast the $^{87}Sr/^{86}Sr$ ratios for separated clinopyroxenes range from 0.7036 to 0.8360 and are completely decoupled from the helium isotopes. Whereas the helium, and by inference CO_2, in the xenoliths is of asthenospheric origin, Sr from such a source ($^{87}Sr/^{86}Sr$ = 0.702-0.703) often does not dominate the Sr budget. The $^{87}Sr/^{86}Sr$ ratios in single amphibole and clinopyroxene crystals of presumed metasomatic origin have been analyzed to constrain the source of the Sr accompanying the introduction of volatiles.

The involvement of significant quantities of 'hotspot' He with $^3He/^4He$ ratios much greater than MORB has not yet been found, even in E. Africa, where such high values appear at the surface. (Authors' abstract)

POREDA, Robert, 1985, Helium-3 and deuterium in back-arc basalts: Lau Basin and the Mariana Trough: Earth & Planet. Sci. Letters, v. 73, p. 244-254. Author at Isotope Lab., Scripps Inst. Oceanog., Univ. California at San Diego, La Jolla, CA 92093, USA.

Samples of fresh basalt glass from the Mariana Trough and the Lau Basin were analyzed for their isotopic composition of water and helium in order to identify the sources of the volatiles in back-arc basin basalts. In the Mariana Trough basalts, the concentration (0.64-2.1 wt.%) and D/H ratio (δD = -46 to -32‰) of the water provide important evidence for a water-rich component from the subducting lithosphere. Extrapolation to infinite water content gives an end-member D/H ratio of δD = -25‰. $^3He/^4He$ ratios are, in general, similar to MORB values (~8 R_A) and indicate that Mariana Trough basalts represent a mixture of a MORB-type mantle and an alkali and water-rich component from the descending slab.

In contrast, the Lau Basin produces both hydrous (1.3 wt.% H_2O) and relatively anhydrous (0.12-0.35 wt.%) basalts. The D/H ratio (δD = -43‰) in the hydrous Lau Basin basalt resembles those of Mariana Trough lavas. The low water contents (0.12-0.35 wt.%) and MORB-like D/H ratios (δD =

-63 to -70‰) in three of five Lau Basin samples show that the water-rich component, observed in all Mariana Trough lavas, is absent in some Lau Basin lavas and not essential for the production of back-arc basalts. The high $^3He/^4He$ ratio of Rochambeau Bank in the northern Lau Basin (11 R_A), confirms an earlier analysis by Lupton and Craig and provides evidence for an enriched mantle source region beneath the Lau Basin which is perhaps related to the high-^3He Samoan "hotspot." (Author's abstract)

PORTER, E.W. and RIPLEY, Edward, 1985, Petrologic and stable isotope study of the gold-bearing breccia pipe at the Golden Sunlight deposit, Montana: Econ. Geol., v. 80, p. 1689-1706. First author at Dept. Geol. Sci., Univ. Texas at El Paso, El Paso, TX 79968.

Fluid inclusion homogenization studies indicate a temperature of deposition for period I mineralization of ~200°C. Values of $\delta^{18}O(H_2O)$ computed from quartz and temperature data an sericite $\delta^{18}O$ values range from -2.4 to +4.0 per mil. Hydrogen isotope values of fluid inclusions in period I quartz and water in equilibrium with late sericite fall between -56 and -33 per mil. Fluid inclusion freezing study of one sample of period I quartz suggests a fluid salinity of <1 equiv. wt percent NaCl.

Isotopic and geologic evidence is consistent with formation of a breccia pipe caused by exsolution of a vapor from a crystallizing magma. Oxygen and hydrogen isotope data suggest that extensive isotopic exchange between a magmatic fluid and igneous rocks occurred prior to open-space filling. Initial brecciation was accompanied by an isoenthalpic temperature decrease, which coupled with conductive cooling led to the precipitation of large amounts of silica. Textural features indicate that brecciation and fracturing, followed by fluid infiltration, occurred episodically. Sulfur isotope data is also consistent with derivation of sulfur from a magmatic source characterized by a $\delta^{34}S(\Sigma s)$ value between 0 and 5 per mil. Evidence from mineral assemblages and sulfur isotopes suggests that gold was most likely transported as a chloride complex and was deposited due to a pH increase accompanied by decreases in fO_2 and possibly temperature. (From the authors' abstract)

PORTNYAGIN, S.I. and KOVYAZIN, S.V., 1985, Studies of melt and solid inclusions in rock-forming minerals of effusives of the Kuril island arch with use of the laser microspectral analyzer LMA-10 (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 73 (in Russian). Authors at Inst. Geol. & Geophysics of Siberian Br. Acad. Sci., Novosibirsk, USSR.

Laser beam of the LMA-10 evaporates substance from the sample surface of dia. 10 to 300 µm and then quantitative determination of element composition is possible by recording of the typical emission lines. Melt inclusions were homogenized and next analyzed, as well as analyses were performed for host minerals to avoid errors especially for trace elements. The authors write about new data on Th and microelements in inclusions in plagioclases, olivines and pyroxenes from basalts, andesite-basalt and andesites from the Kurils indicating their importance, but they do not submit any numerical data from their studies. (A.K.)

POSEY, H.H., FISHER, R.S., HOVORKA, S.D. and ELLIOTT, L.A., 1985, Diagenesis of Early Permian evaporites and carbonates, Palo Duro Basin, Texas (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 692.

POSEY, H.H., WORKMAN, A.L., HANOR, J.S. and HURST, S.D., 1985, Isotopic characteristics of brines from three oil and gas fields, southern Louisiana: Transactions-Gulf Coast Assoc. Geol. Soc., v. 25, p. 261-267. First author at Univ. Texas at Austin, Bureau of Economic Geol., University Station Box X, Austin, TX 78713.

Isotopic analyses of twenty brine samples from two salt diapir-related oil fields and one growth fault-related gas field in southern Louisiana lend support to the model proposed by Workman and Hanor (this volume) that brines from the zone of geopressure are mixing with hydropressured formation waters along the flanks of the Iberia salt dome and, within the limits of the sampling, suggest that this hydrodynamic process may be characteristic of the region. $\delta^{18}O$, δD, and $^{87}Sr/^{86}Sr$ determinations suggest that formation fluids above 2000 m (6500 ft) depth have partly equilibrated with terrigenous clastic rocks. Fluids below 2000 m (6500 ft) appear to be mixed Oligocene/Miocene seawater and clay-mineral water or evolved hydrocarbon-bearing water. These fluid compositions vary with depth due to mixing and possibly to temperature variations. Some samples may contain constituents derived from salt dissolution. (Authors' abstract)

POTDEVIN, J.L., 1985, Kinetics of transport of material through fluid media during synmetamorphic deformation: Examples of a minor fold and a ductile shear zone (abst.): Bull. Minéral., v. 108, p. 94 (in French).

POTTER, J.M., POHL, D.C., GUILLEMETTE, R.N., PONADER, H.B. and LIOU, J.G., 1985, A system for flow through experimental studies at hydrothermal conditions: N. Jb. Miner. Mh., 1985, v. H.7, p. 329-335.

A flow through type experimental reaction system was developed. The designed system enables flow through experiments to be conducted under inert conditions at temperatures of up to 400°C, fluid pressures of 1 kb, and flow velocities from several thousand meters/year to less than 1 meter/year. The apparatus is effective in studying chemical and physical reactions occurring during open system-infiltration type fluid flow through porous media. Two experimental examples are summarized. (Authors' abstract)

POWELL, R., 1985, Geothermometry and geobarometry: A discussion: J. Geol. Soc. London, v. 142, p. 29-38. Author at Dept. Geol., Univ. Melbourne, Parkville, Victoria 3052, Australia.

Deals mainly with mineral thermometers and barometers. (E.R.)

PRADHANANGA, T.M. and MATSUO, Sadao, 1985a D/H fractionation in sulfate hydrate-water systems: J. Phys. Chem., v. 89, p. 1869-1872.

PRADHANANGA, T.M. and MATSUO, Sadao, 1985b Intracrystalline site preference of hydrogen isotopes in borax: J. Phys. Chem., v. 89, p. 72-76.

PRICE, J.G., HENRY, C.D., STANDEN, A.R. and POSEY, J.S., 1985, Origin of silver-copper-lead deposits in red-bed sequences of Trans-Pecos Texas: Tertiary mineralization in Precambrian, Permian, and Cretaceous sandstones: Bureau of Economic Geol., Texas Mining & Min. Resources Research Inst., Report of Investigations No. 145, 65 pp.

Steeply dipping vein-type silver deposits occur in Precambrian, Permian, and Cretaceous red-bed sequences near Van Horn, Texas. These deposits are geochemically similar and contain economically important quantities of silver, copper, and lead, as well as anomalously high amounts of arsenic, zinc, cadmium, and molybdenum. Gold is not enriched. Th of fluid inclusions in barite and calcite suggest formation temperatures in the range of 120°C to 170°C, that is, lower than temperatures typical in copper-lead-zinc-bearing igneous-hydrothermal veins. These temperatures are higher than those usually attributed to strata-bound, red-bed copper deposits. The elevated formation temperatures are the result of high heat flow in the Basin and Range province of Texas at the time of mineralization; they are not the result of igneous activity.

The hypothesis developed in this study on the origin of the veins involves a rise of moderate-temperature, moderately saline hydrothermal fluids along Basin and Range fractures and precipitation of metal sulfides in response to mixing with shallow ground water. This hypothesis has implications for exploration of additional deposits in Trans-Pecos Texas and elsewhere. (From the authors' abstract)

PROKOPOV, N.S., 1985, Amount of information and meaning of chromatographic analysis of fluid inclusions in minerals (methodological aspects) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 65-66 (in Russian). Author at Rostov State Univ., Rostov-on-Don, Ukraine, USSR.

The author recommends before chromatographic investigation, the determination of Td intervals for appropriate selection of heating intervals for inclusion opening. He discusses also the possibility of determination of H_2, O_2, N_T (? - may be either Ne or Ar; A.K.), N_2, CO, CH_4, CO_2, C_2H_6, NH_3, H_2S, H_2O and SO_2 from samples $\leq$100 mg and quality of such determination. (A.K.)

PRUTEK, W.A., 1984, Investigations concerning metal distribution in the silver vein deposit Minas de Arcata, south Peru, particularly with respect to zoning due to geothermometry, metal ratios and the ore mineral paragenesis: Doct. dissertation, Univ. Heidelberg, 133 pp. (in German).

The distribution of metals and metal zoning in the subvolcanic polymetallic silver vein deposit Minas de Arcata (south Peru) is approached methodically in several aspects: zoning due to temperature, silver content, metal ratios, vein thickness and ore mineral paragenesis.

Temperature zoning occurs between Th values in quartz of 180° and 260°C. The 200°C isotherm can be considered as the lower temperature boundary of silver mineralization. Tm ice ranges from -2.6° to -0.7°C. This boundary is also confirmed by the microscopic observations in the zonation based on the ore mineral paragenesis. (Abstract by E.E. Horn)

PUGIN, V.A. and KHITAROV, N.I., 1984a A test determining whether variolitic rocks are produced from immiscible melts: Dokl. Akad. Nauk SSSR, v. 275, no. 6, p. 1485-1487 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 4, p. 96-98, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 270. (E.R.)

PUGIN, V.A. and KHITAROV, N.I., 1984b Liquid immiscibility in andesite (experimental data): Dokl. Akad. Nauk SSSR, v. 279, no. 2, p. 438-441 (in Russian; translated in Int'l. Geol. Review, v. 27, no. 3, p. 367-370, 1985).

See abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 270, 1984.

PUKHNAREVICH, M.M., NAUMOV, V.B., BANNIKOVA, L.A., DEVIRTS, A.L. and SHARIF-ZADE, V.B., 1985, Origin of the mineralizing fluids at the Korshun iron-ore deposit: Geol. Rudnykh Mestoroszhdeniy, 1985, no. 6, p. 51-59 (in Russian; translated in Int'l. Geol. Rev., v. 27, p. 1433-1441, 1985). First authors at Irkutsk Univ., Moscow, USSR.

Calcite samples from the deposit were studied thermometrically. Th ranges from 430 to 130°C (primary) and 203-45°C (secondary). Up to 10 dms are present, including halite, sylvite, and one anisotropic phase with Tm = 70°C. Most dm had Tm <150°C. Iron chloride crystals, formed on cooling, melted at -8°C; Te = -54°C. Total salinity ≤46.5%. P, using Klevtsov and Lemmlein's method, was 70-1400 bars. Isotopic values for these inclusions: δD -89 to -122 per mil; calculated δ^{18}O 14-16 per mil, suggesting sedimentary brines. (E.R.)

PURTOV, B.K., YATLUK, G.M. and ANFILOGOV, V.N., 1984, Ratios of Fe, Mg, Si, Al in chloride solutions at 873°K and 101 MPa and the generation of skarn in limestone: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 1003-1006 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 4, p. 160-162, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 271. (E.R.)

PYOTROVSKIY, V.A., 1985, Spatial-temporal evolution of mineral-forming medium and its role in ontogeny of minerals (abst.), in Kalyuzhnyi, V.A., ed., Thermobarometry and geochemistry of ore-forming fluids (from inclusions in minerals), v. 1, p. 8-9 (in Russian). Author at Geol. Inst. of Komi Div. Acad. Sci. USSR, Syktyvkar, USSR.

The influence of gravitation on the evolution of the mineral-forming medium depends on the size of the mineral-forming system. (...) The relations were determined between a growing crystal and gravitational flows of foreign particles, forming xenogenic inclusions of homogeneous and heterogeneous phase composition. Trapping of components of increasing flows (e.g., gas bubbles) is essentially determined by their size and intensity. Influence of growing crystal on decreasing gravitational flow of solid particles (when oversaturation is moderate) is determined by adsorbing properties caused by P difference between solution volume in concentration flow and relatively immobile essential part of solution. (...) New exact genetic classification of inclusions is proposed(sic). (Author's abstract translated and shortened by A.K.)

PYOTROVSKIY, V.A., LYUTOEV, V.P. and SHIRYAEVA, L.L., 1985, Concentration-density differentiation of fluids in processes of natural mineral formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 27-28 (in Russian). Authors at Geol. Inst. of Komi Div. Acad. Sci. USSR, Syktyvkar, USSR.

During studies of zoned smoky-citrine quartz it was found that pH of the parent solutions changed during passing from smoky to citrine zone. Decrepitation activity proves that the first (lower) zone grew from less concentrated solutions than the second one. These factors influence habit, dimensions and internal features of the crystals. (From the authors' abstract, translated by A.K.)

QI, Zengdu and EVANS, T., 1985, The transformation of the state of nitrogen in diamond: Scientia Sinica, Ser. B., v. 28, no. 10, p. 1009-1021.

RABEANU, Albrecht, 1985, The role of hydrothermal synthesis in preparative chemistry: Angew. Chem., v. 79, p. 1017-1032 (in German; translated in Angew. Chem. Int. Ed., v. 24, p. 1026-1040).

An extensive review of hydrothermal experimentation procedures and limitations. (E.R.)

RABINOWICZ, Michel, DANDURAND, J.-L., JAKUBOWSKI, Marc, SCHOTT, Jacques and CASSAN, J.P., 1985, Convection in a North Sea oil reservoir: inferences on diagenesis and hydrocarbon migration: Earth & Planet. Sci. Letters, v. 74, p. 387-404.

RADTKE, A.S., 1985, Geology of the Carlin gold deposit, Nevada: U.S. Geol. Survey Professional Paper 1267, 127 pp. plus plates.

This is the definitive study of the Carlin deposit, one of the largest hydrothermal disseminated-replacement Au deposits discovered in North America. In addition to extensive geological and mineralogical studies, and isotopic studies of C, H, O, S, and Pb, a large number of microthermometric studies are reported on this generally rather difficult material.

Unpublished P or PS inclusion data by J.F. Slack, and new data, are presented on quartz, calcite, realgar, sphalerite and barite, indicating widespread fluid boiling. These minerals cover the paragenesis from the main hydrothermal stage through posthydrothermal supergene alteration. Most were L-V inclusions with a large range of L/V ratios; a few contained LCO_2. Those with high L/V ratios had salinities of 0 to ~17% NaCl equiv. and average Th (for given samples) of 179-325°C. No dms, hydrocarbons, or iron oxides were found in any inclusion.

Quartz deposited with gold during the mainstage hydrothermal mineralization has inclusions with average Th of 182°C and moderate salinities (2.7-4.6% NaCl equiv.), and no evidence of boiling. During the subsequent acid-leaching and oxidation stage the fluids were hotter (average 223°C), and had similar salinities, but were boiling. These data suggest that only about 300-500 m of overburden has been removed since ore deposition, but if significant amounts of CO_2 or CH_4 are present, P and T, and depth, could have been greater (as much as 2000 m or even greater).

Inclusions from supergene secondary quartz show Th <50°C and very low salinities.

The deposit is believed to have formed in the roots of a hot-spring system, with heat from an igneous source and meteoric or connate waters. The metals and the large amount of organic material were probably leached from sediments. Boiling caused loss of CO_2 and H_2S, and increase to ⩽17% NaCl equiv. The H_2S subsequently oxidized to yield acid which caused the extensive leaching. An esitmate is made of 1×10^9 t of fluid to bring in the ore metals (including $>6 \times 10^6$ g Au), and 1×10^{10} t of fluid during the late acid leaching. (E.R.)

RAFAL'SKIY, R.P., BRYZGALIN, O.V. and FEDOROV, P.L., 1984, Tungsten migration and scheelite deposition under hydrothermal conditions: Geokhimiya, 1984, no. 5, p. 611-624 (in Russian; translated in Geochem. Int'l., v. 21, no. 5, p. 1-13, 1984 (pub. 1985)).

See Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 273. (E.R.)

RAFALSKY, R.P., 1985a, Solubility of pyrite in hydrothermal solutions: Geokhimiya, 1985, no. 1, p. 78-92 (in Russian).

RAFAL'SKY, R.P., 1985b, Solubility of sulfides of heavy metals and their precipitation from hydrothermal solutions: Geokhimiya, 1985, no. 7, p. 998-1002 (in Russian; English abstract).

RAFAL'SON, M.B., BULDAKOV, I.V., KORNEYEVA, S.I. and NESTEROV, A.R., 1985, A study of glass inclusions in coronites and their petrogenic significance (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of

Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 127-129 (in Russian; translation by D.A. Brown). Authors at Leningrad State Univ., Leningrad, USSR.

In many of the layers of the pseudo-stratified Kavakta Massif of the peridotite-pyroxenite-norite association (Southern Yakutia), the authors have found rims, overgrowing grains of olivine and less commonly, orthopyroxene, and intergrowths of these minerals. Numerous optically isotropic inclusions, measuring n.10xn[sic] µm, oriented conformably with the segregations of orthopyroxene and amphibole, are confined to the growth zones of the coronae.

The isotropic inclusions show broad haloes under electron-microscope diffraction indicating amorphous matter. The sections were also ion thinned (argon, 30 hours, EM-1000 microscope, IGiG SO AN SSSR, N.T. Stenina) and the amorphous state of the optically isotropic phase verified; minute unresolved (1 μm^2) inclusions of a polycrystalline aggregate were found in this glass.

Table 1 lists the composition of the glass inclusions, obtained with a SEM-501 scanning electron-microscope. Three trends are apparent: 1) higher FeO in the central zones of the inclusions and of MgO and SiO_2 in the marginal zones; 2) decreasing FeO and increasing SiO_2 and MgO from the lower to the upper sectors of the aggregates; 3) the appearance of sectors of heterogeneous composition with distinct phase boundaries, and a case representing the greatest interest (Analysis 27): SiO_2, 7.46 mol %; Al_2O_3, not found, MgO, 7.83%; FeO, 84.71%; (Analysis 28): SiO_2, 20.61%; Al_2O_3, 1.20%; MgO, 19.85%; FeO, 58.34%; (Analysis 29): SiO_2, 11.46%; Al_2O_3, 2.01%; Mgo, 10.96%; FeO, 75.46%[sic].

The data indicate that: 1) the coronite structures are magmatic and define intervals of extremely high velocity of melt crystallization; 2) the composition of the minerals and the inclusions of glass in definite points is an 'instantaneous' fixation of the distribution of elements in the contact zone of the cumulate olivine-intercumulus melt; and 3) the presence of compositionally-heterogeneous glasses in one inclusion, possibly indicates the appearance of melt liquation into two silicate liquids with differing amounts of FeO, MgO, and SiO_2 under conditions of marked disruption of equilibrium in the crystal-melt. (From the authors' abstract)

Table 1

	SiO_2	Al_2O_3	MgO	FeO	CaO	MnO	Na_2O	K_2O	ZnO
Ia-orthopyroxene	54.14	1.59	33.13	11.15	---	---	---	---	---
glass	13.28	0.80	13.34	72.56	---	---	---	---	---
b-amphibole	41.31	22.32	14.17	8.98	9.59	---	3.74	0.19	---
glass	44.08	41.42	3.02	1.52	3.64	---	6.10	0.23	---
c-amphibole	43.78	18.68	18.16	7.68	11.08	---	---	0.63	---
d-glass	10.69	51.39	17.54	16.79	2.87	---	---	0.13	0.51
e-glass	14.52	47.46	18.00	16.02	3.50	---	---	0.16	0.28
f-glass	17.88	44.98	18.48	14.33	3.84	---	---	0.08	0.42
II g-orthopyroxene	49.97	4.43	29.37	15.40	0.18	0.27	---	0.39	---
glass	14.28	2.36	10.32	73.02	---	---	---	---	---
h-orthopyroxene	49.64	2.59	29.98	17.41	---	---	---	---	---
glass	22.51	2.14	17.14	59.21	---	---	---	---	---

Note. I) Rim of type I: a) inner orthopyroxene zone; b,c) outer amphibole zone; d) lower part of zone; e) middle part of zone. II) Rim of type II: g) inner zones, h) outer zones.

RAITH, M., SPIERING, B. and KLATT, E., 1985, Progressive charnockitization of a migmatite-gneiss-series in the Archaic crust of South India (abst.): Fort. Miner., v. 63, Beih. 1, p. 195 (in German).

Essentially same content as Klatt and Raith, this volume. (E.R.)

RAKHMANOV, A.M., 1985, Use of vacuum-decrepitation method for prospecting and evaluation of perspectives for endogeneous ore mineralization in the Central Tadzhikistan (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 84-85 (in Russian). Author at Tadzhik State Univ., Dushanbe, Tadzhikistan.

Material for investigations was collected in the Chinorsay ore field [the author does not specify what type of ore is in this field], S. Tyan'-Shan', formed in connection with a Variscan granitoid intrusive. Samples were taken along 4 profiles on three hipsometric levels down to 350 m below Earth's surface. Studies were made with the use of vacuum decrepitometer VD-3. Quartz samples were hand-picked under the binocular microscope. Heating interval was 20-720°C (10°/min), accuracy ±10°C. Sections of samples were first checked for inclusion generations under the microscope and Th were measured. On the basis of the obtained Th, the decrepigrams were interpreted, e.g., Td 160-240°C marks decrepitation of S inclusions, 340-420 or 300-360°C - PS and P inclusions, 570-620 or 570-680°C are caused by phase inversion of quartz [does this inversion produce gas? A.K.]. For prospecting work and calculation of fluid saturation coefficient [content?] the data for P and early PS inclusions are useful [the author does not explain how he is able to distinguish early PS inclusions from the other PS ones by decrepitometry or another method]. The author discusses also variations of fluid-saturation coefficient for minerals of various mineralization stages, writing that this coefficient is the "well-founded criterion of commercial evaluation of perspectives for ore mineralization," but he specifies neither what he means using this "coefficient" nor how he calculates it. However, he recommends it "for wide use for prospecting," etc. (A.K.)

RAMBOZ, Claire and BASTOUL, Abdelmajid, 1985, Oxidation of iron in graphite-bearing skarns and schists in Central Jebilet, Morocco: An evidence for mass transfer by fluid flow in a ductile shear zone: C.R. Acad. Sci. Paris, v. 301, Ser. II, no. 13, p. 931-936 (in French; English abstract).

Based on measured oxidation ratios of iron in the rocks (7<O.R.<74 mole%), it is shown that a flux of oxidizing fluids took place during prograde metamorphism in the shear zone of Central Jebilet. Reduction of iron occurred later 100 m around the Ouled Ouaslam granodiorite. The most oxidized rocks are associated with the graphite concentrations, suggesting that graphite may partly have precipitated from the fluid by oxidoreduction. (Authors' abstract)

RAMBOZ, C., SCHNAPPER, D. and DUBESSY, J., 1985, The P-$\bar{V}$-T-X-fO_2 evolution of H_2O-CO_2-CH_4-bearing fluid in a wolframite vein: Reconstruction from fluid inclusion studies: Geochimica Cosmo. Acta., v. 49, p. 205-219. First author at Centre Rech. Pétrogr. & Géochim., B.P. 20, 54501 Vandoeuvre Les Nancy Cedex, France.

Aqueous-carbonaceous and later pure aqueous fluid inclusions in quartz from a ferberite ($Fe_{.95}Mn_{.05}WO_4$) vein within the low-grade metamorphic aureole of the Borne granite (French Massif Central) have been studied by microthermometry and Raman spectrometry. The bulk $\bar{V}$-X properties of the aqueous-carbonaceous inclusions have been derived using the equation of state of Heyen et al. (1982) for the low-temperature CO_2-CH_4 system. A P-T path has been proposed for their trapping using the equations of state of Jacobs and Kerrick (1981a) for the H_2O-CO_2-CH_4 system. Two main episodes were reconstructed for the history of the aqueous-carbonaceous fluid. (1) Primary H_2O-CO_2-CH_4 vapor-rich inclusions in quartz indicated the early circulation of a low-density fluid (65 mole% H_2O - 34 mole% CO_2 - 1 mole% CH_4 and traces of N_2; d = 0.35 $g{\cdot}cm^{-3}$) at around 550° ± 50°C and 700 ± 100 bar. Fluid cooled approximately isobarically to 450°-400°C and was progressively diluted by H_2O with a concomitant increase in density. The fO_2 of the H_2O-CO_2-CH_4 fluid, estimated from the equilibrium $CO_2 + 2H_2O$ $CH_4 + 2O_2$, first ranged from 10^{-22} to 10^{-27} bar, close to the Q-F-M buffer. Within analytical errors, these values were consistent with the presence of graphite in equilibrium with the fluid. (2) A drop in PCO_2, and therefore a drop in fO_2, was recorded by the secondary liquid-rich inclusions in quartz. The inclusions, formed at and below 400°C, were composed of H_2O and CH_4 only, and fO_2 at that stage was below that fixed by the graphite-fluid equilibrium. This second episode in the fluid-rock system could be explained by the drop of temperature below the blocking temperature of the graphite-fluid equilibrium. According to this interpretation, the blocking of the graphite-fluid equilibrium occurred at $T \geqslant 370°C$ and probably at 400°C on account of the pressure correction. Mass spectrometric data show that ferberite contains H_2O, CO_2 and CH_4 in fluid inclusions, which lie in the gap of the $\bar{V}$-X properties of the aqueous-carbonaceous fluid in quartz. Deposition of ferberite probably occurred at around 400°C, the previously inferred blocking temperature, resulting from either the drop in PCO_2, the drop in fO_2 and/or the related pH-increase.

It is concluded that the existence of a blocking-temperature for the graphite-fluid chemical equilibrium may be a critical factor for maintaining a stable fluid pressure gradient in geothermal systems occurring under greenschist facies conditions in graphite-bearing rocks. (Authors' abstract)

RANKIN, A.H. and CRIDDLE, A.J., 1985, Mineralizing fluids and metastable low-temperature inclusion brines at Llanharry iron deposit, South Wales: Trans. Inst. Min. Metall. (Sect. B: Appl. earth sci.), v. 94, p. B126-B132.

A case study is presented of metastable fluid inclusions in quartz and calcite from the limestone-hosted hematite-goethite deposits of Llanharry, South Wales. Th of up to 90°C and two broad salinity groupings with 2-10 wt% and 10-24 wt% NaCl equiv., respectively, were found. New observations on the nature and geological setting of the deposits are integrated with the fluid inclusion data to produce a model that explains the genesis and location of this and similar deposits that are associated with Hercynian faults throughout the Llanharry-Taffs Well ore field. It is suggested that descending groundwaters, which had acquired a high salinity and iron content from overlying Triassic red beds, interacted with episodic pulses of hotter, more dilute fluids that were derived from rocks of the adjacent Coal Measures basin by the mechanism of seismic pumping, which accompanied periodic fault reactivation. (Authors' abstract)

RAU-FIGUEROA, A., LOREDO, J. and IGLESIAS, J.G., 1985, Fluid inclusions in quartz from gold mineralized granodioritic intrusion at "Carlés" (Asturias, Spain) (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 108. Authors at Dept. de Metalogenia. Escuela de Ingenieros de Minas. Independencia, 13. 33004 Oviedo, Spain.

The granodioritic intrusion of Carlés (Salas, Asturias) in NW Spain is intruded in Devonian limestones which are metamorphosed with a skarn mineralization. The mineral paragenesis is formed by mispickel [arsenopyrite], chalcopyrite, pyrite, native gold, etc. The native gold is associated with the mispickel in the form of small inclusions with a particle size between 5 and 100 microns.

This ore deposit, exploited by the Romans in the past, appears in the granodioritic metamorphic aureole, either in the quartz veins or in the same granodiorite by replacement of some rock components as well.

Heating and freezing measurements were carried out on the fluid inclusions present in the mineralized quartz veins and in the quartz from the granodiorite. They reveal the presence of several fluid inclusion types:

1) Aqueous two-phase inclusions which contain liquid and vapor phases. Th occurred over a wide range from 100°C to 320°C.

2) CO_2-rich inclusions containing two phases at room temperature: a CO_2 liquid phase and a CO_2 vapor one, homogenizing between 23°C and 26°C.

3) Inclusions containing H_2O and CO_2 liquid phases.

4) Inclusions containing two liquid phases (CO_2 and H_2O) and a vapor phase (CO_2). Type 3 and 4 fluid inclusions homogenized over a temperature interval from 290°C to 370°C.

5) Aqueous three-phase inclusions containing liquid and vapor phases and NaCl cubic crystals. Homogenization temperatures of (107°C - 350°C).

In conclusion, the possible genetic role of CO_2 in the gold transport as well as the utilization of CO_2-rich inclusions in the gold deposits prospection can be pointed out. (Authors' abstract)

READ, J.J., 1985, Gold-quartz vein deposition in an uplifted blueschist terrane, Seward Peninsula, Alaska (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 696. Author at Dept. Geol., Washington State Univ., Pullman, WA 99164-2812.

The Big Hurrah mine, located on the Seward Peninsula, Alaska, consists of gold-quartz-carbonate veins which cut sheared carbonaceous metasedimentary and metavolcanic rocks. The rocks underwent regional synkinematic blueschist facies metamorphism in the Jurassic. Glaucophane in metabasite and mafic and pelitic schist has been reported from the central Seward Peninsula. Chlorite ± epidote ± albite ± paragonite pseudomorphs after lawsonite and glaucophane have also been reported. The replacement of these blueschist facies minerals probably occurred during uplift and retrogradation of the terrane. Pressures and temperatures of the blueschist facies event were 9-11 kbar and 400-450°C as calculated by mineral assemblages (Forbes, et al., 1984; Thurston, 1985).

The veins at Big Hurrah range from early, concordant metamorphic quartz lenses to discordant tension veins to discontinuous quartz-Au lodes which occur in sheared zones cross-cutting the foliation. The veins are thought to have formed during the late stages of shearing and uplift. Fluid inclusions in the veins are similar to those found in metamorphic rocks in that they are small, most are secondary, and many contain CO_2 and CH_4. Inclusions from all vein types consist of early CO_2-CH_4-bearing inclusions and later aqueous inclusions. There is evidence for CO_2-CH_4/H_2O liquid immiscibility. Pressure estimates of 0.8 kbar were calculated from coexisting CO_2-CH_4 and aqueous inclusions. Pressure corrected homogenization temperatures for quartz deposition are in the range 300-400°C. Hence, the veins were deposited at lower pressures and temperatures than those of the blueschist facies event. It is thought that the veins at Big Hurrah were formed during uplift by a fluid phase derived by metamorphic dehydration and channeled into conduits depositing quartz, carbonate and gold. (Author's abstract)

READ, J.J., 1985, Gold-quartz vein mineralization at the Big Hurrah Mine, Seward Peninsula, Alaska (abst.): Geol. Soc. Am. Abst. with Programs, v. 17, p. 402. Author at Dept. Geol., Washington State Univ., Pullman, WA 99164-2812.

The Big Hurrah Mine is located about 45 miles east of Nome, Alaska. It is the only lode gold mine in the extensively placer-mined Seward Peninsula to have had any production.

The area is underlain by carbonaceous qtz-musc-chlor phyllonites and qtz-musc ± chloritoid schists. The carbonaceous rocks occur in a flat-lying shear zone and have a well developed linear-planar fabric.

Gold vein mineralization occurs only in the carbonaceous rocks. Three types of veins are present at the mine, these are: 1) Ribbon-quartz veins in SW-dipping faults. The mineralogy is >90% strained and cataclastic quartz ± carb, feld, scheel and minor py, asp, and native Au. Sulfides and gold appear to be paragenetically later than the quartz. These veins are up to 12 ft. wide and are associated with zones of qtz-carb stockwork and wallrock silicification; 2) Thin, tabular, steeply dipping tension veins which trend perpendicular to the foliation. Mineralogy is qtz-carb-py-cp-sl and rare gold; and 3) Late quartz-carbonate veins consisting dominantly of calcite with 5-10% quartz as selvages. These veins cut all other vein types.

Ore grade mineralization is present only in the ribbon-quartz veins with grades up to 3.5 OPT Au, and an average gold:silver ratio of 9:1.

Fluid inclusions resemble those from metamorphic rocks in that they are small, mostly secondary, and both CO_2-rich and H_2O-rich inclusions are present. There are at least 2 and possibly 3 generations of inclusions, indicating episodic fluid flow. Mineralizing fluids were possibly derived from metamorphic dehydration reactions at depth and channeled into fault conduits within the shear zone to precipitate quartz and later sulfides and gold. (Author's abstract)

REEDER, R.J. and WARD, W.B., 1985, Possible stretching mechanisms in fluid inclusions in calcite (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 696-697. Authors at Dept. Earth & Space Sci., SUNY, Stony Brook, NY 11794.

Sedimentary calcite crystals containing fluid inclusions have been heated during preparation of thin foils for transmission electron microscopy. Independent studies indicate that the ion-milling technique used to produce TEM foils heats the crystal to temperatures as high as 150°C. In the resulting electron-transparent regions (typically less than 500 nm thick) no fluid is retained, since virtually all inclusions are perforated and only the void remains. Owing to the extremely thin dimension of the foil, holes from inclusions larger than 1-2 µm tend to be selectively etched, masking their former identity. However, abundant spherical and ovoid "holes" in the range 0.1 to 0.8 µm are found, and there is little doubt that they were fluid inclusions. Some even contain daughter crystals.

In the vast majority of cases, the crystal portion surrounding these small "fluid inclusions" exhibit dislocations radiating (in three dimensions) from the walls. Densities are very low in what are otherwise nearly perfect crystals. However, distances over which the dislocations extend are several times the diameters of the inclusions. These characteristic dislocation structures suggest localized plastic deformation resulting from differential expansion of the inclusion and host crystal during heating. These observations suggest that stretching of fluid inclusions in carbonates is accomplished by plastic deformation involving the generation of dislocations. Other workers have also attributed similar dislocation structures in olivines to stretching. (Authors' abstract)

REINTHAL, W.A., BROWN, P.E. and VALLEY, J.W., 1985, CO_2-H_2O unmixing and mineralization controls for a Au-Ag vein system in the Blue Mountains of

NE Oregon (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 698. Authors at Dept. Geol. & Geophys., Univ. Wisconsin, Madison, WI 53706.

As a continuation of the genetic study of Au-Ag hydrothermal systems in NE Oregon, investigation of fluid inclusions on the North Pole-Columbia vein in the Cracker Creek district has led to the definition of a zone where CO_2 "boiling" from a H_2O-rich solution occurred during ore formation. The level at which unmixing of the CO_2-H_2O fluid occurred is manifested by massive quartz deposition along the vein accompanied by total replacement of adjacent wall rocks. Field relations are striking at this level: the massive "quartz blowout" is essentially pure from a mineralogic standpoint and the vein dilates from a typical width of about 20 feet to more than 200 feet. Production records from the vein system show that ores immediately beneath the primary zone of unmixing were of substantially higher grade than were the ores at much lower levels. Very little mineralization appears to have occurred above the "boiling" zone.

Near-solvus entrapment of fluid inclusions can be demonstrated at the primary level of unmixing. Study of fluid inclusions at this level indicates that the fluid varied in temperature from approximately 300 to 350°C and remained very close to the top of the solvus throughout the episode. Nearly simultaneous trapping of inclusions displaying behaviors ranging from truly critical phenomena to simple rapid homogenization provides the primary evidence for near-solvus entrapment.

Although the addition of other fluid components ($CH_4 \pm SO_2 \pm H_2S$) obscures the determination of both apparent salinities and pressure constraints during the time of ore formation, tentative estimates of 500 bars have been corroborated by sphalerite barometry (57 analyses: 20.22 ± 0.45 mol% FeS) in contemporaneous vein systems in the district. Quantification of additional components in inclusions will enable analysis of their effect on the position of the H_2O-CO_2-NaCl solvus. (Authors' abstract)

REX, R.W., 1985, Temperature-chlorinity balance in the hypersaline brines of the Imperial Valley, California: 1985 Int'l. Symp. on Geothermal Energy, International Vol., p. 331-356. Author at 2780 Casalero Dr., La Habra Heights, CA 90631.

The hypersaline brines of the Imperial Valley show a linear correlation of sodium depletion to chlorinity. This relationship reflects the chemical thermometer temperature of the brines, with temperature nearly balancing chlorinity. The main hypersaline brine reservoir shows a gradationally chemically stratified condition over an extent of approximately 1000 km^2. The main reservoir does not appear to be undergoing significant convection but rather owes its condition to a balance of osmotic and thermo-osmotic effects combined with water-rock interactions. Convective mixing is probably important in marginal areas of the reservoir. (Author's abstract)

REYES, A.G., 1985, A comparative study of "acid" and "neutral pH" hydrothermal alteration in the Bacon-Manito geothermal area, Philippines: M.S. thesis, Univ. Auckland, 258 pp.

The Bacon-Manito geothermal area occurs within a cluster of Plio-Pleistocene andesitic to dacitic volcanic centers of calc-alkaline affinity. The maximum measured temperature in the 16 wells studied is 307°C at 2600 m depth. Fluids discharged from the wells are of 2 types: neutral pH-alkali chloride and acid sulfate-chloride. Two wells discharge low pH waters while a third one cyclically discharges acid sulfate-chloride fluids.

[In addition to extensive studies of the alteration assemblage, geochemistry, vitrinite reflectances, well fluid chemistry, etc.] fluid inclusion Th on anhydrite, quartz, calcite and/or wairakite, often cluster into 2 groups: one similar to present-day measured temperatures and another at a hotter range. Freezing point depression temperatures indicate salinities that increase with depth and roughly mimic present field-wide fluid chloride concentration trends, i.e., there is an increase in salinity towards the main upflow of the geothermal system. However fluid inclusion salinities are usually higher than those calculated aquifer chloride[s] and this is probably due to several factors. Daughter minerals were observed in <5% of the inclusions in both acid and neutral pH alteration assemblages and are of 3 types: (a) true daughter minerals [NaCl?, hematite], (b) occluded material, and (c) "secondary" minerals formed after freezing.

Based on the observed mineralogy and fluid inclusion geothermometry, at least two major hydrothermal regimes have occurred in Bacon-Manito. It is possible that there have been 3-4 upsurges of hydrothermal activity in the area, based on the number of intrusive events recognized in the wells. On the average however the system has cooled by ~80°C. (From the author's abstract)

REYF, F.G., 1985, The thermobarogeochemical method in petrology: New data-new problems (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 129-130 (in Russian; translation by D.A. Brown). Author at Buryat Br. Sib. Div. Acad. Sci. USSR, Ulan-Ude, USSR.

A systematic thermobarogeochemical study of inclusions in hypabyssal granitic intrusions and their associated greisen-vein deposits of W and Mo can provide valuable data but has some limitations, as shown below.

1. The associated fluid inclusions (AFI) in magmatic minerals not only indicate fluid-saturation of the melt, but also the dispersed nature of the fluid phase; the dimensions of the AFI correspond to those of the vesicles [globules of fluid] in the magma. Quartz from ore-bearing granites contains submicron size AFI, points to the micro-heterogeneous state of the melt. Calculations have shown that during boiling of even a small quantity (~0.3%) of water, most of the bubbles of submicronic size number n.10^{11} per cm^3 of magma, and the average distance between them does not exceed 2 µm. Melt inclusions (MI) of such a natural microemulsion initially contain a free fluid phase in an amount proportional to the volume of the vacuole. Such crypto-anomalous MI, in spite of their large water content, homogenize at a T which greatly exceeds that of crystallization of the host-mineral; this has been demonstrated in experiments based on their homogenization at high argon P (320 MPa). Hence, the evidence obtained of the existence of micro-heterogeneous melts in nature, poses the question as to the necessity to adopt special measures that will ensure an unambiguous interpretation of the thermometric data, assuming that the magmas was fluid-saturated.

2. Determination of the PT parameters of degassing of granitic intrusions has shown that they most commonly correspond to the conditions of the fluid-saturated solidus of the corresponding model systems. However, ore-bearing intrusions release fluid at such PT parameters where equilibrium is impossible (they are therefore termed disequilibrium). This previously unknown phenomenon arises as a result of a marked and significant decompression, controlled by the auto-decompression of the magama chamber and by the withdrawal of the products of retrograde (equilibrium) boiling that had accumulated in it. It is characteristic that disequilibrium fluid-formation is accompanied by melting of earlier-separated crystals, so that during a single event of such boiling, AFIs are not formed (they are captured only during multi-phase boiling). Consequently, although inclusions

may reveal the disequilibrium nature of the natural processes, not all the phenomena are amenable to thermobarogeochemical self-recording.

3. Laser-spectral analyses of individual inclusions of magmatic and hydrothermal fluids in them have identified unexpectedly high (n %) concentrations of ore-forming elements (W, Mo, and Mn). In addition, control analyses of artificial inclusions of Mg-bearing solutions with a known concentration of the metal, sealed in a silicate glass, have not revealed any significant discrepancies. This suggests the reality of existence of high concentrations of metals in the inclusions, which contradicts the existing hypotheses concerning the upper limit of possible amounts of ore elements in model systems. In the light of these contradictions, the old, but still by no means finally resolved problem of the degree of correlation between the composition of the inclusions and that of the mineral-forming medium, acquires a special reality.

It seems that constant refinement of the thermobarogeochemical method is an essential condition of its future development[sic]. (From the author's abstract)

REYF, F.G. and BAZHEEV, E.D., 1985, Determination principles of ore-bearing (Mo-W-Sn) granites and their thermobarogeochemical features: Geol. Zbornik - Geologica Carpathica, v. 36, no. 3, p. 375-384. Authors at Siberian Br. Acad. Sci. USSR, Buryat Filial, Geol. Inst., Pavlova 2, 670 015 Uhlan-Ude, USSR.

This is the full paper corresponding to an abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 276, 1984. (E.R.)

REYNOLDS, T.J. and BEANE R.E., 1985, Evolution of hydrothermal fluid characteristics at the Santa Rita, New Mexico, porphyry copper deposit: Econ. Geol., v. 80, p. 1328-1347. First author at Fluid Inc., P.O. Box 6873, Denver, CO 80206.

Mineralogic and fluid inclusion investigations conducted in the laboratory combined with in situ observations of temporal relationships among geologic features demonstrate that systematic changes in hydrothermal fluid characteristics occurred with time during evolution of mineralization and alteration of the granodiorite stock at the Santa Rita porphyry copper deposit. The earliest fluids to circulate are recorded in potassically altered (orthoclase- and biotite-stable) veins as vapor-rich H_2O-CO_2 inclusions and hypersaline (30-70 equiv. wt % NaCl ± KCl) inclusions which homogenize over a wide temperature range from 240° to greater than 800°C. The high-salinity fluid inclusions are complex chloride brines with significant concentrations of sodium, potassium, copper, iron, and sulfur, but sulfide minerals are not associated with the early potassic assemblage produced by this fluid. Oxygen isotope ratios of quartz in the orthoclase- and biotite-stable veins are identical to phenocryst quartz in the intrusion (8.2‰). Later solutions circulated through newly formed fractures and older reopened veins, and are recorded in low-salinity (less than 15 equiv. wt % NaCl) fluid inclusions which homogenize primarily in the temperature range of 220° to 360°C. These hydrothermal fluids formed two distinct alteration assemblages as they reacted with potassically altered rock: chlorite is the dominant silicate gangue mineral of the earlier chalcopyrite-bearing, orthoclase- and clay-stable assemblages and sericite characterizes the later phyllic alteration assemblage with quartz and pyrite. Oxygen isotope ratios of quartz of the later assemblages (8.6-10.4‰) are heavier than quartz of the earlier potassic assemblages.

It is concluded that the earliest hydrothermal fluids to circulate within the stock localizing the orebody at Santa Rita could have been derived by phase separations of fluids exsolved from crystallizing magma into condensed, hypersaline liquids and H_2O-CO_2 vapors. As these fluids moved through fractures, potassic alteration of rock occurred without concomitant deposition of sulfides. Later solutions of dominantly meteoric origin progressively formed hypogene copper mineralization associated with chlorite-stable alteration and then phyllic alteration. (Authors' abstract)

RICE, C.M., HARMON, R.S. and SHEPHERD, T.J., 1985, Central City, Colorado: The upper part of an alkaline porphyry molybdenum system: Econ. Geol., v. 80, p. 1769-1796. First author at Dept. Geol., Marischal College, Univ. Aberdeen, Aberdeen AB9 1AS, Scotland.

The distribution of molybdenite, fluorite, rhodochrosite, enargite, and telluride minerals, together with anomalous quantities of Cu, Pb, Zn, and Mo in rocks, and variations in stable isotope ratios define a complex, zoned hydrothermal system in the Central City mining district.

Fluid inclusion data for the molybdenite and precious and base metal mineralization indicate that fluid inclusions associated with early molybdenite veins are of two types: CO_2 rich and rare halite-bearing, with respective Th of 340° to 420°C and 240° to 340°C. Inclusions associated with precious metal-bearing pyrite and base metal veins are aqueous, two-phase types with Th in the range of 220° to 380°C. Those from late molybdenite veins are aqueous, two-phase inclusions with Th of 200° to 280°C. Salinities (as equiv. wt % NaCl) are between 34 and 42 for halite-bearing inclusions and 2 to 12 for all other types. No evidence of boiling has been found. Trapping pressures of CO_2-rich inclusions are 0.46 to 0.75 kb, which suggest an emplacement depth of about 2 km for the molybdenite mineralization.

Respective quartz $\delta^{18}O$ and fluid inclusion δD values are: (1) early molybdenite veins: +9.3 to +14.3 per mil and -87 to -66 per mil; (2) precious metal-bearing pyrite and base metal veins: +8.4 to +15.9 per mil and -90 to -47 per mil; and (3) late molybdenite veins: +10.1 to +15.4 per mil and -77 to -69 per mil with associated fluorite having fluid inclusion δD values of -70 to -57 per mil. A late telluride vein has a quartz $\delta^{18}O$ value of +11.2 per mil and fluid inclusion δD value of -86 per mil. These data suggest that all except the telluride ore fluids contained large proportions of a D-rich (magmatic) fluid. Th distribution of fluid inclusion δD values defines two distinct anomalies, each zoned with δD enrichment occurring inward toward centers which correspond to the areas of known molybdenite occurrences and precious and base metal mineralization. Likewise, δD values for sericites developed during early hydrothermal activity increase inward toward the quartz bostonite pipe, various intrusive breccias, and molybdenite mineralization in the district. There is no indication at Central City of negative $\delta^{18}O$ anomalies in the Precambrian country rock within or peripheral to the centers of mineralization suggesting that ore fluids were thus essentially confined to discrete fractures.

It is concluded that molybdenite and other mineralization in this classic gold mining district may be related and may represent the upper part of an alkaline porphyry molybdenum system. (From the authors' abstract)

RICHARDS, J.P. and SPOONER, E.T.C., 1985, Fluid inclusion and isotope evidence for mixing of magmatically related fluids with groundwaters during Keweenawan Cu-Ag fissure-vein mineralization, Mamainse Point, Ontario (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 699. Authors at Dept. Geol., Univ. Toronto, Ontario, Canada M5S 1A1.

Primary chalcocite (Cc) mineralization at the Coppercorp mine occurs with vuggy Qz and minor calcite (Ct) in hydrothermal breccia veins following normal faults which cut Keweenawan plateau basalts and interflow sediments. Cc is the last and predominant sulphide in a paragenetic sequence of Py-Cp-Bn-Cc-Cu. Hematite (Hm) is found in equilibrium with all sulphides except Py. Fluid inclusion studies of vein Qz reveal a simple mixing trend between high temperature (450 to 550°C), high salinity (15 to 20 eq wt% $CaCl_2$) brines, and lower temperature, more dilute hybrid fluids (100 to 400°C, 0.0 to 12 eq wt% $CaCl_2$). The high end-member fluid temperatures strongly suggest a magmatic association, while the low salinity fluids are probably meteoric groundwaters. $\delta^{13}C_{pdb}$ and $\delta^{18}O^{smow}$ values for ten Ct samples associated with sulphides average -4.0‰ (s = 0.7) and 13.3‰ (s = 2.1) respectively. Closely similar values were obtained from a small Keweenawan Cu-Mo porphyry 10.5 km E of Coppercorp (Jogran prospect); four Ct samples give $\delta^{13}C_{pdb}$ = -4.0‰ (s = 0.8), $\delta^{18}O_{smow}$ = 13.7‰ (s = 1.4). These results suggest that the Coppercorp high-temperature ore-fluids were in equilibrium with an intrusion similar to the Jogran porphyry at depth, and that mixing with groundwaters at higher levels in fissure veins resulted in sulphide precipitation by cooling, dilution and neutralization. Oxidation of this primary fluid at Coppercorp is also reflected by the ubiquitous presence of Hm with sulphide ores; negative $\delta^{34}S$ ratios from ten samples of Py, Cp or Cc (averaging -4.7‰, s = 1.2) and positive ratios from two rare baryte samples (+4.9, +15.5‰) support this interpretation. Two samples of Py from Jogran give ratios typical of porphyry deposits (+1.3, +1.6‰), and may therefore represent the original undisturbed values of the ore-fluid. (Authors' abstract)

RICHARDSON, C.K. and PINCKNEY, D.M., 1985, The chemical and thermal evolution of the fluids in the Cave-in-Rock fluorspar district, Illinois: Mineralogy, paragenesis, and fluid inclusions - A reply: Econ. Geol., v. 80, p. 2045-2046. First author at Dept. Earth Sci., Iowa State Univ., Ames, IA 50011.

A reply to a discussion by Brecke (1985, this issue) of an earlier article by these authors (Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 170, 1981) and a paper by Richardson and Pinckney, 1984 (Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 278-279). (E.R.)

ROBB, L.J. and SCHOCH, A.E., 1985, Deuteric alteration and uranium mineralization processes in leucogranite intrusions from the Namaqualand metamorphic complex: Information Cir., Univ. Witwatersrand, Econ. Geol. Research Unit, v. 173, 11 pp. Authors at Univ. Witwatersrand, Econ. Geol. Res. Unit, Johannesburg, ZAF.

Studies of the moderate- to high-level, leucogranite intrusions in the Namaqualand Metamorphic Complex (~100 Ma), indicate a link between a pervasive deuteric alteration and the concentration of uranium. Quantitative fission track studies indicate that unusually high contents of uranium are associated with the products of deuteric alteration, suggesting efficient flushing of a uranium-charged fluid phase through the system.

Fluid inclusion data indicate distinct populations of brine, pure water and CO_2. Unmixing of the brine-CO_2 probably occurred at temperatures corresponding to the onset of deuteric alteration, and may have been responsible for the precipitation of uranium 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 uranium occurred.

Uranium mineralization in the leucogranites is considered to be a function of a closed-system alteration process and the retention of uranium in situ, rather than the outgassing of the fluid phase and the precipitation of uranium in extraneous vein, breccia or pegmatite systems. (Authors' abstract)

ROBERT, Christian, JAVOY, Marc and KIENAST, J.-R., 1985, Partition coefficients and oxygen partitioning: Comparison of thermometric and barometric data on eclogites and micaschists from the Sesia-Lanzo zone (Italian Alps): Bull. Minéral., v. 108, p. 699-711 (in French; English abstract). First author at C.N.R.S., E.R. 224, Lab. de Géol. de l'Ecole Normale Supérieure, 46, rue d'Ulm, 75005 Paris, France.

Equilibration temperatures on eclogites and eclogitic micaschists from the Sesia-Lanzo zone are determined by using two techniques: Fe-Mg partition data in coexisting phases (clinopyroxene and garnet:phengite and garnet) and oxygen stable isotope measurements on quartz, clinopyroxene, white mica and rutile.

Two groups of temperatures have been observed: around 520°C for the eclogites and around 800°C for the micaschists. (From the authors' abstract)

ROBERTSON, A.D., SUTHERLAND, F.L. and HOLLIS, J.D., 1985, Upper mantle xenoliths and megacrysts and the origin of the Brigooda basalt and breccia, near Proston, Queensland: Pap. Dep. Geol. Univ. Queensland, v. 11, no. 11, p. 58-71.

Two phases of volcanic activity have been recorded in the Garnet Gully area, east of Brigooda. The older volcanic activity occurred during the early Miocene when moderately to strongly undersaturated alkali-basalt, the Brigooda Basalt, was extruded from a single vent. During the late Pleistocene, gaseous outbursts produced several breccia deposits, the largest of which occupies the central part of a maar-like structure at Garnet Gully.

Xenoliths of pyroxenite, garnet pyroxenite, hornblendite, and pegmatitic garnetite accompanied by megacrysts of amphibole and anorthoclase are common. Zircon and sapphire occur as rare inclusions in the breccia.

Experimental temperature-pressure determinations when applied to the Garnet Gully xenolith-megacryst assemblage indicate upper-mantle origins shallower than 60-70 km. The presence of CO_2 in inclusions in pyroxene and amphibole suggests that mantle CO_2 may have formed a large percentage of the volatiles in the gaseous outbursts. (Authors' abstract)

RODEN, M.F. and MURTHY, V.R., 1985, Mantle metasomatism: Ann. Rev. Earth Sci., v. 13, p. 269-296. First author at Dept. Geol., Univ. Georgia, Athens, GA 30602.

Pertinent to the possible composition of fluid inclusions in mantle samples. (E.R.)

RODIONOV, S.M., SHAPENKO, V.V. and RODIONOVA, L.N., 1984, Structure and genesis of tin-tungsten deposits of the Central Sikhote-Alin': Geol. Rudn. Mest., v. 26, no. 1, p. 22-30 (in Russian). First author at Far-East Sci.-Research Inst. of Mineral Raw Materials, Khabarovsk, USSR.

The tin-tungsten deposits of the studied area are connected with apical parts of the Bikino-Malinovskiy cryptobatolith, consisting of the granitoid massifs Izluchinskiy, Priiskovyi, Dal'nearminskiy, etc. Ores occur in flysch-type rocks and they consist of quartz veins and veinlet zones. At the deposit Zabytoe Th of inclusions in minerals of the greisenized granite porphyry (quartz, fluorite) are 318-370°C, greisen association (quartz, topaz, fluorite) 315-380°C, quartz-cassiterite-wolframite association (topaz, fluorite) 330-371°C, sericite-sulfide association (quartz) 180-235°C. Mineral associations of the Tigrinoe deposit yielded the following Th: greisen (quartz, topaz, cassiterite) 317-395°C, (fluorite) 120-130°C, quartz-cassiterite-wolframite (cassiterite, quartz) 290-355°, (fluorite) 120-126°C, pyrrhotite-chalcopyrite (quartz) 180-370°C, stannite-sphalerite (quartz) 200-337°C. T of last ice crystal melting ranges from -7 to -1°C, T of $CO_2 \cdot 5.75H_2O$ melting from +5.0°C to +7.6°C. (Abstract by A.K.)

ROEDDER, Edwin, 1985, Composition of fluid inclusions in salt beds (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 106. Author at U.S. Geol. Survey, MS 959, Reston, VA 22092, USA.

Several methods have been developed and used to extract and chemically analyze the two major types of fluid inclusions in salt. Limited chemical data were obtained on the clouds of tiny inclusions in chevron salt, representing the brines from which the salt originally crystallized. Much more complete data were obtained on a number of individual "large" (~1 mm) inclusions in recrystallized salt. These latter fluids have a wide range of compositions, indicating that grossly different fluids were present in these salt beds during each of the several (?) stages of recrystallization. The analytical results indicating very large intersample chemical variation verify the conclusion reached earlier, from petrography and microthermometry, that the inclusion fluids in salt are generally polygenetic.

The diversity in composition stems from the combination of a variety of sources for the fluids (Permian sea, meteoric, and groundwater, as well as later migrating formation or meteoric waters), and a variety of subsequent geochemical processes of dissolution, precipitation, and rock-water interaction. The compositional data are frequently ambiquous, but do provide constraints and may eventually yield a coherent history of the events that fashioned these beds as we see them now. (Author's abstract)

ROEDDER, E., 1985, Uses for synthetic fluid inclusions in quartz crystals: Nature, v. 315, p. 544-545.

A discussion of the many ramifications of the work of Sterner and Bodnar (1984) (Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 331-332) on synthetic inclusions. (E.R.)

ROMANCHEV, B.P. and KOGARKO, L.N., 1985, A geochemical test for the ore-capacity of magmas (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 119 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

The geochemical test for the ore-capacity of melts has been based on the identification of concentrations of ore components, essential for crystallization during the early stages of magmatism of phases that form the mineral raw-materials.

On the basis of deposits of apatite, eudialyte, and other phases in the nepheline syenite of the Kola Peninsula, the authors have made an attempt to determine the cotectic amounts of P, Zr, and other elements in natural materials, using a microprobe analysis of homogenized inclusions in the minerals of the apatite and eudialyte ores of the Khibiny and Lovozero Massifs. The values of the cotectic saturation of the melts of nepheline syenites, obtained during analysis, with respect to apatite (P_2O_5 = 1.91%) and eudialyte (ZrO_2 = 1.88 wt %), are close to the eutectic amounts of the corresponding elements in synthetic systems of apatite-nepheline-diopside and eudialyte-lujavrite.

During a comparison between these data and the average compositions of the Khibiny and Lovozero intrusions, it has been established that the intruded melts were saturated with respect to the ore components, and the apatite in the ijolite-urtite and eudialyte in the lujavrite intrusions were early minerals, and that just such conditions contributed to the accumulation of apatite and eudialyte in the ore-bearing layers.

The thermometric method with respect to the inclusions has identified the temperature ranges for crystallization of apatite and eudialyte from the earliest stages of formation of the intrusions prior to the late-magmatic processes. In order to determine the concentrations of P_2O_5 and ZrO_2, the authors selected the highest-T crystals of apatite and eudialyte from the quenched facies of the apatite deposits and the lujavrites. (Authors' abstract)

ROMANCHEV, B.P. and KOGARKO, L.N., 1985, Temperature characteristics of the potassic magmatism of Italy (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 139-140 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

On the islands and on the coast of the Tyrrhenian Sea, the volcanic lavas are high K. The K alkaline province of Italy includes Vulsini, Vico, Sabatini, and Vesuvius volcanoes, which consist of volcanic rocks with modal leucite. Volcanics of the shoshonite series, with variable composition from leucite tephrites to trachytes and rhyolites, have been involved in the construction of Stomboli and Vulcano. Agpaitic comendites, the principal minerals of which are sanidine and aegirine, have been developed on San Petro and San Anticho, near Sardinia.

The authors selected two-member rock associations, typical of this area, for their thermometric and geochemical studies: leucite tephrite-leucitite (Vesuvius), leucite tephrite-trachyte (Vulcanello-Aeolian Islands, Vulcano Island), and andesite-comendite (San Petro and San Antiocho Islands).

The Vesuvius lavas have anomalously high concentrations of Ba, large amounts of P, and predominance of light rare-earths over the heavy. Tt for tephrites = 1170-1100°C and for leucitites = 1100-1060°C, with a solidus (Te) of 800°C.

During evolution of the Vulcanello tephrite melt to trachytes, significant accumulation of S, Zr, Be, and rate earths took place. This process occurred under conditions of gradual lowering of T from 1190 to 1110°C.

The andesite-comendite association, according to Th of the inclusions in minerals, forms a discrete pair (andesite - 1170°C and comendite - 1020°C), although Te for these rocks (800 and 620°C) suggest that these rocks are component members of one and the same genetic series. In support of this hypothesis, a mathematical analysis of the rock compositions has shown the possibility of partial melting to yield comendite composition from andesites with an 80% degree of crystallization of the melt. (Authors' abstract)

ROMANKO, E.F., MOMENZADEH, M., MOGAROVSKII, V.V., KOKORIN, I.G., LOTFY, M. and ISHANSHO, G.A., 1985, The barite deposit of central Iran: Dokl. Akad. Nauk SSSR, v. 281, no. 3, p. 677-679 (in Russian).

Td and Th for barite (130-200 and 115-240°C) and galena (130-150) are given for 8 occurrences. (E.R.)

ROSE, A.W., HERRICK, D.C. and DEINES, Peter, 1985, An oxygen and sulfur isotope study of skarn-type magnetite deposits of the Cornwall type, southeastern Pennsylvania: Econ. Geol., v. 80, p. 418-443.

ROSE, W.I., SYMONDS, R.B., CHUAN, R.L., GIGGENBACH, W. and KYLE, P.R., 1985, Rates of SO_2 and particles emitted from White Island volcano, New Zealand and an estimate of the total flux of all gaseous species (abst.): EOS, v. 66, no. 18, p. 411.

ROUVIER, H., PERTHUISOT, V. and MANSOURI, A., 1985, Pb-Zn deposits and salt-bearing diapirs in southern Europe and North Africa: Econ. Geol., v. 80, p. 666-687.

ROWAN, E.L., 1985, Stretching of fluid inclusions in fluorite at confining pressures up to one kilobar: U.S. Geol. Survey Open-File Rept. 85-471, 50 pp.

Essentially same as in Poland, 1982, Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 195, 1982. (E.R.)

ROWAN, Lanier, LEACH, D.L. and VIETS, J.G., 1985, Regional and small scale features of cathodoluminescent zonation in hydrothermal dolomite from the Viburnum Trend, southeast Missouri, and northern Kansas (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 703. Authors at U.S. Geol. Survey, P.O. Box 25046, MS 912, Denver, CO 80225.

A cathodoluminescent (CL) microstratigraphy in hydrothermal dolomite spanning the main stages of mineralization was defined in a 1985 study by R.L. Voss for the Viburnum Trend lead-zinc district, southeast Missouri. Our studies extend the CL microstratigraphy in hydrothermal dolomite from the Trend to samples in barren drill core 7 miles to the east, and 100 miles to the southwest in northern Arkansas. CL zonations in these samples are believed to be correlative with those in Viburnum Trend dolomites. Fluid inclusions in northern Arkansas hydrothermal dolomites yield temperatures and salinities similar to those of fluid inclusions in the Viburnum Trend. Regional correlation of CL and fluid inclusion observations indicates that hydrothermal fluid circulated throughout a vertically and laterally extensive portion of the stratigraphic section in southern Missouri and northern Arkansas. This observation is consistent with earlier hypotheses, based on fluid inclusion evidence alone, that fluids of a common origin were responsible for mineralization of the Viburnum Trend, Tri-State, central Missouri, and northern Arkansas districts, and for the ubiquitous trace occurrences of sulfides.

In the Bonneterre Formation of the Viburnum Trend, premineralization porosity of the host dolomite controlled the abundance of sparry dolomite exhibiting CL zonation; that abundance appears otherwise unrelated to the alteration facies known locally as "brown rock" and "white rock." Episodes of dolomite dissolution not observable in plane polarized light occur throughout the CL microstratigraphy, but are most common in the zone contemporaneous with the main stages of mineralization. Dissolution textures within this zone are far more abundant near ore than in barren drill core from east of the Trend. The cyclic dissolution and precipitation of dolomite is believed to be related to fluctuations in pH associated locally with sulfide deposition. (Authors' abstract)

RUB, M.G., KHETCHIKOV, L.N., KOTEL'NIKOVA, Z.A. and RUB, A.K., 1985, Inclusions of mineral-forming media in minerals of the Precambrian tin-bearing granitoids of the Northern Ladoga region (abst.): Abst. Seventh All-Union

Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 172-173 (in Russian; translation by D.A. Brown). Authors at IGEM, ILSAN, VIMS, Moscow, USSR.

New data have been obtained on inclusions of mineral-forming media in the minerals of all three phases of the Precambrian ore-bearing granitoids of the Northern Ladoga region. Quartz in the granites of all phases contains primary crystallized inclusions of melts, unequivocally demonstrating the magmatic nature of these granites.

Th of the melt inclusions in this quartz indicate that they were formed over a wide T range, from 970 to 650°C, which agrees with the T for the melt inclusions in the Paleozoic and Mesozoic rare-metal granites of other areas, and indicates deep-seated differentiation of the magma.

The melt inclusions in the granitoids of various phases in the complex under discussion are distinguished from each other by their Th, dimensions, the amount of gas phase, and its composition. The lowest Th values are typical of the granites of the third, concluding phase. A microprobe analysis has shown significant difference between the solid phases of the melt inclusions.

Along with the melt inclusions, there are gas-liquid inclusions (GLIs), the number of which increases in the granites of Phase 3 and reaches a maximum in the associated post-magmatic formations.

The appearance of GLIs in the granites reflects the processes of segregation of the fluid phase from the magmatic melt and essentially identifies the origin of the post-magmatic solutions, which is also reflected in their Th (≤400°C). The quantity of GLIs probably depends on the volume of the parent post-magmatic fluids, which determines the scale of ore mineralization, associated with the formation of the actual magmatic complex.

All the samples examined are marked by quite uniform three-phase inclusions (G + L + C), or two-phase forms without the gas component (L + C). It is likely that the appearance of these inclusions has been associated with post-magmatic processes, manifested after crystallization of the granites of the third, concluding phase. These inclusions in the main have a chloride composition and contain (besides Cl and Na), Ca and Mg.

In a number of cases, the solutions also contain F, the amount of which increases in the granites of the third intrusive phase, the greisenized varieties of these granites, and the accompanying post-magmatic formations.

Unfortunately, it has not been possible to determine the composition of the numerous solid phases in the inclusions from the skarns and greisens, but they may be chlorides and fluorides of metals. According to L.N. Khetchikov, the formation of the numerous solid phases in the inclusions has been associated not so much with the high concentration of the parent solutions, as with the abundance of volatiles. This agrees well with the peculiarities in composition of these formations. Thus, amongst the accessory minerals in the third-phase granites, topaz and fluorite have been found, which are the leading minerals in the greisens and in the post-magmatic formations associated with these granites.

These data have confirmed the authors' views about the inheritance of the composition of the magmatic fluids by the post-magmatic solutions. (Authors' abstract)

RUBIN, J.N., KYLE, J.R. and OLIVARES-R., Porfirio, 1985, Calc-silicate alteration and sulfide mineralization, San Martin mine, Zacatecas, Mexico (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 704. First author at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78713.

The San Martin skarn deposit was formed by intrusion of the 46 Ma Cerro de la Gloria quartz monzonite stock into the Middle Cretaceous Cuesta del Cura limestone. Ensuing hydrothermal alteration produced a metamorphic aureole consisting of calc-silicate minerals and economic concentrations of Cu, Zn, and Ag. Orebodies are centered around several large veins that roughly parallel the intrusive contact; mineralized endoskarn is locally developed. Cu and Ag decrease with increasing distance from the intrusive contact, and correlate inversely with Pb and Zn horizontally. Cu, Zn, Pb, and Fe increase with depth.

Initial metasomatism produced andraditic garnet with lesser hedenbergitic clinopyroxene, along with substantial intercrystalline pore space which was subsequently filled with sulfides. Lower temperature calc-silicates include wollastonite, epidote, chlorite, and tremolite. Metallic minerals show a paragenetic sequence of early arsenopyrite, molybdenite, pyrrhotite, bornite, and chalcopyrite; intermediate sphalerite, chalcopyrite, tetrahedrite, and galena; and late native silver, pyrite, and stibnite. Fluorite, calcite, and minor quartz postdate prograde skarn development.

Hydrothermal fluid circulation was controlled by pre-intrusion Laramide deformation and probably was enhanced by intrusion-related fracturing. The intrusive contact and the veins represent the major channels for fluid migration, with local controls affected by layers of impermeable shale and chert. Fluid inclusion data suggest that early mineralizing fluids were dominantly magmatic, with the meteoric component increasing with time. (Authors' abstract)

RUDNICK, R.L., ASHWAL, L.D., HENRY, D.J., GIBSON, E.K., Jr., ROEDDER, E., BELKIN, H.E. and COLUCCI, M.T., 1985, Fluid inclusions in stony meteorites - a cautionary note: Proc. of the 15th Lunar & Planet. Sci. Conf., Part 2, J. Geophys. Res., v. 90, Suppl., p. C669-C675. First author at Res. Sch. Earth Sci., The Australian Nat'l. Univ.

Newly discoverd fluid inclusions in thin sections of Bjurbole chondrules, shergottite EETA79001, lunar meteorite ALHA81005, and Apollo 16 glasses possess physical properties similar to those of fluid inclusions found in thin sections of five stony meteorites recently described by Warner et al. (1983). The distribution and physical properties of these new fluid inclusions indicate they may be artifacts of thin section preparation; we suggest that saw coolant was sucked into vacuum vesicles in glasses and minerals through submicroscopic fractures produced during sawing. The similarities between these fluid inclusions and fluid inclusions previously described by Warner et al. (1983) lead us to conclude that many of the fluid inclusions reported earlier may be artifacts. Consequently, the origin of any fluid inclusions observed in thin sections of extraterrestrial materials must be interpreted with caution. The most probable true extraterrestrial fluid inclusions are those that have been observed in grains prepared without exposure to liquids of any kind. (Authors' abstract)

See also Bourot-Denise et al. (1985) and Fieni et al. (1985a,b) in this volume. (E.R.)

RUDNICK, R.L., McLENNAN, S.M. and TAYLOR, S.R., 1985, Large ion lithophile elements in rocks from high-pressure granulite facies terrains: Geochimica Cosmo. Acta, v. 49, p. 1645-1655. Authors at Res. Sch. Earth Sci., The Australian Nat'l. Univ., Canberra, A.C.T. 2601, Australia.

A comparison of K, Rb, Th and U concentrations in granulite facies rocks with those of unmetamorphosed common rock types shows that depletion of these elements in granulites is variable. K/Rb ratios for granulites are generally higher than unmetamorphosed rocks, but K/Rb ratios only reach extreme values when K <1%. The covariation of K/Rb ratio with K concentration suggests that protolith composition, hence mineralogy, is very important in controlling the degree of Rb depletion in granulites. Felsic granulites exhibiting extreme K/Rb ratios are mainly Archean, reflecting the high abundance of low K felsic rocks in Archean terrains. The Scourian granulites of Scotland all have very high K/Rb ratios and cannot be considered to be representative of granulite facies terrains. It is impossible from this data set to state conclusively whether K is depleted in granulites; K/La ratios of granulites show complete overlap with igneous rocks. Th/U ratios in many granulites are greater than 4, indicating U loss relative to Th. Felsic granulites with low Th/U ratios also have high La/Th ratios, indicating that these granulites have been depleted in Th. The low Th/U ratios of these rocks may reflect retention of Th and U in resistant accessory phases. (Authors' abstract)

RUIZ, Joaquin, KELLY, W.C. and KAISER, C.J., 1985, Strontium isotopic evidence for the origin of barites and sulfides from the Mississippi Valley-type ore deposits in southeast Missouri - a discussion: Econ. Geol., v. 80, p. 773-775. First author at Dept. Geosci., The Univ. Arizona, Tucson, AZ 85721.

A discussion of a paper by Lange et al., 1983. See reply by Lange et al. (this volume). (E.R.)

RUIZ, Joaquin, KESLER, S.E. and JONES, L.M., 1985, Strontium isotope geochemistry of fluorite mineralization associated with fluorine-rich igneous rocks from the Sierra Madre Occidental, Mexico: possible exploration significance: Econ. Geol., v. 80, p. 33-42.

RUMBLE, Douglas, 1985, Carbon isotope geochemistry of hydrothermal graphite vein deposits, New Hampshire (abst.): EOS, v. 66, no. 18, p. 388.

RUMYANTSEV, V.N., 1984, Hydrogeochemical zoning and chloride brines: Manifestations of Le Chatelier's principle: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 1007-1011 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 4, p. 163-166, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 288. (E.R.)

RUMYANTSEV, V.N. and RUDNEV, V.V., 1985, P-V-T diagrams for highly concentrated solutions of sodium chloride (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 14-15 (in Russian). Authors at All-Union Inst. Mineral Raw Materials, Moscow, USSR.

The data on P-V-T parameters of NaCl solutions from experimental works of Lemmlein and Klevtsov (1961), Samoylovich (1969), Ikornikova and Egora (1968) and Urusova (1971, 1974, 1975) were elaborately smoothed and made internally consistent. They present P-V-T diagrams for 10, 15, 20 and 25-mole NaCl concentrations[sic]. The authors also suggest wider use of the Klevtsov and Lemmlein method for P determination on the basis of NaCl-rich inclusion studies. (A.K.)

But see Roedder and Bodnar, 1980a,b, in Fluid Inclusion Research--Proceedings of COFFI, v. 13, 1980, p. 210-211. (E.R.)

RUMYANTSEV, V.N., RUDNEV, V.V. and GANEEV, I.G., 1985, Gas-liquid inclusions in synthetic crystals as source of information about density of mineral-forming medium (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 39-40 (in Russian). Authors at All-Union Inst. of Mineral Raw Materials, Moscow, USSR.

Th of inclusions in quartz crystals grown from water solutions of Na_2CO_3, K_2CO_3 and Cs_2CO_3 of 0.5 mole concentration at 450°C equals about 300°C and is believed to vary regularly from 299-305°C in the lowermost part of autoclave to 306-307°C for crystals from the uppermost part. This is interpreted as the results of differences in parent solution density. However, Th for individual crystals varies in ranges from 1 to 8°C, "reflecting fluctuations in solution density during experiment." (A.K.)

RUPPEL, S.C. and DUTTON, S.P., 1985, Thermal maturation studies in the southern Texas Panhandle (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 189. Authors at Bureau of Econ. Geol., The Univ. Texas at Austin, Univ. Station, Box X, Austin, TX 78713-7508.

The thermal maturity of Permian and older rocks in the Palo Duro Basin area of the Texas Panhandle has been assessed using a number of parameters including thermal alteration index (TAI), vitrinite reflectance (R_0), conodont alteration index (CAI), and pyrolysis. Collectively, these indices suggest that most pre-Pennsylvanian and many Pennsylvanian rocks have reached at least the theoretical minimum level of thermal maturation necessary to generate oil and gas; Permian strata are probably, for the most part, immature.

Vitrinite reflectance data from Mississippian carbonates suggest that maturation levels of 0.5% R_0 are expected at about 7,000 ft (2,130 m). Data from Pennsylvanian shales, surprisingly, indicate that this level should be reached at a much shallower depth. Despite this discrepancy, which may be due to variable maturation rates associated with organic matter in different lithologies, in general, determinations of maturity based on vitrinite reflectance agree well with current heat flow patterns in the area. Present day geothermal gradients (average 1.3°F/100 ft, 23.7°C/km), for example, suggest that temperatures required to cause generation of liquid hydrocarbons (150°F, 65°C) are reached at about 7,500 ft (2,290 m). This indicates that (1) heating of the basin has not been substantially greater in the past and (2) the Palo Duro Basin has behaved essentially as a continuously subsiding basin throughout its history, that is, erosion has not removed any significant part of the stratigraphic section. (Authors' abstract)

RUSSELL, C.W. and COWART, J.B., 1985, Strontium isotope geochemistry of oil field waters in southeasten Mississippi: Evidence for fluid/rock interaction and application as a hydrologic tracer (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 705.

RUTHERFORD, M.J., SIGURDSSON, Haraldur, CAREY, Steven and DAVIS, Andrew, 1985, The May 18, 1980, eruption of Mount St. Helens 1. Melt composition and experimental phase equilibria: J. Geophys. Res., v. 90, no. B4, p. 2929-2947. First author at Dept. Geol. Sci., Brown Univ., RI.

The Mount St. Helens, May 18 pumice is a dacite containing 60% glass by weight and phenocrysts of plagioclase, orthopyroxene, amphibole, titaniferous magnetite, and ilmenite. The glass is uniform in composition, a rhyodacite with 73 wt % SiO_2; the phenocrysts are also uniform in composition except for the plagioclase, which has cores averaging An_{57} and rims averaging An_{49}. Analyses of seven pairs of coexisting Fe-Ti oxides in a representative sample of the light pumice were recast using various mineral calculation procedures; they yielded temperatures ranging from 920° to 940°C and a -log fO_2 of 10.3-10.1. Electron microprobe analyses of 57 glass inclusions trapped in plagioclase phenocrysts in the light pumice showed little deviation from an average rhyodacitic composition (69.90 ± 0.87 wt % SiO_2) when special care was taken to account for Na loss during the analysis. The difference between the average total of these glass inclusion analyses and 100% is 4.6 ± 1 wt %, which is interpreted to be volatiles dissolved in the glass. On an anhydrous basis the average glass inclusion composition is identical to the matrix glass, indicating that neither underwent significant fractionation after melt was trapped by the plagioclase. Experimentally determined phase relations for the representative dacite sample place limits on conditions in the May 18 Mount St. Helens magma chamber, assuming that the dissolved volatiles were 4.6 ± 1 wt % and the temperature was 920°-940°C. Hydrothermal experiments over a range of P.T. and fO_2 indicate that at no pressure is the observed phase-assemblage and residual melt chemistry produced when PH_2O = P(Total). Experiments using CO_2-H_2O fluids to achieve PH_2O's less than P(Fluid) did reproduce the observed residual melt chemistry and an An_{50} plagioclase at a specific set of conditions, i.e., at fO_2's between the NNO and MNO buffers, at a P(Fluid) of 220 MPa (2.2 kb), and at a PH_2O/P(Fluid) ratio was raised to 0.7 or if fluorine were added to the experimental system. It is concluded that just prior to eruption, the upper part of the Mount St. Helens magma chamber was at a pressure of 220 ± 30 MPa corresponding to a depth of 7.2 ± 1 km, PH_2O was 0.5 to 0.7 P(Total), and the temperature was 930° ± 10°C. (Authors' abstract)

RYABCHIKOV, I.D., BARANOVA, N.N., ZOTOV, A.V. and ORLOVA, G.P., 1985, Stability of Au(OH)Osol in supercritical phase of water and metal-bearing capacity of magmatic fluids being in equilibrium with granite magma: Geokhimiya 1985, no. 2, p. 267-268 (in Russian).

RYABCHIKOV, I.D., REYF, F.G., ORLOVA, G.P. and ISHKOV, Yu.M., 1985, On metal-carrying capacity of paleohydrotherms in connection with results of the laser-spectrographical analysis of fluid inclusions: Geologiya Rudnykh Mestorozhd., no. 1, p. 102-105 (in Russian). First author at IGEM, Moscow, USSR.

Calculations of the W and Mo contents in ore solutions indicated the concentrations should be 0.02-0.2 and ~0.1 g/kg of solution, respectively. However, the laser-excited spectrographic analysis of individual inclusions showed much higher concentrations in inclusion fluids: 22-87 g/l for W and 22-53 g/l for Mo. This raised the problem of calibration of the applied laser method. The check was made on artifical inclusions of "ore" solution prepared in IGEM. "Ore" solutions were prepared by dissolving of silicomolybdenic acid, KCl and NaCl in doubly distilled water; the concentration of Mo in two prepared solutions was 1.31 and 13.85 g/l. Powdered "iron-free granite" (Ab-Or-Q) with composition of minimum T melting was placed in one perforated capsule, and granular quartz (as the "trap" for fluid) in another and "ore" fluid were maintained 2 hours at 750°C, 150 MPa in reactors of "Tuttle" type. Under such conditions the silicate mixture formed melt with fluid segregations. In the end of run the samples were quenched under isobaric (±10 MPa) conditions. Mo concentration under experiment conditions was determined in "quartz trap" - amount of water was determined by drying of quartz sample at 120°C, amount of Mo by determination of metal content in quartz. For initial Mo concentration 13.85 g/l, the concentration under experiment conditions was 12 g/l. The silicate glass (product of the experiment) contained two-phase (G + L) inclusions of irregular shape, up to 50-60 µm long. Volume of phases in inclusions used later for the laser analysis were measured using Fyodorov's stage (standard deviation 0.094). Concentration of metal in inclusions was calculated with respect to volume of L phase at 20°C. Formerly, natural inclusions were heated to Th for dissolving of metal-bearing precipitate possibly present at inclusion walls. Determinations for non-heated inclusions are 60% lower than for heated ones. However, this procedure was not possible for artificial inclusions in glass because they decrepitated readily even under slight heating. Thus, the factor 60% was introduced as the correction. Fourteen artificial inclusions were analyzed. For initial Mo content 1.31 g/l the determined values were in ranges <0.4 to 2.0 g/l, average 1.0 g/l, yielding, after correction, 1.6 g/l; for initial Mo concentration 13.85 g/l (effective Mo concentration during experiment determined as equal 12 g/l) - the determined values were in ranges 3.8-17.5 and 2.2-13.5 g/l, averages 7.0 and 5.4, respectively, and after correction 11.2 and 8.7 g/l. The experiments showed that laser emission spectrographc analysis gives the metal concentrations in correct ranges. (Abstract by A.K.)

RYABOV, V.V., KONENKO, V.F. and KRASOV, N.F., 1985, Liquation phenomena in glasses from native iron ores of the Khungtukun intrusion: Dokl. Akad. Nauk SSSR, v. 285, no. 4, p. 982-987 (in Russian). Authors at Inst. Geol. & Geophysics of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

The Khungtukun intrusion (N. Siberian Platform) consists of olivine gabbro-dolerites with discontinuous layers of taxitic gabbro-dolerites in upper part. The latter contain gabbro-pegmatites, ferrogabbroes, granophyres and bodies of native iron. Glasses were found in silicate minerals and in native iron; glass globules have dimensions from 0.2 to 2 mm; their amount ranges from 10 to 20 per 1 cm^2 (of section). Five types of glass occurrence were found: I - homogeneous glass globules, II - glass globules consisting of 2 or more immiscible melts, III - glass globules with crystal phases (clinopyroxene bearing up to 15 wt. % of Al_2O_3, olivine Fa 57-67, augite Fs 35-36, plagioclase Ab 24-40 Or 0-2, Ab 59-72, apatite, ilmenite, pyrrhotite, chalcopyrite, cubanite, native Fe and Cu), IV - glass "films" between crystals, V - glass inclusions in silicates. Chemical composition of glasses varies strongly (11 analyses by electron microprobe): SiO_2 31.37-73.83%, TiO_2 0.00-10.86%, Al_2O_3 3.20-15.65%, FeO (total Fe) 2.20-38.56%, MgO 0.21-5.71%, CaO 0.60-10.85%, Na_2O 0.15-6.91%, K_2O 0.00-3.02%. Between two extreme compositions: high-Si low Fe and low Si high Fe, there are also intermediate compositions. On the diagram SiO_2-(CaO + MgO + FeO + TiO_2 + P_2O_5)-Na_2O + K_2O + Al_2O_3 the points of glass compositions occur along the immiscibility field obtained experimentally by E. Roedder. In the studied rocks clinopyroxenes crystallized at 1220-1200 and 1180-1100°C (Th). Native iron melts at 960-1060°C. (Abstract by A.K.)

RYE, R.O., 1985, A model for the formation of carbonate-hosted disseminated gold deposits based on geologic, fluid-inclusion, geochemical, and stable-isotope studies of the Carlin and Cortez deposits, Nevada, in E.W. Tooker, ed., Geologic characteristics of sediment- and volcanic-hosted disseminated gold deposits: search for an occurrence model: U.S. Geol. Survey Bull. 1646, p. 35-42. Author at U.S. Geol. Survey, Denver, CO, USA.

Includes some discussion of fluid inclusion data. (E.R.)

RYTUBA, J.J., 1985, Geochemistry of hydrothermal transport and deposition of gold and sulfide minerals in Carlin-type gold deposits, in Geologic characteristics of sediment- and volcanic-hosted disseminated gold deposits--Search for an occurrence model, E.W. Tooker, ed.: U.S. Geol Survey Bull. 1646, p. 27-34.

SAGE, J.D. and HEWITT, D.A., 1985, Variable water pressure metamorphic assemblages in the Meguma Group, Nova Scotia (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A53.

SAHAGIAN, Dork, 1985a Bubble migration and coalescence during the solidification of basaltic lava flows (abst.): EOS, v. 66, no. 18, p. 405.

SAHAGIAN, Dork, 1985b Bubble migration and coalescence during the solidification of basaltic lava flows: J. Geol., v. 93, p. 205-211.

SALEMINK, Jan, 1985, Skarn and ore formation at Seriphos, Greece: Ph.D. dissertation, Univ. Utrecht, Geologica Ultraiectina, no. 40, 232 pp.

On the island of Seriphos, Greece, the shallow intrusion of a granodiorite pluton into a series of previously regionally metamorphosed gneisses, marbles and marble-bearing schists produced a contact metamorphic aureole and extensive deposits of Ca-Fe-Mg skarns and Fe-ores. Structural and petrological investigations show that the contact metamorphic aureole was formed as a result of the (dry) thermal heating accompanying the emplacement and gradual crystallization of the magma. At or just after the time of its final solidification the granodiorite was affected by a major stage of (auto-) brecciation that caused an intense fracturing of the plutonic body as well as of the surrounding country rocks. As a consequence of the associated increase in rock permeabilities intense metasomatic-hydrothermal activities along the newly formed transport channels caused a leaching of the granodiorite of its mafic components (Fe, Mg, Mn, etc.) and a deposition of the same (Fe, Mg, Mn-) components in the skarns and ore formations in the country rocks.

Thermodynamic analyses of the observed mineral parageneses in the skarn and ore deposits show that at Seriphos metasomatism continuously took place under gradually decreasing temperature and under constant maintenance of local equilibrium between Fe-saturated, hydrothermal solutions and the solids locally present along the transport channels. Fluid inclusion studies indicate that the metasomatic 'juices' were saline $NaCl$-KCl-$CaCl_2$-$MgCl_2$-($FeCl_2$?)-brines with a dominantly magmatic origin. The fluid inclusion studies also point out that, as metasomatism progressed and temperatures dropped, fluid pressures decreased in proportion. Oxygen isotope ratios of quartz and other mineral phases from the metasomatic formations indicate that the total amount of fluid in the hydrothermal fluid flow system must have been small relative to the total amount of solid phases that equilibrated with the metasomatic solutions. Apparently a limited amount of dominantly magma-derived, saline hydrous solutions percolated along the cracks and fractures in the permeable solid rock system, transporting both heat and matter from the cooling, plutonic heat and fluid source into the adjacent country rocks. Quantitative comparison of the mass exchanges between the granodiorite pluton and the surrounding country rocks confirms that, as a whole, the metasomatic system at Seriphos must have been a largely closed system, and that there were no sources of material outside the granodiorite and its immediate environment.

On the basis of the presented evidence a mathematical model is developed, describing the coupled transfer of heat and mass during the thermal evolution of the intrusive system, both in the magmatic, intrusive stages and in the post-magmatic, hydrothermal cooling stages of the intrusive event. The total amount of Fe, for instance, that is modelled to precipitate in the contact metasomatic skarn and ore deposits is in good accordance with the field estimations. (From the author's abstract)

SALEMINK, J., DE JONG, A.F.M. and OOSTEROM, M.G., 1985, Mass transport and the origin of tungsten in and around Hercynian granites, E-Pyrenees and N-Portugal (abst.): Terra Cognita, v. 5, p. 155. Authors at Inst. Earth Sci., P.O. Box 80.021, 3508 TA Utrecht, The Netherlands.

Results are presented concerning the behavior of W in and around Hercynian granites in the Eastern Pyrenees and in North Portugal. The investigation comprises granitoids associated with W-skarns, or vein-type W-Sn mineralizations, and also barren situations. W-distributions, oxygen isotope and fluid inclusion data are compared with the behavior of major and trace elements in order to develop transport models that can be used in the search for economically important W-occurrences.

In the Pyrenean suite the investigated calc-alkaline magmatics ($\delta^{18}O<10‰$) are not enriched in W (0-5 ppm), nor in such related elements as Sn, Nb, Ta, and there is no difference in W-content between plutons associated with contact metasomatic W-deposits and barren situations. Observed W-accumulations (Costabonne) appear to be associated with the occurrence of intrusion-scale assimilations of W-containing country rocks, and to be controlled by specific conditions of contact metasomatism leading to concentrated scheelite precipitations from magma-derived, hydrous solutions in contact-nearby marbles.

In N-Portugal most of the granites studied have a much larger, homogeneous sedimentary component ($\delta^{18}O$ = 10-12‰), and higher W-contents (5-10 ppm). These granites are associated with vein-type W-Sn-(Ta)-mineralizations, and occasionally scheelite concentrations have formed from magma-derived fluids at places where (aplite bound) concentrations of transport channels cross-cut an occasional marble bed. (Authors' abstract)

SAMORUKOVA, L.M., 1985, Two kinds of early Precambrian plagiogranitoids, based on a study of inclusions of mineral-forming media (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 173-175 (in Russian; translation by D.A. Brown). Author at Inst. Precambrian Geol. & Geochron. (IGGD AN SSSR), Leningrad, USSR.

Amongst the lower Precambrian rocks, gneisses of tonalitic composition are either of deep-seated (I) or crustal (II) association. Plagiogranitoids-I are associated with rocks of basic and intermediate composition, forming multiphase bodies with them. Their characteristic peculiarity is the presence of ortho- and clinopyroxene or a high-Mg garnet amongst the rock-forming minerals. Plagiogranitoids-II display no relations with basic rocks. Only biotite and/or hornblende have been noted as femic minerals in them.

Plagiogranitoids-I are marked by two groups of inclusions with varied T. One group (in py, pl, and gn) has Th = ~950-1250°C (Tav = 1100°C from 50 determinations), with Te = 700-850°C (Tav = 770°C). The other (in pl, quartz, and gn) has Th = 780-820°C (Tav = 800°C from 25 determinations), with Te = 650-700°C. Observations on phase transformations have shown that the inclusions in granitoids-I homogenize mainly with retrograde boiling. Less commonly, homogenization takes place into the liquid phase. A study of a series of high-T inclusions in pl from the two-py quartz-diorites of the Kurkiyek Massif (Western Ladoga region) on a microprobe, have shown that the crystalline phases in them consist of labradorite and a high-Al opx, from which it may be concluded that the composition of these inclusions corresponds to that of a high-Al norite.

For the plagiogranitoids-II, Th = 780-820°C (Tav = 800°C from 47 determinations), with Te = 600-680°C. Homogenization in all cases takes place with retrograde boiling which indicates the marked water-saturation of the melts. A characteristic feature of the inclusions is the substantial content of the gas phase (⩽25%) and frequent decompression (explosion prior to homogenization, which is explained by the high fluid P, developed in the inclusions during heating.

The following conclusions have been reached:

1. Te (or solidus T) mark the conditions at the levels of crystallization of the massifs. These T are comparable with those obtained by means of the garnet-biotite thermometer and mineral equilibria for conditions of regional metamorphism at that level, where emplacement of plagiogranitoids of both kinds occurred.

2. The varying Th-Te intervals in different minerals from granitoids-I mark the succession of crystallization during the early and late stages of evolution (differentiation) of the magma focus.

3. The maximum Th of the inclusions in pl and hyp (1200-1250°C) greatly exceed the Tf of the crustal anatectic granitoids of the amphibolite and granulite facies of metamorphism. They correspond to the liquidus T of dacite, andesite, and quartz tholeiite. The association between granitoids-I and 'basite' chambers is also indicated by the presence of melt inclusions, corresponding in composition to a high-Al norite.

4. The maximum T (780-820°C) obtained for plagiogranitoids-II, are much lower than those for plagiogranitoids-I, but insignificantly exceed the T of metamorphism at the level of their crystallization. Such T are typical of crustal-anatectic magma-formation.

An analysis of the fliud composition of high-T gas chromatography has shown that a common peculiarity of both kinds of plagiogranitoid is the high water-saturation of low K(red)[? reduction]. In addition, the fluid of granitoids-I has markedly more CO_2, which, allowing for the experimental data on the solubility of H_2O and CO_2 in melts, may serve as an indicator of the great depth of generation of the original melts as compared with granitoids-II. (Author's abstract)

SAMSON, I.M., DAVIS, W.J. and WILLIAMS-JONES, A.E., 1985, Fluid inclusion studies on the Mount Pleasant W-Mo-Sn deposit, New Brunswick (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A54. First author at Mineral Explor. Research Inst. (MERI), P.O. Box 6079, Station A, Montreal, Quebec, H3C 3A7, Canada.

At Mount Pleasant, vein and disseminated W-Mo-Sn-Cu-Zn-As mineralization is hosted by a Lower Carboniferous, multi-stage, subvolcanic, granitic stock that was emplaced in quartz-feldspar porphyry. 'Porphyry' W-Mo mineralization is associated with silicified and greisenized breccia zones that grade downward into an unmineralized, fine-grained granite. The quartz-greisen zone is surrounded by zones of quartz-chlorite-muscovite alteration, which extend into the quartz-feldspar porphyry. Sn and polymetallic sulfide mineralization is associated with a later stage of granite-porphyry dykes and chlorite-fluorite alteration.

Greisenization and associated W-Mo mineralization was associated with the exsolution of a high-salinity (>30 equiv. wt. % NaCl), fluorine-rich aqueous fluid from the early fine-grained granite. Homogenization temperatures of such inclusions, typically by salt disappearance, range from about 200 to 490°C. Saline fluids were also present in the peripheral chlorite-muscovite zone but appear later. Such fluids have not been observed in the late sulfide mineralization. Low-salinity, liquid-rich (<7 equiv. wt. % NaCl) inclusions are volumetrically dominant in all samples. Such inclusions are typically late in the gresien zones and early in the mica alteration zones (including the sulfide stage), and probably represent heated meteoric waters (Th = 100 to 350°C). Secondary, vapor-rich inclusions are common in all zones, indicating the common occurrence of boiling, possibly related to a pressure decrease associated with brecciation and/or cooling and a drop in pressure during exsolution of a supercritical, magmatic fluid. (Authors' abstract)

SAN, Lin, LIU, Xiaodong and WU, Wunjing, 1985, Temperature-controlling-type semiconductor cooling stage: Acta Mineral. Sinica, v. 5, no. 1, p. 85 (in Chinese; English abstract). Authors at East China Geol. College.

A temperature-controlling-type semiconductor cooling stage was designed and manufactured by the authors in collaboration with Tianjing Cooler Factory in June 1983. This type of cooling stage can keep constant temperature at a certain degree for a long time. The icepoint can be determined more accurately in full consideration of time. The stage can achieve high precision in keeping constant temperatures. Cooling temperature reaches -70°C without using any coolers, such as liquid nitrogen. Such a cooling stage is a new experimental tool for fluid inclusion study. (Authors' abstract)

SANDERS, Laura and ECKSTEIN, Yoram, 1985, Geochemistry and paleotemperatures of petroleum-bearing formation waters from the lower Silurian "Clinton" sandstone, eastern Ohio (abst.): Geol. Soc. Am. Abst. with Programs, v. 17, p. 324. Authors at Dept. Geol., Kent Univ., Kent, OH 44242.

Formation waters of the major production zones in the lower Silurian "Clinton" sandstone were sampled in 76 oil wells of eastern Ohio. The "Clinton" sandstone consists of interbedded deltaic sandstone and shales. It is confined between the Upper and Lower Cabot Head Shales, which are considered as the source of hydrocarbons in the reservoir.

The samples were analyzed by emission plasma spectroscopy and specific ion electrode methods to determine the concentrations of Na, K, Ca, Mg, Ba, Li, Sr, Zn, Fe, Mn, B, and Cl. The formation waters are heavy brines with total dissolved solids concentration approximately ten times that of seawater. NaCl and $CaCl_2$ account for 98% of the total dissolved solids. The brines are enriched in Ca, Sr, and Li, and depleted in Na, Mg, and K with respect to the normal evaporation curve of seawater.

Average equivalent-magnesium to magnesium ratio is 5.8, indicating that dolomitization may have been a factor in brine evolution. Lack of any consistent correlation between Ca/Na ratio and Cl suggests that membrane filtration did not significantly affect the brines; however ion exchange is being considered as a possible factor in brine evolution.

Temperatures of last water-rock equilibrium were calculated using a Na-K-Ca geothermometer with correction for excess Mg. The temperatures ranged from 65° to 117°C, considerably higher than the average 40°C reported from temperature measurements in "Clinton" sandstone. Assuming that the calculated temperatures of last water-rock equilibrium represent paleotemperatures in "Clinton" sandstone, the comparison of the difference between the old and present time temperatures with the average regional geothermal gradient may facilitate evaluation of the amount of uplift and erosion of the Appalachian Plateau. (Authors' abstract)

SANDERS, P.A. and GIORDANO, Thomas, 1985, Geology of the Kingston mining district, with detailed work on the Black Colt mine (abst.): New Mexico Bureau of Mines & Min. Resources Circular 199, September 1985, p. 55. First author at Redco Silver Inc., Enterprise, UT.

The Kingston mining district is located on the east flank of the Black Range, approximately 50 miles east of Silver City. The district produced more than six million oz. of Ag prior to 1904. The majority of the mineralization occurs between two major N-NW-trending faults which define the eastern structural margin of the Emory caldron. A crude zonation occurs in the district; mines to the south and west have abundant copper, while mines to the east and north have abundant manganese. The Black Colt mine is located in the Mn-rich zone. At the Black Colt the primary mineralization occurs along ESE-WNW-trending fissure veins with related replacement deposits in the Fusselman Dolomite. Pods of massive sulfide, containing pyrite-alabandite-sphalerite-galena-minor acanthite-chalcopyrite (oldest-youngest) occur in a barren quartz vein. Pyrite-sphalerite-galena (oldest-youngest) occur in a rhodochrosite-calcite-quartz gangue in the adjacent replacement deposits. Two types of sphalerite have been distinguished, a dark, marmatitic sphalerite with abundant chalcopyrite blebs and a brown, resinous sphalerite lacking the chalcopyrite. Fluid-inclusion Th for the brown sphalerite range from 307 to 332°C, while the quartz T range from 187 to 351°C. Limited sulfur-isotope analyses suggest disequilibrium during deposition. (Authors' abstract)

SÄNDIG, Rainer, 1985, Numerical calculation of the Onsager transport coefficients for isothermal binary electrolytes: J. Solution Chem., v. 14, no. 5, p. 311-331. Author at Sektion Physik Wilhelm-Pieck-Univ. Rostock, DDR-2500 Rostock, Germany.

Of pertinence to diffusion calculations in solutions of strong electrolytes up to the molar region. (E.R.)

SANFORD, R.F. and LUDWIG, K.R., 1985, Lead isotopic evidence on the origin of hydrothermal veins, Lake City, Colorado (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 706.

SANKAR, Munessar, MACASKILL, J.B. and BATES, R.G., 1985, Activity coefficients of hydrochloric acid and ionic interactions in the system $HCl-LiCl-H_2O$ from 5 to 45°C: J. Solution Chem., v. 14, no. 5, p. 333-344.

SANO, Yuji, URABE, Akiko, WAKITA, Hiroshi, CHIBA, Hitoshi and SAKAI, Hitoshi, 1985, Chemical and isotopic composition of gases in geothermal fluids in Iceland: Geochem. J., v. 19, p. 135-148. First author at Lab. Earthquake Chem., Fac. Sci., The Univ. Tokyo, Bunkyo-ku, Tokyo, Japan.

We have measured chemical compositions (CO_2, CH_4, N_2, O_2, H_2S, H_2, He, Ne and Ar), and isotopic compositions of light elements ($\delta^{13}C$, $\delta^{15}N$ and δD) and of rare gases (He, Ne, Ar, Kr, and Xe) in seven gaseous and four fluid samples collected in Icelandic geothermal areas. Major chemical constituents of the gas samples are CO_2, N_2, H_2 and H_2S. Isotopic compositions of Ne, Kr and Xe are indistinguishable from those of the atmosphere within the experimental accuracy of this study. There are slightly lower $^{40}Ar/^{36}Ar$ ratios than in the air for samples with extremely high $^3He/^4He$ ratios. No positive evidence for excess ^{129}Xe is found. The measured $^3He/^4He$ ratios in the samples can be explained in terms of mixing among three end members: MORB-type He with a $^3He/^4He$ ratio of 1.1×10^{-5}, plume-type He of 5.0×10^{-5}, and atmospheric He of 1.4×10^{-6}. Samples obtained from the northeastern part of the island contain typical MORB-type He, whereas significant contributions (up to 33%) of plume-type He are apparent in samples from the southern region. Based on the $^{13}C/^{13}C$ ratios, CO_2 in Icelandic gases is considered to be directly derived from magma, whereas CH_4 may be formed by reaction of reduced carbon with water in the source magma. There is an inverse correlation between the $^3He/^4He$ ratios and $\delta^{15}N$ values in Icelandic gases, suggesting co-genetic origin of He and N_2. (Authors' abstract)

SANTOSH, M., 1985a Fluid evolution characteristics and piezothermic array of south Indian charnockites: Geology, v. 13, p. 361-363. Author at Centre Earth Sci. Studies, P.B. 2235, Sasthamangalam, Trivandrum-695010, India.

The Precambrian granulite facies metamorphism that gave rise to the charnockites of south India involved the activity of chemically distinct fluids that evolved progressively from early high-density carbonic (1.0-0.95 g/cm^3) through moderate-density carbonic (0.75-0.65 g/cm^3) and mixed carbonic aqueous to low-salinity and moderate-density aqueous (0.88-0.65 g/cm^3) types. The pressure-temperature conditions recorded by fluid inclusions define a piezothermic array that is characterized by higher convexity toward the temperature axis than the array defined by the locus of metamorphic geotherms obtained from mineral assemblages. The convexity depicts a fast rate of uplift that exceeded the rate of heat transfer. The carbonic metamorphism resulting in the formation of charnockites was achieved under high $P(CO_2)$ conditions by the transfer of juvenile CO_2 from the upper mantle. (Author's abstract)

SANTOSH, M., 1985b Crystal growth of zircons in Puttetti syenite: Nature of fluids and implications on CO_2 activity: J. Geol. Soc. of India, v. 26, p. 695-703. Author at Centre for Earth Sci. Studies, P.B. 2235, Sasthamangalam, Trivandrum 695010, India.

Fluid inclusion studies in a number of doubly polished plates of zircons showing interesting features are documented. The equilibrium balanced shapes of inclusions and their pattern of distribution are suggestive of slow growth rate, largely controlled by [a] stacking mechanism, resulting in completed layers. Development of tensional fractures which eventually healed by dendritic growth and typical necking-down textures of long tabular inclusions are recorded. Thermometric studies show that the early fluids were of high density (0.90-0.85 g/cm^3)CO_2 type with probable traces of CH_4 and/or N_2, entrapped at a pressure of 4.5 kb. The fluids evolved into pure CO_2 (0.83-0.68 g/cm^3) and to mixed CO_2-H_2O around 650°C and 3.7 kb due to formation of a vapor phase, while a fraction of the melt was still present. The composition of fluids recorded suggests repeated CO_2 activity in south India with a peak during Late Precambrian-Early Palaeozoic times, affecting the generation and emplacement of alkaline plutons. (Author's abstract)

SASADA, Masakatsu, 1985a CO_2-bearing fluid inclusions from geothermal fields: Trans. Geothermal Resources Council 1985, 6 pp. Author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

Three semi-quantitative methods to estimate the CO_2 concentration of the geothermal fluid trapped in fluid inclusions are described. The crushing method is applicable for the estimation of the low CO_2 concentrations present in most geothermal fields. Intermediate CO_2 is estimated from the presence of clathrate only on freezing, and high CO_2 is estimated from liquid CO_2 at room temperature or on freezing. Their concentrations are calculated within the limits where Henry's Law is obeyed. These methods are then applied to the fluid inclusions from some boiling system. Crushing studies reveal the low CO_2 of the boiling fluid at Hohi, Japan. Formation of clathrate but not liquid CO_2 on freezing inclusions from Broadlands, N.Z. suggests heterogeneous trapping of CO_2-bearing boiling fluid. Liquid-CO_2-bearing vapor-rich inclusions from Tuscany, Italy indicate formation from a local isolated hydrothermal system under more than hydrostatic pressure. (Author's abstract)

SASADA, Masakatsu, 1985b Microthermometry of fluid inclusions from the VC-1 core hole in Valles Caldera, New Mexico (abst.): EOS, v. 66, p. 1081. Author at Geol. Survey of Japan, Tsukuba, Ibaraki 305, Japan.

Fluid inclusions in quartz and calcite from core samples of the VC-1 hole were studied with microscope heating/freezing and crushing stages. They are liquid-rich. Most homogenization temperatures (Th) are above the present well temperature, but some Th of primary inclusions from 515 m and those of secondary inclusions from 723 m fit the present well temperature curve measured 10 months after completion of the well. The maximum temperature recorded by the primary inclusions is 274°C from hydrothermal quartz in the Sandia formation 811 m in depth. The total range of Th for samples from several depths (90°C) indicates cooling from the maximum temperature.

The salinity of fluid inclusions in hydrothermal quartz and calcite is generally low, ≤ 1 wt % NaCl equiv. High salinity fluid, up to 5 wt % NaCl equiv., has been found in several calcite veins from the lower part of the Madera limestone. The salinity decreases with decrease of Th of the secondary inclusions, and that with the lowest Th at the lower part of the Madera limestone is similar to those from the other depths. These data show that the early hot water circulation system involved several types of fluid, whereas the later one was a homogeneous fluid.

The salinity of fluid inclusions in detrital quartz (presumably inherited inclusions) is higher than that in hydrothermal minerals. Some of these inclusions show an extraordinarily low temperature of final melting point of ice, ~-40°C, suggesting that a $CaCl_2$ component is present.

CO_2 contents in fluid inclusions were estimated by the bubble behavior on crushing. Crushing results indicate that the CO_2 content of the early fluid is ≥ 3.5 wt %, and that of the later fluid is ~0.2-0.3 wt %. (Author's abstract)

SASSEN, Kenneth, LIOU, K.N., KINNE, Stefan and GRIFFIN, Michael, 1985, Highly supercooled cirrus cloud water: confirmation and climatic implications: Science, v. 227, p. 411-413.

SAUNDERS, J.A. and ROMBERGER, S.B., 1985, Ore petrology and geochemistry of Tertiary gold telluride deposits of the Colorado mineral belt (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 707. Authors at Colorado Sch. Mines, Golden, CO 80401.

Epithermal gold telluride deposits from the Colorado mineral belt share a number of similarities: relationship to alkalic stocks; high fluorine and CO_2 content; and similar parageneses. Petrography of deposits in the Jamestown, Cripple Creek, and La Plata districts has resulted in a composite paragensis: early Fe-Cu-Pb-Zn sulfies + hematite; tetrahedrite; high Te tellurides (calaverite, krennerite, sylvanite); low Te tellurides (coloradoite, petzite, altaite, hessite); late native gold. Fluid inclusion studies suggest telluride deposition occurred below 200°C from low salinity (fluids less than 5% NaCl eq). Gangue and alteration mineralogy indicates the ore fluids were near neutral pH during telluride deposition. The presence of hematite and locally barite suggest relatively oxidizing conditions. Evaluation of thermodynamic stabilities of tellurides and aqueous tellurium species indicates that progressive oxidation is consistent with the observed ore mineral parageneses. Available data on gold bisulfide and chloride complexes suggest neither were important in the transport of gold in these systems. Thermodynamic data suggest the ditelluride ion (Te_2^{2-}) predominates in the range of inferred physiochemical conditions for the transport and deposition of gold in these systems.

Inferred complexes such as $AsTe_2^-$ could account for the gold transport, and oxidation would be the most effective mechanism of precipitation of gold telluride or native gold. Published data suggest the associated alkalic stocks may be the ultimate source of the metals, since they are enriched in Au, Ag, Te, As, and Bi. (Authors' abstract)

SAVEL'YEV, V.S., OGLOBLINA, A.I., FLOROVSKAYA, V.N., RUDENKO, A.P. and KULIKOVA, I.I., 1984, Polycondensation of carbon monoxide with hydrogen: A possible mechanism for production of natural polycyclic aromatic hydrocarbons: Dokl. Akad. Nauk SSSR, v. 275, no. 3, p. 733-736 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 275, no. 3, p. 141-144, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 299. (E.R.)

SAVIN, S.M. and LEE, M., 1984, Estimation of subsurface temperatures from oxygen isotope ratios of minerals, in Thermal Phenomena in Sedimentary Basins, B. Durand, ed.: Int'l. Colloquium, Bordeau, June 7-10, 1983, Collection Colloques et Séminaries 41, Editions Technip, Paris, 1984, p. 65-70.

SCHELLEN, A.D., 1985, Microthermometric study of fluid inclusions in hydrothermal quartz and scheelite of the Salau deposit, Pyrénées Orientales, France (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 203.

The first measurements were made on quartz of skarns and granodiorite of the upper and middle levels of the mine. Two-phase hydrothermal inclusions are 90 vol.% liquid. Te (-75°C to -69°C) indicate probably a high concentration of several dissolved species such as NaCl, $CaCl_2$... These inclusions homogenize around 260°C in skarns and between 185°C and 210°C in granodiorite.

The lowest level of the mine shows a hydrothermal ore containing pyrrhotite, quartz and a large amount of scheelite. In quartz and scheelite, large two-phase inclusions can be seen. The aqueous phase fills 10 to 75% of the total volume of the inclusion. Generally the other phase is an immiscible liquid. A vapor bubble nucleates in the non-aqueous phase on cooling. It is to be expected that this phase is H_2S-rich because of its melting temperature (-90°C to -60°C) and because only three [inclusions showing] partial homogenization in the vapor phase have been observed (the other inclusions show partial homogenization in the liquid phase). Most inclusions decrepitate before homogenization. Identification by Raman microprobe is necessary for interpretation of microthermometric behavior of both kinds of inclusions. (Author's abstract)

SCHERKENBACH, D.A., SAWKINS, F.J. and SEYFRIED, W.E., Jr., 1985, Geologic, fluid inclusion, and geochemical studies of the mineralized breccias at Cumobabi, Sonora, Mexico: Econ. Geol., v. 80, p. 1566-1592. First author at Noranda Explor., Inc., 139 E. 51st Ave., Anchorage, AK 99503.

Cumobabi is a Cu-Mo-mineralized breccia-hosted deposit. Three types of well-developed primary inclusions (vapor, moderate-salinity liquid, and high-salinity liquid phases) are abundant in stage I quartz. The distribution of salinities of the inclusions suggest that episodic boiling of a probable magmatic fluid at 440° to 350°C accompanied and may have been responsible for mineral deposition. Episodic boiling is supported by (1) separation of inclusion salinities, (2) absence of intermediate salinity inclusions in quartz, (3) zoning of quartz crystals, with each zone representing a renewed boiling event, and (4) variation of pressure between hydrostatic and lithostatic load. A comparison of data from Cumobabi to experimental data on the $NaCl-H_2O$ system suggests that boiling of a 6 to 9 wt percent solution at depths of 1.0 to 1.5 km may have formed two residual phases: a low-salinity vapor phase and a 30 to 50 wt percent salinity liquid rich in metal cations. The resulting concentration produced by boiling gave rise to a varied daughter mineral suite. Many of the daughter minerals from type III inclusions were identified under the SEM. Hematite, chalcopyrite, and delafossite [$CuFeO_2$], along with halite and sylvite, were common. Other unidentified daughter minerals were shown to contain Cu, Fe, Mn, and Zn, with anions presumed to be oxide, hydroxide, or carbonate. These results suggest that solutions are capable of carrying sufficient metals to form an ore deposit but may be deficient in reduced sulfur. In addition, the close association of molybdenite deposition with boiling suggests that such boiling is an important ore-forming process.

Fluid inclusion-rich quartz samples from the mineralized breccia pipes were analyzed for gas and solute components. Gases were analyzed after vacuum line extraction by mass spectrometry, whereas solute components were extracted by leaching techniques and the washings analyzed by DC-plasma atomic emission spectrometry. Gas and liquid analyses along with appropriate thermodynamic data permitted computation of temperature dependent ionic equilibria, including pH and fO_2. These data provide requisite information to constrain fluid chemistry responsible for hydrothermal alteration and metallogenesis at Cumobabi.

Computed reaction paths involving interaction of an NaCl brine with a hypothetical quartz monzonite rock illustrate the role of water/rock ratio on hydrothermal alteration at Cumobabi and the effect of temperature and metal mobility. Reaction path calculations demonstrate, for example, that high water/rock ratios stabilize sericite and propylitic assemblages at a constant temperature. Silicate reactions control pH, whereas fO_2 controls sulfide deposition. Under the conditions modeled here Mo never exceeds concentrations of 3 ppm in solution, whereas Cu can be maintained in solution at 3,000 ppm. Temperature reduction results in albitization of feldspar and precipitation of sulfides, drastically reducing metal contents in solution. (From the authors' abstract)

SCHIFFMAN, Peter, BIRD, D.K. and ELDERS, W.A., 1985, Hydrothermal mineralogy of calcareous sandstones from the Colorado River delta in the Cerro Prieto geothermal system, Baja California, Mexico: Min. Mag., v. 49, p. 435-449. First author at Inst. Geophys. & Planet. Physics, Univ. California, Riverside, CA 92521, USA.

In this system, progressive devolatization reactions within carbonate-cemented, quartzofeldspathic sediment have produced a distinct hydrothermal mineral zonation at temperatures between 200-370°C and fluid pressures below 0.3 kbar. (From the authors' abstract)

Part of the data obtained from fluid inclusion studies. (E.R.)

SCHIFFRIES, C.M., 1985, Reconnaissance study of fluid inclusions in the Bushveld Complex (abst.): EOS, v. 66, no. 18, p. 418. Author at Dept. Geol. Sci., Harvard Univ., 20 Oxford St., Cambridge, MA 02138.

The Bushveld Igneous Complex is the largest exposed layered igneous intrusion and the greatest repository of magmatic ore deposits. Although there is a vast literature about this extraordinary Complex, the role of hydrothermal processes in influencing the observed features has been largely neglected. Microthermometric measurements demonstrate that a wide variety of hydrothermal fluids were present in the Complex.

Small (<10 μm), two phase (L-V) aqueous inclusions predominate within the layered sequence. An upper bond of -40°C was placed on the eutectic melting temperature (Te) of inclusions in samples from widely separated parts of the Complex. The low values of Te indicate that $CaCl_2$ is probably present in the fluids. Final melting temperatures indicate salinities of 10 to 25 weight percent NaCl equivalent for many inclusions. Three-phase inclusions with a halite daughter crystal are locally common. Some samples contain either CO_2- or CH_4(?)-rich inclusions in addition to aqueous inclusions. The CH_4 inclusions homogenize to a liquid in the range -84 to -116°C. The CO_2 and CH_4 inclusions are of special interest because primary graphite has been reported in association with mineralization in both the Bushveld and Stillwater Complexes. (Author's abstract)

SCHLEISS, W.A., BORNHORST, T.J. and RUOTSALA, A.P., 1985, A study of vein mineralization and wall rock alteration at the Delaware mine, Keweenaw County, Michigan (abst.): Abstracts, 31st Annual Inst. on Lake Superior Geology, Kenora, Ontario, May 8-9, 1985, p. 85-86. Authors at Mich. Tech. Univ., Dept. Geol. & Geol. Engrg., Houghton, MI, USA.

The Delaware mine is one of the oldest copper mines in the Michigan native copper district.

Fluid inclusion studies of calcite from eleven veins were conducted to constrain the T of the mineralizing fluids. Th of 136 inclusions ranged from 80°C-280°C, uncorrected for P. Analyzed inclusions were isolated, did not follow obvious fractures, and showed no evidence of necking down. A histogram suggests two and possibly three T peaks: (A) 110-130°C, (B) 160-200°C(?), and (C) 230-260°C. Fluid inclusion Th must be corrected for P. Livnat's (1983) inferred P of 1.5 kb for this part of the stratigraphic column yields a P correction of +125° resulting peak Tt (325-385°C) seems too high. Wall rock adjacent to veins is mildly to intensely chloritized, sericitized, carbonatized, and silicified. Plagioclase in basalt is generally albitized but where the basalt is cut by veins plagioclase is altered to sercite and chlorite and olivine is wholly or partly altered to serpentine. (From the authors' abstract)

SCHMIDT-MUMM, A., 1985, Some theoretical aspects of the solute-solvent interactions in the system CO_2-H_2O (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 110. Author at Inst. Geol. und Dynamik der Lithosphäre Univ. Gottingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

For a large number of processes in solution chemistry, the information obtained through thermodynamics does not sufficiently explain the observed phenomenona. Especially for the complex natural solution systems, mostly mixtures of water and one or several other components, further information concerning the predictability of solvent-solute interactions is of great interest. An often used classification for the ions is the distinction between "hard" and "soft" electron donors and acceptors. Through this classification some of the commonly observed element associations can be explained. For fluid systems the variation of dielectricity, dipole moment, and desolvation and their effect on the complex formation of the solutes was investigated in the CO_2-H_2O system and it can be shown that the solvation of the various metal cations is highly dependent on the composition of the solvent. Especially the CO_2 content is effective for the selective solubility of some cations. The coincidence of certain specific conditions can serve as a mechanism for the enrichment of certain elements. (Author's abstract)

SCHOLLE, P.A. and HALLEY, R.B., 1985, Burial diagenesis: Out of sight, out of mind, in N. Schneidermann and P.M. Harris, eds., Carbonate Cements, Symp. Soc. Econ. Paleon. & Mineral., p. 309-334.

Includes a discussion (p. 328) of fluid inclusion data from the literature on diagenesis. (E.R.)

SCHRADER, H.-W., 1985, A "three-phase inclusion" in an emerald from South Africa: J. Gemm. & Proc. Gemm. Assoc. of Great Britain, v. 19, no. 6, p. 484-485. Author at Inst. Edelsteinforschung, Univ. Mainz, W. Germany.

Presents a photo of an inclusion showing a cube (NaCl?), liquid and vapor in an emerald "said to be" from the Cobra mine in South Africa. (E.R.)

SCHRADER, H.-W., 1985, Three-phase inclusions in an emerald from South Africa: Z. der Deutschen Gemmologischen Gessll., v. 34, no. 3/4, p. 130-131 (in German).

The first description of a three-phase inclusion (L, V, and NaCl(?)). (E.R.)

SCHREURS, J., 1984, The amphibolite-granulite facies transition in West Uusimaa, S.W. Finland. A fluid inclusion study: J. Metamorphic Geol., v. 2, p. 327-341. Author at Inst. Aardwetenschappen, Vrije Univ. Amsterdam, De Boelelaan 1085, Amsterdam, The Netherlands.

This work presents the results of a fluid inclusion study of an amphibolite-granulite facies transition in West Uusimaa, S.W. Finland. Early fluid inclusions in the granulite facies area are characteristically carbonic (CO_2), in contrast to predominantly aqueous early inclusions in the amphibolite facies area. These early inclusions can be related to peak metamorphic conditions (750-820°C and 3-5 kbar for peak granulite facies metamorphism). Relatively young CO_2 inclusions with low densities (<0.8 g/cm^3) indicate that the first part of the cooling history of the rocks was characterized by a near isothermal uplift.

N_2-CH_4 inclusions, with compositions ranging between pure CH_4 and pure N_2 (Raman spectral analysis), were found in the whole area. They are probably syn- or even pre-early inclusions. Only nearly critical homogenizing inclusions have been found (low density). P estimates, based on densities of early fluid inclusions, show that the rapid transition of amphibolite towards granulite facies metamorphism is virtually isobaric. Granulite facies metamorphism in West Uusimaa is a thermal event, probably induced by the influx of hot, CO_2-bearing fluids. (Author's abstract)

SCHREURS, J., 1985, The West Uusimaa low pressure thermal dome, SW Finland: Ph.D. disseration, Univ. Amsterdam, Amsterdam, The Netherlands, 179 pp.

The West Uusimaa Complex in SW Finland comprises a series of Precambrian, Svecokarelian (± 1800-1900 Ma.) volcano sedimentary and intrusive rocks, which have been metamorphosed under granulite-facies conditions. The complex belongs to a belt of supra- and infracrustal rocks, generally metamorphosed in amphibolite-facies conditions. High-grade areas, such as the West Uusimaa Complex occur only locally.

The scope of this study is the characterization of the medium- to high-grade transition zone in terms of P, T and P(fluid) of metamorphism. This transition zone crosscuts lithological unities, which permits the investigation of similar rocks at different metamorphic grade.

Prograde changes deduced from mineral chemistry are related to the prograde introduction of CO_2 in the crystal structure. The fluid-inclusion study reveals the predominance of CO_2 inclusions in samples of the West Uusimaa Complex, contrasting to predominantly H_2O inclusions in the amphibolite-facies domain. The densities of early CO_2 inclusions suggest entrapment at pressures of 3 to 5 kbar, which is in agreement with independent metamorphic estimates. The densities of late CO_2 inclusions indicate a quick uplift of the whole region after peak metamorphism. CH_4-N_2 inclusions have no relation with metamorphic grade nor with a specific rock-type. Their low densities suggest a late entrapment, which is, however, contradicted by the presence of low density CH_4-N_2 inclusions interspersed between high density CO_2 or H_2O inclusions.

Granulite-facies metamorphism in West Uusimaa is isochemical, as is shown by a comparison of whole-rock chemical data of both metamorphic domains. The resemblance of chemical trends in extrusive- and intrusive rocks suggests a common origin, thus the intrusive rock-suite probably intruded its own extrusive volcanic derivatives. Both have distinct calc-alkaline characteristics.

Geothermo- and geobarometry by a number of independent methods and based on mineral-chemical data of both metamorphic domains gives P, T and P(fluid) metamorphic estimates: 550-650°C/3-5 kbar and $PH_2O = 0.4$ P(tot) for the amphibolite-facies domain and 700-825°C/3-5 kbar and $0.1<PH_2O<0.4$ for the West Uusimaa Complex. CO_2-rich cordierites and the predominance of CO_2 fluid inclusions in the granulite-facies domain indicate a high PCO_2. The West Uusimaa Complex is interpreted as a thermal dome, generated at high T conditions and possibly associated with the influx of CO_2-rich fluids from deeper parts of the crust. (From the author's summary)

SCHREYER, Werner, 1985, Experimental studies on cation substitutions and fluid incorporation in cordierite: Bull. Minéral., v. 108, p. 273-291.

SCHRÖN, V.W. and BLANKENBURG, H.-J., 1985, The geochemistry of agates: Z. Geol. Wiss.-Berlin, v. 13, no. 5, p. 675-684 (in German; English abstract).

A study of the trace elements in agate. See also Thomas and Blankenburg, 1981, Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 265-266, 1983. (E.R.)

SCHWARZ, D. and MENDES, J.C., 1985, Comparative study of inclusions in emeralds from Itabira (Minas Gerais) and Santa Terezinha (Goiás), Brazil: Anais do 3O Simpósio de Minas Gerais, Belo Horizonte, (Proceedings of 3rd Symposium of Geology of Minas Gerais), Bull. 5, p. 154-164 (in Portuguese; English abstract). Authors at the Federal Univ. Ouro Preto, Minas Gerais, Brazil.

A classification of the most important inclusions in emeralds from the mines of Itabira/MG and Santa Terezinha/GO is given. While the emeralds from the Itabira mine are principally characterized by the appearance of different types of growth tubes and a large difference in fillings (two-, three-, or multiphase-inclusions), the most interesting inclusion group in the Santa Terezinha emeralds are the mineral inclusions. The following have been identified: picotite, carbonate(s), pyrite, talc, mica, emerald, chalcopyrite(?) and pentlandite(?). More uncommon inclusion features in the Santa Terezinha emeralds are: an irregular color distribution, growth lines, two-phase inclusions and central areas with an elevated inclusion concentration. Mineral inclusions are rare in the emeralds from Itabira mine. Besides the growth tubes and the different cavity fillings, disk-like fractures are typical. (Authors' abstract)

SCOTT, S.D., 1985, Seafloor polymetallic sulfide deposits: Modern and ancient: Marine Mining, v. 5, no. 2, p. 191-212.

SEAL, R.R., II, CLARK, A.H. and MORRISSY, C.J., 1985, The Lake George polymetallic Sb-W-Mo deposits, southwestern New Brunswick (abst.), in R.P.

Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 223-225. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

The hydrothermal veins and veinlets can be divided into three major groups on the basis of their economic commodities, mineralogy and associated alteration. In order of formation, these are: the scheelite- and molybdenite-bearing veinlets (which can further be divided into three subgroups); the economic stibnite-quartz veins; and barren calcite veinlets. The first sub-group of scheelite- and molybdenite-bearing veinlets (Type 1) consists of 5-50 mm wide, calc-silicate/quartz veinlets with zoned, calc-silicate alteration envelopes. Fluid inclusion data indicate that mineralization occurred from 550°C to perhaps as low as 250°C, from a solution of moderate salinity (av. 8.5 equivalent wt. % NaCl). The dominant controls on scheelite (and molybdenite) deposition were decreasing temperature, dependent on distance from the cupola, and increasing pH, controlled by interaction with the wall-rocks.

Fluid inclusion and mineralogical evidence indicates that Type 2 hydrothermal activity occurred from 400 to 175°C, with temperatures locally exceeding 550°C, under a confining pressure of approximately 1.3 kb. These veinlets initially formed from a homogeneous fluid, containing approximately 6.7 equivalent wt. % NaCl (av.) and 17 mole % dissolved CO_2, that subsequently underwent CO_2-effervescence, commencing at approximately 305°C. As in Type 1 veinlets, scheelite (and molybdenite) deposition was controlled by decreasing temperature and increasing pH, but in this case pH was controlled by CO_2-effervescence.

Type 3 veinlets, consisting of prehnite, molybdenite and quartz, represent a volumetrically minor veinlet type. (From the authors' abstract)

SELVERSTONE, Jane and SPEAR, F.S., 1985, Metamorphic P-T paths from pelitic schists and greenstones from the south-west Tauern Window, Eastern Alps: J. Metamorphic Geol., v. 3, p. 439-465. First author at Dept. Geol. Sci., Univ. Colorado, Boulder, CO 80309, USA.

Petrological data from intercalated pelitic schists and greenstones are used to construct a pressure-temperature path followed by the Upper Schieferhülle (USH) series during progressive metamorphism and uplift in the south-west Tauern Window, Italy. Pseudomorphs of Al-epidote + Fe-epidote + albite + oligoclase + chlorite after lawsonite and data on amphibole crystal chemistry indicate early metamorphism in the lawsonite-albite-chlorite subfacies of the blueschist facies at $P \leq 7$-8 kbar. Geothermometry and geobarometry yield conditions of final equilibration of the matrix assemblage of 475 ± 25°C, 5-6 kbar; calculations with plagioclase and phengite inclusions in garnet indicate early garnet growth at pressures of ~7.5 kbar. Garnet zoning patterns are complex and reversals in zoning can be correlated between samples. Thermodynamic modelling of these zoning profiles implies garnet growth in response to four distinct phases of tectonic activity. Fluid inclusion data from coexisting immiscible H_2O-CO_2-NaCl fluids constrain the uplift path to have passed through temperatures of 380 ± 30°C at 1.3 ± 0.2 kbar.

There is no evidence for metamorphism of USH at pressures greater than ~7.5 kbar in this areas of the Tauern Window. This is in contrast to pressures of ≥ 10 kbar recorded in the Lower Schieferhülle only 2-3 km across strike. A history of differential uplift and thinning of the intervening section during metamorphism is necessary to reconcile the P-T data obtained from these adjacent tectonic units. (Authors' abstact)

SEN'KOVSKIY, Yu.N. and KOVALISHIN, Z.I., 1985, The composition and genetic nature of gases from inclusions in druses of quartz crystals from Albian spilites in the southwest of the East European Platform (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 210-211 (in Russian; translation by D.A. Brown). Authors at IGGGI Acad. Sci. Ukrainian SSR, L'vov, USSR.

In the region of Khotyn in the Dnester River area, in spilites in the upper Albian gaize-spongolite sequence, there is a seam (≤2 m) of a highly-siliceous (SiO_2 ≤96%) chalcedony of metasomatic origin, containing cavities lined with quartz crystal druses, along with barite and "papierspath" calcite.

Mass-spectrometric analysis of gases from the quartz has shown that H_2 (48.7%) and N_2 (40.3%) predominate, plus minor CO_2 (7.7%). $\sum C_nH_{2n+2}$ compounds make up 3.3%.

The origin of the gas presumably has resulted from catagenesis of organic matter, enclosed in the rock. During the post-metasomatic phase of lithogenesis of the chalcedony, the low-molecular compounds of H_2-N_2-C composition participated as an interstitial phase in the formation and growth of the crystals of quartz and its fibrous and cryptocrystalline variety, chalcedony. (From the authors' abstract)

SEYFRIED, W.E. and JANECKY, D.R., 1985, Heavy metal and sulfur transport during subcritical and supercritical hydrothermal alteration of basalt: Influence of fluid pressure and basalt composition and crystallinity: Geochimica Cosmo. Acta, v. 49, p. 2545-2560. First author at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN 55455.

Crystalline basalt, diabase and basalt glass have been reacted with a Na-Ca-K-Cl fluid of seawater ionic strength at 350-425°C, 375-400 bars pressure, and fluid/rock mass ratios of 0.5-1.0, to assess the role of temperature, basalt/diabase chemistry and texture on heavy metal and sulfur mobility during hydrothermal alteration.

Alteration of basalt/diabase is characterized by cation fixation and hydrolysis reactions which show increased reaction progress with increasing temperature at constant pressure. Correspondingly, pH in a series of 400 bar experiments range from 4.8 to 2.7 at 350 and 425°C, respectively and is typically lower for alteration of a SiO_2-rich crystalline basalt than for other rock types, due, in part, to relatively high SiO_2 concentrations in solution. High SiO_2 concentrations stablize hydrous Na- and Ca-rich alteration phases, causing pH to decrease.

In direct response to H^+ production, dissolved Fe, Mn and H_2S concentrations increase dramatically. For early-stage reaction, H_2S-typically exceeds Fe and Mn. However, at 425°C, and after long-term reaction at 400°C, H_2S is lost from solution, apparently in response to pyrite replacement of oxide and silicate phases.

Pyrrhotite formed at temperatures ≤375°C, whereas magnetite was identified in all run products, except from basalt glass alteration.

Cu and Zn concentrations in solution are not simple functions of pH. These metals achieve greatest solubility in fluids from experiments at 375-400°C, except when basalt glass is used as a reactant. The relatively low concentration of these species in solution during basalt glass reaction may be due to adsorption by fine grained alteration phases. (From the authors' abstract)

SHAN, L., LIU, X.D. and WU, W.J., 1985, Uranium exploration by radon measurement in inclusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 713. Authors at The East-China Geol. College, Fuzhou, Jiangxi, China.

Exploration for uranium by measuring radon in the inclusions of minerals is a survey technique developed in recent years. Two methods exist: radon measurement in inclusions in bedrock and in the sediments of water systems. The former method is used at the stage of uranium survey and exploration and its principle may be described as follows: The inclusion halo of uraniferous secondary inclusions is formed on a large scale in the rocks adjoining hydrothermal U-deposits. If samples are selected from bedrock at a given range and then heated, the inclusions will decrepitate and, as a result, give off radon. After the measurement of the relative content of radon with radon-meters, one can outline the anomalous areas of radon, which will be the indicators of the location of blind U-orebodies. As for the second method, its principle lies in that the diffusion haloes may be distributed in the sedimentary sands of water system as a result of the weathering, disintegration and transportation of bedrock containing U-deposits. Therefore, the anomalous areas can be determined by measurement of radon in the inclusions in sedimentary sands, which will be conducive to U-ore-formation.

Field and laboratory work done in recent years using the radon measurement method has yielded successful and promising results, showing some advantages of this method over the commonly used gamma, eman, hydrochemical and other methods. (Authors' abstract)

SHANKS, W.C., III and SEYFRIED, W.E., Jr., 1985, Sulfur isotopic fractionation, anhydrite dissolution, and sulfate reduction: Juan de Fuca Ridge and other seafloor hydrothermal vent systems (abst.): EOS, v. 66, no. 46, p. 928-929.

SHARP, Z.D., ESSENE, E.J. and KELLY, W.C., 1985, A re-examination of the arsenopyrite geothermometer: Pressure considerations and applications to natural assemblages: Can. Mineral., v. 23, p. 517-5534 Authors at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109, USA.

Comparisons are made with inclusion Th data. (E.R.)

SHATAGIN, N.N., 1984, Mathematical modelling of liquation exsolution of ore magmas: Geolog. Rudnyk Mestor., v. 26, no. 5, p. 73-80 (in Russian).

SHATSKY, V.S., SOBOLEV, N.V. and TOMILENKO, A.A., 1985, Fluid inclusions in some eclogites and country rocks (abst.): Second Int'l. Eclogite Conf., Terra Cognita, v. 5, p. 443. Authors at Inst. Geol. & Geophysics, 630090 Novosibirsk-90, USSR.

Fluid inclusions in eclogite minerals of schist-gneiss and glaucophane-schist complexes in Europe (West Norway, Austria, GDR, FRG) and Asia (Kazakhstan, Kirgizia in the USSR) have been studied. Fluid CO_2 inclusions have been found in eclogites from West Norway gneisses (Gurskoy, Nordfjord), in garnet and quartz, the most dense inclusions (ρ is 1.14 to 1.18 g/cm^3) being observed in garnet whereas the inclusion density in quartz is 1.04 to 1.09 g/cm^3.

Fluid nitrogen inclusions (ρ is 0.81 to 0.78 g/cm^3) are present in quartz in Münchberg massif (FRG). Inclusions of similar composition are typical also of quartz from eclogites occurring in the form of interlayers in garnet peridotite bodies of Czech massif (Zöblitz, GDR) as well as in eclogites from Saualpe (ρ is 0.60 to 0.68 g/cm^3) and Koralpe (ρ is 0.68 to 0.76 g/cm^3) (Austria). Inclusions of several generations are found in quartz from eclogites of Kokchetav massif (Kazakhstan). The fluid inclusions corresponding to the earliest stages of metamorphism are represented by fluid CH_4 (ρ is 0.40 to 0.44 g/cm^3) which are substituted on later stages by CO_2-H_2O-salt inclusions (ρ is 0.58 to 0.91 g/cm^3). For country rocks, a similar trend is noted in composition evolution of fluid inclusions, i.e., from the earliest inclusions of fluid methane (ρ is 0.42 to 0.44 g/cm^3) to those of CO_2-H_2O-salt (ρ is 0.9 to 1.0 g/cm^3).

Single- and two-phase inclusions of methane (ρ is 0.16 to 0.36 g/cm^3) as well as fluid methane and water-salt solution are found in metagabbro from Koralpe (Austria). Fluid CO_2 inclusions (ρ is 1.07 to 1.09) are present in eclogites from Makbal uplift (Kirgizia). At the same time, single- and two-phase inclusions of water-salt solutions are noted in quartz of eclogites from glaucophane schist complex of Atbashi ridge (Kirgizia). The investigations carried out resulted in determination of all species and varieties of known metamorphogenic inclusions (CO_2, CO, N_2 and water-salt) in minerals of eclogites studied. The data obtained indicate the lack of correlation of fluid phase and metamorphic conditions of eclogite-bearing complexes. (Authors' abstract)

SHAW, G.H., SYBELDON, L.M. and CALDWELL, D.A., 1985, Ultrasonic equation of state for water and NaCl-water solutions at high pressure and temperature (abst.): EOS, v. 66, no. 18, p. 423.

SHAYDETSKAYA, V.S., 1985, The geochemical features of relict mineral-forming solutions in halite from Devonian rock salt in the Dneprovsk-Donets Basin (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 194-195 (in Russian; translation by D.A. Brown). Author at IGGGI Acad. Sci. Ukrainian SSR, L'vov, USSR.

With the object of clarifying the conditions of formation of the Devonian salt deposits and assessing their potassium prospects, the amounts of K, Mg, and SO_4 in individual inclusions were made by the ultra-microchemical method of Petrichenko (1973). The microcolorimetric method (Kalyuzhnyy et al., 1966) was used to determine ferrous and ferric iron, and also boron. Al, Cu, La, Mn, Si, Ti, Sr, and Cr were determined by the semi-quantitative spectroscopy [X-ray fluorescence?] on dry residues of solutions from inclusions. Th, pH, and Eh of the solutions from inclusions were also measured.

It has been shown that inclusions in sedimentary halite belong exclusively to the chloride ($CaCl_2$) chemical type; SO_4 has not been found in the solutions. The average composition of the principal elements is as follows: K, 8.7; Ca, 72.2; and Mg, 31.4 g/L. In normal sections through the salt-bearing sediments, from base to top, there is a regular decrease in the amount of Ca and an increase in K in the solutions. In sedimentary halite from the rock salt of some salt structures, dm crystals of sylvite were observed in the solutions. Th of these inclusions is 63-65°C. Fe^{3+} and Fe^{2+} in the solutions constitutes 0.0001 to 0.01%, and the concentration of ammonia and boron is <25 and <50 mg/L respectively. Cu, La, Mn, Cr, Ti, Al, and Si (0.0007-0.009%) and Sr (0.0004-0.06%) have also been found. The pH value, measured on opening the inclusions, varies from 4.5 up to 6.0. The Eh measurements vary from +40 to 200 mV.

Inclusions in epigenetic halite belong to the chloride type. The main components in them are Ca, Na, Mg, K, and Cl. The average amount of K is 15.8, Ca 98.8, and Mg 28.0 g/L. Distribution of the main components in recrystallized halite through the stratigraphic sequence is similar to that in the sedimentary form. Fe is usually present in the solutions; Fe^{3+} occurs in greater amount (0.001-0.01) than Fe^{2+} (0.001-0.005%). As in the solutions from inclusions in sedimentary halite, the concentration of ammonia and boron does not exceed 25 and 50 mg/L. X-ray analysis of the dry residues has revealed ammonia[sic], Cu, La, Sr, Cr, and Mn (0.0004-0.009), Ti (0.001-0.009), and Si (0.007-0.009%). The pH of the solutions varies within the same limits (4.5-6.0) as in the sedimentary halite, and Eh varies from -160 to +200 mV. Th in the various kinds of inclusions in epigenetic halite are significantly different. Th of the two-phase GLIs, in which the liquid phase is oil, varies from 82 to >120°C. For the GLIs, where the liquid phase is an aqueous solution, Th varies from 38 to >120°C, and in the two-phase inclusions with sylvite dm it ranges from 45 to 99°C. (From the author's abstract)

SHCHEKA, S.A., MALAKHOV, V.V., ROMANENKO, I.M. and MALAKHOVA, V.G., 1985, The fluid regime of the basite-ultramafic magmas (based on inclusions in minerals) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 149-150 (in Russian; translation by D.A. Brown). Authors at Far Eastern Geol. Inst. of Far Eastern Sci. Center of Acad. Sci. USSR, Vladivostok, USSR.

A qualitative attempt has been made to estimate the differences in the gas-fluid regime of basite-ultramafic magmas of varying ore-capacity, by studying the gas-salt inclusions in the minerals. The authors used gas chromatography at high T and microprobe analysis. Inclusions in ol from intrusive basites and ultramafics of different ore-capacity were examined, and also those from lherzolitic and ol-an xenoliths in alkaline and tholeiitic basalts. The gas phase of the secondary inclusions was removed by preliminary heating in He. During analysis of the solid residue in the ruptured GLIs, salts of Na, K, and Ca were used as standards on the microprobe, enabling the authors to make semiquantitative determinations.

The salt composition of the inclusions clearly reveals the specific nature of the intrusions of differing ore-capacity and the xenoliths in the volcanics. The high-T (1160°C) chromite-bearing lherzolites of Kamchatka are marked by inclusions with NaCl-KCl composition and a trace of $CaSO_4$. The ol inclusions in the Ti-bearing troctolites of Dzhgdzhur (T = 950°C) show a predominance of Na and Ca carbonates with traces of $CaSO_4$. The dunites of Northern Near-Baikalia (T = 920°C), with their commerical Cu-Ni mineralization, are distinguished by the KCl-NaCl composition of the salts with a trace of K_2CO_3 and $CaCO_3$, wheres S compounds are lacking. The [inclusions in the] ultramafic xenoliths in the basalts, differ in their salt assemblage, both from the intrusions, and between themselves. The xenoliths from the alkali-basalts are rich in chlorides and sulfates of K and Na, whereas those from the tholeiitic basalts, have only NaCl, reflecting the well-known specific nature of these two kinds of magmas.

The above data show that the low T 'intrusive' ol are most rich in the gas phase, with water predominating. In the minerals of the low-T intrusions, there is a predominance of CO_2, whereas the high-T xenoliths in the volcanics are marked by reduced gases. An intermediate position is occupied by the high-T chromite-bearing intrusions and the ol-an xenoliths in the basalts, in which there is a significant role played by H_2 and CO, with increased CO_2 concentrations. According to the phase diagrams, such ratios of CO_2 and H_2 are formed as the T rises and P falls, which agrees with the subvolcanic nature of these rocks.

On the CH_4-H_2-CO_2 diagram, all the compositions of the gas phase from the various basites and ultramafics are grouped together along the CH_4-CO_2 line. Near the CH_4 apex lie the compositions of gases from diamonds and iron meteorites, and at the CO_2 apex, those from intrusive rocks and impactites. Lunar rocks, xenoliths in volcanics, and high-T intrusions occupy an intermediate position. This trend marks the general evolution of the H_2-CH_4 juvenile fluids during their ascension into various crustal depths.

Thus, the basite-ultramafic magmas of varying ore-capacity are clearly separated with respect to the alkaline and alkaline-earth metals and anions in the fluid, and display a tendency toward an increase in the reduced nature of the gas phase as Tc rises. (Authors' abstract)

SHCHERBAN, I.P., 1985, Estimation of ore content for low-temperature metasomatites through paleotemperature gradients (data on listvenites-beresites and argillizites): Geol. Zbornik-Geol. Carpathica, v. 36, no. 3, p. 369-373. Author at Inst. Geochem. & Physics of Minerals, Ukraine Acad. Sci. of USSR, prosp. Palladina 34, 252 680 Kiev-180.

The article deals with the data on paleotemperature gradients for various types of ore fields. The author arrives at a conclusion on the possibility of the estimation of ore content for listvenites-beresites and argillizites through the analysis of the above-mentioned data and their comparison with the experimental ones. (Author's abstract)

SHCHIRITSA, A.S., D'YAKONOVA, L.V. and ZVOL'SKIY, V.S., 1985, Improved heating stage for studies of inclusions of mineral-forming fluids (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 98-100 (in Russian). Authors at Inst. Geol. of Petroleum, Kiev, Ukraine, USSR.

The described heating stage is an improved version of Kalyuzhnyi's stage with higher heat conductivity, yielding maximum uniformity of temperature field in the working chamber, resulting in better accuracy of the Th determinations. Authors use nickel metal for the stage inner body. Internal part consists of two nickel rings (see figure). External ring 1 is fixed on the stage box, and heating coil (2) is placed on it. Internal ring 3, freely placed in the external one, contains the thermocouple (chromel-copel), which pierces the pyrophyllite insert 4 several times for the best contact with specimen. Thermocouple wires are led through hole 5 and the inner cylindrical body of the stage (6), and fixed to the stage box 9 by screws 7. The inner body is covered by plate 8 made of pyrophyllite and fixed by the same screws. The space between inner body and outer box is filled with asbestos, soaked with [sodium] silicate and calcined. Sufficient thermoinsulation allowed increasing the window diameter to 8-9 mm; windows are made from mica sheets. Stage box is fixed on thermoisolating ebony plate 10. Working T of this stage is ≤600°C with T measurement accuracy ~1%. (A.K.)

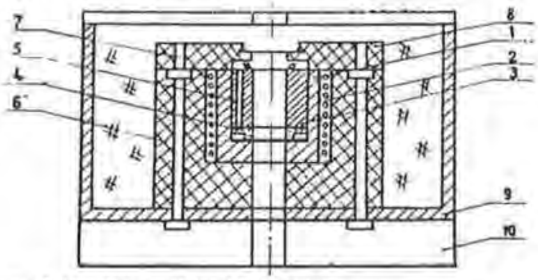

Figure. Scheme of the improved heating stage.
1 - Outer heat-conducting ring; 2 - heating coil, 3 - inner heat-conducting ring, 4 - pyrophyllite insert with thermocouple, 5 - hole for thermocouple, 6 - inner cylindrical body of the stage, 7 - screws, 8 - cover plate of the inner body, 9 - box of the stage, 10 - ebony plate.

SHEARER, C.K., PAPIKE, J.J. and LAUL, J.C., 1985, Chemistry of potassium feldspars from three zoned pegmatites, Black Hills, South Dakota: Implications concerning pegmatite evolution: Geochimica Cosmo. Acta, v. 49, p. 663-673.

SHEARER, C.K., PAPIKE, J.J. and LAUL, J.C., 1985, Pegmatite/wallrock interactions, Black Hills, South Dakota: Exomorphic aureoles as indicators of pegmatite fluid composition (abst.): EOS, v. 66, no. 18, p. 415. First author at South Dakota Sch. Mines & Tech., Rapid City, SD 57701.

Exsolution of a fluid phase during crystallization of a volatile-rich pegmatitic melt provides a medium for fluid transport of relatively incompatible elements out of the pegmatite system and into surrounding country rock. Interaction between pegmatite-derived fluids and country rock can result in the formation of extensive exomorphic aureoles. Compositional characteristics of these aureoles are dependent upon fluid composition and therefore provide an indirect method for constraining the chemistry of pegmatite fluids. Aureoles adjacent to three Black Hills pegmatites (Etta, Peerless, Bob Ingersoll I) illustrate the relationship between aureole characteristics, pegmatite mineralogy and possible fluid composition. The aureole associated with the Etta pegmatite (spodumene-bearing, tourmaline-poor) is enriched in alkali elements (Rb, Cs, Li), whereas, the aureoles associated with the Peerless and Bob Ingersoll I pegmatites (spodumene absent; tourmaline and lepidolite or lithia mica bearing) are enriched in alkali elements, F and B. Fluid compositions approximated from trace element modeling and extent of halogen substitution in sheet silicates indicate pegmatite-derived solutions have relatively high solute concentrations (alkali elements >1000 ppm) and exhibit compositional differences between pegmatites. The most noticeable differences in fluid compositions are (1) alkali element ratios Rb/Cs and Rb/Li decrease in the order Peerless-Bob Ingersoll I-Etta, (2) boron content is relatively high in the fluid phase derived from the Bob Ingersoll I and Peerless pegmatites, and (3) log [f(H_2O)/f(HF)] ranges from 3.7 to 4.5. Low [f(H_2O)/f(HF)] of the fluid phase associated with the Bob Ingersoll I and Peerless pegmatites may be responsible for the stability of lepidolite and lithia mica relative to spodumene in these pegmatites. (Authors' abstract)

SHELNUTT, J.P. and NOBLE, D.C., 1985, Premineralization radial dikes of tourmalinized fluidization breccia, Julcani district, Peru: Econ. Geol., v. 80, p. 1622-1632. First author at College of Mines, Univ. Arizona, Tucson, AZ 85741.

Fluid inclusions containing cubes of halite ± sylvite are present in some quartz fragments within the breccia dikes and in phenocrystic quartz in dacite lava adjacent to the dikes. Estimated salinities require minimum trapping temperatures of about 260° to 450°C and show that fluid pressures during dike emplacement at times were appreciably greater than hydrostatic pressures. A few inclusions contain relatively large grains provisionally identified as hematite, anhydrite and/or gypsum, and carbonate, indicating the existence of solutions rich in these components.

The high boron concentrations and highly saline fluid inclusions in the breccia dikes, the radial dike pattern, the high fO_2 and fS_2 of the magmas, and the general magmatic-hydrothermal history all suggest that the breccia dikes at Julcani were produced by the explosive release of magmatic fluids from a pluton crystallizing beneath the central part of the district. (From the authors' abstract)

SHENG, Jifu, 1985, Mineralization and alteration of the Cihai iron deposit: Bull. of the Inst. Min. Deposits, Chinese Acad. Geol. Sci., Series II, 1985, no. 3, Serial no. 15, p. 89-107 (in Chinese; English abstract). Author at Inst. Min. Deposits, Chinese Acad. Geol. Sci., PRC.

Includes many determinations of Td of various minerals. (E.R.)

SHENG, Jifu and LI, Yidou, 1985, Application of the scanning electron microscope in the study of daughter minerals in fluid inclusions: Yanshi Kuangwu Ji Ceshi, v. 4, no. 3, p. 242-245 (in Chinese; English abstract). Authors at Inst. Miner. Deposits Geol., Chin. Acad. Geol. Sci., PRC.

In the study of daughter minerals in fluid inclusion the scanning electron microscope (SEM) has the advantages of high magnification, good image of the morphology, great depth of focus and ease of sample preparation. In addition, it is equipped with X-ray detector and photograph apparatus.

The first part of this paper briefly discusses the principle of the SEM; the second part describes in more detail the selection and preparation of samples and the experimental procedures of the SEM study; the third part introduces the application of SEM in the study of daughter minerals in fluid inclusions.

The authors observed daughter minerals in fluid inclusions from the Xihuashan tungsten deposit, South China and [identified] sylvite, halite, wolframite and chlorite. [These and previously published] results indicate that the study of daughter minerals in fluid inclusions by use of SEM has a bright prospect. (Modified by E.R. from authors' abstract)

SHENG, Jifu, LI, Yidou, LE BEL, L. and GIULIANI, G., 1985, A study of fluid inclusions and metallogenesis of the Xihuashan tungsten deposit: Bull. Inst. Min. Deposits, Chinese Acad. Geol. Sci., Ser. III, no. 14, p. 44-61 (in Chinese; English abstract). First author at Inst. Min. Deposits, Chinese Acad. Geol. Sci.

Fluid inclusions in the famous Xihuashan wolframite-quartz veins were studied. Tm CO_2, Tm ice, Tm CO_2 hydrate, Th CO_2 V-L, and Th (total) were determined (Chaixmeca); gas composition was determined (Raman microprobe); and dms were studied (SEM), leading to conclusions:

1) Four types of inclusions are recognized: (a) liquid CO_2-bearing triphase; (b) biphase gaseous; (c) biphase liquid; and (d) dm-bearing triphase. Types (a), (b) and (d) are largely early stage primary, while type (c) is S late stage.

2) The early ore fluids are related intimately to W-Sn-Be mineralization and belong to a CO_2-rich $NaCl$-H_2O system with H_2O:CO [CO_2?] = 2.6-12 (molar). Salinity is 5-10 wt.% NaCl equiv. Tungsten and tin mineralization took place under 290-340°C and 1000 bar. The late fluids, however, are closely related to mineralization of the sulphide stage and carbonate stage and belong to a CO_2-poor H_2O-NaCl system with $H_2O:CO_2$ >18 (molar). Salinity is 1-5 wt.% NaCl equiv. Mineralization of the late stages occurred under 200-260°C and <1000 bar.

3) NaCl, KCl, wolframite, muscovite, chlorite, quartz and other dms were found.

4) The gas generally contains >93% CO_2, plus minor CH_4, N_2 and other components.

5) Many of the early fluid inclusions related to tungsten mineralization were trapped under boiling conditions, causing major precipitation of wolframite, forming rich ore masses within the vein. (From the authors' abstract)

SHEPARD, M.D., 1985, Geology and mineralization of the Hermosa mining district, Sierra County, New Mexico: New Mexico Bureau of Mines & Mineral Resources Cir. 199, p. 17-24. Author at 2633B Granite NW, Albuquerque, NM 87104.

The majority of the ore deposits occur in two genetically related forms: (1) as irregularly distributed sulfide pods, stringers, and pipe-like bodies along steeply dipping fissure veins, and (2) as thin, concordant replacements just beneath the Silurian-Devonian unconformity. Both types show strong affinities for talc, with lesser amounts of calcite and quartz. Primary ore minerals include galena, sphalerite, and chalcopyrite, typically in coarse-grained aggregates, with finer concentrations of acanthite, tetrahedrite, polybasite, pyrargyrite, and stephanite.

Fluid inclusion thermometry indicates that the ores precipitated between 240 and 350°C (pressure corrected) from weak to moderately saline solutions (2.1 to 11.4 equivalent wt. % NaCl). The ore deposits are prime examples of unconformity-controlled mineralization within the ring-fracture zone of a major mid-Tertiary cauldron. (From the author's abstract)

SHEPHERD, T.J., 1985, Role of basinal brines in the evolution of magmatic-hydrothermal ore systems in SW England (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 112. Author at British Geol. Survey, 64 Grays Inn Road, London WC1, UK.

Thermometric studies of granite-associated mineral deposits in the eastern part of the Hercynian tin/tungsten province of SW England confirm the presence of $CaCl_2$-rich ore solutions. The inclusions which carry these fluids have very low Te (below -50°C) and show phase changes which conform with the system $NaCl-CaCl_2-H_2O$. These fluids are noticeably absent during the early high temperatue quartz-cassiterite-wolframite-tourmaline stage (350-480°C) [but] are present during the following quartz-polymetallic sulphide stage (<350°C) and dominate the final stages of mineralization. They are best developed in the N-S trending quartz-fluorite-barite-Pb-Zn veins which postdate the normal E-W trending Sn-Cu-W-As veins. Here the inclusions have Th of 110-170°C and compositions of 10 wt% NaCl + 13 wt% $CaCl_2$. Such fluids are similar to the basinal brines associated with the formation of fluorite deposits on the margins of stable blocks adjacent to deep sedimentary basins reported elsewhere in Europe. Temperature-salinity trends indicate progressive mixing of the $CaCl_2$-rich fluids with low to moderate salinity hydrothermal fluids (5-15 wt% NaCl) throughout the period of mineralization.

Rare earth element patterns for fluorite from both environments support this hypothesis. Preliminary strontium isotopic data for the fluids will also be presented. (Author's abstract)

SHEPHERD, T.J. and ALLEN, P.M., 1985, Metallogenesis in the Harlech Dome, North Wales: A fluid inclusion interpretation: Mineral. Deposita, v. 20, p. 159-168. First author at Isotope Geol. Unit, British Geol. Survey, 64-78 Gray's Inn Road, London WC1, England.

A regional fluid inclusion study of Cu-Au (+Zn-Pb) mineralization in the Harlech Dome area, North Wales, gives support to the concept of two distinct metallogenic episodes. The inclusion assemblages associated with the porphyry copper mineralization at Coed-y-Brenin are consistent with a genetic model of early potassic-propylitic alteration overprinted by later phyllic alteration. High salinity fluids, normally characteristic of potassic alteration, are confined to the host rock quartz. The meteoric/hydrothermal system is closely linked to the emplacement of late-Cambrian diorites. Integrated fluid inclusion and mineralogical studies of the Gold-belt veins suggest that the mineralizing fluids were probably dehydration waters released from weakly metamorphosed Cambrian and perhaps Precambrian sediments during hydraulic fracturing in a tensional zone at the close of the Caldeonian orogeny. Localization of economic concentrations of gold in veins at the level of the Clogau Formation is ascribed to a destabilization of metal complexes caused by a change in fluid buffering from a pyrite-magnetite assemblage in the Lower Cambrian sediments to a pyrite-pyrrhotite-graphite assemblage in the Upper Cambrian sediments. Veining associated with the Coed-y-Brenin porphyry copper deposit and related breccia pipes can be distinguished from the copper-gold veins of the coextensive Dolgellau Gold-belt by the presence in the former of inclusions notably richer in CO_2. Furthermore the Gold-belt fluids have a distinctive low $CO_2/CH_4 + N_2 + H_2$ ratio. (Authors' abstract)

SHEPHERD, T.J., MILLER, M.F., SCRIVENER, R.C. and DARBYSHIRE, D.P.F., 1985, An integrated model for Sn-W-Cu deposits in the Hercynian metallogenic province of SW England (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 218.

Fluid inclusion thermometric, gas and isotopic data for various Sn-W-Cu deposits spatially associated with the Hercynian granites of eastern SW England suggest they represent different stages in the evolution of a metalliferous magmatic fluid and its interaction with local groundwaters. Fluid evolution is characterized by a series of "immiscibility cascades;" each cascade influencing the nature and style of mineralization. At Hemerdon, the tungsten ores were deposited from a boiling, low salinity (<12 wt% NaCl), CO_2-rich fluid at 375°-450°C and 250-400 b. Elsewhere mixing with formation fluids was important, especially during the cooler stages of ore deposition. $CaCl_2$-rich brines associated with the E-W trending polymetallic veins indicate a closer chemical and temporal link with the N-S trending base metal veins than hitherto suspected. Significant time intervals between granite magmatism and mineralization cast doubt on established magmatic-hydrothermal models for SW England and emphasize the heterogeneous nature of the Cornubian metallogenic province. The anomalously high level of $CO_2(+N_2)$ in tungstaniferous fluids serves to distinguish them from stanniferous fluids and constitutes a potential exploration signature of tungsten. (Authors' abstract)

SHEPHERD, T.J., RANKIN, A.H. and ALDERTON, D.H.M., 1985, A practical guide to fluid inclusion studies: Glasgow, Blackie & Son, 239 pp., $59.95. First author at Br. Geol. Surv., London, Great Britain.

"A useful bench manual for researchers and advanced students in geology and geochemistry, and for researchers in mineral exploration laboratories" (from the fly leaf). This book consists of 10 chapters (and a 3-page index):

1. The nature, occurrence and geological significance of fluid inclusions.
2. Sample selection and preparation for microscopic examination.
3. Optical examination.
4. Basic principles of thermometric analysis.
5. Heating-freezing stages.
6. Practical aspects of thermometric analysis.
7. Presentation and interpretation of thermometric data.
8. The chemical analysis of fluid inclusions - theoretical considerations.
9. The chemical analysis of fluid inclusions - practical considerations.
10. Future trends in fluid inclusion studies.

This book contains a large amount of interesting and useful material, but has numerous shortcomings, detailed in a rather derogatory review by R.J. Bodnar in Econ. Geol., March-April 1986 (see next volume). (E.R.)

SHEPPARD, S.M.F., 1984, Stable isotope studies of formation waters and associated Pb-Zn hydrothermal ore deposits, in Thermal Phenomena in Sedimentary Basins, B. Durand, ed.: Int'l. Colloquium, Bordeau, June 7-10, 1983, Collection Colloques et Séminaries 41, Editions Technip, Paris, 1984, p. 301-317.

SHEPPARD, S.M.F. and HARRIS, Chris, 1985, Hydrogen and oxygen isotope geochemistry of Ascension Island lavas and granites: Variation with crystal fractionation and interaction with sea water: Contrib. Mineral. Petrol., v. 91, p. 74-81. First author at Centre Rech. Pétrogr. & Géochim., BP 20, 54501 Vandoeuvre-lès-Nancy, France.

Lavas and pyroclastics on Ascension Island contain plutonic blocks that include fluid-inclusion-bearing peralkaline-granite. $^{18}O/^{16}O$ ratios, F and Cl have been analyzed on whole rocks and/or minerals for lavas and granites, and D/H ratios and H_2O^+ for comenditic obsidians and granites. Whole rock $^{18}O/^{16}O$ ratios of fresh alkali-basalt, hawaiite, trachyandesite, trachyte and comendite range from 6.0 to 6.9‰ with ^{18}O tending to increase with increase in SiO_2. The $\delta^{18}O$ values of the granites are from 0.0 to 0.3‰ depleted in ^{18}O relative to the comendites. Comenditic obsidians have $\delta D = -80 \pm 4‰$ and H_2O^+ ~0.3 wt. % while amphiboles from the granites have $\delta D = -56 \pm 2‰$. The O-isotope trend of the lavas is consistent with a crystal fractionation model. Fresh igneous rocks with $\delta^{18}O$ values greater than 7‰ involve processes in addition to crystal fractionation of a basaltic magma. The D/H ratios and Cl contents (~3,000 ppm) of the H_2O-poor comenditic obsidians represent undegassed primary magmatic values. The H-isotope compositions and low H_2O and Cl (167 ppm) contents of the granites are consistent with the major degassing (loss of >90% of initial H_2O) of an H_2O-saturated magma derived from the interaction of sea (or possibly meteoric) water with the H_2O-undersaturated comenditic melt. It is proposed that, associated with caldera subsidence and stopping, water was sucked in around the residual magma before the system had time to be sealed up. The H_2O-undersaturated magma consumed this H_2O with possibly some minor partial dehydration and dewatering of the hydrated volcanic roof blocks, at a pressure of about 1.5 kb. The granites are the plutonic equivalents of rhyolitic pyroclastics and not directly of the comendites. Granites from oceanic islands may, in general, be a result of generating an H_2O-saturated acid melt by such direct or indirect crustal water-magma interaction processes. (Authors' abstract)

SHERBA, G.N. and GUBAYDULIN, F.G., 1984, Origin of Bayan scheelite deposit: Geol. Rudn. Mest., v. 26, no. 3, p. 20-27 (in Russian). Authors at Inst. Geol. Sci. of Acad. Sci. of Kazakh SSR, Alma-Ata, Kazakhstan.

Scheelite ore mineralization in the Bayan deposit belongs to two types: metasomatic and vein-stockwork, with overlapping and regeneration of ore associations. Tungsten source was intrusions of early granodiorites and late granites plus possibly partly wall rocks. Ores formed from hydrothermal solutions at temperatures (Th) 350-200°C, but early quartz and quartz-feldspar associations developed at about 420°C; Th of inclusions in scheelite ranged from 255 to 300°C. (Abstract by A.K.)

SHI, Jixi, LI, Benchao and CAO, Junchen, 1985, Studies of pure liquid inclusions and synthetic equivalents: Acta Mineral. Sinica, v. 5, no. 1, p. 15-22 (in Chinese; English abstract). Authors at Inst. Geochem., Acad. Sinica.

In the study of fluid inclusions, the authors have found that there exist pure liquid inclusions not only in sedimentary minerals, but also in the minerals from sedimentary-reformed and sedimentary-lightly metamorphosed ore deposits and hydrothermal ore deposits related to magmas. This kind of liquid inclusions can be formed not only in cold solutions at 50°C, but also in hydrothermal solutions. Studies of fluid inclusions in natural and synthetic minerals permit one to divide the pure liquid inclusions into two broad types: formed under low T conditions, and under specific geological conditions. Their features and modes of occurrence are quite different from those of gaseous inclusions. Experiments showed that there would appear gaseous and liquid phases when the fluid became heterogeneous by means of freezing. Then, by heating till the two phases homogenized, Th could be accurately measured. This work is of some significance in perfecting the basic theory on fluid inclusions and studying the minerogenetic theory on sedimentary and sedimentary-reformed ore deposits. (Authors' abstract)

SHIGLEY, J.E. and FOORD, E.E., 1985, Gem-quality red beryl from the Wah Wah Mountains, Utah: Gems & Gemology, v. 20, no. 4, p. 208-221. First author at Dept. Research, Gemological Inst. of America, Santa Monica, CA.

The red beryl is thought to have crystallized along fractures, in cavities, or within the host rhyolite from a high-temperature gas or vapor phase released during the latter stages of cooling and crystallization of the rhyolite magma. (From the authors' abstract)

SHIKAZONO, Naotatsu, 1985a A comparison of temperatures estimated from the electrum-sphalerite-pyrite-argentite assemblage and filling temperatures of fluid inclusions from epithermal Au-Ag vein-type deposits in Japan: Econ. Geol., v. 80, p. 1415-1424. Author at Geol. Inst. Faculty Sci., Univ. Tokyo, Bunkyo-ku, Hongo, Tokyo 113, Japan.

The assemblage electrum-sphalerite-pyrite-argentite is common in epithermal Au-Ag vein-type deposits in Japan. On the basis of the iron content of sphalerite and the silver content of electrum in this assemblage, the precipitation temperatures were estimated. The electrum-sphalerite temperatures were compared with the filling temperatures of fluid inclusions in quartz, which was considered to have grown nearly simultaneously with this mineral assemblage. Almost all electrum-sphalerite temperatures are within ±30°C of the filling temperatures, showing a reasonably good agreement. This agreement indicates that (1) the fS_2-temperature relations in the Au-Ag-S and Fe-Zn-S systems can be extrapolated to temperatures below 200°C from ≤300°C experimental data, (2) the electrum-sphalerite-pyrite-argentite assemblage probably formed at close to an equilibrium condition, and (3) the pressure corrections to filling temperatures of fluid inclusions necessary to obtain formation temperatures are relatively small (<30°C). In contrast to the precipitation temperatures for the electrum-sphalerite-pyrite-argentite assemblage, the temperatures for the electrum-sphalerite-pyrite-Ag·Se·Te mineral (naumannite, aguilarite, hessite) assemblage are not in good agreement with the filling temperatures of fluid inclusions. A less than unity activity of Ag_2S in Ag-Se-Te minerals may explain this disagreement. (Author's abstract)

SHIKAZONO, Naotatsu, 1985b Gangue minerals from Neogene vein-type deposits in Japan and an estimate of their CO_2 fugacity: Econ. Geol., v. 80, p. 754-768. Author at Geol., Inst., Faculty of Sci., Univ. Tokyo, Bunkyo-ku, Hongo, Tokyo 113, Japan.

The assemblage and mode of occurrence of common gangue minerals from more than 70 Neogene vein-type deposits in Japan have been studied and summarized. The predominant gangue minerals vary with different deposit types: quartz, chalcedonic quartz, adularia, calcite, smectite, interstratified mica-smectite, interstratified chlorite-smectite, sericite, zeolites, and kaolinite in Au-Ag-rich deposits; chlorite, quartz, sericite, carbonates (calcite, rhodochrosite, siderite), and (magnetite) in Pb-Zn-rich deposits; chlorite, sericite, siderite, hematite, magnetite, and (epidote) in Cu-rich deposits. Based on the gangue mineral assemblage, filling temperature, and preliminary analytical data on fluid inclusions, typical ranges of CO_2 fugacity (fCO_2) and temperature for Au-Ag-rich, Pb-Zn-Mn-rich, and Cu-Pb-Zn-rich deposits were determined to be 10^{-3} to 1 atm, 190° to 250°C; 10^{-1} to 10 atm, 200° to 250°C; and 10^{-1} to 10^3 atm, 200° to 350°C, respectively.

This fCO_2-temperature relationship is similar to those of active geothermal systems. This similarity and that of thermochemical calculations for the stability of gangue minerals suggest that the fCO_2 for vein-type mineralization in Japan is controlled by alteration minerals commonly occurring in the country rocks (e.g., kaolinite, plagioclase, epidote, K-mica, K-feldspar, and calcite).

From a summary of host rocks for Neogene vein-type mineralization districts in Japan, it was found that many Cu-Pb-Zn-rich vein-type deposits occur in organic-rich sedimentary rocks such as shale and mudstone as well as in altered igneous rocks. In contrast, almost all the Au-Ag-rich vein-type deposits occur in altered volcanic rocks, but only a few in sedimentary rocks. Therefore, the difference in the host rocks may explain the relatively higher fCO_2 for Cu-Pb-Zn-rich vein-type deposits and the lower fCO_2 for Au-Ag-rich vein-type deposits. (Author's abstract)

SHIKAZONO, Naotatsu, 1985, Mineralogical anf fluid inclusion features of rock alterations in the Seigoshi gold-silver mining district, western part of the Izu Peninsula, Japan: Chem. Geol., v. 49, p. 213-230. Author at Geol. Inst., Fac. Sci., Univ. Tokyo, Tokyo 113, Japan.

Propylitic and advanced argillic alterations occur in the Seigoshi gold-silver mining district, in the western part of the Izu Peninsula, Japan. The propylitic alteration has the following zonal arrangement from the deeper portion to the shallower portion: and epidote-prehnite-K-feldspar-chlorite zone; a wairakite-laumontite zone; and a stilbite-heulandite-montmorillonite zone. Lateral and vertical zoning is conspicuous in the advanced argillic alteration. The inner zone is silica-rich and this grades laterally and vertically through alunite- to clay-rich zones. Fluid inclusions from the epidote-prehnite-K-feldspar-chlorite zone are liquid-dominated and filling temperatures of this zone are in the range of 225-285°C. Filling temperatures for the zeolite zone are variable, being in the range of 240-380°C. This wide range suggests that boiling of the fluids was responsible for the zeolite zone. Filling temperatures of the advanced argillic alteration range widely from 210° to 430°C. This wide range and the coexistence of liquid- and vapor-dominated fluid inclusions in a given sample suggest that liquid-vapor separation simultaneously occurred during the advanced argillic alteration process.

It is deduced that the ranges of gaseous fugacity are quite different for each type of alteration. For instance $f(S_2)$ and $f(O_2)$ of the advanced argillic alteration are estimated to be higher than those of the propylitic alteration.

Based on the alteration mineral assemblage, chemial composition and mode of occurrence of alteration minerals, fluid inclusions, estimated ranges of gaseous fugacities, and comparison of these features with those of active geothermal systems, it is concluded that the propylitic alteration minerals were probably precipitated due to the loss of gases such as CO_2, and that the formation of advanced argillic alteration was caused by subsurface mixing of volcanic gas and/or condensed hot water with groundwater. These coexisting propylitic and advanced argillic alterations are commonly found in the other Au-Ag mining districts in Japan. (Author's abstract)

SHIMAZAKI, Hidehiko, SAKAI, Hitoshi, KANEDA, Hiroaki and LEE, M. S., 1985, Sulfur isotopic ratios of ore deposits associated with Mesozoic felsic magmatism in South Korea, with special reference to gold-silver deposits: Geochem. J., v. 19, p. 163-169.

SHIMAZU, M., 1985, Altered rhyolites as oil and gas reservoirs in the Minaminagaoka gas field (Niigata prefecture, Japan): Chem. Geol., v. 49, p. 363-370. Author at Dept. Geol. & Mineral., Faculty of Sci., Niigata Univ., Niigata, Japan.

Subsurface geology and petrography of volcanic rocks of the recently discovered Minaminagoaka gas field show that good reservoirs in the field are altered rhyolites of the mid-Miocene Nanatani Formation.

Formation temperature of secondary quartz, estimated by the measurement of the filling temperature of fluid inclusions, is ~150°C and is nearly the same as the present temperature at the bottom of the hole. (From the author's abstract)

SHIMIZU, M. and SHIKAZONO, N., 1985, Iron and zinc partitioning between coexisting stannite and sphalerite: A possible indicator of temperature and sulfur fugacity: Mineral. Deposita, v. 20, p. 314-320. First author at Univ. Museum, Univ. Tokyo, Tokyo 113, Japan.

Stannite and sphalerite coexisting with iron sulfides (pyrite and/or pyrrhotite) from Japanese ore deposits associated with tin mineralization were analyzed. Based on the iron and zinc partitioning between stannite and sphalerite, the formation temperature and sulfur fugacity for this mineral assemblage were estimated. A good correlation between stannite-sphalerite temperatures and filling temperatures of fluid inclusions and sulfur isotope temperatures was obtained. This good correlation suggests that the stannite-sphalerite pair is a useful indicator of temperature and sulfur fugacity. It is deduced that the formation temperatures are not different for skarn-type, polymetallic vein-type and Sn-W vein-type deposits, whereas the sulfur fugacities are different; sulfur fugacities increase from the skarn-type through the Sn-W vein-type to the polymetallic vein-type deposits. (Authors' abstract)

SHMONOV, V.M., VOSTROKNUTOVA, Z.N. and VITOVTOVA, V.M., 1984, Possible effect of adsorption on the concentration of fluid in pores and gas-liquid inclusions: Ocherki Fiz.-Khim. Petrol. 1984, v. 12, p. 78-84 (in Russian).

An attempt is made to delimit the pore and vacuole sizes at which surface interaction can cause differences between the composition in pores and free space, at 400-800° and 100-5000 bar pressures. The zeolite NaX (with channel diameter 12.3 A and pore volume 0.302 cm^3/g) and H_2O-CO_2 mixtures were chosen as a rock with small pores and fluids, respectively, in experiments and calculative modeling. From available data and the equation given by V.N. Balashov and G.P. Zaraishkii (1982), the effective pore-widths were calculated for the samples studied. Adsorption isotherms calculated using an equation based on theory in V.V. Serpenskii and T.S. Yakubov (1983) are presented for H_2O-CO_2 mixtures on the zeolite, for various pressures, temperatures, and compositions of fluid. Change in the configuration of pores alters the ratio of the volume of sorbed fluid to the volume in the free space of pores. Interpretation of the exptl. data on phase equils. at 400-800° and 100-5000 bar shows that correction must be applied to compositions of fluid, for pore sizes <2 μm at 100-500 bar and for 2.0-0.2 μm pore sizes at 500-5000 bar. Surface interaction can lead to noncorrespondence in the compositions of gas-liquid inclusions and the original solution at inclusion sizes <7.5 μm. (C.A. 104: 37050h)

SHMULOVICH, K.N., SHMONOV, V.M. and VITOVTOVA, V.M., 1985, Phase equilibria and thermodynamics of high-temperature fluid systems (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 101-102 (in Russian; translation by D.A. Brown). Authors at Inst. Exper. Min. Acad. Sci. USSR, Chernogolovka, USSR.

Recent investigations of phase equilibria in high-T solutions and the thermodynamics of their components have led to a quantitative prediction of the compositions of the equilibrium phases and the limits of the homogeneous solutions. In the model H_2O-non-polar gas-salt system, the compositions of the homogeneous solutions are located close to the marginal H_2O-non-polar gas and H_2O-salt systems, and as the temperature rises, the fields of homogeneity expand insignificantly. Supercritical salt precipitation leads to the limited solubility of the non-polar gases (especially CO_2) in the water-salt mixtures. Separation of the fluid phase during the early phases of distillation of hypabyssal intrusions with normal ratios of volatiles in the melt leads to the formation of two immiscible phases, differing markedly in composition, thermophysical properties, and acidity. One of them, gas-like, consists of a low-density vapor or a non-polar gas (CO_2, N_2, etc.), with acid products of hydrolysis of electrolytes, and the other consists of a water-salt, liquid-like mixture with alkaline products of hydrolysis.

At 100 MPa and 600-700°C, the heterogeneous nature of the fluid system is ensured by two possible mechanisms. In melts poor in CO_2 and other non-polar gases, dissociation of the concentrated water-salt liquid into an almost pure vapor and a salt solution is achieved. In melts with normal or increased amounts of CO_2, formation of the two phases is dependent on supercritical salting-out. Hence, the norm for hypabyssal intrusions is the stage of the two-phase state of the fluid during the magmatic interval.

When using experimental data based on phase equilibria in reconstructing the conditions of formation of the mineral associations, equality between the concentrations of the components in the natural fluid and in the experiment is assumed. The spatial boundaries of the natural fluid are the mineral faces, which under the influence of lithostatic loading may form micro- and mesopores. In such a case, the pore fluid will be completely or partially represented [by] its adsorbed phase. As a result of different reaction between the components of the solution and the surface of the minerals, the real concentration (activity) of a component in the pores will differ from that of the same component in the free volume. From the data on the adsorption of a H_2O-CO_2 mixture in a zeolite, it follows that the activity coefficient of water varies widely: in pores 50 A wide at $P = 100$ bars, $T = 800°C$, $X(H_2O) = 0.8$, the activity diminishes by 3.5 times, whereas at $P = 1000$ bars, $T = 400°C$, and $X(H_2O) = 0.2$, the activity increases by 3 times[sic].

When using thermobarogeochemical methods for assessing the fluid regime during mineral-formation, identity of composition of the gas-liquid inclusions and the fluid is assumed. For a certain relationship between the surface and the volume of the vacuole, the composition of the captured portion of the fluid, along with the absorbed phase, may differ from that of the fluid that participated in the reaction. Starting with data on the H_2O-CO_2-zeolite system, it follows that if the inclusion had been formed at $P = 100$

bars and T = 800°C, and 80 mole % water in the original solution, then in inclusions of spherical shape with dimensions of 7.5, 0.75, 0.075, and 0.0075 µm, solutions with 78, 72, 55, and 34 mole % water respectively will be captured. With P = 5 kbar, T = 400°C, and $X(CO_2) = 0.8$, the composition of the solution in an inclusion 0.75 µm in diameter will not differ from the original; at diameters of 0.075 and 0.0075 µm, the mole fraction of CO_2 is 0.68 and 0.38 respectively. (Authors' abstract)

SHUGUROVA, N.A. and TSIMBALIST, V.G., 1985, Determination of cationic composition (gold, silver, copper, lead, zinc) in liquid phase of inclusions by atomic-absorption method (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 60 (in Russian). Authors at Inst. Geol. & Geophys. Siberian Br. Acad. Sci. USSR, Novosibirsk, USSR.

In GLI in quartz the following amounts of elements were found in µg/l (detection limit in g per ml): Au 0.002 to 0.12 ($5 \cdot 10^{-9}$); Ag >0.001 to 0.23 ($2 \cdot 10^{-9}$); Pb 0.13 to 16.0 ($5 \cdot 10^{-9}$); Cu 0.8 to 14.0 ($1 \cdot 10^{-9}$); Zn 3.0 to 20.0 ($5 \cdot 10^{-8}$); Co - ($1 \cdot 10^{-9}$); Ni - ($1 \cdot 10^{-8}$); error of determinations 5 to 20%. (A.K.)

SIANISYAN, E.S., VOLKOV, V.N., SLAVYANOV, K.V. and MOROZOV, V.D., 1985, A study of gas-liquid and hydrocarbon-bearing inclusions in sedimentary rocks of petroliferous basins (as exemplified by Ciscaucasia) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 207-208 (in Russian; translation by D.A. Brown). Authors at Rostov State Univ., Rostov-on-Don, USSR.

Gas-liquid aqueous and HC-bearing inclusions in limestones, dolomites, anhydrites, salts, and minerals in joints of different generations, have been examined by vacuum decrepitation (T vac. d), and Th.

Allowing for P correction, Tmax for rocks of Mesozoic age in Ciscaucasia, is found to be 120 to 250°C, depending on the depth of maximum subsidence and the paleogeothermal regime of the region. During the interval of maximum heating of the sequence, increased paleogeothermal gradients have been established, in some sectors ≤70-80°C/km. Maps of Tmax have been compiled from the results for Ciscaucasia, on which the fields of petroleum-accumulation have, as a rule, been controlled by zones of Tmax = <200-220°C.

Inclusions of HC (oil-series) examind by chromatography and IR-spectroscopy, have been found in all the rocks. These inclusions are mainly P, but in the mineral-fillers of the joints, they are sometimes S.

Tf of the minerals in the joints varies widely (95-350°C), as does the chemical composition, from relatively fresh, $CaHCO_3$ waters to Na- and Ca-chloride brines. Analysis of these data has enabled the authors to estimate the route and conditions of migration of the HCs during the past. (From the authors' abstract)

SIDLE, W.C., SAYALA, D. and STEINBORN, T., 1985, Natural analogues in evaporites for the interpretation of mineralogic and geochemical variations in a nuclear waste repository system (abst.): EOS, v. 66, p. 1153. First author at U.S. D.O.E, Columbus, OH 43201.

Contact metamorphism in evaporites resulting from mafic intrusives were investigated to approximate the salt media response to HLW repository conditions. Secondary fluid inclusions are characteristic of the aureoles. (From the authors' abstract)

SIGURDSSON, H., DEVINE, J.D. and DAVIS, A.N., 1985, The petrologic estimation of volcanic degassing: Jökull, no. 35, p. 1-8. Authors at Graduate

Sch. Oceanography, Univ. Rhode Island, Kingston, RI 02881, USA.

Petrologic estimates of degassing of sulfur, chlorine and fluorine and of the total volcanic volatile mass from several eruptions are closely comparable to volcanic aerosol estimates based on total acidity in ice-cores and direct stratospheric satellite-based extinction measurements. The results of petrologic studies of twenty eruptions indicate that three general types of volcanic degassing should be considered: (a) dominated by sulfuric acid from degassing of magma, (b) dominated by halogens (chlorine and lesser fluorine) from degassing of magma, and (c) formed by decomposition of sulfur-rich mineral phase, e.g., anhydrite during eruption (El Chichon-type). (Authors' abstract)

SILVER, Lynn and STOPLER, Edward, 1985, Thermodynamic modelling of hydrous silicate melts (abst.): EOS, v. 66, no. 18, p. 411-412.

SILVER, Lynn and STOLPER, Edward, 1985, A thermodynamic model for hydrous silicate melts: J. Geol., v. 93, p. 161-178. Authors at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125.

A simple thermodynamic model describing hydrous silicate melts has been applied to the system albite-, diopside-, and silica-H_2O. The model is based on the assumption of ideal mixing of hydroxyl groups, H_2O molecules, and oxygens in the melt. Calculated and experimentally determined freezing-point depressions and H_2O solubilities for these systems are in agreement over substantial pressure and temperature intervals. The success of this model in accounting for observed phase equilibria of hydrous systems and its consistency with spectroscopic measurements of the concentrations of H-bearing species in glasses suggests that it accurately represents the interaction between H_2O and silicate melts at a molecular level. (Authors' abstract)

SILVER, L.T., WOODHEAD, J.A., WILLIAMS, I.S. and CHAPPELL, B.W., 1985, On late immiscible Fe-rich melt separation during crystallization of highly differentiated siliceous granites (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 717.

SIMON, K. and HOEFS, J., 1985, Fluid inclusion, oxygen isotope and trace element investigations on granites and gneisses from the Südschwarzwald (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 114 (see also Fortschr. der Mineral., B63, Beih. 1, p. 291, 1985). Authors at Geochem. Inst. der Univ. Göttingen, Goldschmidtstr. 1, D-3400 Göttingen, FRG.

Fluid inclusions combined with oxygen isotope data are of great importance for the interpretation of water/rock interactions especially for hydrothermal alterations, as it was postulated by Hoefs and Emmermann (Contr. Min. Pet 83, 320-329, 1983) for granites and gneisses of the Südschwarzwald.

Microthermometric measurements on quartz from 16 samples of the granite areas Klemmbach (GKS), St. Blasien (GSB), Schluchsee (GSCH) and Bärhalde (GBH), as well as 3 samples of the gneiss area in the southeast of the Feldberg (GN) result in Th between 150°C and 400°C. Salinities up to 8 wt. % NaCl equivalents are rather low. Younger two mica granites (GSCH, GBH) differ from older biotite granites (GKS, GSB) and gneisses (GN) in having lower Th and higher salinities. The occurrence of the inclusions along healed fractures is very similar within all samples. Shape and arrangement are of secondary nature.

Oxygen isotope measurements on whole rock and separated minerals also divide the granites into two groups. Older ones with very low $\delta^{18}O$

values (WR* 1.3-8.4% , Qz 3.7-9.2% , Kf 2.4-8.2% , Bi -1.5-6.3% (SMOW) differ from the younger granites with normal to moderately high values (WR 7.2-10.9% , Qz 8.4-13.0% , Kf 6.5-11.3% , Bi 4.6-7.4% , Ms 7.5-8.9%). The separated minerals are not in isotope equilibrium with each other.

By means of trace element contents (Rb, Sr, Ba, Tl, Pb, Bi) in the K-feldspars it was tried to elucidate a correlation between isotope and cation exchange. Because of the small number of samples only trends can be demonstrated. With progressing alteration older granites increase in their K-normalized (K/elem.) Rb, Tl and Bi-ratios and decrease in their Rb, Ba and Sr-ratios. Younger granites decrease in their Rb, Tl and Bi and increase in their Pb, Ba and Sr-ratios.

The results allow a division into two granite types. In both cases intensive postmagmatic hydrothermal alteration operating under varying temperature and salinity conditions of the hydrothermal fluids is required. (Authors' abstract) [*Whole rock]

SIMONOV, V.A., 1985, Compositions of volatiles in rocks of the ophiolite association in the Mugodzhary (southern Urals) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 121-122 (in Russian; translation by D.A. Brown). Author at Inst. Geol. & Geophys. Sib. Div. Acad. Sci. USSR, Novosibirsk, USSR.

The gas-chromatography method has been used to study the compositions of volatiles in the Mugozhary ophiolites, successively upwards through the sequence: olivine gabbros-gabbros-dike complex-lavas.

Experimental procedure. Rock formations (0.5-0.25 mm), as far as possible monomineralic, were studied in a vacuum decrepitometer. The gas-release kinetics have been determined. Gas compositions were analyzed on a gas chromatograph, through successive T intervals, corresponding to the peaks of gas release. Peaks from absorbed water and from mineral decomposition were ignored.

There is regular decrease in fluid from the lower horizons of the ophiolites (gabbros) to the upper (lavas). The gabbroids contain the largest amounts of reduced gases (H_2, CH_4, and CO). Sills, secondary chambers, and first-generation dikes form an intermediate group. Dikes of the second generation and lavas contain a [more] oxidized fluid.

The driest gases have been observed in the gabbroids, and water increases in the secondary chambers and the second-generation dikes; the third-generation dikes and lavas are water-rich. There is less CO_2 in the gabbroids and the secondary chambers, and the largest amount of CO occurs in the gabbroids. The highest N_2 is in the first generation, and it diminishes successively in the later generation. (From the author's abstract)

SIROTIN, S.K., ARTYOMOV, V.S. and NOVOSEL'TSEV, V.I., 1985, Physical parameters of the decrepitation process in air medium and device for determination of decrepitation activity of rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 86 (in Russian). Authors at Sci.-Investig. Lab. of Saratov State Univ., Saratov, USSR.

Presently used decrepitometers record acoustic effects of frequency 50-10000 Hz, however, calculations prove that frequency of decrepitation sound depends only on the size of grain and for its range 0.25-1.0 mm the main acoustic decrepitation effect has frequency 1 to tens MHz (calculations and experiments). The authors developed a device, based on a microcomputer, that is able to record decrepitation effects of frequencies 0.3-7 MHz with recording speed 5000 impulses per second. (A.K.)

SISSON, V.B., 1985, Contact metamorphism and fluid evolution associated with the intrusion of the Ponder Pluton, Coast plutonic complex, British Columbia, Canada: Doctoral dissertation, Princeton Univ., Princeton, NJ, 363 pp.

Indexed under fluid inclusions.

SKAKUN, L.Z., 1985, Some aspects of the study of inclusions of mineral-forming material in assessing the conditions of formation of massive copper-sulfide deposits (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 76-77 (in Russian; translation by D.A. Brown). Author at L'vov State Univ., L'vov, USSR.

The principal factors affecting the study of inclusions in the minerals of massive-sulfide deposits are: a) the extremely small size of the inclusions; b) the lack of adequate procedures for the thermobaric and geochemical studies of inclusions in opaque sulfides; c) the poor knowledge of the genetic types of inclusions in the minerals of the massive copper-sulfide ores; and d) the vagueness of the genetic relations between quartz, often a natural translucent mineral, and the sulfides. The last two items have been considered with respect to the Mugodzhary deposits (Limannoye, Priorskoye, etc.).

In 1959 Yu.A. Dolgov described colloidal inclusions in quartz from the Middle Urals massive-sulfide deposits. The present author has recognized a similar assemblage of inclusions in quartz from sulfide veinlets and metasomatically-altered rocks in the deposits examined. Relicts of a gel substance, formed as a result of metasomatic transformations of volcanic rocks under the influence of true hydrothermal solutions, have been trapped in them. The following genetic types of colloidal inclusions have been recognized:

1. Inclusions of a compact gel, characterized by complex shape and a non-uniform internal structure.

2. 'Fimbriate' inclusions (according to Yu.A. Dolgov), formed during encapsulation of a syneretic liquid (sol), precipitated during an earlier phase of crystallization of the gel.

3. Liquid or gas-liquid inclusions, encapsulating the latest portions of the syneretic liquid, similar in its characteristics to a true solution.

The spatial relationships of the various types of inclusions and their processes of formation during growth of the crystals in the gel is discussed. Sources of errors, associated with lack of knowledge of colloidal inclusions during investigations by Th and Td, are demonstrated on the basis of actual examples. The low Td or the absence of clearly-defined peaks, without additional microscope studies of the inclusions, cannot serve as proof of the low-temperature nature of the process of ore-deposition.

The massive-sulfide bodies and the essentially sulfide veinlets, formed during the course of a single phase of mineral formation, are characterized by the two-step nature of the process of their formation: a) deposition (characteristically the formation of disequilibrium dispersed precipitate of pyrite and silica); and b) diagenesis (recrystallization to an equilibrium granular aggregate of sulfides and quartz). In the zone of massive-sulfide deposition, suitable gas-liquid inclusions occur only in diagenetic (as defined by A.G. Zhabin) quartz. Th = 420-110°C. The influence of the degree of diagenesis on Td of inclusions in quartz is demonstrated. The temperature and pH gradients during diagenesis define the mineralogical zonation within the orebodies. Differences in T of mineral-formation during precipitation and diagenesis will depend directly on mixing of the hydrothermal solutions with seawater. During thermobarometric investigations it is necessary to take account of the specific nature of the formation of the mineral aggregates of the massive-sulfide ores. Thermobarometric studies must be preceded by a detailed analysis of the mineral paragenetic associations and the mineralogical zonation, not only within the massive-sulfide ores, but also throughout the entire ore-surrounding sequence. (From the author's abstract)

SLOAN, E.D., 1985, Shore-based laboratory experimental measurements on a gas hydrate sample recovered at Site 570, in Orlofsky, S., ed., Initial Reports of the Deep Sea Drilling Project, v. 84, U.S. Govt. Printing Office, p. 695-698.

SMIRNOVA, S.K., YASKOL'KO, T.I., POLYKOVSKIY, V.S. and IVANOVA, N.A., 1985, Experience in the use of decrepitation in studies of above-ore metasomatites and in prospecting for hidden ore mineralization (with an example of gold ore mineralization of Eastern Uzbekistan) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 91-92 (in Russian). First author at Inst. Geol. & Geophysics of Acad. Sci. Uzbek SSR, Tashkent, Uzbekistan.

Linear metasomtic zones above hidden quartz gold-bearing veins were studied. Outer metasomatites consist of albite + chlorite + carbonate + pyrite + (sericite + quartz) but close to ore vein their composition changes to pyrite + sericite + quartz and next to ore, quartz + pyrite. Essential Td of quartz samples is in ranges 180-300°C for ore vein quartz, with peak at 210-220°C (number of impulses 100-480); metasomatic quartz decrepitates in wide T interval from 80 to 700°C (number of impulses 20-65). Decrepitation studies not only confirm the location of hidden gold ore mineralization, but also permit an unambiguous distinction between the gold ore-bearing quartz and the barren one. (A.K.)

SMITH, C.B., 1984, The genesis of the diamond deposits of the West Kimberley, W.A., in The Canning Basin W.A., P.G. Purcell, ed.: Proc. GSA/PESA Canning Basin Symp., Perth Australia, 1984, p. 463-473. Author at CRA Exploration Pty. Ltd., 21 Wynyard St., Belmont, Western Australia.

The diamond deposits of the West Kimberley are hosted by Miocene lamproite volcanics. The morphology, mineral inclusions content and carbon isotopic composition of diamonds from lamproite are similar to those from kimberlite and suggest an origin for the diamonds within the upper mantle at depths in excess of 125 km. The diamonds are thought to have been transported to surface as xenocrysts in a volatile (H_2O)-rich lamproite magma, generated by partial melting of metasomatized mantle peridotite enriched in incompatible elements. (From the author's abstract)

SMITH, D.C. and VIDAL, Philippe, eds., 1985, Isotope geochemistry and geochronology of eclogite, First Int'l. Eclogite Conf. held in Clermont-Ferrand, France, Aug. 31-Sept. 2, 1982: Chem. Geol., v. 52, no. 2.

SMITH, J.V. and DAWSON, J.B., 1985, Carbonado: diamond aggregates from early impacts of crustal rocks?: Geology, v. 13, p. 342-343.

SMITH, P.K., 1985, Genetic aspects of a gold deposit in high grade Cambro-Ordovician metasediments, Nova Scotia: Geological, mineral, geochemical and isotopic evidence (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 720. Author at Dept. Mines & Energy, 1496 Lower Water St., Box 1087, Halifax, Nova Scotia B3J 2X1.

The Cochrane Hill gold deposit is hosted by amphibolite grade turbidite metasediments of the Cambro-Ordovician Goldenville Formation. Interbedded pelitic, semipelitic and psammite host sediments were polydeformed, metamorphosed and intruded by granitoid plutons during the Devonian Acadian Orogeny. Six distinct types of quartz veins are recognized from the 30 m wide mineralized zone. Textural evidence suggests that vein emplacement commenced prior to deformation and ceased after the termination of the Acadian Orogeny. Essential mineralogy of the veins is quartz, plagioclase, phyllosilicates, aluminosilicates, amphiboles and garnet. Arsenopyrite, pyrrhotite, loellingite, pyrite, marcasite, sphalerite, galena, chalcopyrite, Fe-Ti oxides and gold are the ore minerals.

FeO/MgO, Na_2O/K_2O and Al_2O_3/K_2O ratios in biotite and muscovite increase in the ore zone. Whole rock geochemistry of pelitic lithologies shows marked increases in TiO_2/MgO, TiO_2/Fe_3O_3, TiO_2/P_2O_5 and Na_2O/K_2O ratios across the ore horizon. In the psammitic units TiO_2/P_2O_5 shows marked increase whereas CaO/MgO and Na_2O/K_2O ratios decrease slightly in the auriferous zone. Fluid inclusion temperatures from quartz vary from 260 to +450°C.

Preliminary lead isotope data on galenas from Cochrane Hill are substantially more radiogenic than whole rock leads from the Goldenville Formation. These lead isotopic data, which are similar to those from granite-hosted mineral deposits together with other lines of evidence, support a granite related epigenetic gold model. (Author's abstract)

SMITH, R.C., 1984, Mineralogic and fluid-inclusion studies of epithermal gold-quartz veins in the Oatman district, northwestern Arizona: Masters thesis, The Univ. of Arizona.

Epithermal gold-quartz mineralization in the Oatman district, northwestern Arizona, was effected by hydrothermal fluids with T 205°C to 255°C and salinities of about 1.5 wt.% NaCl equiv., or 0.26 molal NaCl. T were highest in the center of the district. The increase in the ratio of total oxidized (C+S) to total reduced (C+S) in fluid-inclusion gases toward the center of the district indicates that boiling of the hydrothermal fluids was more common in that part of the district. Gold, adularia, and wall-rock abundances and total oxidized (C+S)/total reduced (C+S) are commonly proportional and are higher in older, thicker bands of a sample from the Gold Road vein. Adularia deposition may be favored by interaction of hydrothermal fluids with wall rock. Gold deposition is probably effected by oxidation attending boiling. "Green quartz" from various veins is colored by fine-grained disseminated chlorite or corrensite. (Author's abstract)

SMITH, R.L., 1985, Tin, molybdenum, and other metal elements in silicic magmas and their relation to fluorine and chlorine distribution (abst.): U.S. Geol. Survey Circular 949, p. 52-53.

SMITH, S.P., 1985, Noble gas solubility in water at high temperature (abst.): EOS, v. 66, no. 18, p. 397.

SMITH, S.P. and KENNEDY, B.M., 1985, Noble gas evidence for two fluids in the Baca (Valles Caldera) geothermal reservoir: Geochimica Cosmo. Acta, v. 49, p. 893-902. Authors at Dept. Physics, Univ. California, Berkeley, CA 94720.

Noble gas elemental and isotopic abundances were measured in steam from four wells in the Baca geothermal reservoir located in the Valles Caldera, New Mexico. The $^{40}Ar/^{36}Ar$ ratio and noble gas elemental abundances relative to ^{36}Ar are all strongly correlated with $1/^{36}Ar$, the inverse of the argon content. Ratios of (α,n)-produced ^{21}Ne and radiogenic ^{40}Ar to total ^{4}He (dominantly radiogenic) are nearly constant at 2.1 x 10^{-8} and 0.20, respectively. The ^{3}He/^{4}He ratio covers a restricted range of 3.9 to 4.8 times atmospheric. The high ^{3}He content of the gas indicates the presence of a helium component ultimately derived from the mantle. Kr and Xe isotopic compositions are close to atmospheric; excess ^{129}Xe is $\leq$0.25% of total ^{129}Xe.

The high degree of linear correlation among the various noble gas results strongly suggests that the Baca reservoir contains two distinct fluids that are produced in varying proportions from individual wells. The noble gases in fluid A (~2900 mg/l Cl) are air-like, but with lighter gases and isotopes preferentially enriched. The fluid A ^{36}Ar content is low, only 13% that of 10°C air-saturated water (ASW). The second fluid, B (~1700 mg/l Cl), is the dominant carrier of the radiogenic and mantle-derived gases. The heavier non-radiogenic gases are preferentially enriched in fluid B, and its ^{36}Ar content is very low, only 5-7% ASW. The source of the noble gases in fluid A is tentatively ascribed to leaching of the relatively young (<1.4 m.y.) volcanic Bandelier Tuff. The radiogenic gases and mantle-derived helium in fluid B suggest a deeper source, possibly including gases escaping from a magma. (Authors' abstract)

SMITH, T.E., GILLEN, K., TAYLOR S.D. and BROMLEY, A.V., 1985, A fluid inclusion study of some late and post-magmatic phenomena associated with mineralization in the St. Austell pluton, Cornwall, U.K. (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 236-241. First author at Dept. Geol., Univ. Windsor, Windsor, Ontario, N9B 3P4, Canada.

Five separate populations of fluid inclusions can be defined in terms of their size, distribution, nature, homogenization temperatures, salinities and their distribution in the various types of quartz. The magmatic quartz and quartz from the mainstage breccia are characterized by L-V-S and Vd [vapor-dominated] inclusions indicative of high temperature, high salinity boiling brine. The early veins are characterized by L-V-S inclusions of a high salinity, high temperature brine.

The salinity and temperature data suggest that the magmatic quartz formed in the presence of a boiling brine containing approximately 48 wt. % equivalent NaCl at approximately 500°C and 300 bars. The early quartz-tourmaline veins contain inclusions of a brine having about 38 wt. % equivalent NaCl at a temperature of 290°C. The Mainstage Breccias at Fraddon and Remfry contain inclusions of somewhat different brines. At Fraddon a boiling brine having about 48 wt. % equivalent NaCl at about 425°C and 210 bars is indicated. At Remfry the brine has about 42 wt. % equivlent NaCl at about 380°C and 170 bars. The characteristic fluid inclusions occurring at the Collapse Breccia contain about 9 wt. % equivalent NaCl at about 220°C. The late quartz-hematite veins contain inclusions of brine having 22 wt. % equivalent NaCl at 290°C.

It is suggested that the highly saline brines are dominantly of magmatic origin, and that the low salinity brine typical of the collapse breccia has a different origin and may be predominantly meteoric or metamorphic. Calculations show that the intermediate salinity brine, characteristic of the late veins, could be formed by mixing a brine similar to that occurring in the early veins with an equal amount of the low salinity brine trapped in the Collapse Breccia. (From the authors' abstract)

SMITH, T.J. and KESLER, S.E., 1985, Relation of fluid inclusion geochemistry to wallrock alteration and lithogeochemical zonation at the Hollinger-McIntyre gold deposit, Timmins, Ontario, Canada: CIM Bull., v. 78, no. 876, p. 35-46. First author at St. Joe Am. Corp., Deadwood, SD, USA.

Zonation patterns are well developed in the mafic meta-volcanic rocks that host epigenetic quartz-carbonate-gold vein mineralization at the Hollinger-McIntyre deposit. Carbonate alteration assemblages are strongly zoned about mineralization. Proceeding inward from background greenschist facies rocks to alteration envelopes enclosing individual veins, the following [four] assemblages are observed: I - quartz-albite-chlorite-epidote-actinolite-(calcite); II - quartz-albite-chlorite-calcite-epidote; III - quartz-ankerite-sericite-(chlorite-calcite); and IV - quartz-albite-ankerite-sericite.

Lithogeochemical zoning is equally well developed as variations in whole-rock abundances of As, Au, Ba, Rb, and Sb. As and Ba form the most useful zonation patterns, outlining individual ore zones as well as broader trends of mineralization.

Gas chromatographic analyses of fluid inclusions in the quartz carbonate veins indicate that the mineralizing fluid was an H_2O-CO_2 mixture. Locally, CH_4-rich fluid inclusions are associated with graphitic and/or carbonaceous wallrocks. Fluid inclusions in ore-bearing veins have higher CO_2 contents than those in non-ore veins. Extensive sampling and analyses of veins from the area surrounding the deposit reveals a well developed zonation of CO_2 contents about the main zone of mineralization. Low CO_2 levels (1-2 mole%) in veins are peripheral to the deposit and increase to over 12 mole% in mineralized zones.

The observed zoning of the carbonate alteration assemblages is a result of the addition of CO_2 to the wallrock, which is consistent with the zoning of CO_2 in the fluid inclusions. The zoning patterns delineated in this study are useful in exploration both on a deposit scale and on the scale of individual ore zones. (Authors' abstract)

SMOLUCHOWSKI, R., 1985, Stability of CO_2-clathrate in comets (abst.): EOS, v. 66, no. 46, p. 945.

SO, C.-S, CHI, S.-J, SHELTON, K.L. and SKINNER, B.J., 1985, Copper-bearing hydrothermal vein deposits in the Gyeongsang basin, Republic of Korea: Econ. Geol., v. 80, p. 43-56. First author at Dept. Geol., Korea Univ., Seoul, Republic of Korea.

The hydrothermal vein-type deposits which comprise the Sambong, Samsan, and Seongji mines are primarily copper deposits, but they have associated lead, zinc, and silver mineralization. The deposits occur within Upper Cretaceous volcanic rocks of the Gyeongsang basin of the southern Korean peninsula. Mineralization can be separated into three distinct stages (I, II and III) which fill preexisting fault breccia zones. Each stage is terminated by an onset of fracturing and brecciation events. Fluid inclusion data suggest that stages I and II each evolved from initial high temperatures (near 350°C) to later lower temperatures (near 200°C). Each stage represents a separate mineralizing system which cooled and largely abated prior to the onset of the next stage. Fluid inclusion data from stage III, a postore, carbonate stage of mineralization, indicate a much cooler (190°-120°C), more dilute hydrothermal system which was probably the result of increasing influx of meteoric waters.

Sulfur isotope and fluid inclusion evidence suggests that ore minerals were deposited at temperatures between 350° and 250°C from fluids with salinities ranging from 3 to 17 equivalent weight percent NaCl. Fluid inclusion evidence of boiling suggests pressures of less than 100 bars during portions of stage I and II mineralization. This pressure corresponds to depths at the time of mineralization between 500 and 1,250 m.

Sulfur isotope compositions of sulfide minerals are consistent with an igneous source of sulfur with a $\delta^{34}S(\Sigma S)$ value near 4.0 per mil. Carbon and oxygen isotope compositions of carbonate-stage calcites suggest that meteoric water dominated the hydrothermal system at temperatures below 200°C.

The similarity of the features of the Sambong, Samsan, and Seongji mines to those of other copper-bearing hydrothermal deposits in Korea and elsewhere suggests a genetic tie between granitic magmatism and the development of the observed Cu-Pb-Zn-Ag mineralization and parageneses. (Authors' abstract)

SOBOLEV, A.V. and SOBOLEV, S.V., 1985, The theory, practice, and petrological applications of methods of studying melt inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 113-115 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

The present level of approaching and resolving petrological problems demands quantitative information on the conditions of crystallization (P, T, and $f(O_2)$ of melts and the composition of phases (melt, crystals, and fluid) of the magma systems. The present work attempts to make a quantitative determination of errors in Th determinations and to develop new methods of studying melt inclusions in minerals with the object of resolving actual petrological problems.

A physicochemical computer model was made to determine quantitatively the effect of T, external P, crystallization, and heat expansion, on the P and phase transformations within the inclusion. It has been shown that the dependence of Th on the difference in external P during the thermometry experiment and P during the process of capture of the inclusions, may be used as a sensitive geobarometer in the crystallization of cotectic systems.

The consequences of the increased diffusive mobility of H_2 and the associated process of dissociation of H_2O in melt inclusions, have also been modelled and determined experimentally.

On the basis of theory and a comparison with independent mineralogical thermometers, it has been shown that precision in determining absolute Te by microthermometry may actually be reduced to ±20°C, and the compositions of the captured melt to ±5% relatively for components of >5-10% mass and ~2% relatively, for SiO_2. A new method has been suggested for H_2O and CO_2, based on a comparison between Th and the calculated Te [equilibrium] of the homogeneous melt and the surrounding crystalline phase, a modification of V.B. Naumov's well-known method (1979). In addition, we have also developed a method of determining $f(O_2)$ based on spinelid-melt equilibrium data, and an experimental model of the process of fractional crystallization in inclusions.

Study of magmatic inclusions in conjunction with thermodynamic analysis and geochemistry represent a powerful means of resolving important problems of magmatic petrology. (From the authors' abstract)

SOBOLEV, A.V., TSAMERYAN, O.P., ZAKARIADZE, G.S. and SHCHERBOVSKIY, A.Ya., 1983, Compositions and mode of crystallization of parental melts of the lesser Caucasus volcanic ophiolite complex, as inferred from the study of melt inclusions: Dokl. Akad. Nauk SSSR, v. 272, no. 2, p. 464-468 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 272, p. 150-154, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 247, 1983. (E.R.)

SOBOLEV, N.V., TOMILENKO, A.A. and SHATSKII, V.S., 1985, Conditions of metamorphism of rocks of the Zerendinskaya series of the Kokchetav Massif (according to data from a study of fluid inclusions): Geol. Geofiz., 1985, no. 4, p. 55-58 (in Russian; English abstract). Authors at IGIG, Novosibirsk, USSR.

Reported are the results of study of fluid inclusions in minerals of metamorphic rocks of Berlykskaya and Zholdybaiskaya formations, Kokchetav massif. It was established that the present rocks are characterized mainly by metamorphogenetic inclusions of liquid methane and carbon dioxide, aqueous-saline solutions or their mixtures with various ratios of the main components. The calculated pressure values for biotite-garnet-kyanite shales of Berlykskaya formation are $9 \cdot 10^8$ Pa, for Zholdybaiskaya it is $(5.5\text{-}6) \cdot 10^8$ Pa. The conclusion is made that garnet-muscovite-kyanite shales of Zholdybaiskaya formation originated during the rocks diaphthoresis of Berlykskaya formation. (Authors' abstract)

SOBOLEV, N.V., TOMILENKO, A.A. and SHATSKIY, V.S., 1985, Variations in fluid compositions of eclogitic complexes (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 152-153 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. & Geophys. Siber. Div. Acad. Sci. USSR, Novosibirsk, USSR.

The cryometric method has been used to study fluid inclusions in the minerals of eclogites from the schist-gneiss and glaucophane-schist complexes of Europe (Western Norway, Austria, DDR, and Federal Germany) and Asia (Kazakhstan and Kirgizia). The temperature of metamorphism of these rocks has been determined by using geothermometers.

Garnet and quartz in eclogites from the Western Norwegian gneisses (Gurskov, Nordfjord) contain CO_2-liquid inclusions. In this instance, the densest inclusions (ρ =1.14-1.18 g/cm^3) have been found in garnet, whereas the density of the inclusions in quartz is 1.04-1.09 g/cm^3 (P = 9.5 kbar at T = 800°C).

Quartz from eclogite in the Münchberg Massif (Federal Germany) contains liquid-N_2 inclusions (ρ = 0.81-0.78 g/cm^3; P = 10 kbar at T = 700°C). Inclusions of similar composition are also typical of quartz from eclogites, occurring in the form of layers in bodies of garnet peridotites in the Czech Massif (Zeblitz, DDR) (ρ = 0.81-0.78 g/cm^3; P - 11 kbar at Tz[sic] = 750°C), and also in eclogites from the Transalpine region (ρ = 0.60-0.68 g/cm^3) and Karalpe (ρ = 0.68-0.76 g/cm^3; P = 8.5 kbar at T = 780°C), Austria. Quartz from eclogites in the Kokchetav Massif (Kazkhstan) contains inclusions of several generations. The fluid inclusions corresponding to the earliest stages of metamorphism consist of liquid CH_4 (ρ = 0.40-0.44 g/cm^3; P = 10 kbar at T = 950°C), which are replaced during the later stages by CO_2-H_2O-salt inclusions (ρ = 0.58-0.91). The country rocks also display such a trend in the evolution of the composition of the fluid inclusions, from the earliest inclusions of liquid CH_4 (ρ = 0.42-0.44 g/cm^3) to CO_2-H_2O-salt forms (ρ = 0.9-1.0 g/cm^3).

Single- and two-phase CH_4 inclusions (ρ = 0.16-0.36 g/cm^3; P = 5.5 kbar at T = 750°C), and also liquid CH_4 and H_2O-salt solution (with a trace of CO_2) have been identified in a metagabbro from Karalpe (Austria).

Quartz from eclogites in the Makbal' Rise (Kirgizia) contains inclusions of liquid CO_2 (ρ = 1.07-1.09 g/cm^3; P = 5.0 kbar at T = 600°C). At the same time, quartz from eclogites in the glaucophane-schist complex of the Atbashi Range has revealed single- and two-phase inclusions of H_2O-salt solutions.

The studies have shown that there are various kinds of metamorphogenic inclusions in the minerals of eclogites (CO_2, hydrocarbon, N_2, and H_2O-salt).

The data indicate the absence of any correlation between the composition of the fluid phase and the conditions of metamorphism of the eclogite-bearing complexes. (Authors' abstract)

SOBOLEV, V.S. (See Anonymous, 1984, this volume.)

SOBOLEVA, G.I., TUGARINOV, I.A., GOLITSINA, N.S. and KHODAKOVSKIY, I.L., 1984, The behavior of beryllium in fluorine-bearing hydrothermal solutions at 150-250°C: Geokhimiya, no. 6, p. 812-822 (in Russian, English abstract; translated in Geochem. Int'l., v. 21, no. 6, p. 20-30, 1985).

SOKOLOV, B.A., 1985, Creation of a general theory of the oil and gas content of the Earth's interior: Geologiya, v. 40, no. 4, p. 12-22, (in Russian; translated in Moscow Univ. Geol. Bull., v. 40, no. 4, p. 1-11, 1985).

Discussed is the oil and gas content of the Earth's interior as a regular result of the transformation of buried products of the biosphere within thick sedimentary basins under the influence of products of degassing of the mantle. (Author's abstract)

SOKOLOV, S.V., 1985, Conditions of formation of minerals of the humite group (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 162-164 (in Russian; translation by D.A. Brown). Author at VIMS, All-Union Res. Inst. of Mineral. Raw Materials, Moscow, USSR.

In the ultramafic - alkaline-carbonatite complexes (UACC), the formation of the humite-bearing apatite-magnetite ores and carbonatites has been confined to Phases II and III of the ore-carbonatite process. The physicochemical conditions of formation of humite have been estimated from Th, plus experimental data, limiting the stability fields of the mineral associations on the basis of the PT parameters, the H_2O/CO_2 ratio in the fluids, and the activity of fluorine in the system.

From a study of inclusions in chondrite and clinohumite from carbonate-bearing tetraferriphlogopite-magnetite ores and forsterite-calcitic carbonatites of Phase II (Vuorijärvi and Sokli Massifs, Kola Peninsula), the following data have been obtained.

P and S inclusions have been identified. The shape of the P inclusions is varied: prismatic (from short-columnar to long-prismatic), equant-rounded, and irregular; the cavities of the inclusions constantly display elements of facetting and are frequently negative prismatic crystals. The S inclusions are marked by a similar morphology, and in accordance with the orientation, they have the shape of prisms or rhombs. The maximum cross-sectional dimension of the inclusions is 50-60 µm; the S inclusions possess smaller dimensions.

All the inclusions discovered are crystallized and consist of predominant anisotropic crystalline phases, a small quantity of isotropic crystallites, interstitially distributed liquid, and a gas phase (in the form of dark clots of irregular shape).

In rare cases, complete homogenization of the content of the inclusions, the bulk of which has been decompressed during heating, has been achieved. Decrepitation of individual inclusions began at >500°C and became massive at 580-620°C, continuing with lesser frequency until the end of the experiments.

Homogenization of the P and S inclusions (785-745 and 720-660°, respectively) was into the liquid phase, which is a salt melt, because it crystallizes during quench into a very fine-grained aggregate. Small variations in Th in one group of inclusions (10-30°), and the identity of both their phase composition (by visual estimate), and also the course of the homogenization, point to the syngenetic nature of these inclusions.

The measured Th for the P inclusions, accepted as the minimum Tt for the inclusions of the crystallizing mineral, are in good agreement with the experimental stability data. Crystallization of chondrite and clinohumite in the apatite-magnetite ores and carbonatites of the UACC massifs in the Kola Peninsula, took place at 785-745°C from saline highly-concentrated liquids (melts). (From the author's abstract)

SOLOVOVA, I.P. and RYABCHIKOV, I.D., 1985, Conditions of formation of ultra-potassic diamond-bearing rocks of non-kimberlitic type based on thermobarogeochemical data (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 154-155 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. Ore Deposits, Petrogr., Min., & Geochem. of Acad. Sci. USSR (IGEM AN SSSR), Moscow, USSR.

The discovery of a new source of diamonds of non-kimberlitic type (highly-potassic rocks (lamproites)) of unusual composition, poses a number of problems: determination of the physicochemical parameters of formation of such magmas, the depth of their emplacement, the fluid regime, and the source of their material. A sample of an ol lamproite from the Elleydale 26 explosion pipe, Western Australia, consists of 80% ol phenocrysts (Fo_{91}) and a groundmass of complex composition, amongst which phlogopite, diopside, apatite, the Ba-K mineral priderite, other crystalline phases, and glass have been identified.

All the kinds of inclusions examined in this sample have been found in ol phenocrysts. The most numerous are S inclusions (low-density fluid) (CO_2, Tm = -57°C) with homogenization into the gas phase, and fluid-melt, containing both devitrificate, and also well-formed crystals (dms). Tm of the latter = 880°C - 1030-1040°C. Th of the S melt inclusions = 1040-1060°C. Heating of the melt-fluid inclusions to 880°C leads to separation in the fluid (size of gas cavity ≤4 μm) of a very narrow rim of H_2O, which does not appear at 1050°C. P melt inclusions are extremely rare, have a zonal arrangement, contain a gas phase of large volume, and have Th = 1210-1220°C. Moreover, fused and disintegrated[sic] crystalline inclusions of opx, absent amongst the lamproite mineral (X_{AI} = 0.0685, Mg index 90%), have been found in the ol, and an ol, differing in composition from that of the rock examined. These crystalline inclusions are surrounded by glass with a gas phase. Such associations are regarded by the authors as combined or 'ghost' inclusions, whereas the melt + gas inclusions are P for ol. No reactions have been observed between the melt and the crystalline inclusion during heating to 1270°C. A qualitative study of the glass on a 'Camscan' microprobe has clearly shown the presence of a N_2 peak. At the same time, the fluid phase corresponding to this melt homogenizes to a liquid at 26.0-26.2°C, and Tm = -62.0 - -65.5°C. Allowing for the presence of N_2 in the melt, it may be suggested that the lower value of Tm as compared with pure CO_2 of the fluid phase has been associated with the presence in it, in addition to CO_2, of a N_2-bearing component. The minimum $P(CO_2)$ at T = 1220°C is ~6-6.5 kbar.

The fluid inclusions, except for the gas, contain very small anisotropic crystalline inclusions, possibly of carbonate composition. The compositions of the glass from the melt inclusions correspond to highly-potassic and highly-magnesian magmas, containing marked amounts of Al_2O_3, TiO_2, ZrO_2, F, Cl, and P. The large amount of MgO and K_2O in the original magmas, the presence of N_2, congregating towards the highly-potassic primary magmas[1], the presence of crystalline inclusions, judged from the composition to be of mantle origin, and the Tc of the magmas, are in accordance with the experimental data[2], which support the hypothesis of the origin of the ultra-potassic lamproite magmas as a result of melting of metasomatized mantle rocks[3], and the presence of CO_2, H_2O and possibly carbonates, in the fluid, corresponds to P ⩾20 kbar[4].

REFERENCES

1. Stevenson, F.J., Geochim. Cosmochim. Acta, 1962, v. 26, No. 17.
2. Arima M., Edgar, A.D., Contr. Min. Petr., 1983, v. 83, No. 2/3.
3. Gupta, A.K., Yagi, K., Petrology and genesis of leucite-bearing rocks, Berlin, 1980, p. 224.
4. Ryabchikov, I.D., 1982, Dokl. Akad. Nauk SSSR, 268, No. 3. (Authors' abstract)

SOLOVOVA, I.P., NAUMOV, V.B. and BABANSKIY, 1985, Inclusions in minerals of lherzolite xenoliths; a source of information on processes in the upper mantle (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 108-109 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. Ore Deposits, Petrogr., Min. & Geochem. Acad. Sci. USSR (IGEM AN SSSR), Moscow, USSR.

Ultramafic xenoliths, transported into the upper crustal horizons, are a source of information about the fluid regime, the PT conditions, and the oxygen fugacity of the processes taking place in the upper mantle. A comparative analysis of data based on inclusions in xenolith minerals and in the principal minerals of the rock carrying the xenoliths, has enabled us not only to define the physico-chemical conditions of evolution of the latter, but also of the processes preceding them.

We have examined lherzolite xenoliths from alkaline basaltoids from Federal Germany and Mongolia, and from the present-day calc-alkaline andesites of the Kurils. The olivines and pyroxenes in many of them contained isolated primary, single- and two-phase tubular fluid inclusions of CO_2, without significant admixture of another gas (Tm = -56.6 to -57°C). Most of them have usually been partially depressurized. CO_2 density varies from 1.18 to less than 0.3 g/cm^3. In some cases, a phase transition of liquid into solid CO_2 has been observed, with no gas phase present. Hence, the pressures, corresponding to the conditions of their capture, significantly exceeded 11-15 kbar.

The compositions of the sulfide and silicate phases of the CO_2-silicate-sulfide primary inclusions of the liquation type, discovered in clinopyroxenes from megacrysts and druses, and calculations of their relations with the fluid, have enabled us to estimate the bulk composition of the CO_2-silicate-sulfide emulsion of mantle origin. It has been shown that such emulsions may contain from 5.5 to 46 wt % of fluid and may correspond to the formation of the megacrysts and unique druses of lherzolitic composition. The residual high-potassic glasses, after crystallization of the silicate component, may have served as a source for the alkali-basaltic magmatism, whereas the sulfide portion of such emulsions may have led to the formation of deposits of the Noril'sk type.

Pseudo-primary melt inclusions have been found and examined. Their origin has been associated with melting of crystalline inclusions in the lherzolite minerals during capture of xenoliths by hot magmas. The minimum

Tm of the dms in such inclusions (1300°C) points to significant reheating of the alkali-basalts at their point of origin.

This is indicated by the Th of the primary melt inclusions in plagioclases from veinlets in the gabbroic xenoliths in the lherzolites and that of the secondary melt inclusions in olivines and orthopyroxenes in the lherzolites from the andesites of the Kuril Islands. A comparative analysis of Th and equilibration of the plagioclase data with those for the glasses from the melt inclusions, have shown that 'gabbroization' of the lherzolite xenoliths took place in depth in the lower chamber with the loss of a high-alumina basalt, differentiates of which are apparently the calc-alkaline andesites of the Kuril Islands. (Authors' abstract)

SOMAN, K. and NAIR, N.G.K., 1985, Genesis of chrysoberyl in the pegmatites of southern Kerala, India: Min. Mag., v. 49, p. 733-738. Authors at Centre for Earth Sci. Studies, Trivandrum-695010, India.

In southern Kerala, India, chrysoberyl occurs in granitic pegmatites in association with quartz in alkali feldspar and is thought to crystallize earlier than beryl and sillimanite. The pegmatites are thought to have derived from the residual melts of granitic liquids formed by partial melting of the khondalites. In the absence of pyrometasomatic, desilication or aluminum-contamination processes, the genesis of chrysoberyl is explained by the CO_2 activity in residual melts. This model is at variance with the known concepts and may also explain the genesis of chrysoberyl in Sri Lanka where it is still controversial. (Authors' abstract)

Includes gas analyses for water and CO_2 from garnet, chrysoberyl and quartz, heated to various temperatures. (E.R.)

SOMMER, M.A. and GIBSON, E.K., Jr., 1985, Determination of the volatile components of fluid inclusions in Archean rocks using micro-crushing and thermal decrepitation coupled with a capacitance manometer and mass spectrometer (abst.): Lunar and Planetary Sci. XVI, p. 801-802. First author at Lockheed/EMSCO C-23, NASA/Johnson Space Center, 2400 NASA Rd. 1, Houston, TX 77058.

A large range of compositions were found in Archean sedimentary rocks, with $H_2O>CO_2$ (mole ratios 0.0004-0.29), H_2S/H_2O 0.0000 to 0.02, and CH_4/H_2O from <0.0001 to 0.14. Authors believe some samples represent original Archean aqueous fluids pertinent to the problem of the composition of the Archean atmosphere. (E.R.) See also next item.

SOMMER, M.A. and GIBSON, E.K., 1985, Volatile concentrations of submarine glasses from the Juan de Fuca Ridge (abst.): EOS, v. 66, no. 46, p. 926. First author at Lockheed/EMSCO C-23, 2400 NASA Rd. 1, Houston, TX 77058.

H_2O, CO_2, CH_4, and other trace volatiles have been determined from vesicles within submarine glasses and separately from the vesicle-free host glass. Volatile mole ratios were determined using micro-crushing, the released volatiles analyzed with a computer controlled quadrupole mass spectrometer. In all cases the volatiles released from vesicles by crushing in the quenched glasses were dominately CO_2 with lesser amounts of H_2O, CH_4, Ar, and trace amounts of hydrocarbons. CO_2/H_2O mole ratios in the vesicles varied from 33.4 upward to the limit of detection for H_2O. H_2O and CO_2 concentrations within the host glasses (first crushed to remove the volatiles in the vesicles) were determined using step-wise heating from room temperature to the melting point. The evolved H_2O and CO_2 were measured using fractional freezing techniques and a sensitive capacitance manometer. The average H_2O concentrations in the vesicle-free glass were

0.16 wt %, CO_2 concentrations 0.013 wt %. The high concentration of CO_2 in the vesicles indicates that the magma was saturated with CO_2 prior to extrusion onto the seafloor; the exsolved CO_2 was trapped in the vesicles during quenching. Using the Harris (1981) equation CO_2 (wt %) = 0.0005 + 0.059 P (kb) yields a pressure of entrapment of 0.212 kb or an equivalent water depth of about 2200 meters, in agreement with the fact the samples were collected in about 2200 meters of water. (Authors' abstract)

SOMMER, M.A., II, GIBSON, E.K., Jr. and BOURCIER, W., 1985, Trapped volatiles in Archean rocks (abst.): Lunar & Planet. Sci., v. 16, p. 803-804. First author at Lockheed/EMSCO C-23, NASA/Johnson Space Center, 2400 NASA Rd. 1, Houston, TX 77058.

It is our assumption that primary fluid inclusions trapped in sedimentary minerals during Archean time might preserve a relevant assemblage of volatiles present in the atmosphere. Obviously, it is a difficult task to directly equate the volatile composition of the atmosphere with those components trapped within sedimentary hosted fluid inclusions, however, some atmospheric components and especially the isotopic ratios of nitrogen, argon and other nonstructural mineral volatiles might be preserved in primary fluid inclusions. It is our goal to attempt to identify primary fluid inclusions in a suite of Archean rocks as a guide to other studies where the composition of primary volatile components is required. The vast majority of the Archean rock suite analyzed in this preliminary study would seem not to meet criteria for the establishment of primary entrapped sedimentary fluids. Work remains to attempt to dissect the fluid inclusion population of the sample suite to distinguish between possible primary sedimentary fluid inclusions and secondary inclusions. (From the authors' abstract)

See also previous item. (E.R.)

SOMMER, M.A., II, YONOVER, R.N., BOURCIER, W.L. and GIBSON, E.K., 1985, Determination of H_2O and CO_2 concentrations in fluid inclusions in minerals using laser decrepitation and capacitance manometer analysis: Anal. Chem., v. 57, p. 449-453. First author at Lockheed/EMSCO C-23, NASA/Johnson Space Center, 1830 NASA Rd. 1, Houston, TX 77058.

Water and carbon dioxide concentrations within individual and selected groups of fluid inclusions in quartz were analyzed by using laser decrepitation and quantitative capacitance manometer determination. The useful limit of detection (calculated as ten times the typical background level) is about 5×10^{-10} mol of H_2O and 5×10^{-11} mol of CO_2; this H_2O content translates into an aqueous fluid inclusion ~25 μm in diameter. CO_2/H_2O determinations for 38 samples (100 separate measurements) have a range of H_2O amounts of 5.119×10^{-9} to 1.261×10^{-7} mol; CO_2 amounts of 7.216×10^{-10} to 1.488×10^{-8} mol, and CO_2/H_2O mole ratios of 0.011 to 1.241. Replicate mole ratio determinations of CO_2/H_2O for three identical(?) clusters of inclusions in quartz have average mole ratios of 0.0305 ± 0.0041 1σ. Our method offers much promise for analysis of individual fluid inclusions, is sensitive, is selective when the laser energy is not so great as to melt the mineral (laser pits ~50 μm in diameter), and permits rapid analysis (~1 h per sample analysis). (Authors' abstract)

SOMMERAUER, J. and KATZ-LEHNERT, K., 1985, Trapped phosphate melt inclusions in silicate-carbonate-hydroxyapatite from comb-layer alvikites from the Kaiserstuhl carbonatite complex (SW-Germany): Contrib. Mineral. Petrol., v. 91, p. 354-359. First author at Inst. Mineral. & Petrogr. (IMP), ETHZ, CH-8092 Zurich, Switzerland.

Structural and crystal-chemical observations on acicular and skeletal silicate-carbonate-hydroxyapatite crystals (SCHap) from comb-layer alvikite dykes of the Kaiserstuhl carbonatite complex yield strong evidence for their being quenched products. As well as being intimately intergrown with calcite, they also contain distinctive primary phosphate inclusions. In contrast to the host apatite, these inclusions are free of Si, low in LREE but enriched in Sr and the volatiles F and S, and contain a high concentration of Na. This pronounced fractionation combined with the absence of x-ray diffraction and electron diffraction patterns suggests that the phosphate inclusions represent portions of a trapped residual phosphate melt. Therefore the SCHap are considered to be the direct liquidus phase of a carbonate-phosphate melt. That two phosphate phases coexist, however, presumes strong enrichment of phosphorous in the parental carbonatitic melt, since the eutectic would otherwise produce calcite and apatite only. The formation of sharply interfaced apatite- and calcite-comb-layers and the occurrence of trapped phosphate melt inclusions in the quench apatites argue for the existence of two immiscible liquids such as a phosphate-rich and a carbonate-rich melt. (Authors' abstract)

SONNENFELD, Peter, 1985, Evaporites as oil and gas source rocks: J. Petrol. Geol., v. 8, no. 3, p. 253-271.

SONYUSHKIN, V.Ye. and PETROVA, T.L., 1985, Use of complex electron microscopy methods for studies of morphology and composition of inclusions of mineral-forming media (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 77 (in Russian). Authors at Inst. Lithosphere of Acad. Sci., Moscow, USSR.

The authors briefly describe methods of work with inclusions on transmission microscope and electron microprobe, mentioning the possibility of electron microscopy studies of inclusions frozen to T of liquid nitrogen. (A.K.)

SORENSEN, S.S., BARTON, M.D. and ERNST, W.G., 1985, Anatexis of garnet amphibolites from a subduction zone metamorphic terrane (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 722. First author at Dept. Mineral Sci., NMNH, Smithsonian Inst., Washington, DC 20560.

Concomitant rehydration, metasomatism and amphibolitization of eclogite blocks from a mafic/ultramafic complex of the Catalina Schist terrane, southern California, at estimated metamorphic P ~ 8-12 kb, T ~ 600-700°C was apparently accompanied by partial melting of some blocks. Mobilizates of An ~ 10-20 plagioclase (PL) ± zoisite (ZO) + quartz (QZ) + celadonitic (Si ~ 3.3 p.f.u.) white mica (WM) ± tourmaline range from stringers and dikelets (~1 cm - 0.5 m) in "migmatitic" amphibolite blocks to dikes ~ 30 m x 3 m which intrude the surrounding, locally enstatite + chlorite ± talc ± aluminous actinolite ± anthophyllite-bearing ultramafic matrix. The uniform phase proportions and the coarse-grained (PL to ~ 20 cm) pegmatitic, graphic, and "myrmekitic" textures displayed by the dikes and dikelets suggest that they crystallized from silicate melts. WM and ZO appear to be magmatic phases. Hornblendes which display ZO selvages and atoll GT occur locally in the mobilizates. Fe-rich GT in migmatitic portions of blocks exhibits higher Mg/(Mg + Ca) p.f.u. than GT in restitic portions of blocks; rims are richer in Mg than cores. Field relations, microprobe mineral chemistry, and bulk compositions suggest the pegmatites are low fractions of amphibolite-derived partial melt. Abundant fluid inclusions occur in GT, QZ, PL and clinopyroxene. Th for primary H_2O-rich, low salinity L + V inclusions in GT and QZ from a migmatite range from 136-169°C; estimates of T limits for entrapment are 530-640°C at 8 kb, 650-780°C at 10 kb. H_2O-rich fluids evidently enabled metasomatism, amphibolitization, and anatexis of (originally) eclogitic rocks at the P-T conditions reflected by the metamorphic mineral assemblages. (Authors' abstract)

SOTNIKOV, V.I. and BERZINA, A.P., 1984, Essential geological-genetic and physico-chemical characteristics of copper-molybdenum ore formation: Geologiya i Geofizika, no. 8, p. 66-74 (in Russian; English abstract). Authors at Inst. Geol. and Geophysics of Siberian Br. Acad. Sci., Novosibirsk, USSR.

Porphyry intrusions of the copper-porphyry ore-bearing complexes formed at 1230-800°C (Th of inclusions in feldspar phenocrysts 1230-1150°C, in quartz 1110-865°C; lower Th interval for melt inclusions in quartz is very narrow 950-960°C, only few Th determinations were as low as 865°C). Mineralization in explosive breccias formed at T 750-600°C to 300-250°C, maximum P 200-250 MPa. Ore-metasomatic process started at 730-600°C (K-feldspathization, albitization and early silicification) and developed to 450-200°C (main ore stage), P ranged from 150 to 10-8 MPa. Solutions were usually alkaline-chloride, gaseous, high temperature. Explosive stage is characterized by CH_4-H_2 gases in the inclusions, indicating their deep source. At lower T the role of CO_2, N_2 and noble gases increase, especially CO_2 is abundant in the ore stage. Boiling of solutions at shallow levels in permeable rock layers forms highly concentrated brines, and especially capillary filtration under decreasing pressure at about 300°C increased in concentration of solutions. The process was investigated in the deposits Erdenituin-Obo (Mongolia), Shakhtama, Obkoronda (USSR) and others. (Abstract by A.K.)

SOTNIKOV, V.I., CHUPIN, V.P., BERZINA, A.P., POLIVEYEV, A.G. and BERZINA, A.N., 1985, Use of the physicochemical parameters of the formation of granitoids for classifying ore-bearing and ore-enclosing complexes in copper-molybdenum ore fields (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 170-171 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. & Geochem. Siber. Div. Acad. Sci. USSR, Novosibirsk, USSR.

The Cu-Mo deposits are located within regional structures of the superimposed ore-belt type, which are spatially controlled by the volcanic-plutonic belts. Here, rocks of two magmatic complexes are usually distinguished: ore-enclosing and ore-bearing. The former, as a rule, form large multiphase intrusions; the latter form small stock- and dike-like bodies. As there is often a petrochemical and geochemical similarity between these formations, it is necessary to involve other criteria in their classification.

With this in mind, the authors have recommended the use of the physicochemical parameters of formation of the granitoids. An examination has been made of the Cu-Mo (Zhireken, Eastern Transbaikalia) and Mo-Cu (Erdenetuin-Obo, Mongolia) deposits, representing different subassociations of the Cu-Mo association (Table). Contrasting T differences were revealed between the melts of the large granitoid intrusions (ore-surrounding complex) and the porphyritic formations (ore-bearing complex). The former also have higher $p(H_2O)$ values. These data do not suggest that the porphyries are the products of the large intrusions but point to their definite genetic independence, and it is recommended that they be separated as an ore-bearing magmatic complex. The porphyries of different age (pre-, intra-, and post-ore) form an independent evolutional series of magmatites, which generally, during its development, repeated the emplacement of the multiphase ore-surrounding complex. (Authors' abstract)

Physicochemical Parameters of Formation of the Ore-Surrounding and Ore-Bearing Granitoids, based on a study of melt inclusions (numerator), and biotite compositions (denominator)

Rocks	T°C	$P(H_2O)$, kbar
Zhireken Deposit		
Ore-surrounding complex		
Coarse-medium-grained granites	$\frac{690\text{-}620}{660\text{-}600}$	$\frac{1.3\text{-}4.8}{1.8\text{-}3.4}$
Ore-bearing complex		
Fine-grained granites I	$\frac{780\text{-}730}{760\text{-}730}$	$\frac{0.8\text{-}1.4}{1.3\text{-}1.6}$
Fine-grained granites II	$\frac{750\text{-}710}{740\text{-}720}$	
Porphyritic granites	$\frac{850\text{-}770}{\text{---}}$	
Granite-porphyries	$\frac{1020\text{-}910}{850\text{-}790}$	$\frac{\text{---}}{0.9\text{-}1.6}$
Erdenetuin-Obo Deposit		
Ore-surrounding complex		
Gabbros, diorites and granitoids	$\frac{1100\text{-}600}{\text{---}}$	
Granitoids	$\frac{\text{---}}{820\text{-}770}$	$\frac{\text{---}}{1.6\text{-}3.2}$
Granites and granosyenites	$\frac{650\text{-}560}{\text{---}}$	
Ore-bearing complex		
Granodiorite-porphyries (endocontact zone)	$\frac{1100\text{-}950}{\text{---}}$	
Granodiorite-porphyries	$\frac{810\text{-}690}{880\text{-}790}$	$\frac{\text{---}}{0.8\text{-}1.2}$

SPEAR, F.S., 1985, The petrologic implications of leaky rocks (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 723. Author at Dept. Geol., RPI, Troy, NY 12181.

P-T paths computed from zoned garnets in pelitic schist, New Hampshire indicate that prograde metamorphic devolatilization reactions proceeded during cooling, suggesting a decrease in $P(H_2O)$ relative to P(rock). It is proposed that the mechanism for lowering $P(H_2O)$ relative to P(rock) is for the rocks to leak.

Fluids leave rocks at a rate that is determined by the local pressure gradient and permeability. Fluids are generated in rocks at a rate that is dictated by the P-T path, the heating rate and the reactions that are encountered. Calculations show that for (1) reasonable permeabilities, (2) a heating cycle along a model P-T path typical for crustal thickening and (3) a pressure gradient determined by the difference in lithostatic and hydrostatic pressure, the fluid escape rate will exceed the fluid production rate during the heating portion of the cycle. At this point, the rocks begin to dry out with the following consequences:

1) $P(H_2O)$ decreases relative to P(rock) eventually reaching a value that is near hydrostatic.

2) Devolatilization reactions will continue even after the rocks begin to cool (see above).

3) Metamorphic isograds will progress through the crust in a steady state thermal environment, which may explain the formation of some types of granulites.

4) Fluid inclusions that trap late fluids will record P(fluid) < P(rock), which will result in an underestimation of the depth of burial at the time of entrapment if the pressure is assumed to be lithostatic. (Author's abstract)

SPEAR, F.S., FRANZ, G. and THOMAS, S., 1985, Evolution of metasediments from the eclogite zone (EZ), Tauern Window, Austria (abst.): Second Int'l. Eclogite Conf., Terra Cognita, v. 5, p. 425. First author at Cambridge, USA.

Petrologic data on the paragenesis of different types of metasediments metamorphosed at eclogite facies conditions, as well as data on fluid inclusions are presented with the goal of providing constraints on the P-T evolution of the EZ, and to describe the phase relations in different systems at high P and T. The rocks include (1) kyanite-zoisite marbles, (2) garnet quartzites, (3) magnetite-garnet-carbonate rocks.

The peak metamorphic assemblages are: (1) ky-zoi-dol-qz; zoi-phen-dol-cc-qz, (2) gt-chtd-ky-phen-qz ± dol, cc, epi, Zn stau, (3) gt-cumm-Ca amph-qz-phen-dol-mag/sid-mgt. The best P-T estimate based on phase equilibria is 19 kbar 590°C. Retrograde assemblages include (1) margarite, paragonite, phen II, chlorite, sudoite [chlorite], kaolinite and (2) chl, bio, alb, par, phen II. Lawsonite pseudomorphs in garnet from rock group (2) indicate the prograde evolution. The retrograde assemblages together with fluid inclusion data from late qz-veins and reequilibrated minerals provide good constraints on the P-T path of the EZ.

This path is characterized by a strong uplift (Δ P $\geqslant$ 10 kbar) with slight cooling (Δ T = 50°C) followed by strong cooling at smaller uplift rates. The last mineral formation (sudote, kaolinite) occurred at P <2.5 kbar, T <350°C. The P-T path is completely different from that of the rocks immediately north of the EZ (Steinsteg loc. Fronsnitztal; Ohrkogl Raneburg; Tauerntal) where early low P/medium T, followed by medium P/ medium T conditions are indicated by garnet and plagioclase composition. (Authors' abstract)

SPECZIK, S., 1985a Relation of Permian base metal occurrences to Variscan paleogeothermal field of the Fore-Sudetic Monocline. - Results of fluid inclusion studies and vitrinite rank determinations (abst.): Fortschr. Mineral., v. 63, Beiheft 1, p. 222.

The Carboniferous and old Paleozoic basement rocks of the Fore-Sudetic Monocline have been subject to various alteration processes. To establish temperatures of these processes thermobarogeochemical and vitrinite rank determinations were performed. Fluid inclusions were found in epigenetic veinlets cutting basement rocks as well as in basement rocks. These rocks of striking tectonically engaged zones (e.g., Zakowo-3, Zbaszynek IG-4, Czeszow-4 drillholes) were pervasively penetrated by the extensive hydrothermal front of alteration (albitization, chloritization, silification and carbonatization). The network system of secondary fluid inclusions is arranged perpendicular to the rock texture and marks the direction of these processes. The surprisingly high temperatures obtained (ranging essentially from 180 to 350°C) and at places the vast areal character of the alteration point to the paleogeothermal importance and meaning of the work. Discussed veinlets and processes ceased abruptly on the contact between Carboniferous and Permian sediments.

The results of vitrinite rank determinations are similar. The rank of vitrinite is generally higher than 2% R(oil) and reaches up to 4% R(oil) in the discussed zones (Speczik, S.: Geol. Sudetica, 20, 35-105, 1985). Inside the high paleogeothermal field of the Fore-Sudetic Monocline additional positive anomalies, relating to paleoheights and highly tectonically disturbed areas, were recognized. These anomalies show strong spatial correlation with the areas occupied by the known Kupferschiefer occurrences. The actually observed positive geothermal anomaly of Southwestern Poland is interpreted as resulting from Variscan deep thermal disturbing of the upper mantle. This deep fracture zone is still active and produces heat of remnant nature (Majorowicz, J.: Przeg. Geol., 2, 86-94 Warszawa, 1982). However, preliminary results of vitrinite rank determinations of Polish Kupferschiefer (R(oil) 0.5% to 1.5%) may suggest that the major portion of energy was delivered during the Carboniferous. Moreover, it is plausible that Variscan heat flow was mostly of hydrogenic character. The high paleogeothermal field of the Fore-Sudetic Monocline, N and NE of the Dolsk deep fracture, is surrounded by the areas with low paleogeothermal fields. (Author's abstract)

SPECZIK, Stanislaw, 1985b, Metallogeny of pre-Zechstein basement of the Fore-Sudetic monocline (SW Poland): Geol. Sudetica, v. 22, no. 1, p. 97-111. Author at Inst. Geol., The Univ. Warsaw, al. Zwirki i Wigury 93, 02-089 Warszawa.

Among other methods, "thermobarogeochemical" methods were employed. Fluid inclusions with Th(L) of 190-200°, and gas-rich inclusions are illustrated. (E.R.)

SPENCER, R.J., 1985, The role of pore fluids in evaporitic basins: Sixth Int'l. Symp. on Salt, 1983, v. 1, p. 231-245.

SPENCER, R.J., EUGSTER, H.P., JONES, B.F. and RETTIG, S.L., 1985, Geochemistry of Great Salt Lake, Utah I: Hydrochemistry since 1850: Geochimica Cosmo. Acta, v. 49, p. 727-737.

SPENCER, R.J., EUGSTER, H.P. and JONES, B.F., 1985, Geochemistry of Great Salt Lake, Utah II: Pleistocene-Holocene evolution: Geochimica Cosmo. Acta, v. 49, p. 739-747.

SPOONER, E.T.C. and BRAY, C.J., 1985, Fluid inclusion evidence for boiling at ~370°C in the stockwork of the Lasail ophiolitic hydrothermal massive sulphide deposit, Oman (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 724-725. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario, Canada M5S 1A1.

Four samples of stockwork material from DDH#9 through the Lasail ophiolitic massive sulphide deposit in Oman were found to contain satisfactory densities of primary fluid inclusions - OM 2064 from immediately below massive ore (49 m), and OM 2065, OM 2070 and OM 2075 located ~20 m, ~90 m and ~160 m, respectively, below massive ore. Primary fluid inclusions in the latter three samples show evidence typical of boiling: (i) variable phase ratios, and (ii) inclusions which homogenize into the liquid or vapor phases over the same temperature interval (360-400°C). The pooled data show two salinity populations: one with a modal composition near that of seawater, (3.5 wt.% TDS), and the other characterized by the bulk of the data concentrated between 4.9 and 6.4 equiv. wt.% NaCl (x 1.4-1.8 seawater) with values as high as 8.6 (x 2.5 seawater). The latter high salinities are interpreted to have been produced by the boiling process. For boiling conditions, fluid inclusion homogenization temperatures =

trapping temperatures, with some perturbations. Hence, the mode (372°C) and range (360-400°C) of the homogenization temperatures for the high salinity population are estimates of the fluid temperatures during ore deposition. The values are at the upper end of the measured range for "black smokers." The pressure given by these boiling temperatures is ~230 bars, given an estimate for original seawater depth of ~2-2-1/2 km; figures typical of active spreading ridges. The sample from immediately below massive ore (OM 2064) shows a lower hom. T range of 330-350°C, no high salinity population (f.pt. = -2.3 ± 0.2°C; n = 20), and no evidence for boiling. These observations are interpreted to reflect high level mixing with cold seawater immediately below the original sea floor. (Authors' abstract)

SPOONER, E.T.C., WOOD, P.C., BURROWS, D.R., THOMAS, A.V. and NOBLE, S.R., 1985, Grant 236 - Geological, fluid inclusion, and isotopic (carbon and sulphur) studies of Au-quartz-carbonate-pyrite-scheelite vein mineralization and intrusion-hosted Cu-(Au-Mo) mineralization in the Hollinger-McIntyre system, Timmins, Ontario: Ontario Geol. Survey Misc. Paper 127, p. 229-246. Authors at Dept. Geol., Univ. Toronto, Canada.

Includes a brief section that is essentially as given by Wood et. al., Fluid Inclusion Research--Proceedings of COFFI, v. 17, 1984, p. 379. (E.R.)

SRIKANTAPPA, C., RAITH, M. and SPIERING, B., 1985, Progressive charnockitization of a leptynite-khondalite suite in southern Kerala, India - Evidence for formation of charnockites through decrease in fluid pressure?: J. Geol. Soc. India, v. 26, p. 849-872. First author at Dept. Geol., Univ. Mysore, Manasa Gangotri, Mysore 570 006, India.

The crustal segment south of the Achankovil zone in southern Kerala is built up by two litho-tectonic units: The Nagerkoil unit is represented by a series of acid to intermediate magmatogenic gneisses and charnockites associated with layered anorthositic to noritic complexes. The Pon Mudi unit consists of interlayered garnet-biotite gneisses (leptynites), garnet-biotite-sillimanite gneisses (khondalites) and garnet-biotite-sillimanite-cordierite metatexites which represent a series of intensely deformed psammitic and pelitic sediments metamorphosed to upper amphibolite grade (700-750°C; 6-8 kbars). Subsequent to regional metamorphism in the Pon Mudi unit, the leptynites have been partly transformed to massive orthopyroxene-garnet-bearing charnockites along a conjugate set of fractures (s1: N30E and s2: S70E) and the foliation planes of the rocks (N30-60W).

The geochemical data and the results of geothermobarometry show that charnockitization was essentially isochemical and occurred at 750 ± 50°C and 6 ± 1 kbars lithostatic pressure. A complex but conformable development of the fluid phase composition during metamorphism is indicated by the occurrence of at least four generations of fluid inclusions (almost pure H_2O and CO_2 inclusions, mixed CO_2-H_2O inclusions and CH_4-N_2 inclusions) in both the leptynites and the charnockites. The common presence of graphite + pyrrhotite + ilmenite furthermore suggests internal buffering of the fluid composition at oxygen fugacities below those defined by the quartz-magnetite-ferrohypersthene assemblage and $XCO_2>0.5$.

The results of the present study indicate that charnockitization probably was not caused by the influx of CO_2-rich fluids of deep-seated origin, the presently favored model of granulite genesis (Newton, 1984), but rather was induced by an isothermal decrease of fluid pressure relative to lithostatic pressure, due to migration of the pore fluid into the network of fractures and ascent into higher crustal levels. (Authors' abstract)

STALDER, H.A. and VOLLENWEIDER, P., 1985, Salt-rich fluid inclusions in a quartz crystal from Bitsch, Vs, Switzerland. A photographic documentation (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 116. Authors at Naturhistorisches Museu, Bernastr. 15, CH-3005 Bern, Switzerland.

Several years ago a 70 kg quartz crystal out of an Alpine mineral fissure near Bitsch (Wallis, Switzerland), south of the Aar massif has been cut into hundreds of cubes (for sale). In some of these cubes big fluid inclusions were found, studied and described in several papers (Stalder 1976, Poty et al. 1976).

As these inclusions show many morphological phenomena in an exemplary way, we made a new photographic documentation of them.

H.A. Stalder (1976): Flüssigkeits- und Gaseinschlüsse in Quartzkristallen. Naturwissenschaften 63, 449-456.

B. Poty, P. Dhamelincourt, P. Bisson et M. Leclercq (1976): Caractérisation et localisation d'inclusions dans un cristal de quartz des Alpes suisses (Bitsch, Valais). Laboratorie d'applicaton MOL. Lirinord instruments. Lille. (Authors' abstract)

STANDEN, A.R. and KYLE, J.R., 1985, Geologic characteristics of the Scotia-Vanderbilt vein, Silverton, Colorado: Implications for epithermal precious metal exploration in volcanic settings, in Applied Mineralogy, W.C. Park, et al., eds.: Proc. Second Int'l Congress on Applied Mineralogy, Los Angeles, CA, Feb. 1984, Metallurgical Society of AIME, p. 1051-1063. Authors at Dept. Geol Sci., The Univ. Texas at Austin, Austin, TX 78712.

The Scotia-Vanderbilt vein system is representative of epithermal base- and precious-metal veins that occur in structural zones related to caldera development. Tertiary caldera-related volcanic rocks of the western San Juan Mountains have been altered regionally to a propylitic mineral assemblage of chlorite, epidote, calcite, and pyrite. Vein-associated alteration effects consist of a proximal quartz-sericite-zunyite-pyrite assemblage and a distal kaolinite-sericite-calcite-chlorite assemblage. Veins are comprised principally of quartz, pyroxmangite, and calcite with lesser amounts of pyrite, sphalerite, galena, and chalcopyrite. Fluid inclusion studies of quartz and sphalerite indicate precipitation over a 200 to 290°C range from solutions of less than 1 wt. % NaCl equiv. (From the authors' abstract)

STAUFFER, B., FISCHER, G., NEFTEL, A. and OESCHGER, H., 1985, Increase of atmospheric methane recorded in Antarctic ice core: Science, v. 229, p. 1386-1388. Authors at Phys. Inst., Univ. Bern, 3012 Bern, Switzerland.

Air entrapped in bubbles of cold ice has essentially the same composition as that of the atmosphere at the time of bubble formation. Measurements of the methane concentration in air extracted by two different methods from ice samples from Siple Station in western Antarctica allow the reconstruction of the history of the increase of the atmospheric methane during the past 200 years. (Authors' abstract)

STAUFFER, B., NEFTEL, A., OESCHGER, H. and SCHWANDER, J., 1985, CO_2 concentration in air extracted from Greenland ice samples, in Greenland Ice Core: Geophysics, Geochemistry and the Environment, C.C. Langway, Jr., H. Oeschger, and W. Dansgaard, eds.: Geophysical Monograph 33, Am. Geophys. Union, Washington, DC, p. 85-89. First author at Physics Inst., Univ. Bern, Bern, Switzerland.

The principal aim of the analyses of the CO_2 concentration in air extracted from ice samples is to reconstruct the CO_2 concentration of the atmosphere during the last millenia. For this purpose ice from very cold regions is best suited. Ice samples from Dye 3, where the mean annual air temperature is -20°C and summer melting is frequent, are not very well suited from this point of view. The results of CO_2 analyses give however very valuable information on a possible temperature effect on the CO_2 concentration of air in the bubbles. The CO_2 content shows seasonal variations with an annual maximum value in the summer melt layer. The annual minimum values correspond approximately to the estimated atmospheric CO_2 concentrations. Based on this experience, in spite of the complications due to the melt features, we try to reconstruct the history of the CO_2 concentrations of the atmosphere. Of special interest are the fast climatic transitions in the course and especially at the end of the last glaciation which are represented in the ice core by changes of parameters like acidity, dust, and istopic ratios in short depth intervals.

In this respect we discuss the time lag between the climatic warming at the end of the last glaciation and the increase of the atmospheric CO_2 concentration. Finally results of gas content and gas composition of two ice samples from the lowest, silty part of the ice core are discussed. (Authors' abstract)

STAUFFER, B. and OESCHGER, H., 1985, Gaseous components in the atmosphere and the historic record revealed by ice cores: Annals of Glaciology, v. 7, p. 54-59. Authors at Phys. Inst., Univ. Bern, Sidlerstrasse 5, CH-3012 Bern, Switzerland.

The composition of air in bubbles of ice reveals important information on the composition of the atmosphere at the time which the ice was formed. The enclosed air has essentially an atmospheric composition if the ice formation occurred by dry sintering of snow and firn at low temperatures. The history of atmospheric CO_2 concentration is of special interest due to its present increase and its climatic implications. Currently, CO_2 analysis of air extracted from ice cores seems the best and most direct method of determining the natural CO_2 concentration before 1950 and possible pre-industrial variations. Analyses of ice samples representing the past 40 ka show that there were significant changes in concentration of atmospheric CO_2 at the end, and probably during part, of the last glaciation. $\delta^{13}C$ measurements on CO_2 extracted from ice cores can indicate possible mechanisms causing these changes in the concentration of atmospheric CO_2. (Authors' abstract)

STEED, G.M. and MORRIE, J.H., 1985, Gold mineralization in Ordovician greywackes at Clontibret, Ireland (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A59. First author at University College, Cardiff, UK.

Clontibret lies within a belt of mid-Ordovician andesitic greywackes which have been subjected to prehnite-pumpellyite facies metamorphism in an area where no substantial intrusive bodies are exposed. There are two types of mineralized structure, both of which postdate the main Caledonian deformation. The richest grades occur along a series of NNW trending lode-zones, and to the south and east of these is a strike parallel NE trending and relatively extensive stringer zone bearing small amounts of sulphides with associated gold.

Along the lode zones the most widespread and significant mineralization is auriferous arsenopyrite and pyrite disseminated within the wall rocks and rock fragments and to a lesser extent in the lode quartz carbonate vein complexes. Most gold is in arsenopyrite solid solution and this is reflected by strong correlation between Au and As values. Some is in pyrite solid solution and a minor proportion in extremely rare and minute native gold particles. A later and more restricted phase of mineralization formed stibnite within veins containing ferroan dolomite and quartz. In some small lodes to the north of the main deposit stibnite is accompanied by native antimony, pyrrhotite and lead sulphosalts. Adjacent to the lode zones the wall rocks show pronounced phyllic alteration and a greater distance there is an irregular alteration fringe of propylitic character.

Measurements on fluid inclusions show a sharp peak for homogenization temperatures in quartz associated with arsenopyrite-pyrite (gold) between 280 and 300°, and a less clearly defined peak for quartz and carbonates associated with stibnite between 240 and 280°. In both cases the estimated pressure correction to be added to these values is 40 to 50°. Inclusions from the higher temperature range contain high concentrations of CO_2 with an aqueous phase containing about 2% by weight NaCl equivalent. (Authors' abstract)

STEELE, I.M., SMITH, J.V. and SKIRIUS, Christine, 1985, Cathodoluminescence zoning and minor elements in forsterites from the Murchison (C2) and Allende (C3V) carbonaceous chondrites: Nature, v. 313, p. 294-297. Authors at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL 60637, USA.

Forsterite grains in the Murchison (C2) and Allende (C3) meteorites have inclusion-free cores and inclusion-bearing rims, exactly opposite to the findings of Roedder, 1981a (Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 173 and v. 13, p. 209-210). The rim and cores differ widely in their TE composition. (E.R.)

STEIN, C.L., 1985, Preliminary report on fluid inclusions from halites in the Castile and Lower Salado Formations of the Delaware Basin, southeastern New Mexico: Sandia Rept. SAND83-0451, 44 pp. Author at Earth Sci. Div., Sandia Nat'l. Labs., Albuquerque, NM 87185.

A suite of samples composed primarily of halite from the upper Castile and lower Salado Formations of the Permian Basin was selected from Waste Isolation Pilot Plant (WIPP) core for a reconnaissance study of fluid inclusions. Volume percent of these trapped fluids averaged 0.7% to 1%. Freezing-point depressions varied widely and appeared to be unrelated to fluid-inclusion type, to sedimentary facies, or to stratigraphic depth. However, because very low freezing points were usually associated with anhydrite, a relation may exist between freezing-point data and lithology. Dissolved sulfate values [by laser Raman spectroscopy] were constant through the Castile, then decreased markedly with lesser depth in the lower Salado. This trend correlates very well with observed mineralogy and is consistent with an interpretation of the occurrence of secondary polyhalite as a result of gypsum or anhydrite alteration with simultaneous consumption of dissolved sulfate from the coexistng fluids. Together with the abundance and distribution of fluid inclusions in primary or "hopper" crystal structures, this evidence suggests that inclusions seen in these halites did not migrate any significant geographical distance since their formation. (Author's abstract)

STEIN, C.L., 1985b, Mineralogy in the Waste Isolation Pilot Plant (WIPP) facility stratigraphic horizon: Sandia Lab. Report SAND85-0321, 32 pp.

Includes discussion of authigenic quartz crystals found in the salt. (E.R.)

STEIN, H.J. and HANNAH, J.L., 1985, Movement and origin of ore fluids in

Climax-type systems: Geology, v. 13, p. 469-474. First author at Br. Isotope Geol., U.S. Geol. Survey, M.S. 963, Federal Center, Denver, CO 80225.

Climax-type stockwork molybdenum mineralization records a pervasive, outward-directed movement of ore fluids from a central stock. Recently obtained lead, oxygen, and sulfur isotope data document this phenomenon. Both metals and sulfur are derived in toto from within the stock. Meteoric water and host rocks at upper crustal levels play no role in the ore-forming process. Rather, wallrocks have been chemically overwhelmed by material evolving from the stock complex. (Authors' abstract)

STERNER, S.M. and BODNAR, R.J., 1985, Reequilibration of fluid inclusions in quartz during laboratory-simulated burial and uplift of metamorphic terranes (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 727. First author at Dept. Geol. Sci., Virginia Polytech. Inst., Blacksburg, VA 24061.

Fluid inclusion microthermometric analyses combined with geologic observations and mineral stability calculations suggest that fluid inclusions formed during early stages of a regional metamorphic event continue to reequilibrate during burial and subsequent uplift of the metamorphic terrane. These conditions were simulated in the laboratory by forming pure H_2O synthetic fluid inclusions in quartz and then subjecting the inclusions to different P-T conditions in the presence of a 20 wt% NaCl solution, such that the internal pressure of the inclusions was different from the confining pressure.

In both the burial and uplift simulations, new fractures formed in the quartz and, as the fractures healed, inclusions containing 20 wt% NaCl were formed, and the inclusions had densities corresponding to the reequilibration P-T conditions. In addition, several inclusions had salinities intermediate between 0 and 20 wt% NaCl, and the homogenization temperatures of these inclusions were consistent with formation at the new P-T conditions. Along a given microfracture, all inclusions of intermediate salinity had the same salinity and homogenization temperature.

In the burial simulation, the pure H_2O inclusions maintained their original density and homogenization temperature. Pure H_2O inclusions in the uplift experiments decreased in density, as manifested by an increase in homogenization temperature. However, these inclusions did not totally reequilibrate to the new P-T conditions but, rather, only partially reequilibrated, resulting in homogenization temperatures intermediate between the original homogenization temperature and that predicted for the new P-T conditions. (Authors' abstract)

STILLER, M., ROUNICK, J.S. and SHASHA, S., 1985, Extreme carbon-isotope enrichments in evaporating brines: Nature, v. 316, p. 434-435. Authors at Isotope Dept., Weizmann Inst. Sci., Rehovot 76100, Israel.

^{13}C enrichments of up to +16.5‰ (PDB) in natural conditions and up to +34.9‰ in laboratory experiments. (E.R.)

STÖCKHERT, B., MULLIS, J. and DUBESSY, J., 1985, N_2-rich inclusions in a high grade gneiss from the Eastern Alps (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 118-119. First author at Mineral.-Petrogr. Inst., Zülpicher Str. 49, D-5000 Köln 1, FRG.

N_2-rich fluid inclusions, associated with a highly saline aqueous brine, are found in quartz of a paragneiss from the Austridic basement to the south of the western Tauern Window (Eastern Alps). The rock has suf-

fered Hercynian high grade metamorphism with partial anatexis (T = 650 ± 30°C, p = 6 ± 1 kbar). The Alpine p-T path passed through T = 450 ± 50°C, p = 7 ± 1 kbar during early Cretaceous and through T = 350 ± 30°C, p = 3.5 ± 1 kbar during mid-Tertiary times. Alpine deformation is weak; the minerals grown during high grade metamorphism (biotite, quartz, plagioclase, K-feldspar, sillimanite, muscovite) are slightly altered; only sillimanite is largely replaced by fine-grained kyanite and white mica. Coarse quartz grains, up to several mm in size, have survived Alpine overprint; minor recrystallization is restricted to their margins.

The fluid inclusions found in the coarse quartz grains can be placed in four groups according to their phase assemblage at T = 20°C (fig. 1):

A): Aqueous brine, gas bubble (about 4 vol%), four or five different dxls. These inclusions are up to 30 μm in size and have a highly irregular shape with offshoots indicating partial decrepitation. They occur isolated or are arranged in loose groups.

B): Aqueous brine, gas bubble (about 5 vol%), two or three different dxls. These inclusions are up to 15 μm in size; their shape is oval to angular with a slight tendency towards negative crystal shape. They are typically arranged in densely populated, well defined intragranular pore planes; the mean size of the inclusions decreases markedly versus the edges of the pore planes; in places these are preferentially oriented parallel (0001).

C): Apparently monophase (gaseous phase with low refringence); some inclusions show a thin aqueous selvage; then, the gas bubble comprises at least 80 vol% of the inclusion; a very small dxl may be present. The inclusions are up to 15 μm in size and show negative crystal shape with rounded edges. Like those of type B) they are mostly arranged in densely populated, well defined intragranular pore planes; the inclusion size decreased markedly versus the edges of the pore planes; these are preferentially oriented parallel (0001).

D): Aqueous brine, gas bubble (3 to 8 vol%). These inclusions reach up to 20 μm in size; their shape is variable. They are arranged in pore planes, which in places transect high angle grain boundaries.

Types A), B) and C) are exclusively found in coarse quartz grains grown during Hercynian high grade metamorphism. They have not been found in quartz recrystallized in response to Alpine deformation, nor in any sample showing pronounced Alpine retrogression. Thus, these fluid compositions are related to high grade metamorphism.

The low-T behavior of type C) is schematically shown in fig. 2. During warming from T = -180°C Th (L) takes place between -158 and -147°C; (near)critical behavior at T = -147°C is observed in some inclusions; this indicates N_2 of low to moderate density to be the major component; final sublimation of a small amount of solid CO_2 occurs between -104 and -77°C. Raman-spectrometric analysis of five inclusions revealed molar ratios $N_2/(N_2 + CO_2)$ between 0.80 and 0.97 for the gas phase; CH_4 is present in traces. An estimated maximum of 20 vol% of an aqueous phase (wetting the inclusion walls) corresponds to between 30 and 50 mole % of bulk composition, dependent on the density of the gas.

Some constraints on the interpretation of the fluid compositions and on the formation of the inclusions are discussed. (Authors' abstract)

Continued next page.

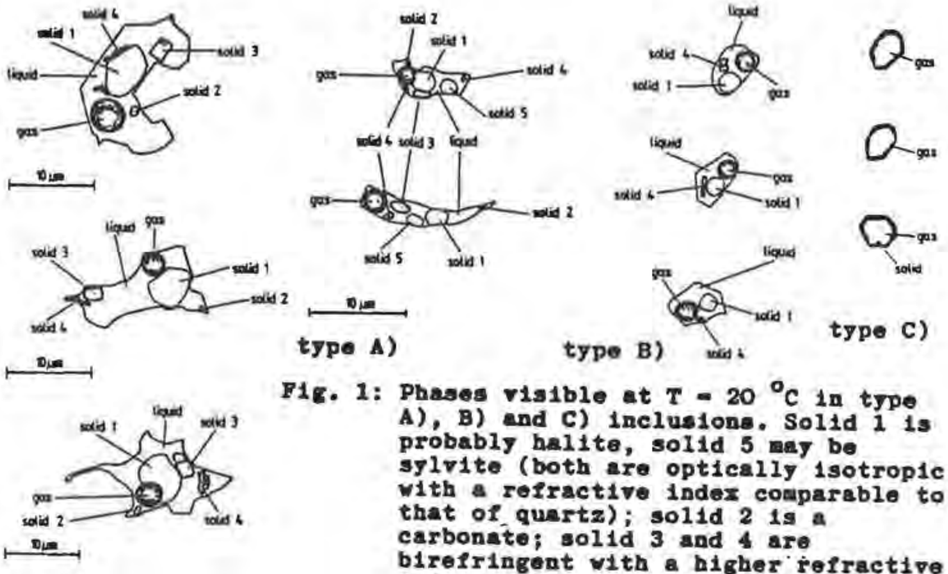

Fig. 1: Phases visible at T = 20 °C in type A), B) and C) inclusions. Solid 1 is probably halite, solid 5 may be sylvite (both are optically isotropic with a refractive index comparable to that of quartz); solid 2 is a carbonate; solid 3 and 4 are birefringent with a higher refractive index compared to quartz.

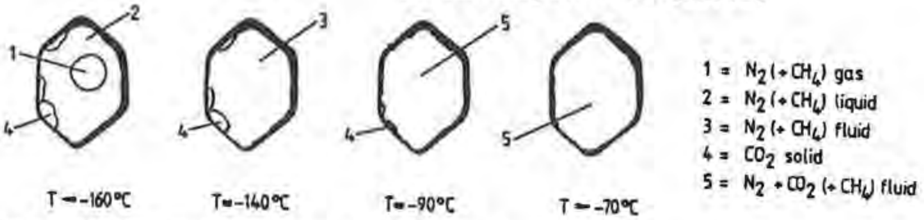

Fig. 2: Low-T behavior of type C) inclusions.

STOLPER, Edward and SILVER, L.A., 1985, Speciation of water in silicate glasses: The influence of bulk composition (abst.): EOS, v. 66, p. 1140.

STRONG, D.F., 1985, Genesis of Ag-Co-Ni-arsenide vein deposits like those of the Cobalt district of Ontario (abst.): Geol. Ass. Canada, Cord. Sec., Symp. Silver '85, Vanc., B.C., p. 13-16. Author at Memorial Univ. Newfoundland, St. John's, Newfoundland.

A study of fluid inclusions associated with the Ag-Co-Ni-arsenide carbonate vein systems in six mines of the Cobalt-Gowganda area of Ontario allows for the following observations:

1. There is a range of homogenization temperatures, from 67 to above 561 °C, observed for both quartz-hosted and calcite-hosted inclusions.

2. The ore fluids were highly inhomogeneous boiling brines, with NaCl concentration reaching a maximum of 54 equiv. wt.% NaCl, and $CaCl_2/(CaCl_2 + NaCl)$ ratios averaging 0.5 but reaching 0.94.

3. Wide variability of the fluid inclusions, along with several demonstrable examples of boiling phenomena, indicate that the ore fluids were boiling during deposition of their host minerals and therefore of the associated ore minerals.

4. The appropriate boiling curves indicate that mineralization took place at pressures up to about 600 bars, equivalent to depths of about 2000 meters, the approximate combined thickness of the Cobalt Group and Nipissing diabase.

5. The average Lundy Township Th of 223° and salinity of 28%, are not significantly different from the average Th of 275°C and 25% salinity for the mineralized veins, indicating that the ore fluids were available throughout a large region of the Huronian basin.

The fluid inclusion and other data lead to a genetic model involving the heating and circulation of Huronian basinal brines by intrusion of the Nipissing diabase, deriving metals from the Archean basement or the Huronian sediments or both, and deposition of the vein material caused by pH increases in the fluids resulting from boiling and CO_2 effervescence, which in turn was the combined result of heating by the diabase and decompression during faulting and fracturing. This model integrates and explains numerous features of the vein systems and their host rocks which were previously not seen to be related. (From the author's abstract)

STULTS, Andrew, 1985, Geology of the Bajo La Alumbrera porphyry copper and gold prospect, Catamarca province, Argentina: Masters thesis, The Univ. Arizona.

Bajo La Alumbrera is a porphyry copper and gold prospect in dacite porphyry. Concentric zones, from center outward, of potassic, phyllic, and propylitic alteration are present. Major Au and Cu mineralization is associated with intense silicification within the potassic alteration zone. Au occurs as disseminated sub-micron-sized native particles and in chalcopyrite (and pyrite?) lattices.

Fluid inclusion thermometry indicates that an early high-T, high-salinity fluid and a later lower-T, low-salinity fluid of distinctly different sources were involved in alteration and mineralization at Bajo La Alumbrera. The early fluid, most probably of magmatic origin, ranged from 300 to 700°C and from 40 to 62.5 wt.% NaCl equiv., while the later fluid varied from 175 to 400°C and from 1.0 to 14.5 wt.% NaCl equiv. Both fluids show decreases in Th, and the high-T fluid shows increasing salinity, moving away from the center of the prospect. (From the author's abstract)

SU, Lianghe, YUAN, Jiazheng and WU, Ruihua, 1985, High temperature experiment on iron ore deposits possibly formed by ore magma in China: Geologic Papers Under the Int'l. Exchange Program, v. 4, p. 143-154 (in Chinese; English abstract). Authors at Beijing Graduate Sch., Wuhan College of Geol.

In connection with the possible origin of the Meishan and Daye iron ore deposits in PRC, experiments were made in the systems apatite-diopside-nepheline-wustite at 1400°C and fluorphlogopite-diopside-albite-wustite at 1250°C; in both systems two immiscible liquids were found, one iron-rich. (E.R.)

SUCHOMEL, B.J., 1985, Geology of the Bajo de Agua Tapada base and precious metal prospect, Catamarca province, Argentina: Masters thesis, The Univ. of Arizona.

Bajo de Agua Tapada is the northernmost occurrence in a NW-SE trending zone of porphyry copper-gold prospects in northwestern Argentina. Hydrothermal alteration consisting of concentric potassic, phyllic, silicic, and propylitic zones is centered on a shallowly-emplaced, extensively fractured dacite porphyry stock. Minor chalcopyrite and anomalous Au accompany pyrite and magnetite in the potassic zone.

Radial jasperoid veins occur in all rock types and are characterized by replacement of wall rock by cryptocrystalline silica, often accompanied by pyrite, barite, alunite, and base metal sulfides. Several jasperoid veins and peripheral, siliceous base metal sulfide veins contain significant Au and Ag mineralization.

Preliminary fluid inclusion analyses indicate that hydrothermal fluids of generally decreasing salinity with time and in the range 330°C to 150°C were operative at the levels of observation. (From the author's abstract)

SUGAKI, Asahiko, UENO, Hirotomo, KITAKAZE, Arashi, HAYASHI, Kenichiro, SHIMADA, Nobutaka, KUSACHI, Isao and SANJINES V., Orlando, 1985, Geological study of the ore deposits in the La Paz district, Bolivia: The Science Reports of the Tohoku Univ., Third Series, v. 16, no. 2, p. 131-198 (in English).

Th of liquid inclusions in quartz from Milluni (Rotschild), Kellhuani, Chojlla and Trinidad mines are 176°-321°C (mean value 261°C), 215°-363°C (294°C), 231°-408°C (311°C) and 217°-427°C (311°C), respectively. Meanwhile salinity in NaCl equiv. conc. of liquid inclusions in quartz from Kellhuani and Trinidad mines are 25.1-26.0 wt% and 23.6-47.1 wt%, respectively. Also Th and salinity of liquid inclusion in quartz from the Viloco (Roberto, Broncera, Cinco, Nueva and Doce veins) and Colquiri (San Carlos vein) mines are 263°-494°C, 18.5-55.4 wt% and 205°-383°C (271°C), 1.2-6.4 wt%, respectively. Th of liquid inclusions in quartz from the Matilde mine is 188°-283°C (233°C). (From the authors' abstract)

SUGISAKI, Ryuichi and SUGIURA, Tutomu, 1985, Geochemical indicator of tectonic stress resulting in an earthquake in central Japan, 1984: Science, v. 229, p. 1261-1262. First author at Dept. Earth Sci., Nagoya Univ., Chikusa, Nagoya 464, Japan.

Conspicuous changes in gas composition [He, CH_4, H_2, SO_2, HCl and HF] were observed at a fumarole and a mineral spring just before the occurrence of an inland earthquake (magnitude, 6.8) in central Japan in September 1984; the fumarole and spring were 9 and 50 kilometers, respectively, from the earthquake's epicenter. Deep-seated fluids emitted as a result of the compressional stress of the earth tide had been observed previously at this mineral spring and at a lava lake in Hawaii. By analogy, the gas anomaly observed before the earthquake in Japan probably resulted from deep-seated fluids being squeezed to the surface by the tectonic stress that caused the earthquake. (Authors' abstract)

SUSAK, N.J. and CRERAR, D.A., 1985, Specta and coordination changes of transition metals in hydrothermal solutions: Implications for ore genesis: Geochimica Cosmo. Acta, v. 49, p. 555-564. First author at Dept. Geol., Univ. New Brunswick, Fredericton, New Brunswick E3B 5A3, Canada.

Optical absorption spectra of Fe(II), Co(II), Ni(II) and Cu(II) have been measured in aqueous solutions of up to 5 m NaCl at temperatures from 25°C to 300°C and at water-saturated vapor pressures. Ni and Co complexes exhibited a change from octahedral to tetrahedral coordination, this occurring at both higher temperatures and Cl^- concentrations. Similar transitions to lower coordination number are predicted for Cu and Fe but were not directly observed because of interference with water overtone bands. The coordination changes in response to ligand type and concentration, pressure and temperature. Formation of lower coordination complexes is attributed to the decrease dielectric constant of the solvent, the predominance of electrostatic forces and a decrease in the octahedral site preference energy at elevated temperatures. Our data suggest that lower coordination complexes with lower or neutral formal charge, will result in minerals having a higher solubility. The molecular properties and changes in coordination of these complexes are important in determining the transport and deposition of hydrothermal minerals. (Authors' abstract)

SUSHCHEVSKAYA, T.M., LUCHITSKAYA, M.I., RYZHENKO, B.N. and BARSUKOV, V.L., 1984, Acidity of the medium during hydrothermal cassiterite formation: Geokhimiya, 1984, no. 4, p. 515-526 (in Russian; translated in Geochem. Int'l., v. 21, no. 5, p. 77-87, 1984 (pub. 1985)).

See Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 336. (E.R.)

SUSTAVOV, O.A., 1985, Diagnostics, conditions of formation and prospecting significance of submicroscopic fluid inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 78-79 (in Russian). Author at Sverdlovsk Geol. Inst., Sverdlovsk, USSR.

Quartz from gold deposits in Yakutia sometimes has under microscope brownish tint, its density is 0.015 g/cm^2 less than of colorless quartz, also refractive index is lower than that of neighboring quartz without brownish tint. Carbon replicas of cleavage surfaces of this quartz showed under electron microscope numerous vacuoles of habit of negative quartz crystals, about 0.12 μm in length. Since dimension of vacuoles is of the range of light wavelength, light dispersion most probably causes the brownish tint of quartz in transmitted light. If it is assumed that the vacuoles are spheres of dia. 0.2 μm, the measured difference of density would require the presence about 10^{10} such inclusions in 1 cm^3 of quartz. Electron microscopy shows the continuous transition from small vacuoles to those of about 2-3 μm dia.; the latter are visible in light microscope as two- or three-phase (with LCO_2) fluid inclusions with Th 280-350°C. Decrepitation activity of this quartz is low. The observed inclusions may cause the absorption bands of water (3200-3600 cm^{-1}) and carbon dioxide (2350 cm^{-1}) in the studied quartz (polished slide preparations). Submicroscopic fluid inclusions are essentially S ones, formed in connection with plastic[?-sic, A.K.] deformation processes and correlate with places of undulant extinction in the quartz (observations in 130 thin sections). The author supposes that submicroscopic fluid inclusions may form due to destruction of former larger inclusions and redistribution of their fillings, or by coalescence of H_2O molecules on dislocations (the molecules form from hydroxyl groups of the deformed quartz); diffusion of CO_2 along dislocations is also possible. The described quartz is most typical for gold-sulfide commerical stages of mainly gold-antimonite formation, and occurs in 35-45% of the studied specimens, whereas barren veins contained such quartz only in 3-5% of the studied specimens. (A.K.)

SVERJENSKY, D.A., 1985, The distribution of divalent trace elements between sulfides, oxides, silicates and hydrothermal solutions: I. Thermodynamic basis: Geochimica Cosmo. Acta, v. 49, p. 853-864.

SVOREN', I.M., 1985a, Defects of crystal lattice of minerals - important source of information about differentiation of volatiles in processes of mineral formation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 33-35 (in Russian). Author at Inst. Geol. & Geochem. of Mineral Fuel Materials Acad. Sci. Ukrainian SSR, L'vov, Ukraine.

Volumes of elementary units [unit cells?] of quartz (0.1130 nm^3), galena (0.2054 nm^3), sylvite (0.2427 nm^3) and most other minerals exceed the volumes of molecules of many volatiles (CO_2 0.0065 nm^3, H_2O 0.0060 nm^3, CH_4 0.0196 nm^3, if imagined as spheres). This makes essential the supposition that during mineral crystallization, unlike metals, the crystal lattice is able to trap both atoms and molecules of foreign substances. Because the chemical activity of various isotopes of the same element is different, the crystal lattice during its growth should trap selectively volatiles from solution mostly with one preferred isotope. E.g., electroconducting sulfides would trap the light carbon isotope, and the solution would be enriched in heavy C. If initial δ^{13}C was -6.1%,* CO_2 released from sulfide lattice by heating would range from -11.0 to -15.0%, and CO in late calcite - from +15.0 to +20.0% or even more. Experimental determination of $\delta^{13}C$ in CO_2 released from lattice of galena (galena + calcite specimen from a vein deposit in Donbass) by heating showed value -11.3%, but CO_2 from calcite - +16.7%. This may help in explanation of carbon isotope evolution during mineral-forming processes. (A.K.)

*Russian text gives here and further in this abstract "%," but more likely these are misprints for "‰". (A.K.)

SVOREN', I.M., 1985b, Crystallization on gas bubbles (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 35-36 (in Russian). Author at Inst. Geol. & Geochem. of Mineral Fuel Materials Acad. Sci. Ukrainian SSR, L'vov, Ukraine.

Experiments with nucleation of Seignette salt crystals [i.e., potassium sodium tartrate] on CO_2 bubbles were performed in glass vessels in a hydrogel of H_2SiO_3 with density 1.02-1.05 g/cm^3, pH 6. To fresh hydrogel, 3% of saturated Na_2CO_3 solution by volume was added, as well as $H_6C_4O_6$ [tartaric acid]. A layer of saturated solution of NaCl + KCl was poured onto the hydrogel. CO_2 bubbles formed by decomposition of Na_2CO_3 migrated upward and became the crystallization nuclei for Seignette salt, formed according to reaction $H_6C_4O_6 + NaCl + KCl \rightarrow NaK(H_4C_4O_6)\cdot 4H_2O + 2HCl$. The spherical shape of CO_2 bubbles was almost undeformed. The results may be useful for interpretation of G inclusions formed in heterogeneous mineral-forming solutions. (From the author's abstract, by A.K.)

SZURGOT, M., SANGWAL, K. and KARNIEWICZ, J., 1985, Study of inclusions and growth bands in potassium bichromate crystals grown from aqueous solutions: Cryst. Res. Technol., v. 20, no. 5, p. 645-654. Authors at Tech. Univ. Lodz, Poland.

The nature of inclusions and growth bands in potassium bichromate crystals obtained from aqueous solutions and their formation in relation to growth temperature and supersaturation are investigated. It is observed that impurities present in solution, fluctuations in growth temperature and high growth rates are responsible for their formation. (Authors' abstract)

TAGUCHI, Sachihiro, IRIE, Atsushi, HAYASHI, Masao and TAKAGI, Hiroshi, 1985, Mushroom structure revealed by fluid inclusion thermometry in the Otake geothermal field, Japan: Proc. Geothermal Res. Council Symp., Kona, Hawaii, Aug. 26-30, 1985, 5 pp. (unpaginated). First author at Res. Inst. of Industrial Sci., Kyushu Univ., Kasuga-shi 816, Japan.

Th of fluid inclusions in quartz, anhydrite and calcite from the Otake geothermal field, Kyushu, Japan, have been measured. The minimum Th at each depth seems to be almost equal to the present subsurface temperature. The Otake reservoir temperature at depths of 300-400 m is estimated to have been in the range of 200-220°C. The distribution patterns of Th suggest that the system had cooled down as much as 15-30°C from the maximum state, whose temperatures are the same as the boiling point curve from the surface. The subsurface thermal profile obtained from the minimum inclusion temperatures is mushroom-shaped and slightly distorted due to an inclined upflow of hot water. (Authors' abstract)

TALANTSEV, A.S., 1985, Primary gas-liquid inclusions as indicators of conditions of development of post-magmatic processes (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 18-19 (in Russian). Author at Inst. Geol. & Geochem. of Ural Sci. Center, Sverdlovsk, USSR.

The author indicates the necessity of use of pressure corrections for

Th values and validity of comparison of inclusion temperature data with data obtained by mineral (i.e., mineral phase equilibria and element partition) thermometry. (A.K.)

TALANTSEV, A.S., ZEVAKOVA, N.Ye. and VORONINA, L.K., 1985, On the difference of formation temperature of calcite and homogenization [temperatures] of gas-liquid inclusions in it: Zapski Vses. Mineralog. Obshch., v. 114, no. 2, p. 248-253 (in Russian). First author at Geol. Inst. of the Ural Sci. Center, Sverdlovsk, USSR.

Authors investigated a crystal of calcite from the deposit Dal'negorsk (Cu-Zu-Pb-B), which bears fluid inclusions in several, distinctly outlined growth zones, alternating with perfectly clear, inclusion-free zones. The studied inclusions had dimensions ≤ 0.08 mm, mostly of negative crystal habit. Inclusions have various degrees of fill, but under microscope this feature is almost unobservable, and is revealed only during Th determinations, since frequently closely associated P inclusions have different Th and the difference is in ranges 30-40°C, suggesting formation from heterogeneous solutions. Th in one zone (4) vary from 181 to 294°C, and in the other one (6) from 186-290°C. Electron microprobe analysis showed small solid inclusions of Ca-Mg-Fe carbonate (ankerite) in calcite. The presence of this Mg-rich phase (21.5% $MgCO_3$) made possible the use of dolomite-calcite geothermobarometer (see Talantsev 1981). Electron microprobe analysis gave the following ranges for calcite: CaO 52.6-54.3, MgO 0.11-0.35, FeO 0.36-1.78, MnO 0.48-2.70 (wt.%), thus the calculated T of calcite crystallization was in ranges 160-310°C (± 15%) and P 0.08-0.64 kbar (± 30%). Since there is no simple agreement in the course of changes of Th and T obtained by the dolomite-calcite thermometer, the author concludes that fluid inclusions are mostly necked-down and do not submit valuable thermometric data, although this invalidity was possible to detect only after very thorough study of mineral substance itself. (Abstract by A.K.) (Note that the T values obtained by the dolomite-calcite geothermometer have, in fact, a wide range of uncertainty: for 160°C it is from 136 to 184°C, and for 310°C from 263.5 to 356.5°C; this brings up the question of which method provides a "check" on the other. A.K.)

TALTYKIN, Yu.V., LIPATOV, V.G. and ABLESIMOV, N.Ye., 1983, Supercritical fluids as factors in generation of deep electrical conductivity anomalies: Dokl. Akad. Nauk SSSR, v. 272, no. 4, p. 935-936 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 272, p. 92-93, 1985).

TAN, Yunjin, 1985a Geological-geochemical characteristics of Lianhuashan porphyry tungsten deposit: Geochemistry, v. 4, no. 1, p. 18-32 (in English). Author at Inst. Geochem., Acad. Sinica.

Tungsten mineralization occurs in the phyllite zone in quartz porphyry. The mineral associations are characterized by the paragenesis of wolframite with scheelite, and high sulfides, especially pyrite, pyrrhotite and arsenopyrite. Stable isotope data are presented and fluid inclusions indicate that the temperature of alteration-mineralization ranges from 650° to 150°C. Ore fluids are high in salinity and rich in Cl. The geological-geochemical characteristics of the deposit permit a conclusion that the studied deposit is a porphyry-tungsten deposit. (From the author's abstract)

TAN, Yunjin, 1985b, Metallogenetic mechanism of Lianhuashan porphyry tungsten deposit: Scientia Sinica, Ser. B., v. 28, no. 11, p. 1207-1217 (in English). Author at Res. Inst. Geol. for Mineral Resources, CNNC, Guilin, China.

This article discusses the metallogenetic mechanism of Lianhuashan porphyry W deposit on the basis of the studies of inclusions, stable isotope, mineralogy and trace elements.

The Lianhuashan porphyry W deposit originated in the hypabyssal to near surface condition. The temperature of alteration and mineralization of this deposit ranges from 150° to 650°C, indicating that the alteration and mineralization have experienced from the late-magmatic stage to the post-magmatic mesothermal stage.

The metallogenetic liquid of Lianhuashan porphyry W deposit had log fO_2 = -26 - -42, log fS_4 = -17 - -7 and pH = 4.5-7.5. The ferberite mineralizaton was formed when log fO_2 = -26 - -31, pH = 4.5-5, while the scheelite and sulfides mineralization was formed when log fO_2 = -38 - -42, pH = 7-7.5. (Author's abstract)

TANAKA, Kiriko, KOIZUMI, Morito, SEKI, Riki and IKEDA, Nagao, 1985, Hydrogen isotope (T, D) study of hot-spring waters from Nasu, Tochigi Prefecture: Geochem. J., v. 19, p. 289-299.

TAYLOR, B.E., 1985, Degassing of rhyolitic magmas: Hydrogen isotope evidence and implications for magmatic-hydrothermal ore deposits (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 258-262.

TAYLOR, B.E. and WESTRICH, H.R., 1985, Hydrogen isotope exchange and water solubility in experiments using natural rhyolite obsidian (abst.): EOS, v. 66, no. 18, p. 387.

TAYLOR, Mark, KESLER, S.E., CLOKE, P.L. and KELLY, W.C., 1985, Fluid inclusion evidence for fluid mixing, Mascot-Jefferson City zinc district, Tennessee - a reply: Econ. Geol., v. 80, p. 1442-1443. Authors at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

A reply to discussion by Churnet (this volume). (E.R.)

TAYLOR, R.P. and SO, Chil-Sup, 1985, Isotope geology of the Dae Hwa tungsten-molybdenum mine, Republic of Korea (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A61. First author at Dept. Geol., McMaster Univ., Hamilton, Ontario, L8S 4M1, Canada.

The Dae Hwa W-Mo mine is located within the Precambrian metamorphic belt of the southern Korean peninsula. The deposit is composed of numerous fissure-filling quartz veins contained within Precambrian granitic gneiss adjacent to a contact with a granitic stock of Mesozoic age. The ore vein paragenetic sequence can be divided into two distinct stages: an early Mo-W stage, during which quartz, muscovite, beryl, molybdenite, wolframite, scheelite, pyrite, cassiterite, chalcopyrite, and fluorite were deposited; and a late stage, during which the carbonate minerals siderite, dolomite, and calcite were deposited. Oxygen isotope $\delta^{18}O$ values of the vein minerals are: quartz (11.2 to 10.9 per mil), muscovite (89.2 per mil), wolframite (4.0 per mil), cassiterite (2.9 per mil), and large euhedral color-zoned, scheelites (cores = 2.2 to 1.4 per mil; rims = -3.9 to -6.8 per mil). Quartz-muscovite mineral pairs yield oxygen isotope temperatures of 390° to 360°C. Homogenization temperatures for primary fluid inclusions in quartz (356° to 194°C), beryl (395° to 260°C), scheelite (cores = 331° to 266°C; rims = 258° to 217°C), and calcite (230° to 161°C) support those derived from isotope geothermometry. Together with the oxygen isotope data and sulfur isotope analyses of sulfide vein minerals ($\delta^{34}S$ = 2.4 to

4.4 per mil suggesting an igneous source for the sulfur) they indicate that the deposition of molybdenite, wolframite, and scheelite occurred during a period of declining temperatures from 400° to 230°C in response to the inundation of an original magmatic fluid system ($\delta^{18}O(H_2O)$ = 6.2 per mil at 360°C) with low temperature waters of meteoric derivation ($\delta^{18}O(H_2O)$ = -.07 to -3.8 per mil for an average carbonate depositional temperature of 200°C). (Authors' abstract)

THOMAS, A.V. and SPOONER, E.T.C., 1985, Occurrence, petrology and fluid inclusion characteristics of tantalum mineralization in the Tanco granitic pegmatite, S.E. Manitoba (abst.), in R.P. Taylor and D.F. Strong, eds., Granite-Related Mineral Deposits, Extended Abstracts of CIM Conf., Sept. 15-17, 1985, Halifax, Canada, p. 274-278. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario, M5S 1A1, Canada.

The Tanco (Ta, Sn, Li, Cs) granitic pegmatite, S.E. Manitoba was, prior to closure in 1982, a major world hard rock source of Ta.

Preliminary investigation of the fluid inclusions (f.i.'s) in the WTO [Western type ore] and ETO [Eastern type ore] have been carried out. The microthermometric observations have been aimed at documenting fluid evolution in the ETO sequence (albitite-beryl fringe-quartz core) and at comparing the high grade (type b) WTO with the ETO.

In the ETO, primary f.i.'s were investigated in quartz intergrown with albite intergrown with wodginite within the albitite, and in the beryl and quartz of the beryl fringe and quartz core respectively. Most inclusions were 3-phase CO_2-bearing, at room temperature, with variable ratios of CO_2:H_2O. On heating to total homogenization the inclusions from each lithology homogenized into both the CO_2 and the H_2O phases over the same temperature range indicating that the variable phase ratios were due to trapping on a CO_2-H_2O-salt, solvus and therefore that Th is equal to Tt. Tt obtained in this way are in the order 327 ± 45°C, n = 25 (albitite), 297 ± 33°C, n = 33 (beryl fringe) and 265 ± 30°C, n = 76 (quartz core; data are given as mean ± 1 std. dev.). These data are consistent with the sequence of deposition inferred from field studies. A best estimate, therefore, for the temperature of deposition of the wodginite would be approximately 330 ± 45°C.

Inclusions in beryl and apatite from within the type (b) lithology of the WTO also exhibit variable CO_2:H_2O ratios. Observations indicate that the degree of variability of this ratio in the WTO is comparable to that in the ETO, but in the former case initial heating work has so far failed to prove phase separation as the cause of the variable ratios because most (>90%) of the inclusions decrepitated on heating.

Freezing work on the WTO and ETO f.i.'s has shown that the two types of ore have very similar fluid characteristics (see Table). Both show final Tm CO_2 which are depressed by approx. 0.5 - 1°C, which are equivalent to the effect of X of 0.1. Depressions in Tm of this order of magnitude are significant because the Linkam TH600 stage is calibrated to within ± 0.1°C at this temperature. The salinity of the aqueous phase as calculated from Tm clathrate of both ores is in the range 8-9 equivalent wt.% NaCl and initial melting points of ice [Tm ice?] in both cases indicate the presence of a divalent cation in the aqueous phase. (From the authors' abstract)

Observation/Measurement	Albitite	West End Min.
T°C Final Fusion CO_2	-57.4 ± 0.8°C n = 58	-57.0 ± 0.8°C n = 41
Salinity (Equivalent wt.% NaCl)	8.2 ± 2.9% n = 11	8.9 ± 1.9% n = 8
T°C Homogenization Total	327 ± 45°C n = 25	199 - 298°C range
Trapping Temperature	327 ± 45°C	Unknown

THOMAS, L.J., HARMON, R.S. and OLIVER, G.J.H., 1985, Stable isotope composition of alteration fluids in low-grade Lower Palaeozoic rocks, English Lake District: Mineral. Mag., v. 49, p. 425-434. First author at Dept. Geol., Univ. St. Andrews, St. Andrews, Fife, KY16 9ST, UK.

A combination of hydrogen and oxygen isotope analyses and fluid inclusion studies has defined the composition of fluids involved in the metamorphism of Lower Palaeozoic rocks in the English Lake District. Three fluid fields have been defined from secondary phases: 1, syn-burial metamorphic D-enriched fluids from epidote and chlorite at a temperature between 250 and 350°C, 2; D-depleted fluid measured from groundmass and quartz inclusions; 3, a mixed magmatic-meteoric fluid with an intermediate H-isotopic composition estimated from W/R granite data and calculated from illite. (Authors' abstract)

THOMAS, Rainer, 1985, Thermobarometric analysis of fluid inclusions in minerals of metamorphic rocks - a contribution to the evaluation of genetic conditions: Freiberger Forschungshefte, v. C390, p. 45-67 (in German). Author at 9200 Freiberg/Sa., Lomonossowstrasse 14, GDR.

The T and P conditions of the formation of Upper Proterozoic to Cambrian parametamorphic rocks from the western part of the Erzgebirge-anticlinorium (southern part of the G.D.R.) were studied using thermometric and cryometric measurements of fluid inclusions in quartz, albite and 1 sample of garnet. Th for quartz and albite ranged from (207 ± 26) to (328 ± 32)°C, Th(CO_2-L) ranged from 4.0 to (22.1 ± 2.3)°C, and Tm(ice) ranged from -1.8 to -4.1°C. The results show a quasi-linear dependence between the T and P of the regional metamorphism from the phyllites (Tt = 360-420°C, Pt = 1.3 to 1.7 kbar) to the garnet-mica-schists and gneisses (Tt $\leqslant$ 680°C, Pt $\leqslant$ 3 kbar).

The T of the first melt formation from silicates in the quartz of gneisses, as found experimentally, is 750°C and was not reached by regional metamorphism.

From these data of Tt and Pt obtained by thermobarometric investigations on fluid inclusions we obtain as a first approximation a value of the geothermal gradient $\nabla T = (51.0 \pm 7)$°C/km.

Beside the data on fluid inclusions in minerals of parametamorphic rocks, first results of measurements on silicate melt inclusions in kornerupine ("prismatine") from the high-grade granulite-facies rock of Waldheim/Sa. were presented: Tm $\leqslant$ 750°C, Th = (840 ± 30)°C.

See also Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 123-124, 1982. (English abstract by R. Thomas)

THOMAS, Rainer and BLANKENBURG, H.-J., 1985, Results from the thermometric examinations of glass inclusions in rhyolitic quartz: Z. Geol. Wiss., Berlin, v. 13, no. 5, p. 667-673 (in German; English abstract).

The genesis of Permosilesian rhyolites of the G.D.R. and adjacent countries is discussed anew after examining thermometrically glass inclusions in disseminated quartzes. The best conformity of all test results is given in the concept of intramagmatic early crystallization of the high-temperature quartz phenocrysts. (Authors' abstract)

THOMASSIN, J.-H., CROVISIER, J.-L., TOURAY, J.-C., JUTEAU, Thierry and BOUTONNAT, Fréderique, 1985, Contribution of the experimental geochemistry to the understanding of seawater-basaltic glass interactions between 3°C and 90°C: Data of ESCA and electron microscopy: Bull. Soc. Géol. France, 1985, ser. 8, v. 1, p. 217-222 (in French).

THOMPSON, A.B., 1985, Fluids in the eclogites facies (abst.): Second Int'l. Eclogite Conf., Terra Cognita, v. 5, p. 443. Author at Erdwissenschaften, ETH-Zürich, CH-8092 Zürich, Switzerland.

Progressive burial at low temperatures can transform greenschist to blueschist without dehydration. Because of the likely stability of unknown hydrated minerals in the eclogite facies and at higher pressures, plus the fact that orthosilicates, at least, exhibit extensive SiH^{-4} exchange, transformation of blueschist to some eclogites can also be H_2O-conserving. Even when dehydration occurs, there is less tendency for such dense fluids to migrate upwards, until the rocks are heated to say over 600°C or undergo uplift, when vein formation probably occurs. Stable isotope studies of continental crust metamorphosd in the eclogite facies often show low $^{18}O/^{16}O$ ratios, but it is difficult to predict when they might have interacted with light-oxygen fluids. Heterogeneous deformation zones and degrees of mineral disequilibrium are also consistent with restricted fluid motion in the deep crust. (Author's abstract)

THOMPSON, T.B. and RICE, J.A., 1985, Paleohydrology in the Creede Formation and formation of a disseminated silver deposit (abst.): Geol. Soc. Am. Prog. with Abst., v. 17, no. 4, p. 267. First author at Dept. Earth Resources, Colorado State Univ., Ft. Collins, CO 80523.

The Creede Formation silver deposit is locallized within a coarse fluvial deposit in a paleovalley that overlies part of the productive vein system of the Creede district. Mineralizing fluids flowed into the Creede Formation from the Amethyst and OH veins as shown by decreasing intensity of silicification and lower filling temperatures of fluid inclusions in barite away from the veins. The silver zone occurs within moderately silicified rock.

Weakly boiling, sulfate-dominate, mineralizing fluids were introduced into a groundwater-saturated Creede Formation. Barite was precipitated throughout a large volume of the Creede Formation as the fluids mixed and cooled within the permeable conglomerate. Local intense boiling of the ore fluids resulted in NaCl-saturated fluids at room temperature. Later less extensive silicification of clasts and matrix occurred as newly introduced ore fluids mixed with groundwater and cooled. Filling temperatures of fluid inclusions in barite vary linearly with ore fluid densities, but density is not entirely related to salinity changes. As a result, simple linear mixing of the two fluids did not occur. Mixing was by density stratification and diffusion between the fluids. Cylindrical zones of argillized rock reflect separation of a sulfuric acid solution which flowed, due to its greater density, in near vertical columns to the lower part of the paleovalley where extensive argillization resulted. Later fluids were less voluminous, and sulfides were precipitated in response to cooling of ore fluids. (Authors' abstract)

THOMPSON, T.B., TRIPPEL, A.D. and DWELLEY, P.C., 1985, Mineralized veins and breccias of the Cripple Creek district, Colorado: Econ. Geol., v. 80, p. 1669-1688. First author at Dept. Earth Resources, Colorado State Univ., Ft. Collins, CO 80523.

Five stages of minerals are recognized in the Ajax mine veins: (1) quartz-fluorite-adularia-pyrite-(dolomite-marcasite), (2) base metals-quartz-pyrite, (3) quartz-fluorite-pyrite-hematite-rutile, (4) quartz-pyrite-rutile-calaverite-acanthite, and (5) quartz-fluorite-dolomite. The proportions of each stage vary within and between veins, but the ore mineralogy is consistent throughout the vertical extent of the developed vein systems. Horizontally, gold values ranged between 0.5 and 1.0 oz Au per short ton.

Fluid inclusion analyses have documented the presence of early stage 1 saline fluids (33 - >40 equiv. wt % NaCl) with the higher salinities found in the upper 300 m of the Ajax mine levels; the fluids were boiling and contained CO_2. Stage 2 and 3 fluid inclusions exhibit progressively lower Th, and salinities are markedly lower (0-8.3 equiv. wt % NaCl). The telluride ore was deposited from weakly boiling, dilute fluids (1.4-3.5 equiv. wt% NaCl) with temperatures below 150°C.

Two hydrothermal events generated gold-silver mineralization and associated wall-rock alteration in the bulk tonnage deposits. The precious and base metals occur with alteration products in breccia clasts or in matrix minerals within the hydrothermal and tectonic breccias. The fluids responsible for alteration-mineralization were boiling as indicated by wide ranges of filling temperatures in fluid inclusions of the same mineral grain, extensive development of "explosion" texture in quartz and celestite, and large variations of liquid/vapor ratios in fluid inclusions within individual crystal growth zones. Temperatures were below 200°C as indicated by minimum filling values. Capping of boiling shallow hydrothermal fluids appears to have been enhanced by the alkali trachyte porphyry intrusion at Globe Hill, which acted as a permeability barrier to upward-migrating fluids. Vapor-dominated fluids developed over-pressuring, leading to hydrothermal brecciation and low-grade gold deposits. On the other hand, the vein systems in the Cripple Creek district formed along structures open to the surface, hence hydrothermal brecciation did not occur. (From the authors' abstract)

THORNBER, C.R. and HUEBNER, J.S., 1985, Dissolution of olivine in basaltic liquids: Experimental observations and applications: Am. Mineralogist, v. 70, p. 934-945. Authors at U.S. Geol. Survey, Reston, VA 22092.

Rates of olivine dissolution in synthetic lunar basalt 77115 and a silica-enriched 77115 composition (Sil-77115) at superliquidus temperatures have been determined. Polished olivine plates of known composition, orientation, and size were placed in basalt mixes contained in high-purity iron crucibles and heated in evacuated silica tubes. Olivine plates dissolve in the 77115 melt at rates of ~0.2 to 616 μm/hr over a temperature range of 1265° to 1450°C; these rates are consistently faster in the more siliceous melt. Olivine resorption rates are independent of crystallographic orientation and run duration.

Dissolution-rate data have been applied to the problem of the thermal history of fragment-laden impact-melt rocks of the lunar highlands. On the basis of estimates of the survival time of angular olivine xenocrysts in lunar basalt 77115, we conclude that the impact melt cooled to near-liquidus temperatures (~1250°C) within 1 hour and that temperatures did not exceed 1450°C for more than several seconds or remain above 1315°C for longer than a few minutes. In addition, textural and chemical criteria for the recognition of olivine resorption (and growth) phenomena in igneous rocks are discussed. (Authors' abstract)

Of considerable pertinence to the experimental problems in interpreting high-temperature melt inclusion equilibria. (E.R.)

THURMAN, E.M., 1985, Organic geochemistry of natural waters: Martinus Nijhoff/Dr W. Junk Publishers, Dordrecht, The Netherlands, 489 pp. Author at U.S. Geol. Survey, Denver, CO, USA.

Consists of three parts: 1) Amount, origin and classification of organic carbon in natural waters; 2) Types and amount of dissolved organic carbon in natural waters; and 3) Organic processes, reactions and pathways in natural waters. (E.R.)

TIKHONENKOV, P.I., NESTERENKO, G.V. and NAUMOV, V.B., 1985, The specific nature of liquation of the plateau basalts of the Siberian Platform (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 140-141 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

The plateau basalts of the Siberian Platform (Putorana Plateau) have revealed the phenomenon of liquation of the residual (interstitial) melt in the form of its separation into mafic globules and a more leucocratic matrix. In this instance, in contrast to the well-known analogous facts in the literature, no marked separation of their compositions (prior to the formation of the silicic matrix) has been observed. The globules are only more enriched in Fe, T, and P, whereas the matrix is enriched in Mg, Al, and Si. The composition of the globules (in wt %) is: SiO_2, 33.08; TiO_2, 9.50; Al_2O_3, 1.56; FeO, 36.70; MnO, 1.64; MgO, 4.60; CaO, 9.34; P_2O_5, 2.76; composition of matrix: SiO_2, 42.86; TiO_2, 0.62; Al_2O_3, 9.39; FeO, 24.17; MnO, 0.24; MgO, 13.22; CaO, 2.56; P_2O_5, 0.04.

The accumulation of femic components in the residual melt is a regular process in these basalts, and is emphasized by homogenization experiments on the residual melt; these demonstrate the equilibrium nature of the liquation. Enrichment of the melt in femic components is determined by the sequential nature of separation of the minerals. Data from both the petrography of the rocks, and also from homogenization of melt inclusions in py (1235-1200°C) and in pl (1200-1190°C), indicate that py finishes earlier. In this respect, separation mainly of pl during the closing phases of the process leads to accumulation of femic components in the residual melt of the plateau basalts, and it converts into two immiscible phases. (Authors' abstract)

TINGLE, T.N., GREEN, H.W., II and FINNERTY, A.A., 1985, The solubility and diffusivity of carbon in olivine (abst.): EOS, v. 66, p. 1135. Authors at Dept. Geol., Univ. California, Davis, CA 95616.

Abundant evidence exists for the presence of carbon in the earth's upper mantle. The amount of carbon, the carbon-bearing phases extant, and the effect of trace quantities of carbon on the physical properties of the mantle remain largely unanswered. Observations of mantle peridotites from kimberlites suggest that at least some of the carbon is dissolved in olivine at high pressure. Single crystals of San Carlos olivine, sealed in platinum capsules with carbon-14 labelled silver oxalate and oxalic acid dihydrate, have been annealed at 0.1 GPa in internally heated pressure apparatus at temperatures from 1200-1600°C. Carbon concentrations were determined by the beta track method. After 100 hrs. at 1175°C and 0.1 GPa, no carbon was observed in the crystals suggesting that either the solubility is negligible or the diffusivity is very low at low pressure. At 3.0 GPa, the inferred solubility is approximately 100 wt. ppm C and is not temperature dependent within experimental error. At 1200°C and 3.0 GPa, carbon concentration gradients that extend 200 microns below the crystal surfaces yield a diffusivity of about 10-10 cm^2/sec. An experiment at 3.0 GPa and 1400°C with a graphite-olivine diffusion couple resulted in a crystal with uncracked regions large enough to be analyzed by infrared spectroscopy; no absorption bands were observed from about 1800 to 4400 cm^{-1} with the exception of a very small band near 3500 cm^{-1}. This leads us to conclude that either the carbon species present are below detection limits for IR, the species present have absorption bands hidden in the silicate fundamental bands or above 4400 cm^{-1} or that the carbon present is not structurally bound. Atomic carbon, such as might exist in neutrally charged interstitials, is one interesting possibility. (Authors' abstract)

TISTL, M., 1985a Metamorphic fluids controlling the formation of gold-quartz mineralizations in the Cordillera Real/Bolivia (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 120-121. Author at Inst. Angewandte Geol. der FUB, Wichernstr. 16, 1000 Berlin 33, FRG.

In the eastern Cordillera of N Bolivia and S Peru metamorphic gold deposits (so called "mantos") occur in a definite horizon of a thick sedimentary succession of Paleozoic age. The deposits are related to the Hercynian orogeny, which was accompanied by voluminous synorogenic S-type magmatism. The latter caused an extended thermometamorphic zoning in its sedimentary cover. The nature of this metamorphism is shown to be isochemical.

Gold mineralization occurs in shear zones in the external area of low grade metamorphism. Blueish ribbon quartz and also white massive quartz occur in paragenesis with pyrite, arsenopyrite and gold. Minor components are albite, chlorite, scheelite, magnetite, galena, and sphalerite. This type of mineralization has been studied in 15 deposits of the northern Cordillera Real, Bolivia. In the gold-bearing quartz aqueous inclusions (sometimes with small NaCl and KCl daughter minerals) occur together with carbon dioxide-rich inclusions. Usually the inclusions have a size of 5 to 15 µm. Th of aqueous inclusions ranges from 190°C to 360°C, showing a zonation with decreasing temperature away from the thermal center (Zongo-Yani granite). In contrast the salinity of the fluids increases from low (~5 NaCl-equiv.%) to highly saline (~20-25 NaCl-equiv.%) solutions from the internal to the external zone. This may be explained by the consumption of dissolved ions by metamorphic mineral blastesis in the internal zone (chloritoid , chlorite, albite) and would indicate that the fluids had been in chemical equilibrium with the metamorphic rocks.

Using the Kalyuzhnyi and Koltun method the mineralization formed at PT-conditions in the range of 1.7 to 2.7 kb and 320°C to 450°C. These data are in excellent agreement with the metamorphic paragenesis observed. Therefore the veins are considered to represent the type of metamorphic Au deposit which formed by metamorphic dewatering of a sedimentary sequence. Primary gold concentration occurred in stratiform massive sulfide layers intercalated in Caradocian shaly sandstones. (Author's abstract)

TISTL, Michael, 1985b The gold deposits of the northern Cordillera Real of Bolivia and their geological setting: Berliner Geowiss. Abh., Section A, v. 65, 102 pp. (in German; English abstract).

There are three different types of gold deposits in the northern Cordillera Real:

(i.) Stratiform sulfide layers of the Upper Ordovician which contain (As-) pyrite, pyrrhotite, minor galena, sphalerite, chalcopyrite and traces of gold (up to the ppm-range).

(ii.) Gold quartz veins (mantos) with quartz, minor chlorite, albite, pyrite, arsenopyrite pyrrhotite, scheelite, galena, sphalerite, and native gold are present. Microthermometric data point to the formation of the veins at 320°-450°C and 1.8-2.7 kb. The mineralizing fluids were mainly NaCl dominated (up to 30% weight NaCl equivalent). The gold quartz veins are interpreted as metamorphic mobilizations of the stratiform auriferous sulfide layers (protore). (From the author's abstract) See previous item.

TOMLINSON, M., 1985, Solubility phenomena in industrial and natural systems: J. Solution Chem., v. 14, no. 7, p. 443-456. Author at Atomic Energy of Canada Ltd., Whiteshell Nuclear Res. Establishment, Pinawa, Manitoba, ROE 1L0, Canada.

The importance of solubility phenomena in industrial and natural systems is illustrated mainly by examples related to nuclear energy development. Illustrative examples are given of the consequences of changes in solubility due to gradients of temperature (hydrothermal mass transport), chemical composition (hydrothermal alteration of minerals), electrochemical potential (corrosion) and mechanical stress (fracture mechanics). The chemical systems of interest are primarily insoluble oxides in high temperature water, for example: transition metal oxides on surfaces of structural metal alloys of power plant steam generators; actinide and other heavy metal oxides of nuclear fuels; silicate glasses for immobilizing fission product wastes, and minerals in the rocks of an underground waste vault in contact with heated ground water. Requirements for improved solubility measurement equipment and techniques, experimental data and theoretical methods are noted. Some recent solubility data and their shortcomings are outlined for specific examples, including UO_2, basic lead carbonates, potassium aluminosilicate (feldspars), three to five component borosilicate glasses and zirconium hydride (in Zr metal). (Author's abstract)

TORGERSEN, T. and IVEY, G.N., 1985, Helium accumulation in groundwater. II: A model for the accumulation of the crustal ^4He degassing flux: Geochimica Cosmo. Acta, v. 49, p. 2445-2452.

TOURAY, J.C., BENY-BASSEZ, C., DUBESSY, J. and GUILHAUMOU, N., 1985, Microcharacterization of fluid inclusions in minerals by Raman microprobe: Scanning Electron Microscopy, 1985, no. 1., p. 103-118. First author at Ecole Supérieure de l'Energie et des Matériaux, ERA 601 du CNRS Univ. Orléans, 45046 Orleans Cedex, France.

The aim of this paper is to summarize the contribution of the Raman scattering microspectrometry to the knowledge of fluid inclusions. Applications are reviewed; identification of ionic species dissolved in aqueous phase, characterization of gases of C-O-H-N-S system, identification of solids and non-aqueous liquids. The complementary characteristics of Raman microanalysis and microthermometry are underlined. The last section is devoted to comparisons with other microprobes from the point of view of chemical and mineralogical analysis of fluid inclusions. (From the authors' abstract)

TOURET, J. and OLSEN, S.N., 1985, Fluid inclusions in migmatites, in Migmatites, J.R. Ashworth, ed.: Glasgow, Blackie, p. 265-288. First author at Free Univ., Amsterdam, The Netherlands.

A review of the studies of CO_2 and H_2O fluid inclusions in migmatitic rocks, using as examples the rocks of the Bamble region, Norway (see also Pineau et al., 1981, Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 161 and Touret, 1981b, Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 214-215), and in the Front Range, Colorado. Also includes a discussion of the evidence and nature of silicate melt inclusions in migmatites. (E.R.)

TOURET, J.L.R., 1985a, High density fluids in the lower crust and upper mantle (abst.): Tenth Airapt High Pressure Conf., Amsterdam, July 8-11, 1985, p. 68. Author at Free Univ., Amsterdam, The Netherlands.

Many rock-forming minerals (quartz, feldspars, olivine, pyroxene, etc.) contain small quantities of fluids trapped under high P-T conditions and preserved until the surface in fluid inclusions. Some basic principles of their study and recent analytical developments (notably Laser Raman microspectrometry) are briefly reviewed; under favorable circumstances which need to be ascertain precisely, the chemical composition and molar volume of the fluids do not change significantly between deep and surface conditions. In rocks from the lower crust and upper mantle, the actual composition of nearly all inclusions can be described in the system C-O-H-N + dissolved ionic species, notably NaCl. However, a deep origin is certain only for 3 fluids and their mixtures (CO_2, N_2, CH_4) and possible for some brines (H_2O + NaCl). "Deep" water, if present, cannot be distinguished from surface fluid and, because of its weakening effect towards silicates, has most probably left the original cavity.

Highest density fluids recorded so far concern essentially CO_2 (granulites and ultrabasites) and to a lesser extent N_2 (eclogites, granulites and ultrabasites). For CO_2, a density of 1.173 g/cm^3 (Homogenization temperature (Liquid), Th-L = -55°C) has been observed in synmetamorphic inclusions from high-pressure granulites (e.g., Furua granulite complex, Tanzania). This would correspond to a depth of about 30 km for a metamorphic temperature of 800°C, but the precision of the estimate is severely handicapped by the lack of reliable P-V-T data in this P-T range. Higher densities (up to 1.257 g/cm^3, corresponding to Th-L = -80°C, along the metastable extension of the liquid-vapor curve below the triple point) have been observed in several granulites and migmatites, but these inclusions are formed under post-metamorphic conditions and their origin remains unclear. High-density CO_2-rich fluids are widespread in rocks from the lower crust and upper mantle; they might sometimes be released in an explosive way, provoking at the surface large-scale circular structures often mistaken for meteorite impacts (Vredeford dome, South Africa). N_2-rich fluids are commonly much less dense than CO_2 ones and a maximum density of 0.82/cm^3 (Th-L = -195°C) has been observed in eclogites from kimberlite pipes (Yakoutia, USSR) and in layered peridotites (Zeblitz, DDR). Most fluids trapped in deep-seated rocks originate in the upper mantle and then migrate eventually in the lower crust; it is well possible that at least some of them derive from former supracrustal rocks subducted in the upper mantle, but direct evidence remains very limited. (Author's abstract)

TOURET, J.L.R., 1985b, Fluid regime in southern Norway: The record of fluid inclusions, in A.C. Tobi and J.L.R. Touret, ed., The Deep Proterozoic Crust in the North Atlantic Provinces, D. Reidel Publ. Co., p. 517-549. Author at Inst. Earth Sci., Free Univ., De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands.

Fluid inclusions have been studied in representative rocks from southern Norway, notably in the Bamble granulites. On the basis of the earliest fluid inclusions trapped in rock-forming minerals (mainly quartz), five major types of fluid distributions have been recognized: 2-phase aqueous (H_2O dominant, without solid), carbonic (mostly pure CO_2, possible occurrence of N_2 and/or CH_4), mixed 1 (aqueous and carbonic inclusions in comparable amounts, but in separate cavities), mixed 2 (aqueous and carbonic fluids in the same cavity, trapped in the miscible state of the H_2O-CO_2 system), brines (H_2O + solids, NaCl dominant).

Only brines show a relation between a dominant inclusion type and a given protolith; these are especially abundant in 3 well-defined environments: Al-rich metasediments (metapelites), skarns and acid volcanics. The distribution of other types is more related to metamorphic grade: high-density carbonic inclusions are typical for the granulite-facies domain, early 2-phase aqueous inclusions occur almost exclusively in the north-western part of the Bamble and in the Telemark gneiss-granites, mixed (1 and 2) inclusions characterize the complicated transition zone between the amphibolite- and granulite-facies domains north of the orthopyroxene-in isograd.

P-T estimates from fluid inclusions are apparently very different for Bamble (maximum CO_2 density during peak metamorphism) and Rogaland (maximum CO_2 density after the peak of metamorphism). Most of the CO_2 originates from the breakdown of carbonate melts (carbonatites) emplaced as immiscible droplets in deep-seated synmetamorphic intrusives. (Author's abstract)

TOURET, J.L.R., 1985c Peak metamorphic fluids and postmetamorphic uplift paths in granulites (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 122. Author at Inst. Earth Sci., Free Univ., Amsterdam, The Netherlands.

From direct observation, in situ analysis (microthermometry, Raman spectroscopy) and P-T estimates for minerals and fluid inclusions, two categories of fluids have been recognized in granulites: i) and earlier, synmetamorphic generation of fluids with a constant and relatively simple composition: pure CO_2, to a lesser extent NaCl-rich brines immiscible with CO_2; (ii) later, more variable and complicated post-metamorphic fluids (CO_2, H_2O ± NaCl, CH_4, N_2, etc.) which may be trapped under a wide range of P, T and age conditions.

Available data, based on few but widespread selected occurrences (Tanzania, India, Baltic Shield, China) suggest a regular increase of the density of the synmetamorphic fluids with depth and a density controlled distribution of fluids in the lithosphere in a 15 to 30 km depth range. Post-metamorphic fluid inclusions may give some essential information on the post-metamorphic uplift trajectory, but the interpretation of the data is hampered by the complexity of involved systems and the lack of mineral control (T estimates). Nevertheless, two opposite trends have been characterized: (i) an "adiabatic" type of trajectory (P decrease at high, nearly constant T), which seems to be the general rule in most investigated terranes; (ii) an "isobaric cooling" type (P constant, T decrease), observed near deep-seated intrusive masses (Rogaland), which leads to ultra high densities at moderate P and T. Evidences of both regimes may be found in most granulites. The result may be hopelessly complicated and only very detailed investigations in favorable cases may lead to an unambiguous interpretation. (Author's abstract)

TOURET, J.L.R.d 1985, Origin of CO_2 fluids in the lower continental crust (abst.): Terra Cognita, v. 5, p. 200. Author at Earth Sci. Inst., Free Univ., Amsterdam, The Netherlands.

CO_2 is present in nearly all lower continental crustal rocks (granulites) as fluid inclusions in many minerals (quartz, plagioclase, garnet, pyroxene, etc.). Several arguments suggest a juvenile, mantle derived major origin, but pervasive flooding of gaseous CO_2 is unlikely. From observations in the Bamble province of southern Norway, it is suggested that CO_2 originates or is associated to magmatic carbonates (carbonatite) immiscible in deep-seated, synkinematic intrusives. In southern Norway, these intrusives have distinct intermediate, trondjemitic affinities and a marked LILE depleted composition which relates to the magmatic stage and not to a later metamorphic effect. The association intermediate intrusive + carbonatite could derive from the melting at depth (P about 20 kb) of a subducted oceanic crust. (Author's abstract)

TRACY, R.J. and RYE, D.M., 1985, Metamorphic fluid flow - a question of scale, crustal depth and bulk rock composition (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 736. Authors at Dept. Geol. & Geophys., Yale Univ., New Haven, CT 06520.

Recent studies have indicated that certain metamorphic rocks interacted with significant volumes of aqueous fluid (2-10 rock volumes or more) during their time-integrated mineral reaction history. Rather than demonstrating that pervasive fluid flow is general in metamorphic rocks, these documented cases instead suggest the likelihood of pronounced to extreme channelization of through-going fluids in deep-seated metamorphic terranes ($P>3$ kbar). In rocks more shallowly buried, and therefore under low lithostatic stress, pervasive flow along grain boundaries and open microfractures probably occurred, as at Skye and the Skaergaard Complex. In higher pressure metamorphic environments, documented cases of high fluid/rock ratio such as Beaver Brook (New Hampshire), Wepawaug Schist (Connecticut), Waterville/Vassalboro (Maine) and Notch Peak (Colorado) make a strong case for flow channelized in veins or in impure marble "aquifers" where pore space and permeability were created by decarbonation (or combined decarbonation/dehydration) reactions driven by infiltration of aqueous fluid. The source of this fluid may commonly be traced to a nearby "wet" granitic intrusion or quartz vein. As long as the pressurized source of aqueous fluid continued, outward flow was possible as fluid held open the intergranular pore space which was created only at the infiltration/reaction front where a reduction in solid volume accompanied reaction. Cessation or interruption of fluid flow would allow the pore space to close due to porous-rock strength being exceeded by lithostatic stress. Further fluid flow would only be possible if a new (probably higher T) devolatilization reaction were initiated. Pervasive flow of aqueous fluid in deep-seated metamorphic terranes is therefore probably limited to carbonate-bearing lithologies adjacent to sources of major voluems of fluid; otherwise, fluid flow is likely to be localized in fractures or veins. (Authors' abstract)

TRAORÉ, Ibrahima, 1984, On the metallogeny of gold with special consideration of the gold deposits in Mali: Dissertation A, Bergakademie Freiberg/Sa., GDR (113 pp., 115 references, 39 diagrams, 33 figures, 15 tables) (in German). Author at SONAREM-Kati, Republique du Mali.

Besides the general metallogenesis of gold and in particular the gold deposits of Mali this paper also discusses thermobarometric, cryometric and isotope-geochemical investigations on gold-quartz of the gold-ore deposit of Kalana/Mali.

Fluid inclusion studies suggest that the productive phase of the gold mineralization occurred in the interval 410 to 270°C from fluids with salinities from 0 to 12.6 wt.% NaCl and 10 to 0 wt.% Na_2CO_3 or $NaHCO_3$, according to cryometric measurements.

The gold deposition occurred in two stages: (1) First in a strongly alkalic environment under low $f(O_2)$ as $Au(HS)_2^-$-complexes and then it is preconcentrated in highly concentrated katathermal solutions. (2) Through the adiabatic expansion of the mineral-forming solutions, which are caused by fluctuations between lithostatic and hydrostatic pressure, from $>875 \cdot 10^5$ Pa to $<260 \cdot 10^5$ Pa, gold changes into the active phase[sic] as $AuCl_2^-$-complex and moves in the direction of tectonically open vein fissures. By contact with alkalic Na_2CO_3- or $NaHCO_3$-solutions or by condensation and neutralization of the fluid phase, gold precipitates in vein fissures. (From an English abstract by R. Thomas)

TREIMAN, A.H., 1985, Amphibole and hercynite spinel in Shergotty and Zagami: Magmatic water, depth of crystallization, and metasomatism: Meteoritics, v. 20, no. 2, pt. 1, p. 229-243. Author at Lunar & Planet. Lab., Univ. Arizona, Tucson, AZ 85721.

Amphibole and spinel occur in the Shergotty and Zagami meteorites only in magmatic inclusions in pigeonite. The trapped magma is essentially identical to the parental magmas for Shergotty and Zagami. The amphibole is a kaersuite with minimal halogen content; by inference, it must have been hydrous. If so, the Shergotty and Zagami melts contained at least 0.2 wt % H_2O and were probably H_2O-undersaturated. Pressures in excess of 1 kilobar seem necessary for the formation of amphibole. Spinel replaces magnetite in the inclusions, and olivine replaces magnetite elsewhere in the meteorites. To stabilize spinel, the melt in the inclusions must have become enriched in Al during fractionation, possibly because the small volume of the inclusions made nucleation of plagioclase unlikely. Pervasive replacement of magnetite through reduction reactions suggests that Shergotty and Zagami interacted with hydrogen-rich fluids during their cooling. (Author's abstract)

TREIMAN, A.H. and ESSENE, E.J., 1985, The Oka carbonatite complex, Quebec: Geology and evidence for silicate-carbonate liquid immiscibility: Am. Mineralogist, v. 70, p. 1101-1113. First author at Dept. Geol., Boston Univ., Boston, MA 02215.

Associated carbonate and silicate igneous rocks from the northern intrusive center of the Oka complex (Quebec, Canada) probably formed from immiscible carbonate and silicate magmas in situ, as their structure, petrography, isotope ratios and mineral chemistry are consistent with immiscibility. (From the authors' abstract)

TROMMSDORFF, Volkmar, SKIPPEN, George and ULMER, Peter, 1985, Halite and sylvite as solid inclusions in high-grade metamorphic rocks: Contrib. Mineral. Petrol., v. 89, p. 24-29. First author at Inst. Mineral. und Petrogr., ETH-Zentrum, CH-8092 Zurich, Switzerland.

Solid inclusions of halite and sylvite, formed during regional and contact metamorphism,have been identified by microscopy and by electron microprobe analysis in rocks from Campolungo, Switzerland and Cornone di Blumone, Italy. The solid inclusions occur in several of the major minerals crystallized during metamorphism and have been observed as idiomorphic crystals and dendrites. The compositions measured in 100 analyses from Campolungo, Switzerland and 40 analyses from Cornone di Blumone, Italy extend across the two-phase region in the system, KCl-NaCl, indicating that the salt inclusions are high temperature precipitates. In both localities compositionally zoned and unzoned crystals have been found. Measured compositions on the temperature maximum of the two-phase region indicate at least 500°C which can be compared with 500° ± 20°C determined by Mercolli (1982) and Walther (1983) from the Mg content of calcites from Campolungo. The solid inclusions have been trapped apart from CO_2-rich and saline, H_2O-rich fluid inclusions which have been described by Mercolli (1982) as the earliest preserved fluid inclusions in the rocks. The early precipitation of salt minerals at Campolungo indicates that fluids were saturated with NaCl and KCl at 500°C and pressures of 2,000 bars or higher. Similar relationships exist between solid and fluid inclusions in the rocks of Cornone di Blumone which formed at temperatures as high as 800°C and pressures between 0.5 and 1 kilobar (Ulmer 1983). The entrapment of halite and sylvite as solid inclusions preserves the composition of the minerals which may therefore be useful as geothermometers. (Authors' abstract)

TRUFANOV, V.N., KURSHEV, S.A., MAYSKIY, Yu.G. and USHAK, A.T., 1985, Scientific basis of the importance of genetic information of natural "mineral-fluid" systems (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 23-24 (in Russian). Authors at State Univ., Rostov-on-Don, USSR.

The intensive development of fluid inclusion studies should lead to the joint investigations of the natural "mineral-fluid" systems. The authors proposed a genetic classification of the forms of trapping of a fluid phase in crystals. (...) Fluids may occur in minerals as separate phase, clathrate inclusions, free radicals, individual molecules and their associates located in defects of crystal lattice. These forms yield various properties and behavior of inclusions. The following forms of fluid-mineral interaction are possible: dissolution-precipitation-recrystallization-self-diffusion and diffusion forced by energetic fields-dissipation and coalescence of fluids trapped in minerals-refilling of vacuoles-homogenization and heterogenization-formation of pseudoauthigenic inclusions, etc. (...). (From the authors' abstract, translated by A.K.)

TRUFANOV, V.N. and SLAVOGORODSKIY, N.I., 1985, New data on vacuum decrepitometry of coal (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 92-93 (in Russian). Authors at Rostov State Univ., Rostov-on-Don, Ukraine.

Varieties of coal from Donbass (from long-flame to anthracites) were used for studies by vacuum decrepitometry method (device VD-4). Samples had grain class 0.25-0.5 mm, weight <50 mg, heating 20 ± 5%/min, up to 1000°C. Studies proved the existence of distinct relation between thermobaric characteristics and petrologic-genetic types of coals. (A.K.)

TSAMERYAN, O.P., SOBOLEV, A.V., ZAKARIADZE, G.S. and KONONKOVA, N.N., 1985, Application of results of studying the composition and thermometry of melt inclusions in geodynamic reconstructions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 102-103 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR, Moscow, USSR.

This study of melt inclusions for geodynamic reconstructions is based on the volcanic series of ophiolite complexes in the Sevan-Akera and Vedi zones of the Lesser Caucasus and in the Troödos Massif (Cyprus). Classification of these ophiolites was carried out previously on the basis of petrochemical and geochemical data. The results of this work have not led to any unified view by the authors concerning the formation of the rocks investigated in any particular environment.

An electron microprobe study of the composition of homogenized and then quenched primary melt inclusions in crystallizing phases has provided information about the composition of the melt and the PT conditions at the moment of crystallization of the mineral-host. Hence, it seems to be possible to classify the crystallizing melts independent of the degree of differentiation of the rocks and of the grade of superimposed metamorphism.

The following conclusions have been reached. During the formation of the ophiolite complex of the Lesser Caucasus, various kinds of melts have been involved, reflecting different geodynamic environments: two kinds of tholeiitic melts (mid-ocean ridges), boninite and tholeiite melts (primitive island arcs), and high-Ti tholeiite and alkaline melts (zones of oceanic and/or continental intracratonic activation).

A comparison between the calculated liquidus T of the homogenized melt inclusions and the experimental Th values, has shown a distinct difference in the amounts of water in these melts. The maximum water content is typical of the boninite melts, an intermediate value occurs in the island-arc tholeiites, and minimum values apply to the tholeiite melts of the mid-ocean ridges and the zones of intracratonic activation, and also the alkaline melts.

So far as the Troődos Massif is concerned, we may assign the differentiated series of lavas of this massif to the interval between the boninite series of the island arcs and the tholeiite series of the oceanic rifts. This agrees with the spreading form of magmatism of the Troődos Massif on the one hand, and with the island-arc characteristics of the volcanic complex on the other. (Authors' abstract)

TSONG, I.S.T., KNIPPING, U., LOXTON, C.M., MAGEE, C.W. and ARNOLD, G.W., 1985, Carbon on surfaces of magnesium oxide and olivine single crystals. Diffusion from the bulk or surface contamination?: Phys. Chem. Minerals, v. 12, p. 261-270. First author at Dept. Physics, Arizona State Univ., Tempe, AZ 85287, USA.

We have conducted detailed studies of the behavior of carbon on the surfaces of MgO and olivine single crystals using various surface analytical techniques. Our results show that the bulk carbon content in MgO is around 40 wt. ppm, considerably lower than the quantities quoted by Freund and co-workers in the past. We also show that the carbon in both MgO and olivine does not display any rapid diffusion behavior leading to surface segregation in the temperature range 78-723 K, in contrast to the previous findings of Freund and co-workers. (From the authors' abstract)

TSUCHIYAMA, Akira, 1985, Dissolution kinetics of plagioclase in the melt of the system diopside-albite-anorthite, and origin of dusty plagioclase in andesites: Contrib. Mineral. Petrol., v. 89, p. 1-16. Author at Dept. Geol., Univ. Oregon, Eugene, OR 97403, USA.

The textures and kinetics of reaction between plagioclase and melts have been investigated experimentally, and origin of dusty plagioclase in andesites has been discussed. Whatever the temperature, the crystal-melt interface became rough and often more complicated (sieve-like texture composed of plagioclase-melt mixture in the scale of a few μm was developed from the surface of the crystal inward; formation of mantled plagioclase) if the crystal is less calcic than the plagioclase in equilibrium with the surrounding melt, and the interface remained smooth if the crystal is more calcic than the equilibrium plagioclase. (From the author's abstract)

Possibly pertinent to the trapping of silicate melt inclusions in natural plagioclase. (E.R.)

TSUI, T.-F. and JORDAN, C.F., 1985, Fluid inclusions and porosity development in Arun gas field, Indonesia (abst.): AAPG Bull. v. 69, no. 2, p. 312-313. Authors at Mobil Res. & Dev. Corp., Dallas, TX.

The Arun gas and condensate field in northern Sumatra is a large Miocene coral-algal reef complex. The Arun limestone is rich in lime mud throughout the section, and low to moderate-energy paleoenvironments are indicated. The reservoir facies are strongly affected by diagenesis and display several secondary porosity types, including moldic, vuggy, breccia, and fracture porosities. Without the diagenetic alteration of otherwise tight muddy limestones, reservoir facies would not have developed at Arun. To put constraints on the timing of porosity development in Arun field, fluid inclusions were examined in coarse calcite cements which partially or completely filled some of the secondary pores. The fluid within the inclusions is brackish with an equivalent of 2.5 wt. % NaCl.

Th, after pressure correction, suggest that the cementation began close to the maximum burial depth and as recently as 5 Ma. Since the cement postdates the formation of secondary pores, it is conceivable that secondary porosity could have developed not only in the shallow subsurface (i.e., the vadose zone), but also in moderate to deep burial conditions. Shales surrounding the Arun reef are overpressured as a result of dewatering during smectite-illite conversion and have expelled water into the Arun limestone. This process may contribute to pervasive secondary porosity as well as remobilization of material for localized late-stage cements. (Authors' abstract)

TURKOV, V.A., 1985, Some peculiarities in crystallization of rocks in the alkaline complexes of Southern Mongolia (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 141-142 (in Russian; translation by D.A. Brown). Author at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

In Southern Mongolia, there is widespread development of upper Mesozoic alkaline potassic complexes of volcanic-plutonic rocks. They are spatially and genetically associated carbonatites and various ore-bearing rocks.

Melt and melt-salt inclusions have been found in the py, pl, K-spar, and quartz phenocrysts in these rocks. Optical thermometry has been used to determine the Tf of the phenocrysts in these rocks.

melanephelinite	1210-1190°C
nepheline-bearing trachytes	1200-1170°C
trachytes	1190-1125°C
latites	1160-1140°C
trachyrhyodacites	1075-1050°C
ongoliparites	1050-1035°C

The conditions of crystallization of the vein rocks of the post-magmatic stage have been estimated. Th of inclusions in fluorite from fine-grained fluorite-barite-silica veins = 590-480°C, and from the coarse-grained varieties with sulfides, 600-340°C.

The widespread occurrence of carbonate minerals in the rocks of the magmatic phase, the presence of silicate-fluorite-carbonate segregations in the melanephelinites, and inclusions with silicate-carbonate composition in feldspar from a trachyrhyodacite, may indicate a liquation process in forming silicate and carbonate-fluoride liquids in this complex.

The high-T crystallization of fluorite possibly implies its formation from a silicate-salt melt during the post-magmatic phase. Th data for the minerals of the rock complex and their genetically associated ore formations suggest a continuous evolutional process during emplacement of the volcanic-plutonic complexes (from the commencement of crystallization of the magmatic rocks until the formation of the ore-bearing rocks). (Author's abstract)

TURKOV, V.A. and POLYAKOV, A.I., 1985, Conditions of crystallization of the Neogene-Quaternary volcanics of the Udokan Range (Eastern Transbaikalia) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 144-145 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

Thermometric studies have been made on melt inclusions in rocks of the alkaline olivine basalt-alkaline trachyte series. The results indicate a wide Tf interval for these rocks (1330-1010°C):

alkaline olivine basalt	1330-1190°C
basanite	1220-1175°C

trachybasalt	1220-1200°C
trachyandesite	1260-1130°C
trachyte	1210-1010°C.

The marked range 'overlaps' are explained by the coexistence of phenocrysts of different composition in the one rock. Thus, in the basalts, the Fo-molecule varies from 65 to 85%, in the trachyandesites from 40 to 80%, and in the trachytes from 35 to 75%. There is a similar picture for the cpx and the pl. The composition has been determined by X-ray microprobe analysis of previously homogenized and quenched inclusions. The composition of the inclusions in the ol and cpx phenocrysts from an olivine basalt does not differ from the bulk composition of the surrounding rock. The composition of the ol inclusions from a trachyandesite turned out to be more basic as compared with the composition of the rock.

Inclusions with high-density CO_2 have been found in ol and pl phenocrysts from olivine basalt and trachybasalt. For the inclusions in ol ($D \leq 0.73$ g/cm^3), P(calc) at 1200-1220°C = 4.8-3.9 kbar. For those in pl ($D = 0.51$ g/cm^3), P(calc) at 1110°C = 2.2 kbar. In the inclusions in ol, consisting of the gas phase only, with $D = 0.94$ g/cm^3, $P \leq 7.3$ kbar.

The gradual lowering of Tc and changes in the chemical composition of the rocks, variations in the phenocryst compositions, and also the temporal and spatial association of the rocks, indicate the comagmatic nature of the Neogene-Quaternary volcanics in the Udokan Range and their formation during the process of crystallization differentiation in the direction:

$$L \rightarrow \text{spn}_{1330°} \rightarrow [\text{spn} + \text{ol}]_{1280°} \rightarrow [\text{spn} + \text{ol} + \text{pl} + \text{cpx} + \text{ap}]_{1200°} \rightarrow [\text{spn(mt)?} + \text{ol} + \text{pl} + \text{cpx} + \text{ap} + \text{amf}]_{1100°} \rightarrow [\text{spn(mt)?} + \text{cpx} + \text{ap} + \text{amf} + \text{fsp}]_{1010°}.$$

(Authors' abstract)

TVALCHRELIDZE, A.G., AREVADZE, D.V. and YAROSHEVICH, V.Z., 1985, The geochemistry and thermobarogeochemistry of sulfide-bearing solutions in deposits of various kinds (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 83-84 (in Russian; translation by D.A. Brown). Authors at Caucasian Inst. Mineral Raw-Materials, Tbilisi, USSR.

Massive sulfide deposits may be divided into four types: 1) chalcopyritic deposits of the Cyprus type; 2) copper-zinc pyritic deposits of the Uralian type; 3) massive-sulfide - barite - polymetallic deposits of the Kuroko type; and 4) massive-sulfide - polymetallic deposits of the Filizchay type. The last three types are represented in the Caucasus, which creates favorable conditions for a comparative thermobarogeochemical study.

1. All deposits may be divided into two types: a) hydrothermal-sedimentary; and b) epigenetic hydrothermal. Th of gas-liquid inclusions in interstitial cryptocrystalline quartz in compact ores of the first type is <160°C. The second class shows a distinct vertical temperature zonation from 400°C for the massive-sulfide ores of the footwall to 100°C for the barite lodes of the hanging wall.

2. Regardless of other differences, the pyrite-bearing hydrothermal fluids are always acid NaCl solutions, as indicated by chemical analyses. At the same time, the Kuroko deposits and their equivalents in the Lesser Caucasus display a higher sulfur activity, resulting in sulfide-sulfate zonation in the deposits.

3. D and O isotopes of the inclusion water in the main massive sulfide ore parageneses show that the water is polygenic, but with a definite magmatic component. A large proportion of seawater was found in the Kuroko deposits, but the sulfur isotopes in sulfides and sulfates, and also ther-

modynamic calculations, preclude the reduction of seawater sulfates. The isotope and petrological data, on the other hand, point to a predominantly juvenile source for the mineral matter.

4. Pyrite-bearing hydrothermal systems have evolved during a gradual drop in temperature along with country rock/fluid interaction. Below 400°C, the fluids have not undergone significant pH inversions.

5. Ore formation in both hydrothermal-sedimentary and epigenetic-hydrothermal deposits takes place under convergent conditions. In both, however, the causes of ore-deposition are external-structural, or lithological-geochemical. Spontaneous evolution of the hydrothermal systems cannot lead to ore-deposition. The origin of the ores is an essentially thermodynamically disequilibrium process, associated with complete breakdown of the internal structure of the ore-bearing fluid[sic]. (Authors' abstract)

TYLER, Noel, LIGHT, M.P.R. and EWING, T.E., 1985, Saline fluid flow and hydrocarbon migration and maturation as related to geopressure, Frio formation, Brazoria County, Texas, in Dorfman, M.H. and Morton, R.A., eds., 1985, Geopressured-Geothermal Energy, Proc. 6th U.S. Gulf Coast Conf.: New York, Pergamon Press, p. 83-92.

UCHAMEYSHVILI, N.Ye., BORSHCHEVSKIY, Yu.A., BYCHKOV, A.M. and MEDVEDOVSKAYA, N.I., 1985, Formation temperatures of the neogranitic rocks of the Tyrny-Auz region (northern Caucasus) based on various geothermometers (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 167-169 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

Th for inclusions in minerals alone are clearly insufficient for a correct estimate of Tf; other methods of geothermometry, in conjunction with a thermodynamic analysis of the conditions of formation, must be used. The neogranitic rocks of the Tyrny-Auz region (the El'dzhurta granites, rhyolites, and granite-porphyries) and the granite-porphyries in the basin of the Kyrtyk River provide good examples. These intrusive bodies, because of their distinct forms, sharp contacts with the country rocks, uniform makeup, simple mineral composition, freshness, and the absence of superimposd processes, are ideal for such studies.

A comparison of Th for the melt and fluid inclusions in the apatite, quartz, and feldspars and oxygen-isotope data based on the mineral pairs quartz-alkali-feldspar, quartz- plagioclase (Friedman and O'Neil, 1977), and quartz-biotite (Iavoy, 1977), and the results of a study of the X-ray-structural state of the K-feldspars, are presented in the following table.

Virtually all the Tf values based on oxygen-isotopes lie in the 725-750°C range, which agrees well with the low T limit for the magmatic phase of formation of the El'dzhurta granites, based on data for the melt and fluid inclusions in quartz. Lower temperatures, corresponding to the post-magmatic stage, have been established for the quartz-sanidine-plagioclase-biotite association from the central parts and deep-seated horizons of the massif and coincide with Th for the fluid inclusions in quartz, containing highly-concentrated chloride solutions, and Tf, established from the degree of ordering of the K-feldspars. (Authors' abstract)

Continued next page.

Rock, Locality	Mineral	Th, °C		Tf, °C	
		Melt Inclusions	Fluid Inclusions	Oxygen-Isotope Geothermometer	Based on ordering of K-feldspar
granite-porphyry, Kyrtyk	apatite	1250-1150	absent		
	plagioclase	>1050			
	sanidine	>1050		750	700-750
	quartz	1250- 900			
	quartz	800- 760			
	biotite	---		740	
granite-porphyry, Tyrny-Auz	quartz	850- 750	730-580		
	sanidine	>1000	730-580	730	650-630
	biotite	---	---	725	
rhyolite, Tyrny-Auz	quartz	880- 790	absent		
	sanidine	>1000		730	---
	biotite	---		725	
El'dzhurta granite					
marginal part, 1800 m	quartz	850- 730	480-270		550-500
	plagioclase	---		725	
	sanidine	---			
central part, 1600 m above sea level	apatite	1150-1050			
	quartz	1050- 780	950-330		550-500
	plagioclase	---		350	
	sanidine	---		470	
	biotite	---		585	
marginal part, 500 m above sea level	apatite	1150-1050			
	quartz	850- 730	750-300		
	plagioclase			725	550-500
	sanidine			380	
	biotite				

UCHAMEYSHVILI, N.Ye. and SHMULOVICH, K.I., 1985, Fluid phases of equilibrium in the El'dzhurta granitoids (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 169 (in Russian; translation by D.A. Brown). Authors at Vernadskiy Inst. Geochem. & Anal. Chem. Acad. Sci. USSR (GEOKhI AN SSSR), Moscow, USSR.

The three kinds of fluid inclusions recognized in quartzes from the El'dzhurta granites (concentrated salt solution-melt, vapor phase, and an intermediate type) have been interpreted on the basis of the phase diagram for the pseudo-ternary system H_2O-non-polar gases-electrolytes + (granitic melt).

The formation of all three kinds of [latter] inclusions during the magmatic phase, syngenetically with the melt inclusions, is possible only when there are variations in P above and below the intersection between the critical curve of the water-electrolyte system and the solidus of saturated melts. The Tf range for the syngenetic vapor and water-salt inclusions overlaps the field of the solidus at $P(total) = P(H_2O) = 100$ MPa, but the formation of a fluid of intermediate composition during the magmatic phase is possible only at $P = 150$ MPa. The stages of homogenization of the fluid phase during rise in P are possibly associated with the formation of rhyolytic subvolcanics.

The low concentrations of CO_2 and other non-polar gases in the original magmatic melt lead to the formation of chloride solutions alone. Excluding the paucity of the El'dzhurta granites in CO_2, the remaining characteristics of the phase ratios are similar to those described for the acid igneous rocks of Japan. (Authors' abstract)

ULFF-MØLLER, Finn, 1985, Solidification history of the Kitdlît lens: Immiscible metal and sulphide liquids from a basaltic dyke on Disko, central west Greenland: J. Petrol., v. 26, pt. 1, p. 64-91. Author at

Geol. Museum, Øster Voldgade 5-7, DK-1350 Copenhagen K., Denmark.

A unique troilite-iron-cohenite-rich lens was found on a ledge in the sediment-contaminated Kitdlît dyke on Disko. The lens displays a mineralogical diversity and extreme liquid evolution not previously described from any single magmatic sulphide or metal liquid system. It was deposited at 1200°C and $fO_2 = 10^{-13}$ as two immiscible liquids--a sulphide liquid and a C-rich metal liquid--which solidified from about 1100° to 300°C as a closed system in a thermal gradient.

The lower iron-rich half of the lens formed by crystallization of iron, cohenite, troilite, schreibersite and wüstite (in that order), with trace amounts of the phases found in the upper half of the lens. The approximate crystallization order of the upper troilite-rich half of the lens was: iron, cohenite, troilite, chromite, wüstite, fayalite (pseudomorphosed), high-T 'chalcopyrite,' high-T 'heazlewoodite' (beta-$(Ni,Fe,Cu,Co)_{3+x}S_2$) and, finally, lead minerals. The latter comprise native lead, galena, altaite (PbTe), shandite ($Ni_3Pb_2S_2$) and an unidentified phase.

Additional immiscible liquids were formed during solidification. Oxysulphide liquid (roughly FeO with a minor FeS-component) exsolved from metal and sulphide liquid in equilibrium with iron and cohenite below 1100°C. Later, FeO-rich silicate liquid, and Pb-rich liquid with Ni, Cu, S and Te, exsolved from the sulphide liquid. Segregation of oxysulphide and Pb-rich liquid may occur during core formation in planetoids, and there are thus important cosmochemical implications. (Author's abstract)

ULMER, G.C., MOATS, M.A. and WEISS, D.A., 1985, Oxygen fugacity, carbon, and the mantle redox state (abst.): EOS, v. 66, no. 18, p. 393. Authors at Geol. Dept., Temple Univ., Philadelphia, PA 19122.

In 1980 Ulmer et al. pointed out that $P\Delta V$, $\Delta(\Delta V)$, dKd/dP, detect concentration variation with total pressure and the possibility of mantle proton or hydroxyl were all factors whose roles needed evaluation for intrinsic oxygen fugacity (IOF) measurements on mantle xenoliths. In 1983 Eggler showed that a dichotomy exists between thermodynamically calculated mantle redox conditions and IOF mantle data.

The terms, "auto-reduction" (Sato and Valenza, 1980) and "auto-oxidation" (Elliott et al., 1979) have been used to describe IOF data that are being influenced by retrograde pressure reactions involving carbon. The IOF data patterns disclose when carbon is involved, but a significant amount of concern about the accuracy of the IOF data has resulted from the confusion over carbon.

In a sample containing 50 ppmw C and little ferric iron, heating at 1 atm in IOF work can produce enough CO gas within the 2 cc volume of the IOF cell to create a - log pCO of 4 (STP), which in turn will register as reduction in the stagnant-argon-filled IOF cell. By contrast, CO_2 may be evolved from fluid inclusions during the one atmosphere heating of IOF work, or CO_2 may be evolved by carbon retrograde-reacting at 1 atm with some ferric iron in the sample during the IOF work. If the $-\log pCO_2$ that develops is >3, this CO_2 may further react with the rest of the oxide sample. If the $-\log pCO_2$ is <4, then the CO_2 may not, in any sensible IOF time frame (30 hrs.?), be reactive with the oxide sample because the population density of the CO_2 is kinetically ineffective. This CO_2, in either case, will dominate the IOF cell and be recorded as an auto-oxidation. At this meeting two companion abstracts detail specific examples of auto-oxidation in olivine and ilmenite xenolithic studies.

However, reliable IOF data for gas-quality megacrysts and for nodule samples with multiple mineral intersects exist. Thus, one must invoke mantle redox heterogeneity. (Authors' abstract)

ULRICH, M.R., KYLE, J.R. and PRICE, P.E., 1985, Metallic sulfide deposits in the Winnfield salt dome, Louisiana: Evidence for episodic introduction of metalliferous brines during cap rock formation, in Transactions Gulf Coast Assoc. Geol. Soc., B.R. White, ed., prepared for 34th Ann. Mtg. Gulf Coast Assoc. Geol. Societies AAPG Regional Meeting/31st Ann. Mtg. Gulf Coast Sec. Soc. Econ. Paleontologists & Mineralogists, October 24-26, 1984, Shreveport, Louisiana, p. 435-442.

URABE, Tetsuro, 1985, Aluminous granite as a source magma of hydrothermal ore deposits: an experimental study: Econ. Geol., v. 80, p. 148-157. Author at Geol. Inst., Faculty of Sci., Univ. Tokyo, Hongo, Bunkyo, Tokyo 113, Japan.

Partition ratios of zinc and lead between synthetic granitic melts and aqueous phase were determined at 800°C and under $PH_2O = 3.5 \pm 0.25$ kb. The results indicate that only aluminous granite is capable of producing hydrothermal fluids which would contain a significant amount of ore metals. In other words, aluminous granite can be "ore-bearing" by postmagmatic processes. This is likely to happen when a granitic magma which originally was slightly alkaline changed its composition to slightly aluminous during diapiric uplift by assimilation of pelitic sediments. If this compositional evolution happened, then granitic magma would tend to store up base metals during the early stages of its evolution and release them very efficiently in the later stages to form a hydrothermal ore solution. (From the author's abstract)

URAI, J.L., 1985, Water-enhanced dynamic recrystallization and solution transfer in experimentally deformed carnallite: Tectonophysics, v. 120, p. 285-317. Author at Inst. Earth Sci., State Univ., P.O. Box 80.021, 3508 TA Utrecht, The Netherlands.

Cylindrical samples of polycrystalline carnallite ($KMgCl_3 \cdot 6H_2O$) were deformed in a triaxial apparatus at 60°C, at confining pressures between 0.1 and 31 MPa and at strain rates between 10^{-4} and 10^{-8} s^{-1}. In a number of cases, small amounts of saturated carnallite brine were added. Samples without added brine deform by intracrystalline slip, mechanical twinning, cracking, and by frictional sliding on crack surfaces. Stress-strain curves of the samples are strongly dependent on confining pressure. Addition of brine has a dramatic effect on both microstructural development and mechanical properties. Grain-boundary migration is strongly enhanced. At lower strain rates, additional intracrystalline effects start to appear, together with the onset of solution transfer. Rapid compaction in samples deformed with added brine causes high fluid pressures to develop. At higher strain rates addition of brine results in a decrease of the flow stress by a factor of two. This weakening will increase even further at strain rates below about 10^{-9} s^{-1}, when solution transfer becomes rate controlling. It is argued that deformation of carnallite in nature is adequately described by the flow law found for samples deformed with added brine. (Author's abstract)

URAI, J.L. and BOLAND, J.N., 1985, Development of microstructures and the origin of hematite in naturally deformed carnallite: N. Jb. Miner. Mh., 1985, no. H.2, p. 58-72.

Microstructures in naturally deformed carnallite ($KMgCl_3 \cdot 6H_2O$) samples from the Asse mine, West Germany, and the Veendam salt pillow, Northeast Netherlands, show evidence for crystal plastic deformation by slip and twinning. Recrystallization occurred by progressive misorientation of subgrains as well as by extensive grain boundary migration. There is also evidence for solution transfer processes operating.

Detailed observation of the hematite inclusions (which give the carnallite its red color) reveals that these are decorating dislocation networks. This is strong evidence for an origin by precipitation from solid solution, rather than by epitaxial growth. In the Asse samples, grain boundary migration is shown to eliminate the precipitates, providing an easy way to distinguish two generations of carnallite in hand specimen.

The observations provide a possibility for a better understanding of the deformation history of carnallite during diapirism. (Authors' abstract)

U.S. GEOLOGICAL SURVEY, 1985, USGS Yearbook, Fiscal Year 1984, 139 pp.

Inclusion data discussed as follows: delineating paleothermal anomalies (p. 25), metamorphic fluids at Coeur d'Alene district (p. 31), etc. (E.R.)

UYAMA, Fumitake, CHIBA, Hitoshi, KUSAKABE, Minoru and SAKAI, Hitoshi, 1985, Sulfur isotope exchange reactions in the aqueous sytem: thiosulfate-sulfide-sulfate at hydrothermal temperature: Geochem. J., v. 19, p. 301-315.

VANKO, D.A., 1985, Direct and indirect fluid inclusion evidence for hydrothermal phase separation beneath a mid-ocean ridge spreading center (abst.): EOS, v. 67, no. 16, p. 392. Author at Georgia State Univ., Atlanta, GA 30303.

Some quartz veins from the Mathematician Ridge (MR) dredged samples contain two types of fluid inclusions that appear to have been trapped simultaneously: one type (type I) contains high-salinity high-density fluid with halite crystals at room T that homogenizes to liquid. The other type (type II) contains low-salinity low-density fluid that homogenizes to vapor. This is interpreted as strong evidence that the vein qtz grew partially in the presence of a two-phase hydrothermal solution. Heating and freezing data support this interpretation. Indirect evidence for the same process includes type I inclusions in several other samples.

The samples from the MR (17°N, 111°W) include metagabbro and amphibolite containing qtz and qtz-epidote veins with rare interstitial sulfides. They represent the deeper portion of a hydrothermal system that was active prior to and during abandonment of seafloor spreading at the MR, 3.5 to 6.5 Ma ago.

Sample 7-45 contains the best evidence for phase separation with type I inclusions averaging 45 wt % NaCl equiv. = 500-600°C, and cognetic type II inclusions with 2 wt % NaCl equiv. = 350-500°C. Because the apparent Th of type II inclusions is lower than the actual Th, the 7-45 type I and type II inclusions probably have identical Th. Using the Bodnar et al. (1985) data on $NaCl-H_2O$, the type I and type II inclusions of 7-45 indicate phase separation at T = 500-600°C, P = 400-750 bar. Assuming a P gradient of 0.1 bar/m, and a rise crest depth of 2500 m, the inclusions were trapped at a depth of 1.5-5 km below the rise crest.

Samples 7-7, 7-31 and 7-41 all contain type I inclusions with most salinities in the range 30-50 wt % NaCl equiv., Th = 400-600°C. Although type II inclusions are not abundant, the type I inclusions probably formed via hydrothermal phase separation as well. (Author's abstract)

VANKO, D.A. and STAKES, D.S., 1985, Fluid inclusion microthermometry of hydrothermal precipitates from a fossil ridge crest (abst.): EOS, v. 66, no. 18, p. 402. First author at Georgia State Univ., Dept. Geol., Atlanta, GA 30303.

Fluid inclusions help document stages of hydrothermal fluid-rock interaction at the Mathematician Ridge (MR) abandoned ridge crest. Combined with textural, chemical and stable isotope data, a detailed chronology of events can be established for each sample.

The MR was abandoned 6.5-3.5 Ma ago. Dredges of the axial rift at 17°N contained gabbro, metagabbro (MG), amphibolite (AMPH), metadiabase, basalt, and serpentinite. Six samples of MG and AMPH contain veins of quartz (qz) and aq-epidote (ep). One sample (7-41) has now been studied extensively. It is a crudely foliated AMPH with relict MG texture, consisting mainly of actinolitic hornblende (hb) and actinolite (act) with chlorite (chl), ilmenite, albite and relict plagioclase. There is a trace of Cl-rich hastingsite (hast) forming irregular zones within act. An irregular vein network (~1 cm wide) of qz + ep contains partially assimilated clasts (~1 mm diam) of host rock.

Abundant fluid inclusions occur in the qz. Most are <10 μ, contain liquid + vapor, and they outline healed fractures. Some contain a halite crystal and these appear to be primary. Heating and freezing run data from 7-41 delineate 2 groups: high-T (500-400°C) saline (20-60 wt % NaCl equiv) primary inclusions, and low-T (350-150°C) moderate salinity (1-5 wt % NaCl equiv) secondary inclusions. Sample 7-41 records the following sequence of events: 1. metamorphism and hb growth at ~600°C; 2. brittle deformation with retrograde act ($\delta^{18}O$ = 3.3), Cl-rich hast, deposition of qz ($\delta^{18}O$ = 8.2) and ep, by a ^{18}O-enriched brine at 500-400°C; 3. injection of 350-150°C modified seawater, with further development of act, chl, and a trace of sulfides. (Authors' abstract)

VAPNIK, Ye.A., 1985, On conditions of decrepitation of inclusions of CO_2 in natural quartz from metamorphic rocks (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 89-91 (in Russian). Author at Inst. Geol. & Geochronology of Precambrian of Acad. Sci., Leningrad, USSR.

Author evaluates pressure necessary for decrepitation of CO_2-filled inclusion in quartz from metamorphic rocks for recognition of the possibility of destruction of fluid inclusions formed during culmination of metamorphism by external excess pressure in inclusions under surface conditions. Samples were taken from two different metamorphic complexes. Preparations had thickness 0.2 mm and surface 2 x 2 mm; they were placed in cryostage for identification of CO_2-filled inclusions on the basis of Tm CO_2 = -56.6°C; Th gave the density of inclusions, and then P for T of culmination of metamorphism was calculated. Next the inclusion was heated to some T, checked in cryostage for possible decrepitation and again heated to somewhat higher T, repeating the procedure to achieve Td. Thus, P of decrepitation was calculated. Thirty-five CO_2-filled inclusions of dia. 4 to 25 m showed that the bigger the inclusion, the easier was decrepitation. Inclusions about 4 m usually decrepitate at P 4.5 kbar, but five inclusions about 10 m [CO_2-filled?] did not decrepitate even at P >5.5 kbar [unfortunately, neither densities nor Td of the described inclusions are given, A.K.]. Most probably, decompression during retrograde metamorphism would cause a decrease in the number of CO_2-filled inclusions but not of those filled by pure H_2O or H_2O + salts. The probability of preservation of CO_2-filled inclusions of size >5 m, formed during culmination of metamorphism, is low, when submitted to retrograde metamorphism processes. (A.K.)

VAR'ASH, L.N., 1985, Hydrolysis of bivalent copper at temperature of 25 to 350°C: Geokhimiya, 1985, no. 7, p. 1003-1013 (in Russian; English abstract).

VASYUTA, Yu.V., KOZHEVNIKOVA, L.I. and ZAIRI, N.M., 1985, Bulk analysis of fluid inclusions by mechanical release of gas phase (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 71-73 (in Russian). Authors at Central Sci.-Research Geol.-Prospecting Inst., Moscow, USSR.

Inclusions in minerals are opened by crushing in a thermostatic (<100°C) air-tight volume under hydraulic pressure. Analysis of gases was performed in gas chromatograph "TSVET-100," sample weight 2.5-1.0 g. Crushing volume was pumped out (10^{-1} atm), next eluent gas was put in and specimen crushed ($P = 100$ kg per cm^2). Next gases are put in the chromatographic column. This method permits determination of gases in inclusions in carbonate rocks and when up to 1% of organic matter was present in the sample. Analysis of G from inclusions in samples from a gold deposit in Middle Asia showed that gases consist essentially of H_2O, CO_2 and CH_4 in metasomatically altered rocks. The ratio CO_2/CH_4 best characterizes the vertical zoning of the deposit: in the pre-ore interval, it is 160, in the ore interval, 6. At a rare-metal deposit in carbonatites, the rocks changed continuously from the fault to the margin of the deposit. The ratio CO_2/CH_4 was, in carbonatites 17-25, in intermediate metasomatites 31-67, in weakly altered (carbonate-bearing) sandstones 4-12. Lateral zoning in CO_2/CH_4 ratio distribution was found in one of the kimberlite pipes in Yakutia, occurring in carbonatized sandstones and aleurolites. The ratio for kimberlites was 12-20, and for their wall rocks from 170 (in aleurolites) to 270 (in sandstones). The authors recommend the mechanical release of gases from this type of investigation. (A.K.)

VAUGHAN, P.J., MOORE, D.E., MORROW, C.A. and BYERLEE, J.D., 1985, The mechanism of permeability reduction during flow of hydrothermal fluids through Westerly Granite: U.S. Geol. Survey Open-File Rpt. 85-262, 27 pp. plus 20 figures.

Includes discussion of crack filling mechanisms and mineralogy. (E.R.)

VAVILOV, M.A., BAZAROVA, T.Yu. and KUZNETSOVA, I.K., 1984, Peculiarities of crystallization of andesite-basalt melt of the Khayryuzovo massif: Geologiya i Geofizika, no. 7, p. 137-142 (in Russian; English abstract). Authors at Inst. Geol. and Geophysics of Siberian Br. Acad. Sci., Novosibirsk, USSR.

Andesite-basalts of Khayryuzovo massif form a large body in the W. Kamchatka volcanic belt. Phenocrysts (about 30 vol.% of rock) consist of olivine, ortho- and clinopyroxene and plagioclase, matrix is the pilotaxite mass of microlites of plagioclase, pyroxene and magnetite. Olivine bears P melt inclusions of dia. 30-40 µm, glass is crystallized to various degrees. Crystal phases start to melt at 1100-1050°C; this is also T of softening of glass. Complete homogenization was not achieved due to intensive melting of matrix surrounding phenocrysts. At 1410°C G bubble decreased to ~ one tenth and extrapolated Th is about 1450°C. P inclusions in orthopyroxene are to 50 µm, and Ti-augite (electron microprobe analysis) occupies about 20 vol.% of inclusion. Unaltered glass makes up about 80 vol.%. Some inclusions bear trapped ore minerals. Observations during Th runs were possible to 1410°C, but very intensive light emanation from the sample made observations extremely difficult. Extrapolated Th is 1440°C. Th of melt inclusions in clinopyroxene is 1190-1300°C. Plagioclase bears very abundant melt inclusions, sometimes up to 50% of crystal volume. Th of these inclusions are in ranges 1200-1280°C. Remnant glass in melt inclusions has more acid composition than the parent melt of the rocks. (Abstract by A.K.)

VEIZER, J., FRITZ, P. and JONES, B., 1985, Geochemistry of brachiopods: Oxygen and carbon isotopic records of Paleozoic oceans (abst.): Geol. Soc. Amer. Abstr. Prog., v. 17, p. 740.

VELIKOSLAVINSKIY, S.D. and TOLMACHEVA, Ye.V., 1985, The ore-forming role of fluids during Archean granite-formation within the central part of the Aldan Shield (based on thermobarogeochemical data) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 166-167 (in Russian; translation by D.A. Brown). Authors at All-Union Geol. Inst. (VESEGEI), Leningrad, USSR.

The oldest, early Archean tectonomagmatic cycle began with a shallow-depth (acid) volcanism (P = 2 kbar; T = 1000-1300°C), the products of which were converted during the phase of subsidence of granulite metamorphism into a complex of isochemical metamorphic granitoids (enderbites) (P = 5 kbar; T = 820-900°C). During the phase of uplift, gneiss-granites (P = 4.5-5 kbar; T = 780-820°C) were formed by palingenic-metasomatic means from the enderbites. Next in time came the middle Archean tectonomagmatic cycle, beginning with volcanism, including an acid episode (P ≈ 8 kbar; T = 960-1200°C), the products of which were converted during the subsidence phase of granulite metamorphism (P ≈ 5 kbar; T = 810-850°C) into enderbites. During the phase of uplift, gneiss-granites were formed (P = 4.0-5.0 kbar; T = 820-910°C) in an autochthonous aspect and massive granites in an allochthonous aspect. In this instance, granite-formation took place not only at the expense of the newly-formed material, but also as a result of remobilization of older granitoid material.

The P inclusions, present in the acid lavas formed during early and middle Archean time, have definite similarities and differences. Similarity amounts to the fact that the fluid inclusions contain H_2O, CO_2, NaCl, and $CaCO_3$. The differences are that the salt concentrations in the fluids of the middle Archean interval are significantly greater and their composition is more varied: in addition to NaCl, KCl is present; there are fluorides and apatite in the inclusions in the enderbites, and magnetite, hematite, and siderite in the inclusions in the gneiss-granites. The water content in the inclusions in the enderbites and gneiss-granites of middle Archean age is 1.0-1.5 wt %, and in the middle Archean gneiss granites[sic], 2.5 wt %.

From these thermobarogeochemical studies and I.D. Ryabchikov's experimental data on the factors controlling the passage of metals into the fluid it follows that the most promising areas are the middle Archean enderbites (for lithophile mineralization) and the gneiss-granites (for siderophile or chalcophile mineralization). The presence of apatite in the inclusions in quartz in the enderbites, and in quartz in the gneiss-granites, suggests that they are one of the most important sources of deposits of P and Fe in the central part of the Aldan Shield. (From the authors' abstract)

VETTER, O.J. and KANDARPA, V., 1985, Chemical thermodynamics in geothermal operations: Energy Research, v. 9, p. 333-344.

VIBETTI, N.J., KERRICH, R. and FYFE, W.S., 1985, Presence of Ca-Na dominated hypersaline brines in quartz-calc silicate veins of Troodos ophiolite (Cyprus) (abst.): EOS, v. 66, p. 1129. Authors at Dept. Geol., Univ. Western Ontario, London, Canada N6A 5B7.

Fluid inclusions containing daughter crystals in vein quartz present in altered gabbroic rocks from Troodos have yielded low eutectic temperatures indicating the presence of hydrothermal fluids of extreme salinity. Gabbros encountered at 970 to 1200 m in drill hole CY-4 are characterized by the calcic alteration assemblage anorthite, epidote, andradite, prehnite, quartz, albite ± laumontite developed pervasively and in veins and contain two populations of primary fluid inclusions in quartz bearing output veins. The first are two-phase liquid + vapor inclusions with eutectic temperatures (Te) -19 to -31°C, melting temp of solid hydrate phase (Tm-hydrate) -0.3 to -23°C and filling temp (Th) 140 to 270°C. The second are three- and four-phase liquid + vapor + solid inclusions containing daughter crystals of NaCl and $CaCl_2$(?) with Te -49 to -55°C, Th 130 to 295°C. These inclusions represent hypersaline NaCl and Ca-Na saturated brines with solute concentrations of 24 to 64 equiv. wt. % NaCl. The origin of these brines is attributed to hydration of oceanic crust and serpentinization of underlying peridotites. In the reaction: peridotite + seawater to serpentine + evolved fluid occurring deep in the pile at low H_2O/rock ratios the ionic species Ca^{2+}, Fe^{2+} are concentrated in the fluid phase while H_2O is removed in the hydration of olivine and pyroxenes leading to the development of hypersaline Na-Ca-Fe dominated brines with extreme Ca-metasomatic capability as observed by Barriga et al. (1985, this volume). These residual fluids are probably injected into overlying rocks as a result of the large bulk expansion and fracturing accompanying serpentinization. (Authors' abstract)

VIETS, J.G., LEACH, D.L., MEIER, A.L., ROSE, S.C. and ROWAN, E.L., 1985, Application of induction coupled plasma mass spectrometry of the analysis of fluids extracted from Mississippi Valley-type deposits of the mid-continent, USA (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 740. Authors at U.S. Geol. Survey, P.O. Box 25046, MS 955, Denver, CO 80225.

The development of induction coupled plasma (ICP) mass spectrometry permits analysis for many cations in fluid inclusion extracts at lower detection limits than previously obtainable. Using ICP mass spectrometry, selected cations were analyzed in fluids extracted from galena, sphalerite, and hydrothermal dolomites from the Northern Arkansas, Tri-State, Central Missouri, and Viburnum Trend Mississippi Valley-type districts.

Regionally, the composition of the extracted fluids are quite similar. However, in the Viburnum Trend, early octahedral galena is enriched in potassium and aluminum relative to late cubic galena. Potassium and aluminum values for late cubic galena are similar to the values for the other districts.

Although carbonate hosted, the lead-rich Viburnum Trend is unique among the districts studied in its proximity to a basal sandstone aquifer underlain by Precambrian felsic igneous rocks. The decrease in potassium and aluminum content through time suggests that early octahedral galena may have been deposited from a fluid channeled primarily through the basal Lamotte Sandstone aquifer. Late cubic galena was deposited from a fluid with less potassium and aluminum. Perhaps this fluid had more interaction with carbonate rocks owing to development of porosity; alternatively, a change in pH through time would also be consistent with these observations. (Authors' abstract)

VIGLINO, J.A., HARMON, R.S., BORTHWICK, J., NEHRING, N.L., MOTYKA, R.J., WHITE, L.D. and JOHNSTON, D.A., 1985, Stable-isotope evidence for a magmatic component in fumarole condensates from Augustine volcano, Cook Inlet, Alaska, U.S.A.: Chem. Geol., v. 49, p. 141-157.

VIKRE, P.G., 1985, Precious metal vein systems in the National district, Humboldt County, Nevada: Econ. Geol., v. 80, p. 360-393. Author at

ASARCO Inc., Great Basin Explor. Div., 510 East Plumb Lane, Reno, NE 89502.

Precious metal quartz-sulfide-silicate veins near the townsite of National and on Buckskin Mountain occur within a 3,000-ft-thick (910 m) sequence of Miocene volcanic and intrusive rocks which vary in composition from basalt to rhyolite. At Buckskin Mountain two distinct but synchronous thermal events are documented by fluid inclusion studies. The earlier event involved temperatures ranging from ~295° to 250°C and culminated in rupture of overlying rhyolite, producing an inverted conical mass of bilithic breccia. Fluids associated with the second, postbrecciation event boiled at 100° to 255°C from the paleosurface to depths exceeding 2,000 ft (606 m). Near-surface hydrothermal assemblages were deposited from low-salinity (1-2 wt % NaCl) solutions containing <2 weight percent dissolved gases. Precious metal precipitation occurred at a temperature of about 250°C and a pressure of about 40 bars, largely from boiling solution. Periodic restrictions to convective heat loss resulting from silica deposition and episodic fluid circulation cause observed temperature and pressure data to deviate somewhat from an ideal hydrdostatic model. The vertical temperature gradient is consistent with a water-saturated melt of granitic composition about 10,000 ft (3,030 m) below the paleosurface during mineralization. Close spacing of isotherms below 200°C reflects paleosurface proximity (cooling by conduction and steam loss) as well as accelerated convective cooling of fluid circulating through permeable rhyolite tuff.

Integration of hydrothermal assemblages, thermal measurements, fluid-mineral equilibria, and active hot springs data suggests that as temperatures in Buckskin Mountain decreased from 250°C at depth to 100°C at the surface, pH increased from ~3.7 to near neutral, ΣS increased from $10^{-4.5}$ m to ~$10^{-2.6}$ m, and fO_2 decreased from 10^{-39} to <10^{-48}. The distribution of alteration assemblages, precious metal minerals, stibnite, and cinnabar was apparently controlled by boiling, a sulfidation gradient, temperature decreases, and near-surface hydrology. (From the author's abstract)

VINOGRADOVA, G.V., VINOGRADOV, A.N., IKORSKIY, S.V., YELINA, N.A. and LEKHANOVA, O.G., 1985, Peculiarities of the fluid regime in the ore-generating systems of the early Proterozoic rare-metal granites of the northeastern part of the Baltic Shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 164-165 (in Russian; translation by D.A. Brown). Authors at Geol. Inst. Kola Br. Acad. Sci. USSR, Apatity, USSR.

In the northeastern part of the Baltic Shield, the ore-generating systems (OS) of the alkali-granite association are productive with respect to rare-earth - rare-metal mineralization. The OS of the plumasitic leucogranites, which terminate the multiphase intrusive series of the granodiorite-granite association, are marked by a rare-metal - W-Mo specialization. In the West Keyv granite-leucogranite complex, an assemblage of inclusions from four groups has been identified for the synchronous single-stage series of alkali-granites, pegmatites, and quartz veins. In each group of inclusions, Th fell as one moved away from the intrusion. There were no signs of boiling.

The OS of the Yuovoayv Complex of granites, leucogranites, quartz porphyries, greisens, and quartz veins is marked by divergence for the T groups of inclusions, with complications: there are gas inclusions in the granites of the main intrusive phase (MIP) and up to five groups with four kinds of inclusions in the late quartz veins. During the transition from the pneumatolytic to the hydrothermal phase, signs of boiling of the solutions have been identified in the veins.

A common property of the OS is the increase in gas-content of quartz from the magmatic rocks to the hydrothermalites, and in this case, the gas-content in the quartz of the granodiorite-granite association is greater than that of the alkali-granite association. The degree of oxidation of the fluids in the OS of the alkali-granites is lower than in those of the plumasite leucogranites (CO_2/CH_4 ratio varies from 2 to 47 and from 10 to 240 respectively, increasing towards the end products). The mineral content of the inclusions diminishes from the granites towards the quartz veins, whereas in the plumasite leucogranites, it increases from the MIP to the alaskites and the high-F leucogranites and their accompanying hydrothermalites. In the alkali-granites, the fluids consist of degassed water-salt melt and brines with a marked predominance of alkali chlorides. In the plumasite series, the MIP is characterized by an alkali fluoride-chloride composition in low concentration fluids, in the supplementary intrusions and hydrothermalites, the fluids belong to the selective alkali-chloride brine type, and in the greisens diluted complex fluoride-hydrocarbonate-chloride solutions have been identified. (From the authors' abstract)

VOGEL, L.M., McCLURE, D.S. and CRERAR, D.A., 1985, Octahedral-tetrahedral equilibrium in ferrous chloride solutions (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A66.

VOLFINGER, M., ROBERT, J.-L., VIELZEUF, D. and NEIVA, A.M.R., 1985, Structural control of the chlorine content of OH-bearing silicates (micas and amphiboles): Geochimica Cosmo. Acta, v. 49, p. 37-48.

VOLLBRECHT, A. and SCHRODER, B., 1985, Postorogenic cooling and uplift interpreted from secondary fluid inclusions in quartz detritus - a simple model (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 124. First author at Inst. Geol. und Dynamik der Lithosphäre Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

The northwestern margin of the Bohemian Massif (NE Bavaria), which comprises parts of the Saxothuringian and Moldanubian zone of the Variscan orogen, was uplifted since the Upper Carboniferous and supplied detritus into the western sedimentary basin (beginning in the Stephanian). Erosion of several kilometers has to be assumed, since very low- to high-grade metamorphic rocks and together with deep-seated late Variscan (Upper Carboniferous) granitic intrusives are exposed at the present surface.

Quartz sandstones of Upper Carboniferous to Tertiary age were investigated for "detrital" fluid inclusions to gain information on the thermal-tectonic history of the eroded structural layers the detritus of which being supposed to occur "upside down" in the sedimentary cover. There is no geological evidence for a postsedimentary thermal alteration of fluid inclusions.

The most striking feature is the predominance of secondary aqueous inclusions with very low salinities (almost pure H_2O) throughout all stratigraphic units. From the frequency distribution of the corresponding Th, however a relationship between erosion level (or age of sedimentation) and inclusion densities becomes apparent: the densities increase toward the present erosion level, and the scattering of densities decreases in the same direction.

These trends are explained by a simple model, which implies that the ascending crust was affected by continuous microcrack formation and healing due to elastic relaxation in a zone fixed at about 5-10 km depth, with a contemporaneous decrease of the geothermal gradient. The decreasing scatter of densities may reflect a reduction of thermal inhomogenities in the upper crust resulting from nappe thrusting and/or the posttectonic intrusives. (Authors' abstract)

VON DAMM, K.L. and BISCHOFF, J.L., 1985, Southern Juan de Fuca Ridge hot spring chemistry (abst.): EOS, v. 66, no. 46, p. 926.

VON DAMM, K.L., EDMOND, J.M., GRANT, B., MEASURES, C.I., WALDEN, B. and WEISS, R.F., 1985, Chemistry of submarine hydrothermal solutions at 21°N, East Pacific Rise: Geochimica Cosmo. Acta, v. 49, p. 2197-2227. First author at Environmental Sci. Div., Oak Ridge Nat'l. Lab., P.O. Box X, Oak Ridge, TN 37831.

The three hydrothermal fields at 21°N latitude, East Pacific Rise, were resampled and an additional one was discovered. Maximum fluid temperatures observed were within a few degrees of 350°C and these waters had concentrations of Mg and sulfate indistinguishable from zero. One field, NGS, which had active 350°C springs in 1979, was inactive when first located in 1981. However, when a chimney was broken open during sampling, water issued at 273°C and continued to flow for at least five days. The chemical composition strongly suggests that these waters cooled conductively from 350°C in the sealed conduit.

The major ion data are consistent with the estimates based on extrapolation of the original measurements made on the hot springs from the Galapagos Speading Center (Edmond et al., 1979a). The fluids have a pH of 3.5 and the sulfide-forming element concentrations show significant inter-field variations. Fe levels range from 0.8 to 2.4 m moles/kg; the ratio Fe:Mn varies from 0.9 to 2.9 similar to metalliferous sediments on the ridge flanks, but much higher than observed at Galapagos (where subsurface precipitation of iron sulfides occurs) indicating that the overwhelming proportion of the mass flux from hydrothermal systems occurs at high temperatures. Zn ranges from 40 to 106 μmoles/kg with Cu being substantially lower. Since the ratio of these elements in tholeiites is about unity, there is strong net preferential mobilization of Zn. Lead ranges from 183 to 359 n moles/kg. Nickel and Be are highly immobile relative to the other trace elements. The abundance of H_2S is about three times that of the total sulfide-forming cations. These data demonstrate that acid solutions at elevated temperatures can transport substantial amounts of ore-forming elements in the presence of large excesses of sulfide. (Authors' abstract)

VON DAMM, K.L., EDMOND, J.M., MEASURES, C.I. and GRANT, B., 1985, Chemistry of submarine hydrothermal solutions at Guaymas Basin, Gulf of California: Geochimica Cosmo. Acta, v. 49, p. 2221-2237. First author at Environmental Sci. Div., Oak Ridge Nat'l. Lab., P.O. Box X, Oak Ridge, TN 37831.

Reconnaisance ALVIN dives in the sediment-filled southern trough of the Guaymas Basin found active hot springs with temperatures ranging up to 315°C. High temperature activity is generally restricted to the crests of large mounds that rise out of the flat-lying basin sediments. The chemistry of the hydrothermal waters is distinctly different from the characteristic of sediment-starved, open ocean ridge axes in that the solutions are alkaline, contain ammonium as a major ion and are strongly depleted in the "ore-forming" metals. These compositions are interpreted as the result of reaction of a primary solution, similar in composition to those as 21°N, EPR, with the biogenous sediments overlying the intrusion zone. The pH of this fluid is raised both by the dissolution of carbonate and the addition of ammonium from thermocatalytic cracking of immature planktonic carbon. Metal sulfides are consequently precipitated at depth in the sediment column. The Guaymas Basin is thus the site of active formation of a sediment-hosted massive sulfide mineral deposit: the exiting waters are the "spent" ore-forming fluid. The ammonium data demonstrate that organic carbon (black shale) is, by itself, a sufficient source of alkalinity to induce the precipitation of sulfides from ascending solutions. Since ammonium does not participate directly in these reactions but does form secondary aluminosilicate minerals these latter should constitute a valuable exploration tool in the search for shale hosted deposits. (Authors' abstract)

von GEHLEN, Kurt, 1985, Halides and calcium sulfate in a pseudomorphous quartz vein, Odenwald, F.R. Germany: N. Jb. Miner. Mh., 1985, no. H 11, p. 508-512.

First results of a SEM-EDAX study of pseudomorphous quartz from the Odenwald indicate that brines containing Ca, Fe, and K as cations and Cl, Br, and SO_4 as anions were present, probably contemporaneous with the formation of sulfate (barite/anhydrite?) and the quartz replacing it. The brines most probably descended at some time during the Tertiary. (Author's abstract)

VOROB'YEV, Yu.K., 1985, Mechanism of formation of primary inclusions in minerals and validity of thermometry (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 20-21 (in Russian). Author at IGEM, Moscow, USSR.

(...) 1. A crystal, growing under conditions close to ideal, i.e., in continuous and stable inflow of weakly oversaturated solution (or weakly overcooled pure melt) does not contain inclusions.

2. P inclusions are not representative samples of this medium, from which crystal is growing - they contain either admixtures concentrated at the growth front, or solution that is already lacking in components of the crystal, G bubbles or foreign melt.

3. Inclusions of mineral-forming medium (that do not[sic] represent its properties) generally form when any form of crystal growth loses its stability. The following essential mechanisms of trapping during growth may be listed: a) trapping between branches of dendrites, or between subindividuals of crystals, b) formation of inclusions in the "shadow" of elevation of growth element (during layer growth), c) trapping of inclusions during interaction of growth front with foreign inclusions; d) trapping of foreign inclusions, e) formation of inclusions during healing of relaxation fractures. The above mechanisms do not exhaust all possible cases of trapping of syngenetic inclusions by growing crystals.

4. It was found experimentally that even during the action of one mechanism on pyramids of the same face, but growing with different speed, inclusions with various phase ratios form. Differences between inclusions formed due to various mechanisms may be very large - especially in filling degree, consequently in Th, and thus are not connected with T of trapping. Such "anomalous" (Sensu Ermakov 1979) heterogeneous inclusions regularly form during crystal growth from a homogeneous medium, and are for many conditions of growth more typical than "normal" i.e., homogeneous inclusions.

5. There is no possibility in most cases to distinguish in natural vein minerals the truly working mechanisms of inclusion formation, and the inclusions may give various Th (from 100 to 400°C). The probable, valid estimations of T of trapping are possible only in those extremely rare cases, when mechanisms of trapping may be recognized in natural crystals.

Most interesting (from the point of view of thermometry) are inclusions in healed relaxation fractures due to relatively easy diagnostics, primary homogeneity and biggest similarity of their composition to composition of solution surrounding solution. (Author's abstract translated by A.K.)

VOROB'EV, Yu.K. and SERGEEV, V.I., 1985, Determination of the concentration of the solution in unsealed gas-liquid inclusions: Zap. Vses. Mineral. O-va, v. 114, no. 4, p. 502-505 (in Russian). Authors at IGEM, Moscow, USSR.

Unsealed fluid inclusions in which the primary gas composition is not preserved but the original solution remains are shown to still provide useful information for geothermometry. This is illustrated in the example of fluid inclusions in quartz crystals from the Darasun Au ore deposit (eastern Transbaikalia) and ferruginous quartzites of Karelia; unsealed inclusions in these crystals have elongate, irregular shapes or are distributed along cracks. The location of points plotting the degree of filling of the unsealed inclusions vs. their homogenization temperature is compared with standard curves determined by G.G. Lemmlein and P.V. Klevtsova (1956) for NaCl solutions of known concentration; match-up of the plotted points to a curve provides an estimate of the solution composition and concentration. Error in estimating the degree of filling of the inclusions can be reduced by selecting a group of a large number of inclusions (32-50) for study. (C.A. 103: 218404b)

VOSS, R.L. and HAGNI, The application of cathodoluminescence microscopy to the study of sparry dolomite from the Viburnum Trend, southeast Missouri, in Mineralogy - Applications to the Minerals Industry, D.M. Hausen and O.C. Kopp, eds.: Proc. of Paul F. Kerr Memorial Symp., Feb. 28, 1985, AIME, New York, NY, p. 51-68.

VOVK, I.F., 1985, Brines in the crystalline basement of the East-European Platform (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A66. Author at Div. Research & Lab., Int'l. Atomic Energy Agency, Vienna, Austria, A-1400.

Saline waters and brines have been repeatedly encountered in the crystalline basement of the East-European Platform, in particular within the Russian Plate and the Ukrainian and Baltic shields. Samples of brines and associated gases were obtained from several dozens of mines and boreholes two of which, in Tatar Dome and Kola Peninsula, pass through shear zones and fractures filled with brine right up to the depth of 5000 m and 11000 m respectively. Highly concentrated brines and gases are also often found as fluid inclusions in minerals of igneous and metamorphic rocks. The salinity of water sampled from mines and boreholes increases with depth from 0.1 - 100 $g \cdot L^{-1}$ at 0 - 1000 m to more than 300 $g \cdot L^{-1}$ at 2000 - 3000 m and deeper. The brines are of two major chemical types: Na-Cl and Na-Ca-Cl. The Na-Cl brine is found mainly along the Krivoy Rog regional fault crossing the Ukrainian shield, while the Na-Ca-Cl brine is more widely distributed on the rest of the territory of the platform. The major component of gas dissolved in Na-Cl brine from iron mines in Krivoy Rog is CO_2, accompanied by H_2, He and CH_4, while Na-Ca-Cl brine from the borehole in Tatar Dome contains mainly N_2 and CH_4, accompanied by He and H_2. Free gases associated with brines and filling the porous media of crystalline rocks are predominantly of H_2-CH_4 or CH_4-H_2 composition with smaller amounts of N_2 and He. The chemical and isootopic data, as well as geological position suggest that saline waters of Na-Cl type from the Krivoy Rog region may be diluted Paleozoic sea brine. The source of the Na-Ca-Cl brines and major gases, particularly H_2, is not well understood but could be residual metamorphic fluids originated from Precambrian sea water highly modified radiolytically and/or in some other way. Drilling of a new superdeep borehole (15000 m) has been started in Krivoy Rog. (Authors' abstract)

VOZNYAK, D.K., 1985, Alterations of inclusions of mineral-forming media (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 95-98 (in Russian). Author at Inst. Geochem. & Physics of Minerals, Kiev, Ukraine, USSR.

Change of inclusion composition occurs due to: a) loss of some components of inclusion due to nonhermetic structure of minerals, e.g., water from inclusions in zeolites and apophyllite; b) possible diffusion of H_2 from inclusions at high (magmatic) T; c) exchange between inclusion filling and substance of host mineral; d) flow of admixture atoms from mineral structure into inclusion vacuole - new inclusions may form then, up to 3-4 µm in size, during post-crystallization cooling of mineral; e) radioactive decomposition of substance in inclusion and influence of external radiation on inclusion filling; f) precipitation of substance on walls of vacuole from inclusion filling due to T decrease, important for magmatic inclusions; g) refilling of inclusions.

The following processes cause the alteration of the former inclusion habit: a) achieving of equilibrium habit of inclusion; this may cause change of composition of inclusion filling[sic]; b) necking down of inclusions; c) natural decrepitation of inclusions; d) alteration and migration of inclusions in thermogradient field may also cause coalescence of inclusions and change of initial composition of filling. The alterations listed above may be recognized and even used successfully as additional help for reconstruction of genesis conditions of geological objects. (A.K.)

VOZNYAK, D.K., GLUKHOV, A.P., GEVORK'YAN, S.V. and KUZNETSOV, G.V., 1985, Properties and conditions of formation of apatite in the Davidkovsk massif of gabbro-syenites (northwestern Ukrainian Shield) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 157-159 (in Russian; translation by D.A. Brown). Authors at Inst. Phys. & Geochem. Minerals Acad. Sci. Ukrainian SSR, Kiev, USSR.

Apatite is the main accessory mineral in rocks of the gabbro-anorthosite association, which is at present the most promising of all the apatite-bearing associations on the Ukrainian Shield. Therefore, clarification of the conditions of its formation is important for our understanding of the origin of apatite deposits in the basic rocks of the region and for revealing their mineral prospects.

The Davidkovsk gabbro-syenite massif is a complex differentiated intrusion, the apical portion of which consists of syenites, gabbro-syenites, near-contact anorthosites, and gabbros. Apatite crystals $\leq$1.5-2 mm in size are present in substantial amounts in the gabbros, and in the endocontact between the massif and the granitoids, and is associated with ilmenite, titanomagnetite, and pyroxenes.

The apatite contains a large quantity of inclusions of mineral-forming medium of elongate-prismatic shape (negative crystals), measuring 0.001 to 0.15 mm in length, coinciding with L_6 of the crystals. Content: colorless glass (70-100 vol%) is usually isotropic or with a brownish tinge (more commonly anisotropic), and mineral phases (up to 20%) are anisotropic, including dark-brownish platelets, resembling biotite. The gas phase does not form a distinct bubble, but has been observed in the form of irregular segregations on the boundary between the dark mineral phases and the glass

(<10%).

Heating: at ~620°C, the glass becomes soft and gas bubbles appear, which later separate into one or several bubbles. Their volume is greatest (~10-15%) at 900-500°C. Th = 1310-1350°C with a marked increase in inclusion volume from dissolution of the host-mineral, and sometimes marked disappearance of the gas phase is noted[sic]. The gas bubbles are readily displaced into cavities, which indicate the low viscosity of the melt. It is sometimes possible to extract entirely the content of the inclusions of mineral-forming medium. Its density is 3.0 ± 0.1 g/cm^3 (4 measurements), which is less than that of the apatite studied.

The association between apatite and ilmenite, titanomagnetite, and pyroxenes may be explained by crystallization differentiation (gravity settling), hence there is a possibility of rich ores being revealed. (From the authors' abstract)

VOZNYAK, D.K., MATYASH, I.V., BRIK, A.B., LARIKOV, A.L. and MAZYKIN, V.V., 1984, ESR data on the formation of honeycomb quartz: Geokhimiya, no. 4, p. 534-540 (in Russian, English abstract; translated in Geochem. Int'l., v. 21, no. 4, p. 93-99, 1985). Authors at Inst. Geochem. & Mineral Physics, Ukrainian Acad. Sci., Kiev.

ESR [Electron spin resonance] has been applied to the distributions of Al-O centers in zoned honeycomb quartz crystals. There is a correlation between the contents of structural aluminum in the zones, the honeycomb jointing, and the dauphiné inversion twins. The formation of the inversion (honeycomb) jointing is related to the metastable transformation of the quartz in association with a smooth change in P and T in the mineralizing medium. These quantities, determined from the inclusions, are equal to (if the mineral is only under the pressure of the solution) or less than (if the crystals are exposed to lithostatic pressure) the P and T of the mineralizing fluid during the $\beta \to \alpha$ transformation. (Authors' abstract)

VOZNYAK, D.K., ZVOL'SKIY, V.S. and GORBACHOVA, L.Yu., 1985, Device for chromatographic studies of gases released from minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 66-68 (in Russian). First author at Inst. Geochem. & Physics of Minerals, Kiev, Ukraine, USSR.

The authors propose a device for introduction of gas released from minerals into gas chromatograph. The device [see figure] allows the following:

1. During calibration of chromatograph a gas mixture may be put in gas line by syringe with P = 1 atm (after sample insertion change valve B from position II to position I).

2. Calibrated volume may be joined instead of device for inclusion opening (7) for introduction of known volume of gas.

(...) 4. Flush the device for inclusion opening with eluent gas.

5. Gases from inclusions may be extracted in closed volume under different pressure.

6. Device for release of gases from inclusions may be easily replaced by another one.

7. Released gas may be introduced in chromatograph in portions.

8. Released gas may be introduced into one of two columns of chromatograph (switch valve A to position I or II).

T in thermostat is 120°C. One sample of mineral (50-100 mg) gives amount of gas sufficient for 3-5 or more analyses. Such gases as H_2O, CO_2, CH_4, O_2, N_2, H_2, H_2S, CO, NO, SO_2, NO_2, NH_3, etc., may be determined. (Authors' abstract; translated and shortened by A.K.) Continued next page.

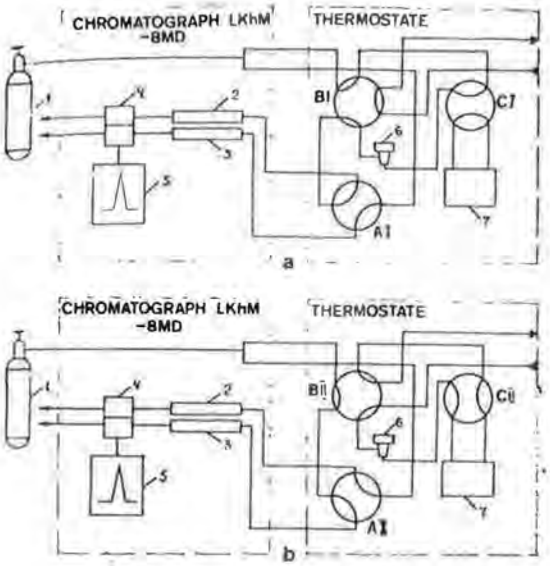

Figure: Scheme of the gas supply device: "a" and "b" - various valve positions; 1 - source of gas eluent (He); 2 and 3 - chromatographic columns with Polisorb-1 and zeolite CaA; 4 - katharometer; 5 - recorder; 6 - place for gas input by syringe; 7 - device for gas release; A, B, and C - valves.

VROLIJK, P.J., 1985, Fluid and paleohydrologeologic evolution during progressive melange deformation (abst.): Geol. Soc. Am. Abst. with Programs, v. 17, p. 415. Author at Earth Sci. Board, Univ. California, Santa Cruz, CA 95064.

Three units of the Kodiak accretionary complex, the Cretaceous Uyak Complex (UC), the Paleocene Ghost Rocks Fm (GR), and Eocene Sitkalidak Fm (S), underwent a grossly similar structural evolution, but deformation in each younger unit was interrupted at an earlier stage. Each unit was pervasively deformed by cataclasis (web structure); however, degree of overprinting recrystallization and pressure solution increases from nil (S) to moderate (GR) to intense (UC).

What information remains of the fluid evolution during progressive melange deformation? Carbon and oxygen stable isotope data from calcite-cemented concretions and calcite veins together with fluid inclusion data from quartz veins suggest the following generalizations: (1) Hydrologic boundaries change with time. During earliest deformation, localized (with respect to $\delta^{13}C$) hydrologic systems exist (similar to the present Barbados accretionary margin), but these systems open as fracture density increases. Finally, water-rock ratios diminish, and the system closes. (2) Defomation is coeval with high water-rock. $\delta^{18}O$ values of early calcites are very quickly reset and reflect later fluid conditions; early fluid histories become obliterated in UC and GR. (3) Carbonate for calcite cements and veins originate from the following reservoirs (approximately from shallow to deep): interstitial seawater; carbonate produced during bacterial sulfate reduction; carbonate produced during thermal (metamorphic) methanogenesis; dissolution of marine limestone. (Author's abstract)

VYNAR, O.N., NAUMKO, I.M. and REMESHILO, B.G., 1985, Characteristics of composition and properties of postmagmatic fluids of pegmatite and quartz veins from Ukrainian Shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 16-18 (in Russian; translation by S. Jaireth). First author at IGFM Inst. Geol. & Geochem. of Fuels, Acad. Sci., Ukraine SSSR, L'vov, USSR.

The pegmatites and quartz veins are genetically associated with lower Proterozoic formation of normal granites of Osnits and Krivograd-Jhitomir complexes of the Ukrainian Shield. Pegmatite veins have a weakly developed zonal structure. Most widely developed are the pegmatoid and quartz-feldspathic blocky zones. The following mineralogical types of pegmatites are recorded: quartz-microcline-muscovite of Gorodnitsk field, quartz-feldspathic (ceramic) of Korostishevsk field and quartz microcline-albite with accessory Be and Ta-Nb mineralization of Korostishevsk and Gorodnitsk fields. Other dominant accessories in pegmatites are apatite, garnet and tourmaline (schorl). Monomineralic quartz veins cut across contaminated country rocks (Osnitsk complex), granite of Krivograd-Jhitomir complex, and rarely pegmatites (Boguslav, Bobrinetsk granitic massives). Apparent thickness of veins varies from 5-10 to 40 cms and length from 3 to 5 m. Quite often quartz veins fill fracture zones.

Characteristic feature of postmagmatic fluids of pegmatite and quartz veins is their heterogeneous nature. Fluids are marked by subcritical P-T parameters and hence temperatures of homogenization of these inclusions correspond to the true temperatures of mineral formation[sic]. Temperature of formation of pegmatite veins varied between 250 and 400°C, of accessory minerals between 250 to 300°C and healing of fractures between 150 to 240°C. Fluid pressure at the time of entrapment varied between 60 to 100 MPa. Silica in quartz veins is represented by blocky quartz. Crystallization of quartz crystals in the viens of Boguslav massive occurred at temperatures of 180 to 200°C.

Chemical composition of postmagmatic fluids based on leachate analysis of inclusions in quartz can be characterized by ratios of main components of solutions - Na/K and Cl/F. In granites, ratios are nearly one, varying between 1.4 to 2.5 and 0.5 to 1.3 respectively. In pegmatites and particularly in quartz veins of Osnitsk complex ratio abruptly increases; Na/K - 0.5 to 23 and 30 to 37 respectively; Cl/F - 8.2 to 11 and 154 to 778. In zonal pegmatites, Na/K ratio increases from graphic (0.4 to 0.6) to blocky zone (1.7 to 3.0). Cl/F ratio in pegmatites with accessory Be mineralization varies between 1.1 and 3.9; in ceramic pegmatites between 1.9 and 18.1. Salinity[sic] of solution declines in a sequence: granites (42-218 mg/kg of sample), quartz veins (157-170) pegmatites (16-84). Accessory rare metal mineralization (beryl, apatite, garnet, tourmaline) is localized in zones of pegmatite where the effect of CO_2-H_2O fluids is most dominant.

A tendency toward increase in the concentration of CO_2 in the inclusions is observed in the sequence - country rocks (22-24 vol%), graphic zone (35-65 Vol%), quartz-blocky zone (80-85 vol.%). Unaltered granites and quartz-feldspathic zones of pegmatites are marked by higher concentrations of nitrogen. Variation in the concentration of CH_4 is similar to that of CO_2, only methane is far lower (9-31 vol%) than CO_2. CO_2/CH_4 ratio increases in zones of intensive metasomatic activity and concentration of rare metal mineralization.

Variations in Na/K and CO_2/CH_4 ratio in the inclusions of postmagmatic fluids can be used as geochemical signature in the exploration for pegmatites with accessory rare metal mineralization. (Authors' abstract)

VYNAR, O.I., NAUMKO, I.M., SUPRUNENKO, N.S. and KOSTENKO, N.M., 1985, On the study of gas-liquid inclusions in quartz of veined pegmatites from basic rocks of northwestern parts of Ukrainian Shield (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 19-21 (in Russian; translation by S. Jaireth). First author at IGFM Inst. Geol. & Geochem. of Fuels, Acad.

Sci., Ukraine SSSR, L'vov, USSR.

Fluid inclusions have been studied in minerals of veined pegmatites intruding into basic rocks (gabbro, diorite, gabbro-diabase) of Kirovsk-Kocherovsk metallogenic zone of Ukrainian Shield. Pegmatites show accessory Ta-Nb mineralization and are accompanied by widespread albitization. The weakly differentiated pegmatites are marked by graphic, pegmatoid or fine blocky structures and muscovite-albite, microcline composition with thickness of 0.3 to 2.0 m. Quartz of the pegmatite is grey to light grey, transparent and fractured.

Optical microscopy reveals gas-liquid inclusions to be the main types of inclusions in quartz. Groups of inclusions are either randomly distributed unrelated to healed cracks (early secondary[sic]) or more often along planes of healed rocks (secondary). The first type are spherical, negative crystal shaped with degree of filling of 60-65% and T of 260-280°C. The second type have more variable shapes, with Th of 210-220°C and 190-200°C. Healing of cracks occurred by homogeneous and occasionally heterogeneous, predominantly H_2O and CO_2-H_2O solutions. Heterogeneous fluids are indicated by syngenetic inclusions of variable composition: CO_2-H_2O (D.F. = 40-50%, L_1 = 30-40%) and predominantly aqueous (D.F. = 10-15% and 70-75% Th = 210-215°C into liquid and gaseous phases). [Other] CO_2-H_2O inclusions are characterized by homogeneous entrapment of aqueous as well as CO_2 fractions.

Mass spectrometric analysis (analyst S.D. Vishtaluk) of volatile components in fluid inclusions of quartz and rare metal minerals from different structure zones of pegmatites reveals a predominance of CO_2, the concentration of which increased from graphic (50 vol.%) to pegmatoid and fine blocky zones (91-96 vol.%). Optical quartz-bearing "zanorysh" type pegmatites of Volhyn (Kalyuzhnyi, Kovalishin, 1967) and rare metal veined pegmatites of Ukrainian Shield (Vynar et al., 1980, 1981; Naumko et al., 1982, 1983) also show similar behavior of CO_2 in fluids. Higher concentration of nitrogen in quartz from graphic zone (50 vol.%) with abrupt decrease in its concentration in other zones (3.5 to 2.4 vol.%) and complete absence of methane compared to low but consistent presence of it in minerals of pegmatites of adjacent Korostishevsk field (Vynar et al., 1981) is worth mentioning.

Reasonably high concentration of CO_2 in gaseous phase of entrapped solutions in quartz and other minerals of veined pegmatites intruding into basic rocks reveals significant role of CO_2 as regulator of pH conditions of mineral forming media (Naumov et al., 1972) in transportation and localization of rare metal mineralization in granitic pegmatites localized in acidic and even basic rocks. These facts expand the possible use of variation in the concentration of endogeneous CO_2 in fluid inclusions during exploratory work. (Authors' abstract)

WADA, Keiji, 1985, Magma mixing process of calc-alkalic andesites from Funagata volcano: J. Japan. Assoc. Min. Petr. Econ. Geol., v. 80, p. 467-483. Author at Dept. Earth Sci., Asahikawa College, Hokkaido Univ. of Education, Asahikawa 070, Japan.

Calc-alkalic andesites from the Funagata volcano are characterized by disequilibrium phase assemblages, reverse zoning of plagioclase and pyroxenes, wide compositional range of plagioclase, and coexistence of basaltic and rhyolitic glass inclusions. These mineralogical features can be ascribed to magma mixing process involved in the formation of the calc-alkalic andesites. Compositional profiles of plagioclase and pyroxenes suggest that the phenocrysts have crystallized from three distinct magmas such as mafic and silicic end-member magmas and mixed magma. Mixing ratio of mafic end-member magma to silicic end-member magma within individual andesite was calculated by available mineralogical data. Whole-rock chemical composition of andesites exhibits linear correlation with both the mixing ratio and SiO_2 content. Two mixing lines in $MgO-K_2O$ diagram are constricted at the MgO-rich tholeiitic basalts which represent the mafic end-member magma. Chemical composition of the silicic end-member magmas was deduced by the mixing ratio. Calculated silicic end-members are felsic andesite (SiO_2 = 64%, K_2O = 1.1%) and dacite (SiO_2 = 66%, K_2O = 1.8%). Available Sr-isotopic data suggest that the dacite magma is not produced by fractional crystallization of the tholeiitic magmas. (Author's abstract)

Five melt inclusion analyses are tabulated, ranging from 51.6% SiO_2 (in plagioclase) to 77.8 (in orthopyroxene); these are not corrected for crystallization on the walls during cooling. (E.R.)

WALLACE, R.H., Jr. and KRAEMER, T.F., 1985, Geopressured-geothermal energy in aquifers of the northern Gulf of Mexico basin (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 742. First author at U.S. Geol. Survey, 905 National Center, Reston, VA 22092.

An estimated 17,100 quintillion (10^{18}) joules of thermal and thermal-equivalent methane energy comprises the geopressured-geothermal fluid resource base (energy in place) in sandstone aquifers underlying a 310,000 km^2 area of the northern Gulf of Mexico basin. The fluid resource base estimated to be contained in the the finer-grained rocks, treated collectively as "shales," represents an additional very large quantity of energy.

Research conducted in the past decade by the U.S. Geological Survey and U.S. Department of Energy has focused on understanding the geopressured-geothermal resource and determining the potential of the resource as a major energy source. Knowledge of the physical and chemical properties of geopressured rocks and fluids and of geopressured aquifer characteristics in the northern Gulf of Mexico basin has been significantly advanced by research drilling and testing of geopressured aquifers. Principal results indicate that geopressured-geothermal aquifers exist at depths greater than about 3 km; that fluid-pressure gradients range as high as twice the hydrostatic gradient; that temperatures range upward from about 120°C; that salinities range upward from about 15,000 mg/L; that reservoir fluids are saturated with dissolved methane; and that reservoir permeabilities are higher than predicted by a factor of 3 to 5. Flow tests of wells at rates up to 35,000 Bbls/day have revealed a yet-to-be defined mechanism for sustaining reservoir pressure. All wells on long-term test have produced variable amounts of liquid hydrocarbons with the brine. (Authors' abstract)

WALLIS, D.S., HAWKINS, P.J. and KAY, J.R., 1985, Report on the occurrence of hydrocarbons in thunder eggs at Cedar Creek, Tamborine Mountain, southeast Queensland: Geol. Survey of Queensland Record Series, 13 pp.

Following the reported occurrences of hydrocarbons in cavities of two thunder eggs mined at the Cedar Creek thunder egg deposit, the Geological Survey of Queensland undertook an investigation to ascertain whether the 'oil' was indigenous or whether it could be related to the lubricating fluid used in the slicing process. Selected samples were analyzed by the Bureau of Mineral Resources, Geology and Geophysics, Canberra, and the Government Chemical Laboratory, Brisbane. Gas chromatographic profiles showed a full range of n-alkanes from nC_{10} to nC_{31}, which could not be related to contamination. The hydrocarbons exhibited features typical of natural crude oils but could not be matched with any of the Australian crudes used for comparison. Closest affinities were with oils from the

Surat Basin.

Analytical evidence indicates a non-marine source together with a short migration path or recent emplacement. Two possible origins are proposed: (a) Migration from a source in the nearby Ipswich Basin strata; or (b) Conversion to oil of organic material caught up in the lava flow.

Before either origin can be substantiated, more geological information is required. (Authors' abstract)

WALTHER, J., 1985, Fluid inclusions in peridotite xenoliths (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 126-127. Author at Mineral. Inst. Univ. Karlsruhe (T.H.), FRG.

Premagmatic metasomatic fluids in the Eifel volcanic region and the Northhessian depression introduced water into the uppermost mantle as demonstrated by the presence of amphibole or phlogopite in peridotite xenoliths brought up in these regions. The study of fluid inclusions in these xenoliths, however, does not show remnants of the premagmatic fluids. Cavities in olivine and pyroxenes contain CO_2 without detectable H_2O. CO_2 densities scatter from below 0.2 up to nearly 1 g/cm^3 with broad maxima around 0.6-0.7 g/cm^3. Quite similar patterns recur in dunites as well as harzburgites, peridotites or wehrlites (believed to be of cumulative origin).

The cavities often clearly lie on linear and planar structures, even crosscutting grain boundaries and therefore should be considered as rehealed fissures and gas lamellae from which single inclusions detached. Magmatic temperatures prevailing (1000-1200°C), the sealings of microsystems are crustal events persisting more or less continuously from about 25 km depth up to levels shallower than 2 km (seemingly empty inclusions).

Two alternative processes fit these characteristic inclusion patterns: 1) explosions of primary mantle cavities and crustal rehealing after pressure release, or 2) penetration of fluids degassing from the magma into fissures and cracks of the xenoliths due to their decompression during uprise. Both processes will be discussed and arguments elaborated in favor of the second mechanism. It will be shown that CO_2, though probably of mantle origin, should be interpreted as the ultimate product of fluid fractionation brought about even by water-rich magmas. (Author's abstract)

WANAMAKER, B.J., 1985, The fO_2-dependence of fluid inclusion composition in San Carlos olivine (abst.): EOS, v. 66, no. 18, p. 372-373. Author at Princeton Univ., Princeton, NJ 08544.

Originally pure CO_2 fluid inclusions in single crystals of San Carlos olivine (Fo$_{90}$) change their composition to mixtures of CO_2 plus CO during annealing at temperatures from 1000°C to 1400°C and oxygen fugacities between the QFM and iron-wustite buffers. The fluid inclusions occur as isolated, negative crystal-shaped pores, 5-30 μm in diameter. The mole ratio CO/CO_2 was measured by Raman microprobe for several inclusions and found to be the same as that predicted via the equilibrium $CO_2 \rightarrow CO + 1/2O_2$ for the specific fO_2 maintained during annealing. Assuming that a diffusional mechanism is rate controlling, the apparent activation energy is approximately 50 kcal/mole (209 kJ/mole) and the effective diffusivity is on the order of 10^{-7} cm^2/sec at 1200°C. Since San Carlos olivine crystals contain dislocation densities on the order of 10^6 cm^{-2} and abundant subgrain boundaries as well as high concentrations of point defects at these fO_2s, the composition of fluid inclusions is controlled by external fO_2 either by rapid diffusion of point defects or by direct diffusion of oxygen along fast pathways such as dislocations and subgrains. (Author's abstract)

WANG, Jianming, NING, Renzu, DING, Haohua, ZHANG, Huimin and DING, Guichun, 1985, Geochemical characteristics of the Lishui silicified zone type gold-tellurium deposit in Jiangsu Province: Mineral Deposits, v. 4, no. 4, p. 57-67 and p. 88 (in Chinese; English abstract). Authors at Central Lab., Bureau of Geol. & Mineral Resources of Jiangsu Province, PRC.

The Lishui gold mine in Jiangsu Province is a gold-tellurium deposit in silicified Mesozoic volcanics. The mineralization may be divided into four stages: quartz-pyrite; quartz-pyrite-chalcocite; quartz-barite-pyrite; and quartz-pyrite-marcasite.

The temperatures for the mineralization are 320-120°C, and the pH values of the ore-forming fluids range from 4.1 to 5.6. The upper limit of log $f(O_2)$ during the mineralization is estimated to be in the range of 36.3 - -35.3[sic; presumably -36.3 - -35.3] at the earlier stage, and -34.4 - -33.2 at the late stage. The gold is mainly derived from the upper mantle. (From the authors' abstract)

WANG, Shiqi et al., 1985, Hydrogen and oxygen isotope compositions and mineralization of the Zhangjiakou gold deposit, Hebei Province: Mineral Deposits, v. 4, no. 1, (Ser. No.: 11), p. 84-89 (continued on p. 30) (in Chinese; English abstract).

WATANABE, H. and IIZUKA, K., 1985, The influence of dissolved gases on the density of water: Metrologia, v. 21, p. 19-26. Authors at Nat'l. Res. Lab. Metrology, Sakura-mura, Niihari-gun, Ibaraki 305, Japan.

The effects of dissolved atmospheric gases on the density of water are investigated by hydrostatic pycnometry, and subsequently the effect of air dissolved in water is estimated according to the contributions of the respective gases and the air composition. The calculated result agrees with the experimentally-obtained decrease of the density with a systematic deviation of less than 0.16×10^{-3} kg/m^3 (0.16 ppm) in the temperature range between 0°C and 40°C. In addition, the partial molar volumes of nitrogen, oxygen, argon, and carbon dioxide under atmospheric pressure are calculated. (Authors' abstract)

WATKINS, K.P., 1985, Geothermometry and geobarometry of inverted metamorphic zones in the W central Scottish Dalradian: J. Geol. Soc. London, v. 142, p. 157-165. Author at Geol. Survey Western Australia, Mineral House, 66 Adelaide Terrace, Perth, Western Australia, 6000.

Based on mineral thermometers and barometers. (E.R.)

WATSON, E.B., 1985, Henry's law behavior in simple systems and in magmas: Criteria for discerning concentration-dependent partition coefficients in nature: Geochimica Cosmo. Acta, v. 49, p. 917-923. Author at Dept. Geol., Rensselaer Polytechnic Inst., Troy, NY 12180-3590, USA.

Although numerous questions still surround the topic of Henry's law (HL) as it applies to trace element partitioning, there now exist sufficient experimental data to make some generalizations regarding HL behavior in minerals. The most important of these is that the commonly-observed failure of HL at low concentration occurs at distinctly different levels even for chemically-similar elements in a single mineral. This observation in turn provides a basis for discerning effects of HL failure in natural systems: through examination of element ratios in minerals and rocks, it is possible, in principle, to distinguish HL effects from changes in partition coefficients due to variations in other magmatic parameters such as temperature and the compositions of phases. Initial applications of this approach to plagioclase/liquid partitioning of REE and to the general behavior of Zr/Hf and Ba/Rb during basalt production suggest that HL usually does hold in nature. (Author's abstract)

WEBER, C. and PICHAVANT, M., 1985, Melting of plagioclase in the granite-granodiorite system (abst.): Terra Cognita, v. 5, p. 335 (in French).

The authors studied phase relations in the system Ab-Or-An-Qz-H_2O at $p(H_2O)$ = 3 kb, with particular emphasis on the melting of plagioclase. Electron microprobe analyses of plagioclase crystals show that they are much higher in An than the bulk starting material. Liquidus temperatures determined from reversal of the experiment were identical, indicating that there likely were no problems associated with plagioclase nucleation in these experiments. The authors conclude that "non-equilibrium" phase relations between plagioclase and silicate liquids need reconsideration. (From the authors' abstract, translated by M. Logsdon)

WEBER, K. and de Wall, H., 1985, Hydraulic fracturing under sillimanite-facies conditions at the Hercynian suture of the "Erbendorf Line" (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 128-129. Authors at Inst. Geol. und Dynamik Lithosphäre, Univ. Göttingen, Goldschmidtstr. 3, D-3400 Göttingen, FRG.

Moldanumbian sillimanite-facies gneisses and mica schists at the boundary between the Saxothuringian and Moldanubian Zones of the Oberpfalz are extremely rich in s-parallel layers and lenses of coarse-grained exudation quartz. This quartz is very abundant and reaches ~30 vol% of the total rock. It imparts a macroscopic texture similar to migmatite to the rock. The sillimanite-facies rocks are overprinted by an intensive retrograde metamorphism in a late stage of tectonic deformation. Sillimanite and K-feldspar are converted into muscovite, and biotite is chloritized. The intensity of diaphthoresis matches the intensity of quartz exudation. The s-parallel exudation quartz displays only a very weak ductile deformation. It contains brittle fragments of polyphase-deformed wall rocks. The quartz grains up to 1 cm in size contain fibrolitic sillimanite as inclusions which are partially transformed into fibrous muscovite. The centers of larger quartz grains are generally deficient in sillimanite inclusions. Sillimanite is occasionally zoned with the prism faces being parallel to, but frequently 60°-90° to the surface of the quartz grains.

The grain fabric of the exudation quartz is greatly loosened by numerous intergranular and minor intragranular fractures. Cracks are filled with fine-grained, mostly fibrous muscovite. A younger authigenic quartz generation, in addition to albite and light-colored biotite, appears secondarily on the fracture plans. In all cases, however, the fracture planes in the fabric of the quartz grains can be closed when this fine-grained muscovite (sericite) formed on the fracture planes is subtracted.

The formation of the exudation quartz and subsequent fracturing within it are interpreted as being the result of hydraulic fracturing. This began under sillimanite-facies conditions and extended into the diaphthoresis stage as the stability field of sillimanite and K-feldspar was no longer attained. The necessary water for the reaction: sillimanite + K-feldspar + $H_2O \rightarrow$ muscovite + quartz, cannot be derived from other dehydration reactions within the Moldanubian metamorphics. One possible explanation for the origin of the water results from the tectonic position of the diaphthorites which occur at the immediate boundary to Saxothuringian metasediments. This boundary, the Erbendorf Line, is interpreted as a Variscan suture at which Moldanubian rocks were overthrust onto Saxothuringian rocks. The sillimanite-facies metamorphism encompassed both of these rock units in the boundary zone, but decreases rapidly to the north in the Saxothuringian to lower metamorphic grades. Accordingly, the Saxothuringian metasediments, dewatered tectonically during the overthrusting and by additional dehydration reactions, are given as the origin of the water necessary for the hydraulic fracturing and the formation of exudation quartz and retrograde-metamorphic minerals. This hydraulic fracturing in the overthrust Moldanubian metamorphics began under sillimanite-facies conditions. The exudation quartz with sillimanite inclusions began to form at this stage. This formation continues during the uplift of the overthrust Moldanubian rocks, whereby hydraulic fracturing and mica formation in intergranular and intragranular cracks of the exudation quartz resulted during further reduction of the effective stress through the reduction of lithostatic pressure connected with uplift and denudation. (Authors' abstract)

WEDEKING, K., SHIPP, R. and CHANG, S., 1985, Carbon isotopic composition of individual hydrocarbons, carbon dioxide, and oils from the Fischer-Tropsch reaction (abst.): Lunar and Planetary Sci. XVI, p. 899-900.

WEDEPOHL, K.H., 1985, Origin of the Tertiary basaltic volcanism in the northern Hessian Depression: Contrib. Mineral. Petrol., v. 89, p. 122-143. Author at Geochem. Inst. Univ., D-3400 Göttingen, F.R.G.

Metasomatism in the mantle by H_2O-CO_2 fluids containing K, Na, P, etc. is suggested. (E.R.)

WEI, C.-S., 1985, A preliminary temperature study on the bedded cupriferous iron sulfide deposits in the Tungao and Nanao ares, Taiwan, in Applied Mineralogy, W.C. Park, et al., eds.: Proc. Second Int'l Congress on Applied Mineralogy, Los Angeles, CA, Feb. 1984, Metallurgical Society of AIME, p. 1031-1049. Author at Energy & Mining Res./Service Organization, Ind. Tech. Res. Inst., Taiwan, RPC.

The metallic deposits in the Tungao and Nanao areas in northeastern Taiwan consist mainly of bedded cupriferous iron sulfide ores that occur in the Tananao metamorphic terrain. In the eastern portion, deposits at Tungtahsing, East Tapaishan and West Tapaishan are composed of a common sulfide assemblage characterized by pyrrhotite-chalcopyrite-sphalerite with or without pyrite. An assemblage of pyrite-pyrrhotite-chalcopyrite with or without sphalerite is typical of the Tungshan deposit in the western part of the area studied.

Preliminary measurements on fluid inclusions contained in crystals of quartz and calcite associated with the sulfide deposits have revealed that Th, uncorrected for pressure, fall in a narrow range of approximately 211 to 264°C, a range that is consistent with the temperatures shown by temperature measurements using the pyrrhotite geothermometer. The similarity in mode of occurrence, composition, and texture of the ores in the four deposits in the Tungao and Nanao areas suggests that most of the deposits have a common origin, were related to submarine volcanism, and were deformed and recrystallized by subsequent regional metamorphism. A comparison of the deposits of Tungao and Nanao with those at Besshi, Japan shows some common features. (From the author's abstract)

WEISS, D., ULMER, G., BUNTIN, T. and MOATS, M., 1985, Fluid inclusions and IOF data: Group II composite nodules from San Carlos, Arizona (abst.): EOS, v. 66, no. 18, p. 392. Authors at Geol. Dept., Temple Univ., Philadelphia, PA 19122.

Mineral separates (+90 - 150 μm) from Group II (Frey & Prinz, 1978) composite nodules from San Carlos, AZ, were analyzed for intrinsic oxygen fugacity (IOF) using a double-opposed ZrO_2 cell apparatus. Analyses were carried out on Fo-77 olivine, aluminous augite and hercynite-spinel. Resultant data-fit lines (fO_2/T) showed an apparent parallelism that was counter to the expected mineral intersect geometry. These lines range from below the wüstite-iron to above the quartz-fayalite-magnetite buffers. This spread of data encompasses the envelopes of both Group II and Group I data reported by Arculus et al. (1984).

The influence of CO_2, released from fluid inclusions, was investigated as an explanation for the IOF data collected in this study. Point counts of olivine separates led to an estimate of 10^6-10^7 inclusions of the 1-5 μm size in an average (25 mg) Group II olivine IOF sample. Based on 2 cm^3 free volume in an IOF cell, and a density of CO_2 of 1.03 g/cm^3, liberation of CO_2 from these inclusions would provide a log pCO_2 of -3.5 to -4. TGA data indicate that oxidation of the olivine does not take place in the pCO_2 at 1100°C. Therefore, the CO_2 liberated during IOF experiments on olivine disrupted the test system without oxidizing the sample. The apparent parallelism of data lines is interpreted as the result of CO_2 "flooding" of the test cell atmosphere. The spread of data lines may be a measure of bulk CO_2 released. It is suggested that caution be exercised in interpreting IOF data from nodules suspected of having high concentrations of fluid inclusions. (Authors' abstract)

WELHAN, J., 1985, Abiotic methane in hydrothermal systems and in rocks (abst): Geol. Assoc. Canada/Mineral. Assoc. Canada Program with Abst., v. 10, p. A67. Author at Dept. Earth Sci., Memorial Univ. of Newfoundland, St. John's, Newfoundland, A1B 3X5.

The formation of hydrocarbons, principally CH_4 through the butanes, is well-known in hydrothermal environments where hydrocarbon composition and isotopic ratios provide strong evidence for a thermocatalytic source, due to high-T pyrolytic decomposition of buried organic carbon compounds. Methane is also found in high-T mid-ocean ridge (MOR) hydrothermal environments where sources of sedimentary organic carbon are conspicuously absent. Carbon isotope ratios and light hydrocarbon compositions in these occurrences are anomalous, and together with data on gases in MOR basalts, support an abiotic source for this methane, probably from the basalt itself. Synthesis of methane from carbon dioxide within gaseous inclusions in the rock is possible at temperatures of ca. 600°C or less. Methane- and hydrocarbon-rich inclusions in pre-Cambrian igneous rocks of South Greenland and the Kola Peninsula, Russia, also have been found to contain anomalous carbon isotope ratios, with inferred equilibration temperatures of 500°C. These data suggest that abiotic methane can be generated in situ within crystalline rocks at moderate to high-T and thus could later become available to circulating groundwater. (Author's abstract)

WENRICH, K.J., 1985, Mineralization of breccia pipes in northen Arizona: Econ. Geol., v. 80, p. 1722-1735. Author at U.S. Geol. Survey, P.O. Box 25046, Mail Stop 916, Denver, CO 80225.

The Paleozoic sedimentary rocks on the Colorado Plateau of northern Arizona are host to hundreds of breccia pipes. The uranium and copper deposits in these breccia pipes transgress formation boundaries; there is no volcanic rock associated with them in time or space. They are the result of solution-collapse and stopping of the overlying strata. At present the origin of the mineralizing fluids is not known. The lack of extensive silification within the breccia, along with the 80° to 173°C fluid inclusion-filling temperatures on sphalerite, dolomite, quartz and calcite, suggests relatively low-temperature mineralizing fluids, although heated in excess of what would be expected from the normal geothermal gradient on the Colorado Plateau. With the exception of the U-mineralized rock, the mineral assemblage and geochemistry is similar to Mississippi Valley-type deposits. (From the author's abstract)

WENRICH, K.J. and PRATT, L.M., 1985, Paragenesis and conditions of formation of ore minerals from metalliferous breccia pipes, N. Arizona (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 747. Authors at U.S. Geol. Survey, MS 916, Box 25046, Denver Federal Center, Denver, CO 80225.

Ore deposits within N. Arizona breccia pipes are currently being exploited for U, but at various times during the past century Cu, Pb, Zn, and Ag were mined. These pipes formed as solution-collapses within the Mississippian Redwall Ls and stopped upward through overlying strata.

The principal ore minerals are: uraninite, chalcopyrite, chalcocite, tennantite-tetrahedrite, galena, sphalerite, millerite, gersdorffite, siegenite, and molybdenite. Common gangue minerals are marcasite, pyrite, barite, dolomite, calcite and quartz. Marcasite and pyrite appear to have formed prior to the ore minerals, followed closely by chalcopyrite. The Ni and Co phases also appear to be early: gersdorffite crystals are rimmed by later galena. Tennantite-tetrahedrite formed later than both galena and sphalerite; uraninite, the latest ore mineral, consistently fills interstices. Vuggy quartz, the least common gangue mineral, postdates all ore. A black, pore-filling pyrobitumen, apparently a late phase, rims pyrite, barite, and quartz.

Primary fluid inclusions in dolomite, quartz, and sphalerite show filling temperatures from 80 to 145°C and high salinities, averaging 15 wt% NaCl (eq). Secondary inclusions in sphalerite have consistently higher filling temperatures from 105 to 173°C, but similar salinities. Rock-Eval pyrolysis of pyrobitumen yield little or no volatile hydrocarbons (S_1 = 0-0.2 mg/gm), but large amounts of pyrolytic hydrocarbons (S_2 = 105-216 mg/gm). Temperatures of maximum pyrolytic yield are relatively low (424-430°C), suggesting temperatures did not exceed 150°C following pyrobitumen emplacement.

Except for uraninite, the breccia pipes are similar to Mississippi Valley-type (MVT) deposits in mineralogy, fluid-inclusion filling temperatures and salinities, and associated organic material. Because MVT deposits do not host U minerals, a possible two-stage mineralization history of the pipes is suggested, the first by a MVT brine and perhaps a second forming the uraninite. Evidence suggests the time gap between the two stages was no more than about 10 m.y. (Authors' abstract)

WESOLOWSKI, D., COLE, D.R., DRUMMOND, M.S. and STAKES, D.R., 1985, Stable isotope and fluid inclusion studies of metamorphic fluid flow in an evolving tectonic system (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 748. First author at Oak Ridge Nat'l. Lab., Oak Ridge, TN 37831.

The Southern Appalachian borehole represents a unique opportunity to couple O-H-C-S isotope and fluid inclusion studies with textures, mineralogies, and chemical compositions in order to assess the role of fluids in metamorphism, deformation, element migration, and heat transfer throughout the evolution of a complex orogen. Studies which focus on hydrothermal veins, felsic/mafic intrusives and juxtaposed but chemically and isotopically distinct lithologies such as volcanics-clastics and silicates/carbonates will be particularly informative.

That large-scale metamorphic fluid flow has occurred in the Southern Appalachians is evidenced by devolatilization of enormous masses of rock during prograde metamorphism and extensive revolatilization along major shear zones exhibiting retrograde assemblages. Our own textural, chemical and oxygen isotope studies of granitoids and their host rocks in northern Alabama document substantial isotopic, major and trace element (e.g., U, Th, Pb, Rb, and Sr) redistribution over thousands of cubic kilometers via exchange with infiltrating metamorphic fluids. Even chemically and mineralogically unaltered granites in the area have been isotopically enriched, perhaps reflecting differing chemical and isotopic exchange capacities of the fluid/rock system.

These observations suggest that the chemical and isotopic effects of metamorphic fluid flow must be quantified in order to determine the origins of sedimentary and igneous rocks based on their geochemical signatures and age dates and to evaluate the role of fluids in the tectonic evolution of the proposed study area. In order to adequately assess these effects substantial core recovery is required and sampling of borehole fluids and gases would be highly desirable. (Authors' abstract)

WESTRICH, H.R., STOCKMAN, H.W. and TAYLOR, B.E., 1985, Volatile content of Obsidian Dome and the Inyo dike (abst.): EOS, v. 66, no. 18, p. 387.

WHELAN, J.F., COBB, J.C. and LANDIS, G.P., 1985, Stable isotope evidence for the origin of epigenetic pyrite and sphalerite in coal of the Illinois basin (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 748-749. First author at U.S. Geol Survey, DFC, MS 963, Denver, CO 80225.

Stable isotope studies indicate that volatiles released during coalification reactions played an important role in the formation of epigenetic pyrite and sphalerite in cleats and nodules of Illinois basin coals. Pyrite-hosted fluid inclusions have δD and $\delta^{18}O$ values that range from -137 to -61 and from -12.3 to -5.2, respectively. Such compositions must reflect either interaction with or generation from the coal organic matter. Pyrite-hosted inclusions contain CO_2, CO or N_2, Ar, H_2S, SO_2, and a wide variety of hydrocarbons.

$\delta^{34}S$ values of epigenetic pyrite from the Nos. 2, 5 and 6 coals in Illinois range from -12.4 to -0.1; within individual mines the range is smaller, commonly 4. Such ranges are much smaller than those formed during bacterial sulfate reduction. Literature research suggests that coalification is accompanied by an increase in the proportion of pyritic to organic sulfur, with little change in the coal's total sulfur content. This increase and the narrow range of pyrite $\delta^{34}S$ values, reflect pyrite precipitation from sulfur produced by the breakdown of organo-sulfur compounds during coalification.

Sphalerite was deposited from MVT brines at temperatures of 90-100°C. Sphalerite-hosted fluids range from D- and ^{18}O-enriched compositions typical of MVT brines to compositions approaching those of pyrite-hosted fluids. This range suggests mixing between the sphalerite-depositing fluids and coal-hosted fluids similar to those trapped in the pyrite fluid inclusions. The $\delta^{34}S$ values of spatially associated sphalerite and pyrite are quite similar, suggesting either that sphalerite also precipitated from organically-derived sulfur, or that it replaced earlier pyrite. Sphalerite fluid inclusions have lower hydrocarbon contents than pyrite fluid inclusions. (Authors' abstract)

WHITNEY, J.A., HEMLEY, J.J. and SIMON, F.O., 1985, The concentration of iron in chloride solutions equilibrated with synthetic granitic compositions: The sulfur-free system: Econ. Geol., v. 80, p. 444-460. First author at Dept. Geol., Univ. Georgia, Athens, GA 30602.

The concentrations of iron in 1 N chloride solutions have been determined at temperatures from 400° to 700°C and a pressure of 1 kb for fluids in equilibrium with synthetic magnetite- or biotite-bearing granitic (quartz monzonite) compositions. K/H and Na/H ratios in solution were controlled by reactions similar to those observed in natural alteration assemblages involving alkali feldspar and plagioclase with aluminosilicate, muscovite, or montmorillonite. Oxygen fugacity was controlled by internal or external methods using hematite-magnetite, Ni-NiO, and quartz-fayalite-magnetite assemblages. Starting compositions of fluids were solutions of HCl, 2HCl:$FeCl_2$, HCl:NaCl, and NaCl:KCl:$FeCl_2$. Equal masses (i.e., low liquid/solid ratios) of solid and solution were used to expedite equilibration. Iron was added as synthetic magnetite, synthetic biotite, or in solution. Run times ranged from four days to several weeks.

At 400°C, the dominant cations in solutions are Na, K, and Ca, with Fe concentrations of 0.01 to 0.03 molal. At 500°C, Na, K, and Fe are dominant with Fe concentrations of 0.10 to 0.17 molal. At 600°C, the Fe concentration reaches a maximum of 0.20 to 0.25 molal and then appears to drop to between 0.10 to 0.15 molal at 700°C. The effect of fO_2 on concentration is consistent with changes in the iron-bearing assemblage from magnetite to biotite, and along with charge balance in the iron-bearing assemblage from magnetite to biotite, and along with charge balance calculations, suggests that ferrous chloride is the dominant species at low temperatures. These data indicate that in natural magmatic systems, the concentration of iron in chloride solutions coexisting with magnetite or biotite is extremely high. This high solubility may explain the large quantities of iron deposited in skarns and related deposits around some mineralized granitic stocks. (Authors' abstract)

WICKHAM, S.M. and TAYLOR, H.P., Jr., 1985, Stable isotope evidence for large-scale influx of marine fluids into a regional metamorphic-anatectic terrane: the Trois Seigneurs massif, Pyrenees, France (abst.): EOS, v. 66, no. 18, p. 391.

WIDOM, B., 1985, Phase equilibrium and interfacial structure: Chem. Soc. Reviews, v. 14, no. 2, p. 121-140.

Involves a detailed examination of the equilibrium of fluid phases and the properties of the interfaces between them. (E.R.)

WIEDEMANN, Ranier, 1984, Quartz-fabric-facial investigations in the NW and SW part of the Erzgebirge-anticlinorium: Dissertation A, Bergakademie Freiberg/Sa., GDR (in German).

Results of quartz-fabric investigations, thermobarometric and geochronological studies on metamorphites of the NW-flank and the SE-part of the Erzgebirge-anticlinorium in the region of Augustusburg-Wolkenstein-Oberwiesenthal-Hartenstein were represented. Fluid inclusion studies show a temperature drop from 600°C in the Niederschlag-/Klinovec-series to 350°C in the Schwarzburger series. K/Ar-age determinations mark stages of retrograde metamorphism, the intrusion of postkinematic granites, and Saxonian events. (English abstract by R. Thomas)

WILHELM, Emmerich, 1985, Precision methods for the determination of the solubility of gases in liquids: CRC Critical Reviews in Anal. Chem., v. 16, issue 2, p. 129-175.

WILHELM, Emmerich, 1985, Solubility of gases in liquids: a critical review: Pure & Appl. Chem., v. 57, no. 2, p. 303-322. Author at Inst.

Phys. Chem., Univ. Wien, WährringerstraBe 42, A-1090 Wien, Austria.

Selected theoretical and experimental aspects of vapor-liquid equilibria involving supercritical (noncondensable) components are reviewed. The focus is on the rigorous thermodynamic basis on which high-precision methods for the determination of Henry coefficients have to rest. A condensed outline of current theories and correlations for the prediction of auxiliary quantities, such as virial coefficients and partial molar volumes, is presented. Finally, attention is given to recent work on relatively simple aqueous solutions of nonelectrolytes, which may contribute toward a better understanding of hydrophobic effects. (Author's abstract)

WILKINS, R.W.T., 1985, Relationships between dislocations and fluid inclusions in minerals - a brief review (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 130. Author at CSIRO Div. Mineralogy & Geochem., P.O. Box 136, North Ryde, N.S.W., Australia.

In the majority of studies of fluid inclusions currently being reported, knowledge of the defect structure of the host mineral is nonexistent. This is unfortunate because the linear defects, or dislocations, form the major store of information on the growth and deformation history of crystalline materials. For this reason the relationship between fluid inclusions and dislocations is highly pertinent to questions on the origin of fluid inclusions and their subsequent modification.

Several techniques, chiefly transmission electron microscopy (TEM), Lang topography and etching of dislocations have yielded useful information. The major part of our knowledge of fluid inclusion/dislocation relationships comes from TEM studies, but this concerns inclusions of suboptical microscopic dimensions and it is questionable just how much of this information is applicable to the 10-100 micron inclusions usually studied by heating-freezing stage techniques. Etching is the most appropriate technique in terms of scale because the size of etch pits can be adjusted to a convenient 1-2 micron, and the inclusions and associated dislocation sites can be observed together in the same microscopic field. The potential of this technique is just beginning to be explored.

In the area of inclusion origin, the major source of information on growth dislocations in minerals is Lang topography. Its application may be illustrated by the mechanism of formation of syngenetic inclusions from etch pits in quartz crystals. This technique has considerable potential for the investigation of the origin of the many different types of primary inclusions. The nature of the relationship between simple and complex healed fractures and associated secondary fluid inclusions may be explored by etching of dislocations which intersect mineral cleavage surfaces. Dislocation structures associated with lineage boundaries are similar to those associated with simple healed fractures and a distinction must be made on orientation, intersection or other criteria which have not been researched in detail at the present time.

In the area of inclusion modification after formation, fluid inclusion/dislocation relationships are very significant. In fluorite heated at atmospheric external pressure, inclusions leak via cracks or dislocations in glide planes. In fluorites containing a high density of growth dislocations, a dislocation-rich zone develops around overpressured inclusions showing that a permanent volume expansion has taken place. It seems likely that overpressured inclusions in some quartz may also plastically expand under special conditions. (Author's abstract)

WILKINS, R.W.T., GRATIER, J.-P. and JENATTON, L., 1985, Experimental observations on the healing of cracks and the formation of secondary inclusions in halite and quartz (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, Abstracts, p. 132. First author at CSIRO Div. Mineralogy & Geochem., North Ryde, Australia.

Experiments were carried out on the healing of simple flat fractures in single crystals of halite and quartz with the aim of studying the mode of formation of secondary fluid inclusions at constant temperature.

With halite, healing was observed at 20°C both with and without the addition of solution to the cleavage crack. With no added solution, healing proceeds by the growth of dendrites which develop from a thin layer of water apparently adsorbed at the crack tip from the air. The primary stems of the dendrites follow cleavage steps which run normal to the boundary of the crack. Fluid inclusions form between the coalescing dendrite arms and make linear arrays parallel or perpendicular to the crack margin. When saturated solution was added, and the crack sealed to prevent evaporation, healing occurred by a distinctly different mechanism - nucleation, growth and fusion of columns which develop along the cleavage steps. The columns have a syntaxial relationship to the fracture surfaces. Necking down and sealing of residual channelways between the coalescing columns leaves a random array of fluid inclusions behind the migrating boundary of the fracture. An unexpected feature is the occasional development in the late stage of healing of skeletal halite crystals which are not syntaxially oriented and which dissolve and penetrate those columns with which they come in contact.

Quartz fracture healing experiments were carried out at 400°C and 2 kb using distilled water in a large volume autoclave with the fractured quartz partly or fully surrounded by a packing of amorphous silica. Under these conditions healing was rapidly accomplished in a period of days. Some partly healed fractures were re-opened and the complex structures produced by the growing together of the walls of the cracks were studied by scanning electron microscopy. $NH_4F.HF$ etching of polished faces intersected by a healed crack decorated by fluid inclusions revealed a single row of dislocations adjusting the mis-match in orientation of the two fracture surfaces. (Authors' abstract)

WILSON, G.A. and EUGSTER, H.P., 1985, Metal-chloride speciation from supercritical solubility experiments (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 751. Authors at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218.

Mineral solubility studies yield information on metal-ligand speciation when metal concentration is measured as a function of free ligand concentration. Above about 400°C, however, experimental control is difficult and it is usually not possible to determine free ligand concentration independently of the other species in solution. This has led to reliance on the condition that only one metal-ligand complex is of significant concentration at a given P & T.

We have devised a relatively simple method of data analysis for high temperature solubility experiments in HCl solutions to identify two or more species based on the best fit of the simultaneous solutions of mass-action and mass-balance equations for each of a number of runs at the same P & T. Cassiterite solubility data (Wilson & Eugster, GSA abstr., 1984) have been recalculated and have yielded data on the two species $SnCl^+$ and $SnCl_2$ under the conditions of NNO, 1.5 kb, and 400-700°C. For the reaction

$$SnO_2 + 2H^+ + nCl^- \rightleftarrows SnCl_n^{2-n} + H_2O + 1/2O_2 \qquad (1)$$

for $n = 1$, $\log K_1 = 34.33 - 30459/T(K)$ and
for $n = 2$, $\log K_1 = 40.53 - 34690/T(K)$.

Published talc-quartz solubility data (Frantz & Popp, GCA, 1979) have been recalculated in terms of Mg^{2+}, $MgCl^+$, and $MgCl_2$. For the reaction

$$1/3\ talc + 2H^+ + nCl^- \rightleftarrows MgCl_n^{2-n} + 4/3H_2O + 4/3quartz \qquad (2)$$

for $n = 0$ (at 400°C), $\log K_2 = 7.49$
for $n = 1$ (400-500°C), $\log K_2 = 11.21 - 2865/T(K)$
for $n = 2$ (450-600°C), $\log K_2 = 24.89 - 12896/T(K)$.

These results are in fair agreement with the data of Frantz & Marshall (AJS, 1982).

Analysis of other published solubility data in this manner verifies the usual conclusion that only the neutral species is abundant. (Authors' abstract)

WILSON, T.P. and LONG, D.T., 1985, The behavior of bromide during the dissolution of halite at 25°C and 1 atm (abst.): Geol. Soc. Am. Abst. with Programs, v. 17, p. 331. Authors at Dept. Geol. Sci., Michigan State Univ., East Lansing, MI 48824-1115.

Partitioning of trace elements between solid and liquid during the crystallization of evaporites can be determined using partition coefficients. Little is known about the ability of partition coefficients to describe the behavior of trace elements during dissolution reactions.

The purpose of this investigation was to determine if known partition coefficients describe the distribution of Br between solid and solution during the dissolution of halite. Four aspects were investigated: 1) the effect of surface area, 2) the time necessary to approach equilibrium, 3) the effect of Mg in solution, and 4) the effect of cycling fresh salt through the reacting fluid.

Clear halite samples (170 ppm Br) were reacted initially with distilled water. Different batches were prepared and varied as a function of surface area of halite exposed to solution and as a function of solid-solution ratio. Steady state conditions for each cycle were approached within 2 weeks. After each cycle the resultant brine was transferred to fresh halite maintaining solid-solution ratios. Reactions were also run without halite cycling and in the presence of Mg.

Results show that the initial Br content of the reacting solution is set by halite solubility. During the cycling reactions, the Cl/Br ratios decreased and approached a value predicted by the partition coefficient. The rate of change of the Cl/Br ratio with time did not follow predicted rates of change based on a bulk solid solution model. This was interpreted to indicate that the equilibrium distribution for Br is controlled by surface area. The Cl/Br ratios in the solutions of the non-cycling reactions reached a steady state at higher values than prediced from partition coefficients. The rate of change of Cl/Br with time was also found to be a function of surface area, solid-solution ratio, and the presence of Mg in solution, albeit, still approaching a value predicted by the partition coefficient.

The results suggest that Cl/Br ratios of brines may not be true indicators of brine origin. (Authors' abstract)

WINOGRAD, I.J., SZABO, B.J., COPLEN, T.B., RIGGS, A.C. and KOLESAR, P.T., 1985, Two-million-year record of deuterium depletion in Great Basin ground waters: Science, v. 227, p. 519-522. First author at U.S. Geol. Survey, Reston, VA 22092.

Fluid inclusions in uranium series-dated calcitic veins from the southern Great Basin record a reduction of 40 per mil in the deuterium content of ground-water recharge during the Pleistocene. This variation is tentatively attributed to major uplift of the Sierra Nevada Range and the Transverse Ranges during this epoch with attendant increasing orographic depletion of deuterium from inland-bound Pacific storms. (Authors' abstract)

WINTSCH, R.P. and DUNNING, Jeremy, 1985, The effect of dislocation density on the aqueous solubility of quartz and some geologic implications: a theoretical approach: J. Geophys. Research, v. 90, no. B5, p. 3649-3657.

WOERMANN, E. and ROSENHAUER, M., 1985, Fluid phases and the redox state of the Earth's mantle: Extrapolations based on experimental, phase-theoretical and petrological data: Fortschr. Miner., v. 63, no. 2, p. 263-349. First author at Inst. Kristal. der RWTH Aachen, Templergraben 55, D-5100 Aachen.

A review of literature data on subsolidus and melting relations in lherzolite and harzburgite model systems is presented. Based on this information an attempt is made to delineate, by thermodynamic calculations and by Schreinemakers analyses, conditions for equilibria in the system $CaO-MgO-SiO_2-C-H-O$ and $MgO-SiO_2-C-H-O$, treating these systems as open systems with an external control of oxygen fugacities.

In a lherzolite-CO_2-H_2O system a carbonate phase is stable under pressures above about 26 kbar. Under low oxygen fugacities, however, carbonates are reduced to form assemblages containing elementary carbon. Carbon-carbonate reactions are divariant. Thus, with arbitrary temperatures, pressures and oxygen fugacities in the mantle, carbonates and graphite or diamond as a rule exclude each other.

The composition of the fluid phase is controlling the solidus temperature of a fluid bearing peridotite with solidus minima being connected with H_2O-maxima. The composition of a fluid phase in the C-H-O system in equilibrium with elementary carbon, however, is defined for any given temperature, pressure and redox state. The solidus temperature in a graphite or diamond bearing peridotite is thus a function of oxygen fugacity.

A great number of independent analytical and experimental data is indicating that some parts of the mantle are relatively oxidized - in a fO_2-range around QFM - while other parts show a much lower oxidation state - around or below WM. High oxygen fugacities seem to be characteristic for samples having passed through a cycle of metasomatism or partial melting.

Under pressures between 80-100 kbar H_2O reacts with forsterite in a hydration reaction. While H_2O is a volatile component in the mantle under lower pressures it is non-volatile in the higher pressure range. From the steep P-T slope of the hydration reaction it follows that any temperature increase will transfer an originally hydrated mantle section into the stability range of fluid H_2O. The liberated fluid acts as transport medium for dissolved elements. A hypothesis is presented suggesting that this process is a source of mantle metasomatism and eventually also of magma generation. (Authors' abstract)

WOODS, D.C., CHUAN, R.L. and ROSE, W.I., 1985, Halite particles injected into the stratosphere by the 1982 El Chichon eruption: Science, v. 230, p. 170-172. First author at Atmospheric Sci. Div., NASA Langley Res. Center, Hampton, VA 23665.

Halite particles about 2 micrometers in size were collected by a quartz crystal microbalance cascade impactor from the El Chichon eruption cloud in the lower stratosphere during April and May 1982. These particles are probably derived from the erupted chloride-rich, alkalic magma. Enrichments of hydrogen chloride and increases in optical depolarization in the eruption cloud observed by lidar measurements may reflect the influence of the halite particles. There is evidence that the halite particles reacted with sulfuric acid after about 1 month, releasing gaseous hydrogen chloride, which can influence the catalytic destruction of ozone in the stratosphere. (Authors' abstract)

WORKMAN, A.L. and HANOR, J.S., 1985, Evidence for large-scale vertical migration of dissolved fatty acids in Louisiana oil field brines: Iberia field, south-central Louisiana: Transactions-Gulf Coast Assoc. Geol. Soc., v. 25, p. 293-300. Authors at Dept. Geol., Louisiana State Univ., Baton Rouge, LA 70803.

There is considerable interest at the present time in the origin and distribution of dissolved volatile fatty acids (VFAs) in oil-field brines. This interest has developed as a result of the recognition of the role these compounds may play: 1) in subsurface acid attack and porosity enhancement, 2) as precursors of natural gas, and 3) as possible proximity indicators of hydrocarbon accumulations. The detailed study of the distribution of dissolved VFAs on a field scale provides much useful information on processes of generation, transport, and degradation of these compounds.

At the Iberia oil field, one of several fields we have studied in the Tertiary section of South-Central Louisiana, spatial variations in pore water compositions and temperatures indicate the presence of an on-going, dynamic, subsurface circulation system. Deep brines with VFA levels in excess of 150 mg/l are migrating up the south flank of the Iberia salt dome a vertical distance of at least 2 km (6000 ft). The VFAs in these waters are dominated by acetate and propionate. As these waters ascend, they mix with an ambient mass of water having total VFA concentrations of 20 mg/l or less and dominated by n-butyrate. Preferential decarboxylation of acetate and propionate relative to iso- and n-butyrate and iso- and n-valerate are occurring in this system. The byproducts of these decarboxylation reactions should be methane, ethane, and bicarbonate. Temperatures are cool enough (<80°C) in the shallower parts of the sequence to permit the existence of bacteria that could break down acetate through fermentation.

The spatial distribution of individual dissolved VFAs is complex but systematic, and must ultimately be related to the rates of advective transport, dispersive mixing, and chemical reaction. We believe that a potential new application of the study of these dissolved organic compounds lies in helping to unravel the dynamics of some types of subsurface flow systems. (Authors' abstract)

WORL, R.G. and DOEBRICH, J.L., 1985, Mahd adh Dhahab, a Proterozoic epithermal precious-metal deposit, Kingdom of Saudi Arabia (abst.): U.S. Geol. Survey Circular 949, p. 57.

Mahd adh Dhahab is the largest of the many ancient gold mines scattered throughout the Precambrian Sheild of Saudi Arabia and is the only one with recent production. Mineralization and alteration, except for early propylitization and silicification, is interpreted to have been caused by a single, large meteoric-water hydrothermal system, heated by a rhyolite, that was part of a larger, deeper magmatic-hydrothermal system.

Primary ore is composed of abundant chalcopyrite, sphalerite, pyrite, and less abundant complex precious-metal minerals. Gold and silver occur mainly as inclusions in chalcopyrite and sphalerite and as minute grains of telluride minerals disseminated in chlorite bands of banded quartz-chlorite-hematite veins. Reconnaissance study of abundant, minute fluid inclusions in quartz veins showed them to contain both low-density, vapor-rich fluids and liquid-rich fluids. Primary fluid inclusions yielded homogenization temperatures of 110-238°C. Preliminary isotopic analyses of sulfide minerals and quartz showed $\delta^{34}S$ values that range betwen 1.2 and 6.3 per mil, a typical range for hydrothermal sulfide minerals derived from an igneous sulfur source. The sulfur-isotope data and the ore mineral assemblages together suggest a large sulfide system (porphyry?) at depth. The $\delta^{18}O$ values of all stages of vein quartz throughout the area range between 8.5 and 11.1 per mil; these values indicate that the hydrothermal system consisted of dominantly meteoric water, which circulated in a single system uniform in temperature and $\delta^{18}O$ content throughout the area during the entire period of mineralization. (From the authors' abstract)

WRIGHT, D.P. and NAVROTSKY, Alexandra, 1985, A thermochemical study of the distribution of cobalt and nickel between diopsidic pyroxene and melt: Geochimica Cosmo. Acta, v. 49, p. 2385-2393.

WU, Jieren, 1985, Geological characteristics of the Xitieshan massive sulfide deposit, Qinghai province: Min. Deposits, v. 4, no. 2, p. 1-12 (in Chinese; English abstract). Author at Xian Inst. Geol. & Min. Resources, Chinese Acad. Geol. Sci.

The Xitieshan Pb-Zn deposit is one of the largest massive sulfide deposits in northwest China. The mineral assemblage is quite simple, consisting mainly of pyrite ("pyritogelite"), sphalerite and galena, locally associated with chalcopyrite. The structure and texture of the ore are rather unusual. The stripes of the ore trend essentially in accordance with the stratification and schistosity of wall rocks.

Th = 220°C ± in sphalerite, which is essentially concordant with Td data on sphalerite. The temperature, however, only reflects a possible state of [re]crystallization during the mobilization stage of the ore deposit. The S-isotopic composition in ore minerals is close to meteoritic sulfur. The Pb isotopes indicate the lead in the ore must be a polystage evolutionary product instead of a normal lead.

The Xitieshan Pb-Zn deposit is thus characterized by stratabound volcanogenesis and multiple-reformation. The source of metallogenic materials and the process of mineralization may also be associated with volcanism. The ore deposit, therefore, should be called volcanic exhalation-sedimentary and hydrothermal superposition-reformed massive sulfide ore deposit. (From the author's abstract)

WU, Shangquan, 1984, The genetic implication and typomorphic characteristics of quartz in porphyry gold deposits in Tuanjiegou: Acta Mineral. Sinica, 1984, no. 1, p. 21-28 (in Chinese; English abstract). Author at Research Inst. Jilin Metallurgical & Geol. Explor. Co.

The type of quartz, including decrepitation characteristics, is useful as an indicator for geological exploration for gold deposits. (E.R.)

XIA, Linqi, 1985, On barometry studies of magmatic inclusions: Bull. Xi'an Inst. Geol. Min. Res., Chinese Acad. Geol. Sci., 1985, no. 10, p. 15-28 (in Chinese; English abstract).

The paper is a review of direct and indirect geobarometry methods. (E.R.)

XIA, Linqi, 1985, Origin and significance of magmatic inclusions: Bull. Chinese Acad. Geol. Sci., no. 11, p. 55-73 (in Chinese with 3-page English summary). Author at Xi'an Inst. Geol. & Mineral Resources, CAGS, PRC.

A review of the literature of magmatic inclusions, plus some new data on Th of 21 samples and electron microprobe analyses of 19. (E.R.)

XIA, Linqi and CLOCCHIATTI, Roberto, 1985a A new classification of silicate melt inclusions: Kexue Tongbao, v. 30, no. 4, p. 488-492 (in English). First author at Xi'an Res. Inst. Geol. & Mineral Resources, Chinese Acad. Geol. Sci.

An amplification of the earlier classification of magmatic inclusions (Clocchiatti, 1975) into "non-slightly evolved" [i.e., non- to slightly-evolved] and "evolved," based on the degree of evolution of the included melt after trapping. Examples are given from various localities, along with 19 probe analyses of samples before and after heating. (E.R.)

XIA, Linqi and CLOCCHIATTI, Robert, 1985b, The magmatic inclusions in the anorthoclase lapilli of Erebus volcano from Antarctic: Bull. Xi'an Inst. Geol. Min. Res., Chinese Acad. Geol. Sci., 1985, no. 9, p. 1-14 (in Chinese; English abstract). First author at Xian Inst. Geol. & Mineral Resources, CAGS.

Anorthoclase lapilli constitute the main part of pyroclastic rock formation of Erebus volcano. This paper reports the results of study on the magmatic inclusions in this anorthoclase.

The presence of a large number of magmatic inclusions and the absence of devitrification of the inclusions indicate that they are non- [to] slightly-evolved inclusions and that their host anorthoclase has undergone a rapid cooling. The trapped silicate melt could remain in equilibrium with host mineral and congealed to glass. This type of magmatic inclusion permits obtaining directly precious data on the chemical composition of the initial magma at the time of crystallization of the host mineral.

The slight variation of the chemical composition of the magmatic inclusions and their host mineral shows that the crystallization-nucleation of the anorthoclase megacrysts took place in a trachyphonolitic melt, with a homogeneous composition, under relatively constant physicochemical conditions. Because of the continuous cycle and supply of a new magma which has the same composition, the crystallization of various minerals (anorthoclase, salite, titanomagnetie) did not lead to [much] variation of the total composition of magma.

Microprobe analyses show that the sum of chemical composition (wt. % oxides) of the magmatic inclusions is near 100% (deficit is generally less than 1.5%). The softening temperature of the glass phase of inclusions is high (740°C). The glass phase of inclusions shows a good stability under the experimental conditions of microprobe analysis. The above characters of inclusions indicate that the trapped silicate melt doesn't contain abundant dissolved volatiles.

The studies of magmatic inclusions permit us to determine that the anorthoclase megacryst lapilli of Erebus volcano crystallized at 300-900 bars $P(H_2O)$ and 1042-1068°C, and the crystallization temperature of early salite crystals trapped by them being about 1120°-1130°C.

In the course of crystallization experiments (magmatic reanimation) of the trapped silicate melt in the magmatic inclusions, the growth of anorthoclase, salite and titanomagnetite was realized. The difference of chemical composition between the anorthoclase daughter mineral on the cavity walls and the anorthoclase host mineral proves that the experimental conditions (closed system, small volume, absence of the mixing and the continuous supply of magma with identical composition) are different from the initial crystallization conditions of the anorthoclase host minerals. (Authors' abstract)

XIA, Linqi and CLOCCHIATTI, R., 1985c, The thermobarogeochemistry of dacitic lava of Sainte-Lucie island from the Caribbean Sea: Bull. Xi'an Inst. Geol. Min. Res., Chinese Acad. Geol. Sci., 1985, no. 11, p. 15-32 (in Chinese; English abstract). First author at Xi'an Inst. Geol. & Min. Resources, CAGS.

Sainte-Lucie island is in the Lesser Antilles arc, just south of Martinique. It is entirely volcanic. The last volcanic activity (<1 m.y.) occurred in the "Soufrière" region. This is a calc-alkaline association which comprises acidic hornblend-andesites and dacites. The dacite consists of phenocrysts of quartz, plagioclase, cummingtonite, ferrohypersthene, biotite and rhyolitic glass matrix. These dacites form many domes, piton and vast layers of glassy pumice. The phenocrysts of dacitic lavas contain many primarily magmatic inclusions studied here.

The dacite domes belong to an exudative facies and were formed generally at a late stage of eruption, especially after intensive explosion. By then a lot volatile materials had escaped, increasing the viscosity of the lavas; this type of dacite cooled slowly. The magmatic inclusions in minerals of dacites after their closing stage have undergone some degree of evolution and belong to the evolved inclusions.

Because of rapid cooling, the magmatic inclusions in phenocrysts of dacitic pumices have undergone a slight or no evolution and belong to the slightly-nonevolved inclusions.

Based on the thermobarogeochemistry study of magmatic inclusion, the various phenocrysts in the dacites and dacitic pumices crystallized simultaneously at a late stage of magma differentiation. Electric microprobe analysis shows that the initial chemical compositions of magmatic inclusions in various phenocrysts are identical and analogous to those of glass matrix of lavas. The volatile contents of dacite are lower (2-3%) and those of dacitic pumices are more higher (3-5%, and 6-10%). For the dacite, the phenocrysts crystallized at following conditions: temperature - 880°C, pressure - 1 kb (P-H_2O); for the dacitic pumices: 795-850°C, 1.4-1.8 kb (P-H_2O); and 840-900°C, 0.6-0.8 kb (P-H_2O).

This study shows that the full exploitation and utilization of various information provided by the study of magmatic inclusions can play a unique role in explaining the thermobarogeochemical conditions of formation of volcanic rocks. (Authors' abstract)

XIA, Linqi, PEN, Ligui, LIU, Bin and XIA, Zuchun, 1985, Magmatic inclusions in quartz-keratophyres from Baiyinchang area: Bull. Xi'an Inst. Geol. Min. Res., Chinese Acad. Geol. Sci., 1985, no. 11, p. 1-8 (in Chinese; English abstract).

Numerous primary magmatic inclusions and secondary fluid inclusions have been observed in quartz phenocrysts of quartz-keratophyric rocks from Baiyinchang. Most magmatic inclusions are crystallized. The totally crystallized magmatic inclusions consist of daughter minerals: quartz (on the cavity wall), orthoclase, albite, muscovite (in the cavity) and a deformed shrinkge bubble.

The results of thermometry show that Th of slightly crystallized magmatic inclusions vary from 860 to 910°C and that of the intensely crystallized magmatic inclusions are higher than 1000°C, because of the evolution after they have been trapped, which leads to a partial loss of the volatile components conserved in the cavities. The chemical compositions of homogenized inclusions, which represent those of magma at the time of crystallization of their host minerals (quartz), analyzed by electrical microprobe are analogous to those of total rocks. The high contents of K_2O of chemical composition of total rocks relate to the late K-metasomatism. Secondary high-salinity fluid inclusions are often joined with the devitrified magmatic inclusions by some microfissures. This high-salinity fluid conserved in the secondary fluid inclusions represents probably the ore-fluid liberated from the crystallizing silicate melt at the late-magmatic stage. They are generally considered as the vehicle [for the transport of] of useful metals in the post magmatic stage. Based on magmatic inclusion studies, the quartz phenocrysts of this type of rocks crytallized from an acidic magma rich in Na at 860-910°C and 400-700 bars (PH_2O). (Authors' abstract)

XU, Yongxue, ZHANG, Guilan and LI, Jiazeng, 1985, The distribution of halogen elements in the Dongguashan copper ore deposits and its relationship with mineralization: Min. Deposits, v. 4, no. 1, p. 90-96 (in Chinese; English abstract). Authors at Nanjing Geol. School.

Two kinds of copper ore deposits are observed in the Dongguashan mining area. One is made up of contact-metasomatic skarn type which are characterized by comparatively high chlorine content in relevant rocks such as diorite and skarn, (F/(F+Cl))<(Cl/(F+Cl)), and direct correlationship between copper and chlorine; the other consists of stratabound deposits or syngenetic sedimentary-hydrothermal superimposition transformation deposits which are emphasized in this paper. This sort of deposits have a close relationship with fluorine, (F/(F+Cl)>(Cl/(F+Cl)) and positive correlationship between copper and sulfur. (From the authors' abstract)

YALOVETS, T.N., BORODIN, V.A., LEZHNEV, A.E., SIKHARULIDZE, STERIOPOLO, T.A. and TATARCHENKO, V.A., 1985, Composition of gaseous inclusions in sapphire crystals: Inorganic Materials, v. 21, no. 2, p. 212-215.

YANG, Bing and WANG, Zhitian, 1985, Discovery of a new type of ore body and the metallogenic model of the Tongguanshan copper deposit (China) with a discussion on its relationship to the complicated regional copper metallogenic model: Kuangchuang Dizhi, 1985, v. 4, no. 4, p. 1-12 (in Chinese). Authors at Beijing Res. Inst. Miner. Resour. Geol., CNNC, Beijing, PRC.

A commerical-grade, quartz vein-type Cu ore body in the Tongguanshand area and the associated porphyry-type disseminations are described. Four types of ore bodies are recognized: sedimentary-reformed, quartz vein, skarn, and porphyry types. A metallogenic model is described, based on the geology, geochemistry and fluid-inclusion characteristics. During the Middle Carboniferous, a chalcopyrite ore bed was localized in a confined salinized platform; during the Yanshanian, an intermediate-acidic magma intruded and extracted the ore-forming metals from the country rocks. (C.A. 105: 9432m)

YARDLEY, B.W.D., 1985, Apatite composition and the fugacities of HF and HCl in metamorphic fluids: Min. Mag., v. 49, p. 77-79. Author at Dept. Earth Sci., The University, Leeds LS2 9JT.

Microprobe analyses of the halogen contents of apatites from two samples of amphibolite-facies schist from Connemara, Ireland, have been used to calculate the fugacity ratios $f(HCl)/f(H_2O)$ and $f(HF)/f(H_2O)$ using the experimental data of Korzhinsky. The results imply fugacities for both acids in the range 0.03 to 0.1 bars, but whereas for the lower grade rock $f(HF)>f(HCl)$, the migmatitic sample gives $f(HF)\simeq f(HCl)$. An independent estimate of $f(HF)/f(H_2O)$ from the biotite composition in one sample is in acceptable agreement with the result obtained from apatite. (Author's abstract)

YARDLEY, B.W.D., 1985, Field studies of crustal fluid movement in metamorphism (abst.): NERC 3rd Deep Geology Workshop Programme and Absts., Univ. Durham, 3-4 Jan., 1985 (unpaginated). Author at Univ. Leeds.

Many metamorphic rocks preserve evidence of fluid movement in the crust, both in the indirect form of the progressively lower volatile contents of higher grade rocks, and the more direct evidence of veining and metasomatism. Examples are described of both apparently pervasive fluid movement and of focussed flow in veins and their wall rocks. Very large fluid:rock ratios (≥1:1) can result in metasomatism, and for the majority of natural rocks and fluids the dominant effect will be exchange between Na and K. (From the author's abstract)

YASINSKAYA, A.A., 1985, Classification of inclusions in minerals of cosmic and cosmogenic objects (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 47-48 (in Russian). Author at L'vov State Univ., L'vov, Ukraine.

Classification of inclusions in minerals of meteorites, Lunar rocks and impactites of astroblemes was made with use of criteria of 1) origin and 2) phase composition: class A - P inclusions, 1 - formed by rapid cooling, 2 - formed by slow cooling, 3 - formed due to immiscibility in Lunar magmas; class B - S inclusions, 1 - formed due to repeated heating (pyrometamorphic), 2 - impact phenomena (impact-metamorphic (genetic classification)). On the basis of phase composition, inclusions are classified as follows: class 1 - trapped crystals and their fragments, proto- and syngenetic; class 2 - melt inclusions, glassy and crystallized, one-, two- and polyphase, immiscible melts, two- and polyphase; class 3 - G inclusions (with glass and crystal components or without them). (A.K.)

YATES, M.G. and RIPLEY, E.M., 1985, Fluid inclusion and isotopic studies of the Galena mine, Coeur d'Alene district, ID (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 756. Authors at Dept. Geol., Indiana Univ., Bloomington, IN 47401.

The Ag-Cu-Pb ores of the Galena Mine in the Coeur d'Alene District of northern Idaho are mesothermal, vein-type ores, localized along steeply dipping fractures in Proterozoic, Belt Supergroup rocks. The veins are primarily filled with siderite with lesser amounts of quartz, tetrahedrite (td), chalcopyrite (cp), galena (gn), pyrite (py), and arsenopyrite (asp). Siderite and arsenopyrite deposition predates that of main-stage td, cp, gn, py, and quartz. Oxygen isotopic analyses of quartz show values ranging from 9.8‰ to 18.0‰, averaging 14.5‰. The $\delta^{18}O$ values fo the Revett Quartzite country rock range from 12.2 to 13.8‰. Calculated $\delta^{18}O(H_2O)$ at 325°C is approximately 8.5‰, suggesting exchange of isotopically light meteoric water with isotopically heavy country rocks. Analyses of carbon and oxygen isotopes in siderite are highly variable. The $\delta^{13}C$ values vary from -8.3 to -4.4, as $\delta^{18}O$ varies from 11.7 to 19.0‰ respectively. These analyses describe a simple curve, concave to the $\delta^{13}C$ axis. This trend may result from deposition from a constant carbon and oxygen reservoir of -5.6‰ and 9.3‰, respectively, with varying temperature. Fluid inclusions from quartz vugs contain constant proportions of liquid H_2O, liquid CO_2, and vapor. The inclusions rupture before homogenizing at temperatures around 325°C. Freezing temperatues average -7.5°C, indicating a salinity of ≃11 wt. percent NaCl Equiv. CO_2 comprises a mole fraction of .05 to

.1 of extracted fluids. Analysis of water extracted from the inclusions show δ D to vary from -110 to -144%., strongly suggesting a meteoric water origin of the mineralizing fluid. (Authors' abstract)

YAU, Y.-C., PEACOR, D.R. and McDOWELL, Douglas, 1985, Microstructure and formation mechanism of phyllosilicates in hydrothermally metamorphosed Salton Sea shales (abst.): Geol. Soc. Am. Abstracts with Programs, v. 17, p. 756. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

TEM/AEM study of authigenic phyllosilicates in a sequence of hydrothermally metamorphosed shales and siltstones from the temperature (depth) interval 115°C (256 m) to 330°C (1547 m) in the well IID No 2, Salton Sea Geothermal Field shows that the overall progression of mineral assemblages is consistent with that observed in the sandstone sequence of nearby wells, despite significant differences in the bulk chemistry between shale and sandstone. The phyllosilicates progress from an illite/muscovite zone at temperatures less than 260°C, through a chlorite zone (220-305°C) and a biotite zone (310-330°C).

By contrast with observations of shales in other burial metamorphic sequences, the Salton Sea samples contain significant proportions of pore space (estimated to be ≅30%) even in shales. All phyllosilicates and other authigenic minerals (e.g., pyriboles, epidote, Ti-oxide, sphene) occur as discrete euhedral crystals which partially fill pore space. The mixed-layering and structural/chemical heterogeneity, typical of phyllosilicates in shales subject to diagenesis, are generally absent. AEM analyses yield compositions of illite/muscovite as $(K_{0.7})(A_{1.5}MG_{0.2}Fe_{0.4})(Si_{3.4}Al_{0.6})O_{10}(OH)_2$ at 220°C, chlorite as $(Mg_{2.9}Fe_2Al_1)(Al_1Si_3)O_{10}(OH)_8$ at 300°C and biotite as $K(Fe_{1.6}Mg_{1.2}Al_{0.3})(Al_{0.9}Si_{3.1})O_{10}(OH)_2$ at 330°C. Compositional variations with increasing (depth) include a decrease in (Mg+Fe) and an increase in Al of illite and an increase in Mg/(Mg+Fe) of chlorite.

Texture and microstructure indicate that the mineral progression in the low grade hydrothermal metamorphic sequence involve complete dissolution of detrital phases, mass transport through interconnecting pore space, and direct crystallization of phyllosilicates from solution. (Authors' abstract)

YEFIMOVA, M.I., MALAKHOV, V.V., SOLYANIK, V.A. and KOMAROVA, T.N., 1985, Temperature conditions of formation of granitoids of the ore fields of the Dal'negorsk region of Primor'ye (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 118 (in Russian; translation by D.A. Brown). Authors at Far Eastern Geol. Inst., Far Eastern Sci. Center Acad. Sci. USSR, Valdivostok, USSR.

Endogenic mineralization here consists of tin-polymetallic and polymetallic ores of the cassiterite-sulfide association, and borosilicate and polymetallic ores of the skarn association. In the deposits of the Krasnogorsk ore field, a small stock of porphyritic quartz diorite shows the interval of crystallization of plagioclase phenocrysts to be 885-780°C.

The borosilicate mineralization of the Dal'negorsk ore field has been superimposed on a wollastonite-hedenbergite-garnet skarn, formed at the contact between Triassic limestones and granitoids. Rocks of two phases have been recognized in the intrusion. The quartz in the quartz diorites of Phase I crystallize in the 990-980°C range, and that of Phase II, at 820-770°C.

Within the Nikoleyevka volcanic-tectonic depression, hedenbergite skarns with a superimposed sulfide mineralization, have been localized near a volcanic complex. The quartz of a quartz diorite intrusion crystallized in the 950-860°C, and phenocrysts of quartz in the granite porphyries were formed at 1200-980°C. (From the authors' abstract)

YEGOROV, K.N., 1985, The genetic significance of mineral inclusions in major minerals of Yakutia kimberlites: Zap. Vses. Mineral. Obsh., 1985, no. 2, p. 178-186 (in Russian; translated in Int'l. Geol. Review, v. 27, no. 7, p. 824-833, 1985).

The article gives quantitative data on inclusions in a large collection of olivine and other kimberlite phenocrysts. (IGR abstract)

YONOVER, R.N., SOMMER, M.A. and GIBSON, E.K., 1985, Laser decrepitation and mass spectrometric volatile analysis of silicate melt inclusions (abst.): EOS, v. 66, p. 1108. First author at Dept. Geol. & Geophys., Univ. Hawaii, 2525 Honolulu, HI 96822.

Intratelluric volatiles (primarily H_2O and CO_2) have been analyzed from individual silicate melt inclusions in feldspar and olivine phenocrysts from basalts collected in 1985 at 95.5°W along the Galapagos Propogating Rift (GPR) by DSRV ALVIN. Samples were prepared as polished sections to expose bisected silicate melt inclusions. These samples were placed in a vacuum chamber in the optical path of a Nd-glass laser (0.1 to 1.0 joules, 1-2 microsecond, Q-switched). The laser produces ~20 micrometer pits within the melt inclusions which subsequently release trapped volatiles. The volatiles are then introduced directly into a quadrupole mass spectrometer for analysis operating under computer control. Alternatively, volatiles are trapped invacuo with an LN_2 cold trap and subsequently analyzed with a capacitance manometer. Successive laser zaps do not appear to fractionate the trapped volatile compositions. Blanks were typically 10-20% of the measured total volatiles which were about 10^{-10} moles/zap. Preliminary results from the GPR samples yield CO_2 concentrations of about 0.01-0.05 wt. %, which is less than solubility of CO_2 in the magma and show little apparent trend with tectonic environment. Volatile compositions released by laser decrepitation agreed favorably with separate thermal decrepitaton methods. (Authors' abstract)

YOSHIDA, Katsusuke, EJIMA, Yashiko and SHIMOIKE, Tadahiko, 1985, Recent understanding of the reservoirs of Otake and Hatchobaru geothermal areas: 1985 Int'l. Symp. on Geothermal Energy, International Vol., p. 405-410.

YOUN, S.T. and PARK, H.-I., 1982, Mineral paragenesis and fluid inclusion study of Ssangjeon tungsten deposits: J. of the Korean Inst. of Mining Geol., v. 15, no. 4, p. 221-233 (in Korean; English abstract).

Ssangjeon is a complex pegmatite tungsten deposit embedded along the contact between pre-Cambrian Buncheon granite gneiss and amphibolite. This pegmatite vein developed 2 km along the strike and varies in thickness from 10 m to 40 m. Mineral constituent of the normal pegmatite are quartz, microcline, plagioclase, muscovite, biotite, tourmaline and garnet.

The vein paragenesis is complicated by repeated deposition of quartz but three distinct depositional stages can be recognized. Quartz A stage is the stage of the earliest milky white quartz deposition as a rock forming mineral of normal pegmatite. Quartz B stage is the stage of gray to dark gray quartz replacing earlier normal pegmatite minerals. Quartz C stage is the stage of latest white translucent massive quartz replaces quartz A and B. Tungsten ore minerals and other sulfide minerals were precipitated during quartz B stage.

Ore minerals are ferberite and scheelite. Minor amounts of molybdenite, arsenopyrite, pyrrhotite, pyrite, chalcopyrite, sphalerite, galena, pentlandite, bismuthinite, native bismuth and marcasite accompany the tungsten.

Fluid inclusions in quartz A and B are gaseous, and primary liquid inclusions are found in quartz C. Salinity of inclusions in quartz A and B ranges from 4.5 to 9.5 wt. % and from 5.1 to 6.0 wt. % equiv. NaCl respectively. Th of quartz A, quartz B and quartz C range from 415 to 465°C, from 397 to 441°C and from 278 to 357°C. CO_2 content of the ore fluid increased at the end of quartz B stage. (Authors' abstract)

YOUNGMAN, K.J., 1985, The application of fluid inclusion geothermometry based on secondary inclusions in primary igneous quartz crystals: Proc. 7th NZ Geothermal Workshop 1985, p. 189-191. Author at Geothermal Inst., Univ. Auckland, NZ.

Primary igneous quartz crystals in the cores and cuttings of volcanic rocks from the Wairakei-Tauhara geothermal field usually have been fractured. Secondary fluid inclusions have formed along many of the fracture planes as the fractures have healed. These inclusions exhibit little variation in Th within single fracture planes, suggesting that annealing was rapid.

Due to the large size (up to 5 mm diameter) and common occurrence of primary igneous quartz crystals at Wairakei-Tauhara, more detailed and complete fluid inclusion geothermometry of the field in now possible compared to the previous use of hydrothermal minerals only. This, in turn, allows a better evaluation of past variations in the thermal regime of the field.

Results for samples from well TH1, for example, show that temperatures of over 280°C have occurred at 975 m depth in the past, but that it has since cooled to the present 250°C. (Author's abstract)

YU, Jianhua, ZHANG, Deren and LIU, Baocong, 1985, Temperature and chemical studies of glass inclusions in the pumice from sea bed: J. Geochem. & Geol., 1985, no. 5 (in Chinese). Authors at Beijing Geol. Research Inst.

From the sea bed of the China Southeast sea area, there are many large glass inclusions in the porphyritic crystals of plagioclase, hypersthene and quartz in Cenozoic intermediate to acid pumice. Some are negative crystal cavities, and the phenomenon of magma unmixing [i.e., immiscibility] can be seen in them.

According to electron probe analysis, the chemical constitution of the inclusion glass is homogeneous, but it's SiO_2 is higher and K_2O, Na_2O are lower than that of the pumice or acid rocks. Thus to consider the inclusions as samples of the original magma is still a problem to be solved.

Using the quenching method, Th is 1038 ± 72°C. It can be shown by histograms that the crystallization of porphyritic crystals began at about 1200°C, and as the temperature dropped to ~1038°C, most phenocrysts formed. When the temperature dropped to about 950°C, the magma extruded into sea water and formed pumice. (Translation courtesy H.-Z. Lu)

YUSUPOV, S.Sh., 1985, Thermobarometry of the massive-sulfide deposits of the Urals sulfide and sulfide-bearing inclusions in the phenocrysts of volcanics, in pyrites of ores, and ore quartz (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 78-79 (in Russian; translation by D.A. Brown). Author at Inst. Geol. of Bashkirian Br. AN SSSR, Ufa, USSR.

Inclusions in quartz, carbonates, pyrite, and sphalerite, have been studied in the ores from more than ten Cu-Zn massive-sulfide deposits in the Urals, as well as inclusions in pyroxenes and β-quartz in the volcanic rocks. The methods employed are: Th, Td and cryometry; micro-X-ray-diffraction, etching, and calcining of preparations in different media; and special illumination microscopy of the ore dms in melt (MI) and gas-liquid inclusions (GLIs). The following results have been obtained.

1. Quartz contains two kinds of inclusions: A. Two-phase GLI (F = 5-40%). Th of quartz from weakly-metamorphosed deposits = ~100-440°C, and in the intensely-metamorphosed deposits, ~300-505°C. Aqueous chloride solutions have salinity from 2-3 up to 13% NaCl-equiv. and pressures from 1 to 95 bars for Th = 310°C (Sibay). Data are presented on Th and Td of GLI in quartz and carbonates throughout the deposits. B. Sulfide-liquid inclusions (SLI), contain ~70-90% sulfide dms, 5 to 15% gaseous (G) and 10-25% liquid (L) phases. The gas bubble is often deformed, and the volume with respect to L varies from 15 to 40%. The sulfide dms are difficult to distinguish both in transmitted and reflected light. In any case, owing to wetting of the SLIs by the liquid and to internal reflection, the SLIs look like sulfur[sic], and unidentified, so that they have been previously rejected during thermobarometry. The method of combined illumination in transmitted and reflected light has enabled us to observe SLIs in three dimensions in color, and it has also been established in polished sections that the sulfide dms consist mainly of pyrite, with minor sphalerite, chalcopyrite, pyrrhotite, etc. The thermometry of the SLIs is extremely difficult using the homogenization method. The author used the quench method. During heating to 520°C, the sulfides retain their shapes. In the 570-590°C interval, pyrite melts, and above 500°C, chalcopyrite melts, sometimes flowing along the cracks and forming a halo of drop-like reflecting globules around the vacuoles. Heating above 610°C leads to rupture of the inclusions. SLIs have also been identified in carbonates and in light-colored sphalerite.

2. Inclusions in pyrite have been examined microscopically, by decrepitation in helium (P = 1-16 bars), calcination, etching, etc. The pyrite from all deposits, irrespective of the grade of metamorphism of the ores, contains: a) rounded, drop-like, or angular inclusions of other sulfides, 2 to >15 μm in size, arranged randomly or in growth zones in the core, single- or multiphase, and consisting mainly of pyrrhotite (po), chalcopyrite (ccp), sphalerite (sp), and their combinations; b) vacuoles (a few microns), from GLIs, either empty, rounded or deformed, smooth or encrusted; isolated, with sulfides, etc; and c) inclusions of other minerals. Experiments have shown that inclusions of cpy, ccp+po, and ccp+sp melt above 500°C with the formation of a halo of droplets in pyrite. The pyrite itself is readily melted above 600°C with the formation of fine patterns. Intense decrepitation peaks occur at 200-350°C and 400-700°C.

3. Phenocrysts of pyroxenes in basic volcanics and of β-quartz in acid volcanics contain inclusions of sulfides (MS) and sulfide dms in melt inclusions (MI). The sulfide dms are best seen in combined light after melting of the glass. The composition of the MSs and sulfide dms is identical to the fundamental composition of the ore in the massive-sulfide deposits. These are pyrite, sphalerite, chalcopyrite, pyrrhotite, etc. In the MIs of pyroxenes, these phases are constantly present, in total comprising from 2-3 up to 15 vol%. Melting of the MIs commences above 700°C, and Th at 850-1000°C. In β-quartz, sulfide dms have not been observed in all MIs, and only in small amounts, from <1 up to 3-5%. They begin to dissolve in the glass above 550°C and homogenize in the 730-950°C range.

On the whole, the studies have contributed to: 1) clarification and establishment of the widespread distribution of sulfide micro-inclusions in the minerals of volcanogenic rocks, and also their compositional identity with the massive-sulfide ores, and their quantitative (and through time) decrease from basic to acid basaltoids; 2) the discovery of sulfide-hydrous inclusions in ore quartz with a relatively high Tt (>500°C); and 3) clarification of the nature of the localization and mechanics of capture, Te of sulfide inclusions in pyrites (500°C), etc.

All this has significantly refined our ideas about the source, forms of occurrence, and the nature of the evolution of the ore material. (Author's abstract)

YUSUPOV, S.Sh. and MUKHTAROV, R.Kh., 1985, Certain improvements in investigations of inclusions in minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 51-52 (in Russian). Authors at Geol. Inst. of Bashkirian Div. Acad. Sci. USSR, Ufa, USSR.

The authors recommend the use of both reflected and transmitted light illumination for studies of DMs in inclusions and the use of immersion technique. Decrepitation of sulfide minerals can be studied with use of a device with P of inert gas in the working volume about 20 bar; this inhibits the decomposition of sulfides up to 700°C. The working system is cleaned from traces of air by pumping out and flushing with inert gas three times. Good reproducibility of Td was obtained for T <400°C. (A.K.)

ZAKIROV, I.V., 1984, The P-V-T relations in the H_2O-CO_2 system at 300 and 400°C up to 1000 bar: Geokhimiya, 1984, no. 6, p. 805-811 (in Russian; translated in Geochem. Int'l., v. 21, no. 6, p. 13-20, 1984 (pub. 1985)).

See Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 387-388. (E.R.)

ZAMOKINA, N.S., KOKINA, T.A. and SUSHCHEVSKAYA, T.M., 1985, Sulfide sulfur in inclusion solutions in minerals (potentiometric method and results obtained for certain ore deposits) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 58-60 (in Russian). Authors at GEOKHI, Moscow, USSR.

Total soluble sulfide sulfur was determined in solutions of as small volume as 1 to 50 µl by 1) direct potentiometric method and 2) express potentiometric method. Method 1): powdering of 0.5-4.0 g of mineral sample in 1.0 molar NaOH solution + ascorbic acid (protection from oxidation of sulfur) and potentiometric determination with use of sulfide-silver electode. Method 2): eluent solution of sulfide sulfur (0.1 molar $NaNO_3$ and 0.01 molar NaCH) is moved by peristaltic pump (type 304, made in Poland) with speed 6-9 ml/min. through measuring cell with sulfide-silver measuring electrode and calomel reference electrode; the sulfide-bearing solution is injected into eluent solution in amount 10-50 µl that gives S concentration 10^{-4} - 10^{-1} moles. Measurements are made by pH-meter OR-208/1 and recorded by potentiometirc recorder ON-814/1^3 (both made in the USSR). Sulfide-silver electrode is sensitive to HS^- and S^{2-} ions, linear relation between E_{max} (mV) and logarithm of S concentration occurs in the above named ranges. Fluids forming various types of tin deposits have average concentration of sulfide sulfur about 10^{-3} M (mineralization with arsenopyrite, chalcopyrite, pyrrhotite, pyrite and stannite), variations are in ranges 10^{-4} - 10^{-2} M. Similar concentrations of sulfide ions were typical of commercial ore solutions in certain cinnabar and pyrite deposits. (A.K.)

ZASHU, S., OZIMA, M., NITOH, S. and KIRSTEN, T., 1985, Apparent K-Ar isochrons for Zaire diamonds (abst.): Terra Cognita, v. 5, p. 201. First author at Geophys. Inst., Univ. Tokyo, Tokyo, Japan.

In order to shed light on the frequent occurrence of excessive quantities of ^{40}Ar in diamonds, we have K-Ar dated 10 diamonds of supposedly common origin from Zaire with rather high K-concentrations ranging from 12.3 to 50.7 ppm. PIXE analysis of one diamond has revealed K-rich micron-sized inclusions. Among the various diamonds, K and ^{40}Ar (as well as ^{40}Ar/^{36}Ar vs. K/^{36}Ar) are correlated. If interpreted in terms of an isochron, they would correspond to apparent ages of ~6 b.y. The observations can best be understood as the result of admixture of various proportions of some (probably liquid) carrier component with a constant K/^{40}Ar ratio, where part of the ^{40}Ar must have been parentless. Evidence for ultrabasic crystal mushes with very high ^{40}Ar/K ratios due to K-depletion has previously been reported. The ^{4}He/^{40}Ar is rather constant and low (~0.8), supporting such interpretation. ^{129}Xe excesses in quantities of $\sim 10^{-13}$ cc/g will also be reported. (Authors' abstract)

ZATSIKHA, B.V., 1985, Crystallogenetic criteria of determination of primary nature of inclusions of mineral-forming solutions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 10-11 (in Russian). Author at IFING, Ivano-Frankovsk Inst. Oil & Gas, Ivano-Frankovsk, Ukraine.

The author apparently proposes a crystallogenetic criterion of primary nature of inclusions to add to Ermakov's criteria of relative time of inclusion formation and its position in a crystal. A mechanism of formation of inclusions in layer-growing faces and during dendritic growth of crystals is presented. A tendency toward decrease of surface energy during change of inclusion habit is indicated. (A.K.)

ZATSIKHA, B.V., DIDENKO, A.V., DOLISHNII, B.V., IORISH, Z.I. and SKUL'SKAYA, L.I., 1985, Morphology and formation conditions of whewellite in the Slavyansk mercury ore deposit: Mineral. Zh., v. 7, no. 3, p. 74-78 (in Russian). Authors at Ivanov.-Frankovsk. Inst. Neft. Gaza, Ivanovo-Frankovsk, USSR.

Some whewellite crystallized from low-temperature dilute aqueous solutions, others from strong brines, as shown by inclusions. IR spectroscopy, carbon isotopes and organic analyses are presented, along with relationships to mercury deposition. (E.R.)

ZATSIKHA, B.V. and GALABURDA, Yu.A., 1985, Physicochemical conditions of formation of mercury and arsenic-mercury deposits of the Transcarpathians: Geokhimiya, 1985, no. 5, p. 657-666 (in Russian; English abstract). Authors at Ivano-Frank. Inst. Nefti Gaza, Ivano-Frankovsk, USSR.

The data on study of inclusions in quartz of the mercury and arsenic-mercury deposits of the Transcarpathian (thermometry, cryometry, pH-metry, gas composition) are given. It has been shown that formation of mercury ores took place from low-temperature solutions saturated in carbon dioxide with admixture of methane and other hydrocarbons. Density of mixture of the gases determined by cryometric technique was ≤ 0.135 g/cm^3 (Borkut deposit). Pre-ore quartzes of the "marmarosh diamond" type of arsenic-mercury ore-shows crystallized from a hydrocarbon-bearing heterogenous solution (according to cryometry data, often only CH_4 predominates) under 140°C and 37-38 MPa. (Authors' abstract)

ZATSIKHA, B.V. and PANOV, B.S., 1985, Quartz with hydrocarbon inclusions: Dokl. Akad. Nauk SSSR, v. 285, no. 5, p. 1186-1189 (in Russian).

Inclusions of hydrocarbons in quartz from many localities were analyzed for gases (CO_2, N_2, CH_4, C_2H_6, mostly CH_4), Th (120-190°C) and "cryometry" (mostly -75 to -80°C). (E.R.)

ZAV'YALOV, G.Ye., GERTMAN, Yu.L. and four others, 1985, Experience of use of decrepitation method for studies of epithermal gold ore mineralization (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 88-89 (in Russian). Authors at Complex Geol.-Prospecting Expedition of Prospecting Geol. Concern "Tashkentgeologiya," Tashkent, Uzbekistan.

In a low-sulfide gold ore deposit in paleovolcanic area the pre-ore propylites have very low decrepitation activity; this activity of near-ore argillite metasomatites strongly increases and it achieves maximum in quartz-carbonate veins. The contours of areas submitted to ore-forming processes are more distinctly outlined by decrepitation than by geochemical methods. (A.K.)

ZAYKIN, I.D. and MOISEENKO, V.G., 1985, Contribution to the problem of true crystallization temperature of minerals (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 28-29 (in Russian). Authors at Amur Complex Sci.-Research Inst., Blagoveshchensk, USSR.

Homogenization of the mineral-forming medium trapped in inclusions in minerals is still the main method of determination of mineral crystallization temperature. However Th<T of host mineral crystallization (Tcr) as was proved by experiments with inclusions in synthetic quartz, and the difference increased with P growth, reaching e.g., for Tcr 480°C and P 1920 atm the value Tcr-Th = 178°C (S.V. Blokhintseva et al. 1978). This indicates the invalidity of the inclusion homogenization method for determination of Tcr, especially for deep processes (especially if P correction is not taken into account).

Studies performed by the authors and concerning thermokinetics of fluid release from gas-liquid inclusions from synthetic quartz (grown in VNIISIMS, Alexandrov, USSR) permitted the proposal of a new method of determination of true Tcr. Thermokinetics of fluid release was studied* by gas chromatographic determination of CO_2 in narrow T intervals with subsequent description of the integral curve of sigmoid shape by the equation:

$$X = \alpha Ko \cdot \frac{\exp[(Ko + K\alpha)(T - To)] - 1}{K\alpha + Ko \exp[(Ko + K\alpha)(T - To)]}, \qquad (1)$$

where X - number of moles** of CO_2 released during heating from T of beginning of gas release To to final temp. T; α - initial number of CO_2 moles, Ko and K[sic] - thermokinetic constants. Doubly differentiating the equation (1) on temperature and comparing the result to zero, the expression for determination of T of maximum gas release inensity (from fluid inclusions):

$$Tmax = To + \frac{\ell n(\alpha K/Ko)}{\alpha K + Ko} \qquad (2)$$

The values $\alpha \approx X/2$ Tmax, Ko and K are found by analytic solution of equation (1). For all studied quartz samples the curves described by equation (1) well agree with experimental data (...):

Quartz	Pcr, MPa	Tcr, °C	Tmax, °C
Q-1	130	357	352
Q-2	65	340	334
Q-3	58	336	341

Uncertainty of the determined Tmax is ±5°C, like the error of measurement of Tcr. Tmax was determined for natural cassiterite, fluorite, calcite and antimonite, giving values agreeing with generally accepted T of their origin. Tmax and Th may help in evaluation of P of mineral formation. (Authors' abstract, translated by A.K.)

*See also Zaikin, 1984, Fluid Inclusion Research--Proceedings of COFFI, v. 17, p. 387.

**Russian text has here "number of salts" that obviously is a misprint for "moles" (in Russian "soley" for "moley").

ZEIHEN, G.D., 1985, Paragenetic relationships, zoning, and mineralogy of the Black Pine mine, Granite County, Montana: MS thesis, The Univ. of Arizona.

Ore from the Black Pine mine near Philipsburg, Montana, is won from the Combination vein, a flat-dipping quartz vein that cuts across the quartzite of the Mount Shields 2 unit of the Missoula Group. Normal-grade, quartz-tetrahedrite-pyrite ore and high-grade, quartz-tetrahedrite-galena-sphalerite-pyrite ore are the two separate ore types in the mine. This suggests two mineralizing events, but only one stage of tetrahedrite was observed, and fluid-inclusion homogenization temperatures for both ore types were nearly the same. Electron microprobe analysis of the tetrahedrite revealed a positive correlation between silver and antimony and detected several ore shoots along the main haulage drift but failed to outline a central, high-arsenic conduit. Mineralogical and elemental zoning, vein flattening, and lateral high-angle fault movement appear to localize high-grade zones. If the dike to the north is considered a possible fluid source, high-grade zones may trend N. 60° E. (Author's abstract)

[Fluid inclusions in quartz associated with huebnerite and sulfides contained liquid CO_2, liquid H_2O and vapor at room temperature, and homogenized near 250°C.]

ZENG, Qingfeng, 1985, A study of the migration direction of ore-bearing fluids: Mineral Deposits, v. 4, no. 1, (Ser. No.: 11), p. 73-83 (continued on p. 10) (in Chinese; English abstract). Author at Inst. Geol., Academia Sinica.

Based on such mineralization features as the metallogenic structures, the orebody and wall rock alterations, the distribution of mineral constituents, the metallogenic temperature-pressure indicators, the growth of mineral crystals, the concentration of ore solutions and the variations in isotopes, this paper deals with the migration direction of ore solutions.

Ore-forming structure is a prerequisite for ore-formation in that it provides space for the migration and precipitation of ore-bearing fluids. The largest open part along the fault of the Tashan hydrothermal deposit coincides with the distribution of the orebody, both stretching in the dislocation direction along the fault. Therefore, under high temperature and high pressure the ore-bearing fluids probably migrated upward along the direction of structural dislocation and then precipitated to form rich orebodies.

The geochemical behavior, mineral assemblage and sequence of crystallization of elements in orebodies reflect the migration of ore-bearing fluids in the process of mineralization. For the Dayu deposit the isopleths of such ratios as W/Sn, Pb/Zn and W-Sn/Cu-Pb-Zn show a similar character, i.e., the peak axial line is inclined to the west, implying that the ore-bearing fluids moved upward along the peak axial line.

One important approach to the study of migration of ore-bearing fluids is to find out the pressure and temperature variations during mineralization, because in this process the ore-bearing fluids migrate from high to low-pressure segments, accompanied by the decrease of temperatures. In the Dayu ore field, an isotherm diagram drawn on a vertical section shows strikingly the existence of a high temperature area in the middle with its axis inclined to the west and a gradual decrease of temperature on both sides. This indicates that the ore-bearing fluids first ascended in this direction, followed by the formation of wolframite at a higher temperature[sic].

The budding and growth of mineral crystals often depend on the supply of the ore-forming materials, as reflected in such aspects as the asymmetry of crystals, the variation in inner growth rings, the incompleteness of crystal growth and the orientation of parallel axial intergrowth.

The study of concentration fluctuations of ore solution sheds light on the problem of the migration direction of ore-bearing fluids. For example, in an Sn-polymetallic ore field in Guangxi, the metallogenic temperatures vary in order of 700-400-300-140-120°C in outward succession and the variations in salinity are from >26.3 wt‰ to 4 wt‰[sic], which coincides with the metallogenic zoning as well as the bulk migration direction of ore solutions.

The variations in isotope abundance seem to be related to both the migration direction of ore-bearing liquids and the sequence of ore deposition. The average δS^{34} values of sulfides for a porphyry copper deposit in Jiangxi are 1.34‰ within the instrusive body, 2.67‰ at the contact zone, and from 2.82‰ to 4.29‰ outwards, accompanied accordingly by a decrease in the ore-forming temperature in the sequence 360-300-270-170°C from the interior of the intrusive mass outward. This also reflects the migration direction of ore solutions.

The results obtained indicate that a comparatively correct solution to this problem may be found by means of an integrated investigation using a variety of methods.

A study of this problem enables us to further understand metallogenic mechanisms, ore zonation, ore enrichment regularity and ore distribution tendency, thus having great significance in mineral exploration, especially in the prediction of orebodies at depth. (Author's abstract)

ZENT, A.P. and FANALE, F.P., 1985, Solis Lacus brines: Possible chemistry and kinetics (abst.): Lunar & Planet. Sci., v. 16, p. 930-931. Authors at Planet. Geosci. Div., Hawaii Inst. Geophys., Univ. Hawaii, Honolulu, HI 96822.

Involves a discussion of the low-temperature eutectics in the systems of H_2O plus NaCl, KCl, K_2SO_4, $CaCl_2$, $MgCl_2$ and $MgSO_4$ and their possible pertinence to brines on Mars. (E.R.)

ZHAMGOTSEV, O.S., RYLOV, V.G. and BYKOV, N.V., 1985, Diagnosis of the origin of massive-sulfide ore-shows by vacuum decrepitation (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 2, p. 82-83 (in Russian; translation by D.A. Brown). Authors at Rostov State Univ., Rostov -on-Don, USSR.

In the Caucasus, there are numerous massive-sulfide copper and massive-sulfide polymetallic deposits and prospects, confined to Devonian volcanogenic rocks, and also to Jurassic shales and siltstones. We recognize hydrothermal, hydrothermal-metasomatic, and combined types. The most promising type seems to be the combined volcanogenic hydrothermal-metasomatic category, since this includes the commerical and best studied deposits in the Caucasus (Urup, Kizildere, etc.).

Vacuum decrepitation provides the best method to assign individual prospects to a definite genetic type. The nature of sulfide decrepitation has also been established. Pyrite crystallized over a wide temperature range; this is lowest in the massive-sulfide ores in the Urup deposit (Td = 50-190°C) and the collomorphic pyrite in the Kizildere deposit (60-160°C). The pyrite from hydrothermally-altered rocks, and also from the pyrite-pyrrhotite and pyrite-chalcopyrite associations displays higher Td (210-290° and 320-380°C). Several Td intervals have been recognized in pyrrhotite, high (260-340° and 380-420°C) and medium (160-220°C). Chalcopyrite Td data are complex. In most cases, four intervals of gas-release are found (100-190°, 220-280°, 260-320°, and 360-440°C). From its Td, sphalerite has been subdivided into two forms: high-temperature, with three intervals of gas-release (160-220°, 330-360°, and 430-440°C), and low-temperature (60-120°, and 180-260°C).

Of the sulfides, pyrite is the most decrepitative, with two maxima of gas-release observed in the low-temperature (80-160°C) and medium-temperature (210-290°C) intervals. The maximum of gas-release for chalcopyrite, sphene, and pyrrhotite lies mainly in the 250-360°C interval. Their decrepitative activity diminishes similar to pyrrhotite, chalcopyrite, and sphene. Thus, the combined type of prospect reveals four principal intervals of ore-formation: 50-190°, 160-220°, 210-290°, and 320-340°C, and in each interval, any of the ore minerals may possess a gas-release maximum. (From the authors' abstract)

ZHANG, Ligang, 1985, The application of the stable isotope[s] to geology: The hydrothermal mineralization of metal activation and it's prospecting[sic]: Shaanxi Sci. & Tech. Publ. House, 267 pp. (in Chinese; English abstract).

ZHANG, Ligang, 1985, Hydrogen, oxygen, sulfur and carbon isotope geochemistry of the Lianhuashan porphyry type tungsten deposit: Mineral Deposits, v. 4, no. 1, (Ser. No.: 11), p. 54-63 (in Chinese; English abstract). Author at Yichan Inst. Geol. & Min. Resources, Chinese Acad. Geol. Sci.

Located in Mesozoic volcanic rock east Guangdong and associated with Middle Yenshanian subvolcanic rocks, the well-known Lianhuashan porphyry type tungsten deposit consists of two major ore bodies: one is made up of wolframite-bearing quartz veinlets distributed extensively around both sides of the contact zone and accompanied by biotitization and greisenization; the other is composed of scheelite- and sulfide-bearing stockworks occurring inside the contact zone and accompanied by sericitization, silicification and propylitization. An attempt is made in this paper to investigate the sources of rock-forming and ore-forming materials and water as well as the material exchange between water and rocks in the light of stable isotopes.

Rhyolite and quartz porphyry are both characterized by high δO^{18} values; they have whole rock δO^{18} values of +10.8‰ and +9.5‰ respectively.

Of the deposition stage of wolframite (stage II), δO^{18} values are +10.8-14.0‰, ore-forming temperatures are 350-300°C, calculated $\delta O^{18}(H_2O)$ values are +3.5 - +8.7‰, decreasing upward, inclusion water of quartz has δD values from -49 to 60‰, increasing from great depth to shallow depth, and δO^{18} values of two wolframite samples are +0.8‰ and +1.4‰ respectively, obviously out of equilibrium with quartz. These data imply that metallogenic water originated from reequilibr [ated] magmatic water and that during the deposition of wolframite, these waters mixed with meteoric water, especially at very shallow depths.

As for mineralization stages III and IV, δO^{18} values of quartz vary in a relatively narrow range (+8.8 - +11.0‰); ore-forming temperatures are from 300°C to 200°C; equilibrium water has δO^{18} values of -2.4 - +3.7‰; δD values of inclusion water in quartz are -44 - -53‰, slightly heavier than those of the stage II, the whole rock δO^{18} values of the altered rocks (+61 - +8.9‰) are generally lower than the values of fresh rocks; calculated W/R ratios are 0.2-0.7. These data suggest that mineralized water of stages III and IV is principally meteoric water. It has also been noted that δD values of Mesozoic meteoric water in the mining area are lower than those of the present surface water by about 20‰, which must have had to do with the fact that in east China the coast line in the Mesozoic era lay east of the present coast line.

δS^{34} values of sulfides are -1.1 - +4.5‰; mineral assemblage and temperature determinations suggest that H_2S is the dominant constituent in the ore-forming fluids, and the $\delta S^{34}(\Sigma S)$ values are estimated to be about +3‰; δC^{13} values of two calcite samples are -6.0‰ and -7.2‰ respectively. These data denote a probable derivation of sulfur and carbon from igneous sources at depth.

The isotope composition of lead is anomalous; slope of anomalous lead as obtained by the least square method is 0.1948; when t_2 = 135 m.y., the calculated t_1 is about 2880 m.y. This suggests that the Lianhuashan granitoids might have resulted from the anatexis of Precambrian basement rock 2800 m.y. ago. (Author's abstract)

ZHOA, Bin, LI, Tongjin and LI, Zhaopin, 1985, Experimental study of the physico-chemical conditions of skarn formation: Geochemistry, v. 4, no. 2, p. 114-126. Authors at Inst. Geochem., Acad. Sinica.

Experimental results show that skarns [form at] 800°C and 500-1000 bars. Starting materials include intermediate-acidic igneous rocks, volcanic rocks, metamorphic rocks, carbonates of various purities and chemical reagents of analytical grade. Experimental solutions are: NaCl, NaCl + $CaCl_2$, NaCl + $CaCl_2$ + $MgCl_2$, Na_2CO_3 and Na_2SiO_3.

The results show that skarns can form under a wide range of physico-chemical conditions: T = 400°-800°C, P = 500-1000 bars, pH = 4-11, and $fO_2 = 10^{-23}-10^{-11}$ bar. The mineralogy of skarns and the chemical compositions of skarn minerals are generally controlled by a combination of the chemical composition of the original rocks, pH values, redox conditions, temperatures and pressures. Isomorphous substitution may have a great effect on the temperature of formation and fO_2 of some major skarn minerals. It is found that skarnization occurs preferentially in solutions of NaCl and NaCl + $CaCl_2$ and subordinately in $MgCO_3$ and Na_2SiO_3 solutions. (Authors' abstract)

ZHOU, Yiji, 1985, Alteration and mineralization zoning of ore deposits in the Yulong porphyry copper belt: Min. Deposits, v. 4, no. 2, p. 23-30 (in Chinese; English abstract). Author at Jiangsu Inst. Geol. & Min. Resources.

Ore deposits and wall rocks in this porphyry copper ore belt have distinct alteration zoning, composed mainly of K-alteration, silicification, sericitization, kaolinization, hornstonization and propylitization. Superposed alterations are closely related to the ore mineralization, and propylitization serves as a good indicator for ore prospecting.

Three metallogenic epochs can be roughly recognized on the basis of fluid inclusion studies. (From the author's abstract)

ZHOVTULYA, B.D., 1985, A study of glass inclusions in a plagioclase from explosion formations at Shirokiy Verkh (Transcarpathia) (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 126-127 (in Russian; translation by D.A. Brown). Author at IGGGI Acad. Sci. Ukrainian SSR, L'vov, USSR.

Magmatic inclusions have been found in spheroidal intergrowths of plagioclase crystals in explosion rocks at Shirokiy Verkh. The single- and two-phase P inclusions have been filled with glass + globules (V + K). The globules consist of crystalline matter with a high R.I. (1.706), and occupy 10-90% of the volume of the vacuole. In individual inclusions, besides globules, there is a black, evidently ore mineral. The glass of the inclusions has an R.I. of 1.550, which corresponds to 54% SiO_2. At ~700-750°C, gas bubbles are released from the glass of the inclusions, and redissolve in it at ~1050-1100°C; immediately afterwards the globules dissolve at ~1105-1160°C. If the globulites occupy >50 vol %, the glass of the inclusions dissolves in them at these same temperatures (1105-1160°C) and the vacuole becomes homogeneous. They reappear on cooling to 1050°C.

Thus, plagioclase crystallized at 1005-1160°C from a mobile, low-silica melt. The behavior of the globules indicates possible liquation of the melt. (From the author's abstract)

ZHUYKOVA, T.L., VDOYVKIN, G.P., LEBEDEV, V.S., IL'CHENKO, V.P., MUSIN, M.Kh. and ZIMENKOVA, O.I., 1983, Gaseous hydrocarbons in igneous rocks of eastern Siberia: Dokl. Akad. Nauk SSSR, v. 272, no. 4, p. 956-960 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 272, p. 192-195, 1985).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 299, 1983. (E.R.)

ZIL'BERSHTEYN, A.Kh., 1985, Determination of temperature and pressure of formation of minerals bearing gas-liquid and solid inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 30-31 (in Russian). Author at VSEGEI, Leningrad, USSR.

Most of the known methods of determination of P of crystallization (Po) need the temperature of crystallization (To) to be known and vice versa. The present abstract shows the method of simultaneous determination of Po and To on the basis of studies of crystals bearing G/L or solid inclusions, or other inhomogeneous (zoned, sectorial etc.) crystals. It is possible to determine Po and To not only for the host crystal but also for each individual of an aggregate. The general feature of such aggregates is the existence of at least two neighboring fragments of minerals differing in thermal expansion coefficients α and compressibility β. Under conditions of formation (Po,To) of the aggregate, its members do not cause the deformation of each other. However, when PT conditions change, each of the two members expands or contracts and in various measures, because $\alpha_1 \neq \alpha_2$ and $\beta_1 \neq \beta_2$, thus causing deformation $(\sigma_1 - \sigma_2)$ of these members. This bilateral deformation forms, in the area adjacent to the boundary zone of tension, resulting in changes of the optical properties of the crystals due to the piezooptical effect, especially visible as anisotropy in optically isotropic crystals.

One may present the relation between deformation and P and T as follows:

$$3(\sigma_1 - \sigma_2) = (\alpha_1 - \alpha_2)(T_1 - To) - (\beta_1 - \beta_2)(P_1 - Po) \qquad (1)$$

The value of the bilateral deformation may be obtained (as it appears) from theory at piezo- and elastic-optical effects) from the induced birefringence Δn of the zone of tension in an isotropic crystal:

$$\left|\sigma_1 - \sigma_2\right| = \frac{2}{n^3}\left|\frac{\Delta n}{p}\right| \qquad (2)$$

where n and p are respectively birefringence index and a combination of elastic-optical coefficients of the considered fragment.

For crystals with P G/L inclusions at Th (≈T of formation for low-T crystals), from equations (1) and (2) one may obtain an evaluation of Po:

$$Po - P_1 = \frac{3\left|\sigma_1 - \sigma_2\right|}{\left|\beta_1 - \beta_2\right|} = \frac{\sigma}{n^3}\left|\frac{\Delta n}{p(\beta_1 - \beta_2)}\right| \qquad (3)$$

From the values Δn measured in the neighborhood of G/L inclusions in halite (deposit Artyomovskoe) and in fluorite (deposits Kent in Kazakhstan and Abagatuy in Transbaikalia) at Th and P_1 = 1 bar, when the inclusion content was assumed to be incompressible, the Po values were respectively: 160 ± 40 bar (Artyomovskoe), 1.7 ± 0.2 kbar (Kent) and 0.9 ± 0.2 kbar (Abagatuy). (...)

It appears from (1) that under the condition:

$$\left|\frac{d(\beta_1 - \beta_2)}{dT}(P_1 - Po)\right| < \left|\alpha_1 - \alpha_2\right|,$$

as it happens for known minerals when $Po \approx (Po - P_1) \lesssim 10^4 - 10^5$ bar, the function $|\Delta n(T)|$, as well as $|(\sigma_1 - \sigma_2)(T)|$ has the absolute minimum if temperature = To. With use of experimentally obtained relation $|\Delta n(T)|$, the values To were determined for zoned garnet from Pitkyaranta as equal 450 ± 50°C, and for fluorite and coeval quartz from Abagatuy as equal 100 ± 5°C; Th of inclusion in this fluorite were in the same ranges. (...) From $|\Delta n|$ of fluorite at T = To and with use of formulae (1) and (2), the value of Po was found for quartz and fluorite from Abagatuy to be 0.9 ± 0.4 kbar, similar to Po obtained from G/L inclusions in this crystal (see above).

If two adjacent fragments are not coeval, the values Po and To refer to conditions of formation of such an aggregate. (Author's abstract, translated by A.K.)

ZIMMERMANN, J.L., CHEMINEE and DELORME, H., 1985, A mass spectrometric study of gases trapped in different flows at Arenal, Costa Rica (abst.): Fluid Inclusions, 8th Symp. on Current Research, Univ. Göttingen, 10-12 April, 1985, p. 134 (in French).

The authors studied gases trapped in four lava flows from Arenal, which has been essentially continuously active since September 1968. The study used andesite flows of June 1979, April 1980, June 1980, and the June 1980 eruption. The chemical composition of these four flows is very similar, and the gases also have molar compositions that are very similar (66% H_2O; 20% CO_2; 10% CO; 1.5% N_2; 0.1% H_2; and 0.02% CH_4). Nonetheless, the four flows can be grouped into two families: 1) one for the flows of June 1979 and April 1980 and 2) one for the flows of June 1980. The latter group has gases more characteristic of eruptive phases of vulcanism.

The amounts of water and CO_2 of the first family (H_2O: 0.08 wt %; CO_2: 0.05 wt %) are distinguishably less than those of the second group (H_2O:

0.10 wt %; CO_2: 0.08 wt %).

The dehydration curves as well as the diffusion characteristics for water and carbon dioxide are distinct. Additionally, based on the CO/(CO + CO_2), 0.35 for the first group and 0.30 for the second group, the T of equilibration between CO_2, CO and C was 1125°C for the first group and 1080°C for the second group, at a pressure of 2.5 kbar. These Ts would be lower by about 50° at 1 kbar. All the flows contain a small amount of organic material, probably trapped by the magma at the time of its eruption. (Authors' abstract, translated by M. Logsdon)

ZINCHUK, I.N., 1985, Cryometric studies of gases in inclusions (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, L'vov, USSR, Sept. 1985, v. 1, p. 94-95 (in Russian). Author at Inst. Geol. & Geochem. of Mineral Fuels of Acad. Sci. Ukrainian SSR, L'vov, Ukraine, USSR.

The author gives a general outline of cryometry of gases in inclusions and reports his own phase diagram for N_2-CO_2 systems in T ranges -150°C to +300°C, P up to 15 MPa and N_2 content up to 60 mole %. Analysis of this diagram shows that N_2 addition to CO_2 causes the extension of field of two-phase equilibrium G+L towards high P with decrease of T of phase changes. The latter should be taken into account during P determinations from CO_2-filled inclusions, since even small N_2 admixture may cause too high P values. (A.K.)

ZOLOTUKHIN, V.V., SHCHERBAKOVA, Z.V., KOVYAZIN, S.V., VASIL'YEV, Yu.R. and RYABOV, V.V., 1985, Peculiarities in the composition and temperatures of the basite and ultramafic deep-seated melts on the Siberian Platform (abst.): Abst. Seventh All-Union Conf. on Thermobarometry & Geochem. of Ore Forming Fluids, USSR, Sept. 1985, v. 1, p. 151-152 (in Russian; translation by D.A. Brown). Authors at Inst. Geol. & Geophys. Siber. Div. Acad. Sci. USSR, Novosibirsk, USSR.

The Permian-Triassic magmatism on the Siberian Platform consisted of basite (trappean), and also alkaline and ultramafic kinds of magmatic rocks. The available fragmentary data on their Tf based on melt inclusions, have been summarized in two monographs "Magmatogenic Crystallization' (1975) and 'Magnesian Basites and Their Nickel Occurrences' (1984). The maximum T and the composition of the inclusions have remained unknown. A study of melt inclusions in peri-liquidus minerals of early generations, such as magnesian ol and basic pl, is of great significance. Using a thermo-chamber with an inert medium, the authors have obtained Th for melt inclusions in Mg-ol phenocrysts (8-12% Fa) from the meimechites of the Gula ultramafic pluton, of ≥1500°C. They have also studied a substantial number of ol-enriched traps. In ol (20-30% Fa) from the picritic gabbro-dolerites in the differentiated ore-bearing intrusions of the Noril'sk region, Th of the melt inclusions = 1440-1470°C, and according to the pl (An_{80-70}), it is ~1250°C. For ol (Fa_{22-24}) from the magnesian traps (picritic and troctolitic gabbro-dolerites on the Bakhty River), Th = 1350-1400°C, whereas for the pl (An_{85-70}), it is 1280-1300°C. In the relatively ferriferous ol (Fa_{35-50}) from picritic rocks on the Fat'yanikha River, T reaches 1360°C, and in the pl (An_{75-60}) from these rocks, it is 1180-1270°C.

Chromatographic determination of the gas composition of ol from trap rocks, during heating to ≤1000°C, revealed CO_2, H_2O, H_2, CH_4, and CO, the ratios of which may vary in different samples.

A study of melt inclusions on IXA-5A and 'Comebax' electron-probes has shown (IGiG SO AN SSSR, Novosibirsk), their composition is extremely varied, and the principal components rarely approach the bulk chemical composition of the rock itself. More often, they are similar to the daughter fractions, as obtained by computer according to the program, employing Nathan and Van Kirk's model of fractionation crystallization (1978) respectively for basic (average-weighted composition of the Noril'sk I intrusions) or ultramafic (composition of meimechite) original melts. Hence, it follows that, with respect to the host-crystal (ol, pl), such inclusions must be PS and have developed as a result of sealing of cracks by a fractionated late melt and other defects in crystals already formed. This factor evidently explains the manifestation itself and the preservation of melt inclusions (with an effect similar to chilling). The amount of alkalis in the melt inclusions naturally exceeds by two and more times that of the alkalis in the corresponding calculated daughter fractions, and in this case the K/Na ratio may vary. This indicates the existence of higher concentrations of alkalis during the melt phase and their withdrawal as crystallization proceeded. The mobile behavior of the alkalis is probably explained by their filtration through the melt in the make-up of the trans-magmatic fluids. Normal-acid inclusions may evidently appear as a result of local micro-liquation of the melt.

In summary, it is emphasized that a direct correlation between T(max) for the parent melts and changes in their Mg-content during the fractionation process has been established on the basis of ol compositions and the Th of the inclusions in them for the magnesian trap rocks. (Authors' abstract)

ZOTOV, A.V., BARANOVA, N.N., DARINA, T.G., BANNYKH, L.N., KOLOTOV, V.P., 1985, Stability of hydroxocomplex $AuOH^o$ in water under 300-degrees-C to 500-degrees-C and pressure 500-atm to 1500-atm: Geokhimiya, 1985, no. 1, p. 105-110 (in Russian).

ZOTOV, A.B., LEVIN, K.A., KHODAKOVSKY, I.L. and KOZLOV, B.K., 1985, Thermodynamic properties of Ag+ in aqueous solution at 273 to 573K: Geokhimiya, 1985, no. 9, p. 1300-1310 (in Russian; English abstract).

ZUKIN, J.G., HAMMOND, D.E., KU, T.L., MARTON, R.A. and ELDERS, W.A., 1985, Uranium and thorium series radionuclides in Salton Sea geothermal brines (abst.): EOS, v. 66, p. 1144.

Indices

The user should keep in mind the following features of these indices. The indexing procedures and entries are 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, so caveat emptor. 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 481. 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, as in Shan, Lin below.

TEXT Volume	Page	Item†	Line*	
10	168	2	1	MADSEN, J.K., 1977, should be listed under KONNERUP-MADSEN instead, and put on p. 133.
14	xiii	bottom		Pascal units given in error. Replace with: 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.
15	xiii	bottom		Pascal units given in error. See above.
15	137	5&6	1	LIN, Shan, 1982a and 1982b, should be listed under SHAN, Lin instead, and put on p. 227.
16	xiii	bottom		Pascal units given in error. See above.
17	xiii	bottom		Pascal units given in error. See above.
17	26	4	1	BELKIN et al., 1983, was actually published in 1985, not 1983.

†Partial items are also counted.

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