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FLUID INCLUSION RESEARCH

Proceedings of COFFI

Edwin Roedder, *Editor*
Andrzej Kozlowski, *Associate Editor*

Volume 17

1984

Fluid Inclusion Research

Volume 17

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has been provided by the editor

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Volunteers Needed

The editors would appreciate any help that can be offered by the readers in issuing future volumes of Fluid Inclusion Research--Proceedings of COFFI. 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 either editor at the above addresses. We are acutely aware of the inadequate coverage in "COFFI" of the French literature, and would particularly welcome volunteers to make these items available to inclusion workers. On an informal basis, it would be most helpful if readers could send to the editors reprints or even just reference citations of pertinent literature. Such help is particularly useful to avoid missing obscure publications, such as theses, or ones in which the presence of inclusion data may not be obvious from title or abstract. If important papers have been missed in previous volumes, they also should be noted.

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Preface

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

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

Of the 275 items from Russian sources in this volume, 80 were translated or abstracted by Associate Editor Kozlowski; this represents an enormous contribution by Kozlowski toward achieving the aims of COFFI. There are 1045 items from other foreign language sources (including 59 from the Chinese literature) and the English language literature for a total of 1320 abstracts, citations, or annotated citations, plus subject and locality indices, and translations of three short items.

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 Drs. H.A. Stalder (Bern, Switz.); P. Lattanzi (Firenze, Italy); C. Eastoe (Tucson, AZ); M.J. Logsdon, C.E. Barker and G. Landis (Denver, CO); R. Bodnar (Blacksburg, VA); R. Thomas (Freiberg, DDR); K. Fuzikawa (Belo Horizonte, Brazil); J. Mangas (Gran Canaria, Spain); and Huan-Zhang Lu (Guiyang, PRC). Many other individuals, too numerous to list here, have helped by sending books, reprints, references, and abstracts. I am also indebted to Prof. J. Guha (Chicoutimi, Quebec); and particularly to H.E. Belkin and Kevin Howard (U.S.G.S.) for extensive literature searches. 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 21 months five volumes (13 through 17) have been sent to press.

I will be glad to learn of unpublished translations of Russian inclusion literature, and will also be glad to furnish photocopies of the original Russian 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 disserations.

March 14, 1986

Edwin Roedder, *Editor*

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Past Meetings

The Proceedings of the Sixth Quadrennial IAGOD Symposium (held in 1982 in Tbilisi, USSR) were published in 1984 (see Janelidze and Tvalchrelidze, this volume). Many of these papers have less detailed abstracts than were published in the Abstracts Volume (1982, see volume 15).

An Anniversary Meeting of the Mineralogical Society (G.B.) was held 12 January, 1984, at the Geological Society, Burlington House, London. Abstracts of the nine papers were published in 1983 and hence will be found in volume 16 of COFFI.

A meeting on Recent Advances in the Geochemistry of Ore Deposits, sponsored by the Mineral Exploration Research Institute (IREM-MERI), was held May 7-8, 1984, in Montreal, Quebec, Canada. Citations of the 11 review papers presented will be found in this volume.

A session on "Molten and gas-liquid microinclusions of mineral-forming substances" was held as a part of the International Geological Congress in Moscow in 1984. Abstracts will be found in this volume.

The first Indian National Seminar on Scientific and Industrial Applications of Fluid Inclusions in Minerals was held 21-22 October, 1984, at Dehra Dun, India, convened by Dr. R.R. Patil at the Wadia Institute of Himalayan Geology. Abstracts of the 31 papers will be found in this volume.

A meeting on Diagenesis and Metamorphism was held April 12-13, 1984, at the University of Bristol, England; pertinent abstracts will be found in this volume.

The Society of Economic Geologists held a short course on Fluid-Mineral Equilibria in Hydrothermal Systems, October 27-30, 1983. A major book for this course was published (Henley et al., 1984) and is abstracted in this volume.

A Fluid Inclusion User School was held 27-29 June, 1985, at Imperial College, London, arranged by A.H. Rankin and colleagues.

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 Volume 18.

A Conference on Stable Isotopes and Fluid Processes in Mineralization was held 10-12 July, 1985, at the University of Queensland, St. Lucia, Brisbane, Australia. Dr. D.I. Groves gave the keynote address on the Role of Fluid Inclusions.

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 Volume 18.

The Second International Symposium on Hydrothermal Reactions was held August 12-14, 1985, at the Pennsylvania State University, University Park, Pennsylvania. Abstracts will be found in Volume 18.

A symposium on Organics and Ore Deposits was held April 25-26, 1985, in Denver, Colorado, under the auspices of the Denver Region Exploration Geologist Society; it included organic fluid inclusion studies as one topic.

The Fourth Heidelberg Symposium on Ore Genesis was held at the University of Heidelberg, F.R.G., February 14-15, 1985.

A sympoisum on Metallogeny of Basic and Ultrabasic Rocks was held 9-12 April, 1985, in Edinburgh.

The Fourth International Platinum Symposium was held July 27 - August 7, 1985, in Toronto.

The Third International Low-Temperature Biological Microscopy and Analysis Meeting was held at Cambridge University, UK, 1-4 April, 1985. Presentations dealt with topics such as metastable water, processing of quench-cooled samples, scanning electron microscopy, cryomicroscopy, low-temperature microanalysis, molecular microscopy, and radiation damage.

An international conference on Concentration Mechanisms of Uranium in Geological Environments was held at Nancy, France, October 2-5, 1985.

A symposium on High Heat Production (HHP) Granites, Hydrothermal Circulation and Ore Genesis, under the sponsorship of the Inst. of Mining and Metallurgy was held 22-25 September, 1985, in Cornwall, England.

The Society of Economic Geologists held a Short Course on The Epithermal Environment, October 24-27, 1985, at Port St. Lucie, Florida, in connection with the Geological Society of America Annual Meeting.

The Seventh All-Union Conference on Thermobarogeochemistry was held in L'vov, USSR, September 1985. The abstracts will be found in Volume 18.

At the International Fair in Zagreb, Yugoslavia, September 1985, a new commercially available heating/freezing stage ("cryothermotable") was displayed. Temperature range is -195 +600°C. Further information can be obtained from Institute of Geological Sciences, Alma-Ata, Kazakhstan, 480100 USSR.

Past and Future Meetings

Fluid Inclusion Symposia in People's Republic of China. There have been a series of national meetings in PRC on various aspects of fluid inclusions, but the connection between these meetings and the resulting publications has been difficult to unravel. In 1978 the First National Meeting was held. The 44 papers from this meeting, plus 10 abstracts from earlier (non-national?) meetings were published in 1981 (see Acad. Sinica, 1981, in COFFI volume 14, 1981). Following this 1978 conference, meetings were held with 15 papers on composition (1980) and 51 on decrepitation (1981). All 66 papers (plus 35 "Titles of unpublished papers or those included in other publications") were published as "Vol. 2" (see Anonymous, 1984, in this volume of COFFI. Volume III, dealing with the homogenization, freezing and quenching methods, and edited by Mrs. Jiaxue Wai has not yet been printed. In addition, a 2-day short course on phase diagrams applied to fluid inclusion studies was held, with about 50 people in attendance, at Wuhan Geological College. In October 1985, E. Roedder gave a series of 12 lectures on various aspects of inclusion studies to a class of over 140 inclusioners at Changsha (and elsewhere) in PRC. The Second National Meeting is scheduled for 1987.

Future Meetings

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, will be held April 17-19, 1986, in Nancy. A. Weisbrod, ENSG, BP 452, 54001 Nancy Cedex, France, is Chairman.

The Sixth International Conference on Geochronology, Cosmochronology and Isotope Geology will be held at Cambridge, UK, June 30 - July 4, 1986.

A Fluid Inclusion User School will be 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.

The Forteenth General Meeting of the International Mineralogical Association will be held 13-18 July, 1986, at Stanford University, Stanford, California, U.S.A.

The Fifth International Symposium on Water-Rock Interaction will be held in Reykjavik, Iceland, August 8-17, 1986.

The Seventh IAGOD Symposium will be held at Lulea, Sweden, August 18-22, 1986. A fluid inclusion session will be convened by E. Roedder.

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

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.

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

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,
Egyptian Nuclear Materials Corp.,
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Abbreviations

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

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

*For explanation, please see next page.

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

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

The original author's usage has also been followed on <u>pressure</u>. Most use bars (≈ atm ≈ kg/cm^2), kilobars (kb or kbar), or megabars (Mbar), but others use pascals: one kPa = 0.1 kbar; one GPa = 10^8 bars = 10^5 kbar = 10^2 Mbar. 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, 1984

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 (but perhaps 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.

AHMED, G.A. and BROWN, P.E., 1984, Mississippi Valley type Zn-Pb ores of Stevens and Pend Oreille counties, NE Washington State (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 427. Authors at Dept. Geol., Univ. Wisconsin, 1215 W. Dayton St., Madison, WI 53706.

Most of the zinc-lead deposits of NE Washington State are poorly known examples of Mississippi Valley Type (MVT) mineralization. Several ore deposit morphologies are present but this study has concentrated on the Josephine-type breccia ores. These deposits occur as concordant horizons in the Josephine Breccia of the Cambrian Metaline Limestone. Ore bodies are irregular, ranging in size from pods and lenses a meter thick to deposits with strike expressions of 1 km and thicknesses up to 60 m.

Small (<15 micron) fluid inclusions are present in much of the gangue Qtz, Dol and Cal. Th for Qtz range from 150-250°C while many fewer determinations for Dol and Cal are clustered in the ranges 190-200 and 165-175°C respectively. Further fluid inclusion and stable isotope analyses of ore and gangue are in progress. (From the authors' abstract)

AHUJA, S., ed., 1984, Symposium on Ultrahigh Resolution Chromatography: Am. Chem. Soc. Series, v. 250, 231 pp.

AINES, R.D., KIRBY, S.H. and ROSSMAN, G.R., 1984, Hydrogen speciation in synthetic quartz: Phys. Chem. Minerals, v. 11, p. 204-212. First author at California Inst. Tech., Div. Geol. & Planet. Sci., Pasadena, CA 91125, USA.

The dominant hydrogen impurity in synthetic quartz is molecular H_2O. H-OH groups also occur, but there is no direct evidence for the hydrolysis of Si-O-Si bonds to yield Si-OH HO-Si groups. Molecular H_2O concentrations in the synthetic quartz crystals studied range from less than 10 to 3,300 ppm (H/Si), and decrease smoothly by up to an order of magnitude with distance away from the seed. OH^- concentrations range from 96 to 715 ppm, and rise smoothly with distance away from the seed by up to a factor of three. The observed OH^- is probably all associated with cationic impurities, as in natural quartz. Molecular H_2O is the dominant initial hydrogen impurity in weak quartz. The hydrolytic weakening of quartz may be caused by the tansformation $H_2O + Si - O - Si \rightarrow 2SiOH$, but this may be a transitory change with the SiOH groups recombining to form H_2O, and the average SiOH concentration remaining very low. Synthetic quartz is strengthened when the H_2O is accumulated into fluid inclusions and cannot react with the quartz framework. (Authors' abstract)

AINES, R.D. and ROSSMAN, G.R., 1984a The high temperature behavior of water and carbon dioxide in cordierite and beryl: Am. Mineral., v. 69, p. 319-327. Authors at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125.

We have studied the behavior of molecular water and carbon dioxide in the channels of cordierite and beryl at temperatures up to 900°C using high temperature infrared spectroscopy. Above 400°C water that is structurally bound in the channels begins partitioning into an unbound state with the characteristics of a gas. The process is fully reversible and involves both type I and type II water in both minerals. Dehydration occurs after most of the water is in this unbound state, and channel cations are no longer coordinated by the type II water molecules. These cations can then move to the wall of the channel or be expelled from the channel, opening the channel for dehydration of the water contained in it. This behavior is contrasted with that of muscovite, in which the hydroxide shows no change in speciation and only slight changes in its spectroscopic properties at temperatures below the dehydration point. CO_2 in the channels of cordierite does not undergo major changes in bonding at high temperatures. Although all the water in the cordierite was released, about 40% of the CO_2 remained after heating to 800°C. Heating to 900°C was required to expel all CO_2. This is indicative of the tighter wedging of CO_2 in the channels. Because of an equilibrium among type I, type II, and unbonded gas-like water at high temperature, the concentration of type I alone serves as an indicator of the water fugacity. The type II concentration only responds to the number of channel cations and need not be considered in water fugacity calculations. Cordierites with greater numbers of channel cations will effectively close to re-equilibration at higher temperatures, making them more suitable as indicators of water and carbon dioxide fugacity. (Authors' abstract)

AINES, R.D. and ROSSMAN, G.R., 1984b Water in minerals? A peak in the infrared: J. Geophys. Res., v. 89, no. B6, p. 4059-4071. Authors at Div. Geol. & Planet. Sci., California Inst. Tech.

The study of water in minerals with infrared spectroscopy is reviewed with emphasis on natural and synthetic quartz. Water can be recognized in minerals as fluid inclusions and as isolated molecules and can be distinguished from hydroxide ion. The distinction between very small inclusions and aggregates of structurally bound molecules is difficult. New studies of synthetic quartz using near-infrared spectroscopy are reported. These demonstrate that water molecules are the dominant hydrogen containing species in synthetic quartz but that this water is not in aggregates large enough to form ice when cooled. (Authors' abstract)

AINES, R.D. and ROSSMAN, G.R., 1984c,Water content of mantle garnets: Geology, v. 12, p. 720-723. Authors at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91225.

Garnet megacrysts from Colorado Plateau diatremes (Green Knobs, Garnet Ridge) and the Wesselton kimberlite, South Africa, commonly contain a structural hydrous component. The Colorado Plateau samples range from 0.0 to 0.26 wt% H_2O, and the Essselton samples contain from 0.01 to 0.07%. Concentrations were measured using P_2O_5 cell coulometry, H_2 gas manometry, and thermogravimetry. These were used to calibrate infrared integrated absorbance in the 3-µm region, which is a more sensitive measure of total O-H content than the other analytical methods. Infrared absorbance patterns were also used to differentiate structural hydrous component from water contained in alteration and included phases. The structure of the hydrous component in these garnets appears to be the classic $H_4O_4^{4-} = SiO_4^{4-}$. Profiles at 100-µm intervals across these samples show flat concentration profiles or slightly increasing concentration toward the center. A large range of water content among samples appears to represent real differences in water fugacity at the point where the garnets equilibrated. Garnets in eclogite nodules from South Africa and the Solomon Islands were also studied but were either anhydrous or too badly altered to determine the content of structurally bound water. The high concentration of hydrous component in the Colorado Plateau samples is consistent with other indicators of high volatile content in the region of the mantle. The water content of mantle garnets may prove to be an accurate indicator of mantle-water fugacities. (Authors' abstract)

AKANDE, S.O. and ZENTILLI, Marcos, 1984, Geologic, fluid inclusion, and stable isotope studies of the Gays River lead-zinc deposit, Nova Scotia, Canada: Econ. Geol., v. 79, p. 1187-1211. First author at Dept. Geol. & Mineral Sci., Univ. Ilorin, Ilorin, Nigeria.

The Gays River deposit is the largest carbonate-hosted lead-zinc deposit known in the Mississippian Windsor Group of Atlantic Canada. The orebody mainly occupies one flank of a porous, dolomitized carbonate bank that unconformably overlies a basement ridge of the metasedimentary lower Paleozoic Meguma Group. The orebody consists of: stratiform, disseminated sulfides as open-space fillings in primary and secondary pores of the dolomite and fault-controlled veinlike bodies of high-grade, massive sphalerite and galena. The carbonate bank is overlain by evaporite deposits of Mississippian age.

Underground mapping and laboratory studies suggest four main stages of evolution for Gays River: (1) deposition of the (Visean) carbonate bank, preore evaporite deposition, pervasive dolomitization and growth of diagenetic marcasite, (2) deposition of sphalerite, galena, chalcopyrite, and calcite as a result of influx of hydrothermal metal-rich saline brines into fractures and porous dolomite, (3) postore deposition of calcite, fluorite, barite, marcasite, pyrite, and selenite, and (4) uplift, localized dedolomitization of the mineralized carbonates, and exposure by erosion in Cretaceous times.

Microthermometry of fluid inclusions yields the following mean homogenization temperatures: sphalerite, 215°C; ore-stage calcite, 173°C; postore calcite, 142°C; fluorite, 142°C; and barite, 137°C. Pressure corrections should be minimal for these temperatures. No evidence of boiling was observed in the inclusions. Salinity determinations from the ice-melting temperatures of inclusions in postore fluorite and calcite yield a value of ca. 20.4 equivalent wt. percent NaCl for the hydrothermal fluid during the waning stages of mineralization.

Isotopic analyses indicate that anhydrite and gypsum in the overlying evaporites and barite within the orebody are enriched in heavy sulfur ($\delta^{34}S$ = 13.1-16.5‰), suggesting a Mississippian seawater source. Ore-stage sphalerite, galena, and chalcopyrite probably derived their sulfur ($\delta^{34}S$ = 8.0-13.65‰) from sulfates or possibly a homogenized basement source. Postore marcasite and pyrite are characterized by light, probably biogenic, sulfur ($\delta^{34}S$ = -9.7 to -46‰). Mineralized carbonates are significantly depleted in the heavier isotopes of oxygen and carbon with respect to their unmineralized equivalents. Preliminary lead isotope data for galena suggest that the metasedimentary basement was a source of lead.

This study disputes an earlier interpretation that the stratiform lead-zinc ores are an early low-temperature diagenetic cement of the carbonate bank. The high-grade zones are not residual concentrations related to sinkholes as originally thought. Instead, both disseminated and massive ores are probably the result of the same mineralizing episode involving deeply convecting brines, or brines expelled during basin dewatering under high geothermal gradients in the late Paleozoic. (Authors' abstract)

ALABASTER, C, 1984, Native sulphur from Stancombe Quarry, Flax Bourton and Dan-y-graig Quarry, Risca (S. Wales): Proc. Bristol Naturalists' Soc., v. 43, p. 13-27.

Crystalline α-sulphur occurs as a supergene alteration product of galena. Fluid inclusion data suggest a formation T of <50°C for the sulphur, which is currently forming as a result of chemical leaching of galena by highly acidic Fe^{3+}-bearing ground-water resulting from bacterially assisted oxidation of disseminated pyrite adjacent to the galena. (From Min. Absts.)

ALBINO, G.V., 1984, A Proterozoic volcanic peridotite-associated nickel deposit, Ungava, Quebec (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 41. Author at Dept. Earth Resources, Colorado State Univ., Fort Collins, CO, USA 80526.

The Boundary Ni-Cu(-PGE) deposit is located at the eastern end of the Aphebian Cape Smith-Wakeham Bay Foldbelt in northern Quebec. The mineralized ultramafic body occurs at the contact of two thick basaltic sequences, a lower tholeitic and an upper komatiitic suite.

The host ultramafic body consists of a cigar-shaped feeder 'sill' and four related komatiite flows, which are confined to an elongate (fault-bounded?) trough. High-grade Ni sulphide ore occurs in both the intrusive and extrusive units, and is concentrated in the thicker, olivine-rich central part of the complex. The three lowermost ultramafic units are well-mineralized, with the 'ore' zones becoming thinner, but more laterally extensive, up-section. Massive, net-textured and disseminated ore, consisting of pyrrhotite, pentlandite, chalcopyrite and magnetite occurs at or near the base of the mineralized units. 'Droplet' sulphides are common in the chilled upper zone of one of the flows, indicating that the magma was S-saturated at the time of eruption.

Greenschist facies metamorphism has modified primary sulphide-silicate textural relationships, and has mobilized Cu, Ni, Co and S into footwall stringer zones. Primary igneous minerals, except for augite oikocrysts, have been altered to serpentine, tremolite, chlorite, magnetite and carbonates. Original igneous textures are, for the most part, preserved.

The Boundary deposit, hosted mostly by extrusive komatiites, differs from previously described deposits in the Cape Smith Belt, which occur in sub-volcanic intrusions. It is more similar in form and setting to the Archean deposits of Western Australia, southern Africa and the Abitibi Belt, differing chiefly in lacking associated olivine spinifex textured volcanics. (Author's abstract)

ALEKHIN, Yu.V. and SRETENSKAYA, N.G., 1983, The system H_2O-H_2S, in Experimental studies of endogeneous ore formation: "Nauka" Publ. House, Moscow, p. 61-89 (in Russian).

The paper presents temperature relation of dissociation constants of H_2S (at 25, 100, 200 and 300°C), pressure relation of the first dissociation constant of H_2S, P-T data on equilibrium L-G for H_2S, P-T plot of equilibria in the system H_2O-H_2S (P from 10^{-5} to 10^4 bars, T from -200 to +400°C), table of compositions of coexisting G and L in the system H_2O-H_2S at 310-444 K, 293-303 K and 433-603 K, plots of isotherms and isobars of H_2S solubility in water. (A.K.)

ALEXEYEV, V.A., MEDVEDEVA, L.S. and RAFALSKY, R.P., 1984, Kinetics of sulfur interaction with water under high temperatures: Geokhimiya, 1984, no. 7, p. 1020-1028 (in Russian; English abstract).

Based on experimental data obtained at 180 to 250°C, the following were calculated: equation of rate of reaction of sulfur with water, equation of temperature dependence of specific constant of the rate, and energy of activation of the reaction (37-43 kcal/mol). A time of achievement of equilibrium and a value of supersaturation of solutions in process of their transport to the surface are estimated. It was shown that supersaturation is possible at temperatures lower [than] 150-170°C only in hydrothermal systems which are characterized by high permeability. If the near-surface zone of stagnant waters [is] present, the interaction of hydrogen sulfide and sulfate sulfur can be the reason for formation of volcanogenic deposits of native sulfur. (Authors' abstract)

ALLEGRE, C.J., 1984, History and structure of the mantle studied by rare gases systematics (abst.): Terra Cognita, v. 4, no. 2, p. 197.

ALLEN, Dermot, 1984, A one-stage precision polishing technique for geological specimens: Min. Mag., v. 48, p. 298-300.

ALVES, J.V. and FUZIKAWA, K., 1984, Fluid inclusion study of the Cachoeira uranium deposit, Caetité, Bahia - Preliminary results: Anais do XXXIII Congresso Brasileiro de Geol., Rio de Janeiro (Proc. 33rd Brazilian Geol. Congress), p. 1503-1517 (in Portuguese; English abstract). Authors at Nuclebrás, Av. Uruguai 531, Belo Horizonte, Minas Gerais, Brazil.

The Cachoeira uranium deposit is presently the richest deposit among those in the Lagoa Real Uranium Province. The mineralization is associated to the albitites formed during the onset of strong sodium metasomatism on the granite-gneissic rocks of the area.

Fluid inclusion study of several uraniferous albitites indicated the presence of strong brines ($\approx$20 wt.% NaCl equiv.) and the dominance of hydrocarbons over CO_2 in the gas phase. In country rocks, which are the hosts of the albitites, and in unmineralized albitites the salinity of aqueous solutions is variable and light hydrocarbons are the predominant gas phase.

These data have been obtained by microthermometry and crushing tests from a larger set of samples than that used in previous studies. However, the results do not differ significantly from the data of these earlier works and reinforce the hypothesis of the importance of CH_4 in UO_2 precipitation. (Authors' abstract)

ANAN'YEV, V.V. and SHNYREV, G.D., 1984, Garnet in melt inclusions from olivine in the Ol-An-segregations (Ksudach volcano, Kamchatka): Akad. Nauk SSSR Doklady, v. 274, no. 2, p. 402-406 (in Russian). Authors at Inst. Volcanol., Petropavlovsk-Kamchatskiy, USSR.

Olivine-anorthite nodules are typical examples of association of protocrysts of K-low alumina basalt melts. The studied specimen has composition, Fo 80 + An 96, olivine crystallized before plagioclase. Melt inclusion size in olivines ranges from few µm to 0.5 mm, the filling consists of glass with variable amount of fine crystals. Two kinds of dms were recognized: garnet (in wt. %): SiO_2 38.59, TiO_2 1.22, Al_2O_3 15.34, Fe_2O_3 8.88, FeO 7.81, Mn 0.18, MgO 5.76, CaO 21.42, Na_2O 0.19, K_2O not found, average of 3 electron microprobe analysis, Fe_2O_3 calculated from garnet stoichiometry, and amphibole: SiO_2 39.91-42.72, TiO_2 0.84-1.09, Al_2O_3 16.33-17.97, total Fe as FeO 15.29-18.5, MnO 0.19-0.25, MgO 5.93-8.69, CaO 12.15-15.72, Na_2O 0.91-1.76, K_2O 0.1-0.19 (four electron microprobe analyses); inclusion glass has the following composition: SiO_2 48.18-51.20, TiO_2 0.85-0.89, Al_2O_3 18.57-21.56, total Fe as FeO 4.28-9.68, MnO 0.14-0.15, MgO 0.94-3.58, CaO 12.82-12.85, Na_2O 1.20-2.46, K_2O 0.24 (two analyses). Garnets of the above composition are rare in eruptive rocks, most similar are garnets from kyanite eclogites and grospydites from kimberlite pipe "Udachnaya;" generally they place in the field of garnets from migmatites and autochthonous plutons formed in the granulite level of the Earth's crust. Th of inclusions in similar olivines from Malyi Semyachik and Kikhpinydr volcanoes are 1430-1270°C. Hence, probably dm parageneses formed during rapid T decrease from 1430-1270°C and P of granulite facies. (Abstract by A.K.)

ANDERSEN, T.B., 1984, Inclusion patterns in zoned garnets from Magerøy, north Norway: Mineralogical Mag., v. 48, p. 21-26. Author at Geol. Inst. Avd. A., 5014 Univ. Bergen, Bergen, Norway.

Discussion of the several types of solid inclusions may help in understanding the significance of fluid inclusions among or attached to such solids from other localities. (E.R.)

ANDERSEN, T., O'REILLY, S.Y. and GRIFFIN, W.L., 1984, The trapped fluid phase in upper mantle xenoliths from Victoria, Australia: implications for mantle metasomatism: Contrib. Mineral. Petrol., v. 88, p. 72-85. First author at Inst. Geol., Univ. Oslo, Blindern, Oslo 3, Norway.

Mantle-derived xenoliths of spinel lherzolite, spinel pyroxenite, garnet pyroxenite and wehrlite from Bullemerri and Gnotuk maars, southwestern Victoria, Australia, contain up ot 3 vol.% of fluids trapped at high pressures. The fluid-filled cavities range in size from fluid inclusions (1-100 µm) up to vugs 1-1/2 cm across, lined with euhedral high-pressure phases. The larger cavities form an integral part of the mosaic microstructure. Microthermometry and Raman laser microprobe analysis show that the fluids are dominantly CO_2. Small isolated inclusions may have densities $\geqslant 1.19$ g/cm^3, but most inclusions show microstructural evidence of partial decrepitation during eruption, and these have lower fluid densities. Mass-spectrometric analysis of gases released by crushing or heating shows the presence of He, N_2, Ar, H_2S, CO_S [sic; probably COS] and SO_2 in small quantities; these may explain the small freezing-point depressions observed in some inclusions. Petrographic, SEM and microprobe studies show that the trapped fluids have reacted with the cavity walls (in clinopyroxene grains) to produce secondary amphiboles and carbonates. The trapped CO_2 thus repesents only a small residual proportion of an original volatile phase, which has undergone at least two stages of modification - first by equilibration with spinel lherzolite to form amphibole (± mica ± apatite), then by limited reaction with the walls of the fluid inclusions. The inferred original fluid was a CO_2-H_2O mixture, with significant contents of (at least) Cl and sulfur species. Generation of this fluid phase in the garnet-peridotite stability field, followed by its migration to the spinel peridotite stability field, would provide an efficient mechanism for metasomatic enrichment of the upper mantle in LIL elements. This migration could involve either a volatile flux or transport in small volumes of silicate melt that crystallize in the spinel peridotite field. These observations suggest that some portions of the subcontinental upper mantle contain large reservoirs of free fluid CO_2, which may be liberated during episodes of rifting or magmatism, to induce granulite-facies metamorphism of the lower crust. (Authors' abstract)

ANDERSON, A.T., Jr., 1984, Probable relations between plagioclase zoning and magma dynamics, Fuego Volcano, Guatemala: Am. Mineral., v. 69, p. 660-676. Author at Dept. Geophys. Sci., The Univ. Chicago, Chicago, IL 60637.

Millimeter-sized plagioclase phenocrysts were explosively erupted in high-alumina basaltic ash from Fuego volcano, Guatemala on October 14, 1974. The crystals have unzoned, patchy-zoned and oscillatory-zoned parts. Unzoned, inclusion-poor cores, up to 2 mm thick have round edges and compositions between An_{97} and An_{88}. Patchy-zoned cores and regions are rich in inclusions of glass and gas, about 50 μm thick and An_{90} to An_{83}. Oscillatory-zoned regions surround the cores and occur between patchy-zoned regions; compositions are An_{90} to An_{83} except for thin rims (An_{75} to An_{70}).

Patchy-zoned, inclusion-rich regions probably crystallized in gas-saturated environments during episodes of relatively large supersaturation because: (1) such regions are either cores (homogeneous nucleation?) or have flat inner terminations suggestive of a constructive rather than resorptive origin, (2) most such regions are relatively sodic (relatively large concentration gradients in the nearby melt?), (3) such regions terminate outward with irregular, convolute oscillatory zones suggestive of morphological instability, and (4) such regions are rich in inclusions of gas many of which are large and flat against the inner boundary suggesting onset of patchy-zoned growth together with effervescent decompression. Crystallization with effervescence is supported by decreasing Cl/K_2O with increasing K_2O for inclusions of glass. Patchy-zoned regions alternating with oscillatory-zoned regions suggest episodes of accelerated decompression.

Oscillatory zones are 0.5 to 8 μm thick; average internal compositional variation is about 1% An, with the most calcic portion being earliest. Although individual zones are thinnest on {010}, many thin zones on some forms correspond to non-oscillatory-zoned growth on {010} and other slow-growing forms, not cessation of growth. Consequently, zones are generally thinnest and most numerous on the fastest growing forms: {001}, {201}, {110}, and {110}. Discontinuous zones suggest dominant sideways rather than radial growth for individual zones. Thickening of zones on irrational or curved surfaces and in reentrants suggest dominant surface-attachment control of growth rate. Most of the zones correlate between opposite faces of the same crystal form on individual crystals. Some zones correlate between different crystals. The number of zones from the outside of the crystals to patchy-zoned regions or other disturbances cluster around 25 and 50. The various textural and compositional features of the zones are consistent with modulation of growth by hypothetical pulses of upward motion of a gas-saturated magma which sheared the boundary layer of melt near the growing crystals, thereby renewing the level of supersaturation of the crystal face. Tidal triggering of the motion seems likely. The oscillatory zones on the fast growing faces of the Fuego plagioclases probably are twice daily "ticks" of a volcanological "clock."

Probably the Fuego magma body inherited initial unzoned crystals (cores). Subsequent growth probably accompanied ascent and was alternately patchy or oscillatory, possibly associated with various distances from the walls of the body: a crystal temporarily near a wall might ascend relatively slowly, experience only moderate decompression and supersaturation, and consequently grow only oscillatory zones; a crystal near the center of the body might ascend rapidly, experience greater decompression and supersaturation, and consequently grow some patchy-zoned regions. Explosive eruption could coextrude crystals from the various environments. (Author's abstract)

ANDERSON, A.T., Jr., SWIHART, G.H., ARTIOLI, Gilberto and GEIGER, C.A., 1984, Segregation vesicles, gas filter-pressing, and igneous differentiation: J. Geol., v. 92, p. 55-72. Authors at Dept. Geophys. Sci., The University of Chicago, Chicago, IL 60637.

Some vesicles in certain subaerial flows of basalt and basaltic andesite are partially filled with dark, partly-glassy segregation material. The segregation material has about three times the concentration of K_2O, TiO_2, and P_2O_5 as the associated host rock. Therefore, the segregation materials are inferred to be frozen residual liquids that migrated into the vesicles. Several possible processes for filling the vesicles are examined within the context of the cooling time implied by heat conduction. The preferred process is one in which the residual liquid migrates through a porous and permeable, but rigid, network of interlocking crystals in response to a pressure gradient generated by vapor saturated crystallization. As crystallization proceeds H_2O is concentrated in the residual liquid and gas. This produces a higher pressure in the gas-poor matrix than in the vesicles and forces liquid to migrate into the vesicles. Textural features suggestive of or consistent with the process include: (1) vesiculation of segregation material, (2) convex perforations of the segregation lining of vesicles, (3) vuggy voids in the matrix, and (4) bubbles in residual glass. We suggest that filter pressing by gas effervescence may petrologically be important to crustal depths as great as several kilometers. (Authors' abstract)

ANDERSON, G.M., 1984, Sulfate reduction and sulfide precipitation in carbonate rocks: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 3-7.

ANDERSON, R.N., 1983, Boiling deep beneath the ocean: Nature, v. 303, p. 283. Author at Lamont-Doherty Geol. Observatory Columbia Univ., Palisades, NY 10964.

Discusses the concept of Delaney and Cosen (1982, Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 51-52) that highly saline fluids can form in deep sea geothermal systems. See rebuttal by Hedenquist (this volume). (E.R.)

ANDRAWES, F., HOLZER, G., ROEDDER, E., GIBSON, E.K., Jr. and ORO, J., 1984a, Gas chromatographic analysis of volatiles in fluid and gas inclusions (abst.): Advances in Chromatography Meeting, New York, N.Y., April

1984, Program p. 22.
See next item. (E.R.)

ANDRAWES, F., HOLZER, G., ROEDDER, E., GIBSON, E.K., Jr. and ORO, J., 1984, Gas chromatographic analysis of volatiles in fluid and gas inclusions: J. Chromatography, v. 302, p. 181-193. First author at Am. Cyanamid Co., Chem. Res. Div., 1937 West Main St., Stanford, CT 06904, USA.

Most geological samples and some synthetic materials contain fluid inclusions. These inclusions preserve for us tiny samples of the liquid and/or the gas phase that was present during formation, although in some cases they may have undergone significant changes from the original material. Studies of the current composition of the inclusions provide data on both the original composition and the change since trapping.

These inclusions are seldom larger than 1 millimeter in diameter. The composition varies from a single major compound (e.g., water) in a single phase to a very complex mixture in one or more phases. The concentration of some of the compounds present may be at trace levels.

We present here some analyses of inclusions in a variety of geological samples, including diamonds. We used a sample crusher and a gas chromatography-mass spectrometry (GC-MS) system to analyze for organic and inorganic volatiles present as major to trace constituents in inclusions. The crusher is a hardened stainless-steel piston cylinder apparatus with tungsten carbide crushing surfaces, and is operated in a pure helium atmosphere at a controlled temperature.

Samples ranging from 1 mg to 1 g were crushed and the released volatiles were analyzed using multi-chromatographic columns and detectors, including the sensitive helium ionization detector. Identification of the GC peaks was carried out by GC-MS. This combination of procedures has been shown to provide geochemically useful information on the processes involved in the history of the samples analyzed. (Authors' abstract)

ANDREWS, A.J., KERRICH, R. and OWSIACKI, L., 1984, Petrographic and geochemical studies of the Ag-Co-Ni arsenide vein deposits, Cobalt and Gowganda, Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 42. First author at Ontario Geol. Survey, Toronto, Ontario, M5S 1B3, Canada.

This study is an attempt to characterize on a reconnaissance basis, the source, transport medium, depositional environment and timing of these vein deposits. It is based on detailed mapping and petrographic-geochemical examination of samples collected from the six operating mines in the Cobalt and Gowganda camps.

Throughout both camps the vein systems exhibit a general uniformity in their petrography and paragensis. The precipitation of Ag and related arsenides occurred during the transition from an early silicate dominated to a later carbonate dominated fluid environment. The silicate comprise actinolite, chlorite, K-feldspar and quartz. The carbonate is mainly calcite with minor dolomite. Stable iosotpe (O, H) and fluid inclusion analyses indicate that the ore fluids were heated, highly saline formation brines indigenous to the Huronian sediments. Vein precipitation occurred mostly between 200-300°C, possibly accompanied by boiling. The distribution of strong Na-metasomatism indicates that hydrothermal activity was widespread affecting large volumes of the country rocks well beyond the area of known mineralization.

The geochronology of the deposits was investigated by ^{40}Ar-^{39}Ar analysis of vein silicates and paleomagnetic examination of their hematite and magnetite bearing alteration halos. The preliminary results are equivocal, suggesting that the viens and mineralization either formed close to the age of the Nipissing diabase (~2100 my) or much later, between 1700-1600 my. (Authors' abstract)

ANDRIESSEN, P.A.M., HEBEDA, E.H. and VERSCHURE, R.H., 1984, K-Ar dating of tourmalines: a reappraisal (abst.): Terra Cognita, v. 4, no. 2, p. 203.

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).

ANGUS, J.G., BEVERIDGE, David and RAYNOR, J.B., 1984, Dolomite thermometry by electron spin resonance spectroscopy: Chem. Geol., v. 43, p. 331-346. First author at Dept. Geol., Univ. Leicester, Leicester LE1 7RH, Great Britain.

Electron spin resonance (ESR) spectroscopy has been used to distinguish different genetic types of dolomite in the complex metamorphic terrain of the Ballachullish area of NW Scotland. By measuring the ESR signals of Mn^{2+} from the two inequivalent sites in dolomite, the partition coefficient can be determined and related to temperature. A systematic one hundred fold increase in the partition coefficient from the highest grade of contact metamorphic skarn to supergene dolomites was found. The use of this partition coefficient complements fluid inclusion and gross chemical data and is a useful aid in geothermometry. (Authors' abstract)

ANONYMOUS, ed., 1984, Studies of fluid inclusions in minerals, Symp. Nat'l. Meeting on Composition Research and Decrepitation Method of Fluid Inclusions in Minerals, Vol. 2: Geol. Pub. House, Beijing, 246 pp. (in Chinese). See Translations.

ANTHONY, E.Y., REYNOLDS, T.J. and BEANE, R.E., 1984, Identification of daughter minerals in fluid inclusions using scanning electron microscopy and energy dispersive analysis: Am. Mineral., v. 69, p. 1053-1057. First author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

Scanning electron microscopy combined with energy dispersive analysis provides a method for identification of daughter minerals in fluid inclusions. Previous studies using this method have not applied absorption and fluorescence corrections to the spectrum; thus stoichiometry of the minerals was not determined and ambiquities in characterization remain. We have found that, despite the irregular surface geometry of daughter minerals in the fluid inclusions, use of standard data reduction programs yields compositions which are sufficiently accurate to allow identification in many instances.

Inclusions in quartz associated with early potassic alteration from the Santa Rita porphyry copper deposit, New Mexico, were examined in this study. Standard fluid inclusion plates revealed the existence of a number of minerals in the inclusions which met the criteria for daughter rather than trapped minerals, viz. occurrence of the same minerals, and the same proportions of phases, in many inclusions. These daughter minerals and their average elemental ratios as determined in this study are: halite (Na = 1.00, Cl = 1.00), sylvite (K = 1.07, Cl = 1.00), chalcopyrite (Cu = 1.06, Fe = 1.07, S = 2.00), anhydrite (Ca = 1.07, S = 1.00), potassium feldspar (K = 0.87, Na = 0.16, Al = 1.00), phengitic muscovite (K = 1.00, Al = 2.66, Fe = 0.56), and iron-rich trioctahedral mica (K = 1.00, Al = 3.16, Fe = 1.83). (Authors' abstract)

AOYAGI, Koichi and ASAKAWA, Tadashi, 1984, Paleotemperature analysis by authigenic minerals and its application to petroleum exploration: The Am. Assoc. Petroleum Geol. Bull, v. 68, no. 7, p. 903-913. First author at Tech. Res. Center, Japan Nat'l. Oil Corp., 2-2-2 Uchisaiwaicho, Chiyoda-ku, Tokyo 100, Japan.

Transformation temperatures of authigenic minerals (e.g., clay minerals, zeolites, etc.) are used to establish paleogeothermal gradients. (E.R.)

ARCULUS, R.J., 1984, Redox states of the upper mantle (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 219 (in English).

AREVADZE, D.V. and YAROSHEVICH, V.Z., 1984a, The origin and sources of substances of some juvenile volcanogenic deposits in the USSR: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 23-31.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 6-7. (E.R.)

AREVADZE, D.V. and YAROSHEVICH, V.Z., 1984b Sources of ore-bearing solutions based on fluid inclusion isotope data (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 8-9 (in English). Authors at Caucasian Inst. Mineral Resources of USSR Ministry Geol., Tbilisi, USSR.

Genetic interpretation of isotopic investigations of elements in minerals is greatly complicated due to usually disequilibrium crystallization conditions. This drawback can be avoided by isotopic study of water-H, carbon dioxide-C and Ar in fluid inclusions. Some attempts have been undertaken to determine the isotopic compositions of O (in H_2O and CO_2), He, N, S (in SO_2), Pb and Sr. These studies indicate that ore-forming solutions in the great majority of high-temperature deposits (pegmatite, rare-metallic, skarn, Cu-Mo) at initial stages of their development have a deep-seated origin, whereas at later stages these fluids are mixed with surface waters. The same situation is characteristic of a number of pyrite-polymetallic, vein-type and metasomatic deposits, in which, however, a considerable part of surface water is remarkable, even in early stages. In stratabound Cu pyrite and pyrite-polymetallic deposits the hydrothermal-sedimentary stage ores are characterized by seawater; the water of the later stages is meteoric. In the studied Au-Ag deposits only meteoric water is typical. In stratiform Pb-Zn deposits, as well as As-Sb-Hg, deep-seated or meteoric fluids are intensively altered as a result of their interaction with wall rocks.

The great majority of endogeneous deposits are characterized by a deep-seated source of carbon, except deposits in carbonate rocks, where the fraction of sedimentary and biogenic C is considerable. Ar in fluid inclusions represents the water regime. In the initial stages of high-temperature deposits Ar is deep-seated, whereas the later stages are distinguished by increased content of air constituent.

Results of isotopic investigations of fluid inclusion components in addition to sulphur isotope data indicate that deep-seated matter plays a considerable role during the formation of endogeneous ore deposits. (Authors' abstract)

ARNETH, J.-D and MATZIGEIT, U., 1984, The behavior of δ^{13}C org) and δ^{13}C(bit) isotope ratios during the stages of diagenesis and catagenesis: results from natural sediments and thermal maturation experiments (abst.):

Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 220-221 (in English).

ARUTYUNYAN, L.A., MALININ, S.D. and PETRENKO, G.V., 1984, Solubility of pyrrhotite in chloride solutions under high temperature and pressure: Geokhimiya, 1984, no. 7, p. 1029-1039 (in Russian; English abstract).

Using the method of loss in weight a solubility of synthetic pyrrhotite $Fe_{10}S_{11}$ in solutions of HCl, NH_4Cl, $MgCl_2$ and NaCl in the range of temperatures 200-500°C and pressures 300-1200 atm was studied. Direction of shift of equilibrium of the dissolution reaction from temperature is determined by 1) decrease of the activity product with temperature (that decreases a solubility) and 2) decrease of dissociation constant $K(H_2S)$ and increase of complex-formation of metal with Cl^- along with temperature increase (factors increasing the solubility). Because the two last factors are predominant, solubility increases with temperature. An important peculiarity of solubility of pyrrhotite in solutions of hydrolyzed salts (NH_4Cl, $MgCl_2$) is the negative effect of pressure on solubility: at 400°C within the pressure range 300-1200 atm the solubility value is decreased almost twice. This is explained by large positive volume effect of reaction (approximately 130-230 cm^3/mol); the latter should be attributed to large values of $V(H_2S)$ (the reaction product) judging by value of $V(CO_2)$ (keeping in mind an analogy in properties of CO_2 and H_2S in their aqueous solutions). Volume effects of reactions "dissolution-precipitation" of sulfides (due to their significant value) should be taken into account in quantitative models of sulfide-formation at temperatures higher than 250-300°C. (Authors' abstract)

ASH, J.P. and KYLE, J.R., 1984, Fluid inclusion evidence for fluorite mineralization associated with peralkaline rhyolite intrusions, Paisano mine, Trans-Pecos Texas (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 433. Authors at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78713.

Fluorite deposits in Trans-Pecos Texas and contiguous Coahuila, Mexico, occur within Cretaceous limestones and typically are associated with Tertiary hyabyssal rhyolitic intrusions. Paisano and other fluorite deposits in the Christmas Mountains are comprised of stratabound concentrations of fine-crystalline fluorite with minor quartz, chalcedony, and calcite, and lesser pyrite, molybdenite, and cinnabar. These deposits formed by passive replacement of favorable limestone beds along contacts with peralkaline rhyolites and along post-intrusion faults which provided conduits for ascending F-rich solutions. Less significant fluorite concentrations occur as vein- and pore-fillings in limestone and argillized rhyolite.

Th of 350 type I fluid inclusions in fluorite indicate that mineralization took place over a range of 165 to 215°C. Tm of inclusion fluids indicate that the mineralizing fluids were relatively dilute, ranging from 0.1 to 1.5 wt % NaCl equivalent. Fluid inclusions in fluorite from manto concentrations tend to be lower in temperature and less saline than those in associated mineralized conduits, suggesting that ascending higher temperature solutions locally mixed with cooler, dilute ground water at the site of fluorite deposition. The nature of the fluorite concentations, fluid inclusion data, and the alteration assemblage of the rhyolites indicate that the mineralizing fluids were relatively acidic. The Paisano deposit represents a fossil geothermal system in which heated meteoric water may have become F-rich through the alteration of mafic minerals in peralkaline rocks. Fluorite was precipitated as the result of cooling and neutralization accompanying dissolution of the host limestones. (Authors' abstract)

ASHMYAN, K.D., SKRIPKA, 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). Authors at All-Union Oil & Gas Res. Inst., Moscow, USSR.

The solubility of CH_4 and N_2 in water were determined at 350°C and 98 MPa. (E.R.)

AVADICH, P.C., 1984, Nature of fluid inclusions in barite of Jagat area, Udaipur district, Rajasthan: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 14. Author at Dept. Geol., Univ. Rajasthan, Udaipur, India.

Barite mineralization in Jagat area occurs in granite gneisses and mica schists belonging to Banded Gnessic Complex. Association of other minerals is lacking, however, minor quantities of calcite and quartz are seen in some veins.

Barite is white, off-white and pink in color and is medium to coarse grain in size. The fluid inclusions found in barite are small (5-15 μm) and two-phase. Freezing studies indicate that the fluids have low dissolved salts content (4-9 equivalent wt.% NaCl). Upon heating the fluid inclusions homogenize in liquid phase, with Th 169.5°C-205°C. (Author's abstract)

AVADICH, P.C. and RANAWAT, P.S., 1984, Fluid inclusion study of fuchsite-quartzite of Jagat area Udaipur, Distt. (Rajasthan): Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 21. Authors at Dept. Geol., Univ. Rajasthan, Udaipur, India.

The paper describes the fluid inclusion study of fuchsite-quartzite occurring in Banded Gneissic Complex of Jagat area. Minerals other than fuchsite present in quartzite are ilmenite, leucoxene and rutile.

P fluid inclusions in quartz of the quartzite show aqueous phase and a vapor bubble. Trails of S inclusions (biphase) are present. P and S inclusions are small in size (2-18 μm). P inclusions have Th 244°C-277°C. Low-density CO_2 has been observed in some of the P inclusions (dCO_2 = 0.164 to 0.221). Te range of -33°C to -35°C indicates presence of $MgCl_2$ in the aqueous phase, Tm of which gives salinity range of 8.94 to 18.79 eq. wt. % NaCl. (Authors' abstract)

BAKUMENKO, I.T., BAZAROVA, T.Yu., PANINA, L.I., SIMONOV, V.A. and KOSUKHIN, O.N., 1984, Specific features of equilibrium and non-equilibrium magma crystallization as based on inclusion study (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 12 (in English). First author at Inst. Geol. & Geophy. Siberian Br. USSR Acad. Sci., Novosibirsk, USSR.

Thermobarogeochemical methods were applied to studying crystallization conditions of alkaline-earth and alkaline magmas, beginning with subliquidus early magmatic minerals. Their temperatures and the succession of crystallization were determined. In some of the ophiolitic massifs a similarity between the crystallization temperatures of clinopyroxenes of gabbroid rocks and that of the dike rock series was established. Microprobe analyses of the melt inclusions permitted one to prove the differentiation trends in the closed alkaline-basalt systems: it was found that the residual melts here are enriched in potassium and aluminium. This provides a new approach to the problem of generation of the ultra-potassic high aluminous synnerite-type rocks. The examination of inclusions has shown both mixing and contamination of the magmas. Thus Armenian syenite-porphyries were formed as a result of mixing of tephritic and phonolitic magmas, that may explain the compositional disequilibrium of genetically different phenocrysts and the differences in the composition of inclusions contained in them. It was shown that formation of rhythmically banded quartz-porphyry, granite-porphyry and pegmatites is due to the effect of non-equilibrium magmatic crystallization under conditions of directed diffusion. The study of the accompanying fluid inclusions of magmatic stage has provided data on the composition and pressure maintained in magmatic fluids and the conditions of magma degassing. The difference in the fluid regime during crystallization of pegmatite magmas of residual and anatexic genesis has fixed the boundaries of the magmatic stage of pegmatite generation; the existence of cavities inherent to a magmatic stage has been fixed as well as the peculiarities in variable fluid composition during transport of degassing basic magmas ascending from the zones of generation to the surface. (Authors' abstract)

BAKUMENKO, I.T., BAZAROVA, T.Y., PANINA, L.I., SIMONOV, V.A. and KOSUKHIN, O.N., 1984b, Peculiarities in the equilibrated and disequilibrated magma crystallization as based on the data of inclusions study: Akad. Nauk SSSR, Sib. Otdel., Geol. I Geofiz., 1984, no. 8 (296), p. 81.

See previous abstract. (E.R.)

BAKUMENKO, I.T. and KOSUKHIN, O.N., 1981, Magmatic quartz in cavities of chamber pegmatite: Dokl. Akad. Nauk SSSR, v. 258, no. 6, p. 1441-1445 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., v. 258, p. 152-156, 1983).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 9, 1981. (E.R.)

BAKUMENKO, I.T., et al., 1984, Faceted inclusions in diamond crystals: Akad. Nauk SSSR Doklady, v. 278, no. 6, p. 1461-1465 (in Russian).

Deals with solid inclusions; no fluid inclusion data. (A.K.)

BALASHOVA, S.P., 1983, A model for ore formation associated with waters of nonmagmatic origin (in Russian; translated in Int. Geol. Rev., v. 26, p. 26-39, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 10, 1983. (E.R.)

BALLURKAR, Ashok and SABNAVIS, Murali, 1984, A simple equipment for homogenization of two-phase liquid inclusion in minerals: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 29. Author at Center of Explor. Geophys., Osmania Univ., Hyderabad 500007.

The T of formation of a mineral can be estimated from the associated transparent minerals by the homogenization of two-phase (liquid-gas) inclusions usually found in them. Appropriate equipment to carry out such studies is not yet available in India. A simple and inexpensive experimental setup has been designed and fabricated by the authors for the purpose of carrying out homogenization and measurement of corresponding temperatures. The paper deals with the description of the setup along with some practical observations. (Authors' abstract)

BANNER, J.L., PROSKY, J.L., HANSON, G.N. and MEYERS, W.J., 1984, Multiple episodes of dolomitization in the Burlington-Keokuk limestone (Mid-Miss.): evidence from trace element and isotopic variations (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 436. Authors at Dept. Earth & Space Sci., SUNY, Stony Brook, NY 11794.

Pervasive dolomitization of lime-mudstone is observed over tens of thousands of square miles in the Osagean Burlington-Keokuk Limestone of Iowa, Illinois and Missouri. At least two generations of dolomite can be defined using cathodoluminescent petrography. These two differ in $^{87}Sr/^{86}Sr$, $\delta^{18}O$, REE, Sr, Fe, and Mn contents, and epsilon Nd values.

These results suggest that the earlier dolomitizing fluid was predominantly Mississippian seawater, or the fluid did not significantly affect the isotopic ratios of the marine carbonate precursors. Later fluids resulted in the replacement of dolomite I with dolomite II, and imparted iron enrichment and a more radiogenic Sr and depleted ^{18}O isotopic signature to dolomite II. These later fluids may have been similar to the basinal brines which have been proposed as agents of Mississippi-Valley type mineralization around the Illinois Basin. (Modified from the authors' abstract)

BANNIKOVA, L.A., KOLESOV, G.M. and BARSUKOV, V.L., 1983, Metals in bitumoids from some hydrothermal deposits: Geokhimiya, no. 8, p. 1139-1149 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 4, p. 123-131, 1984). Authors at Inst. Geochem. and Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Neutron activation applied to bitumoids extracted from mineral associations in certain hydrothermal deposits shows that the levels of the elements in ppm in the chloroform bitumoids are Au 0.007-0.33, Cu 3.9-25, As 8.2-859, Sn 0.017-0.63, Ag 0.00014-0.25, Sb 0.22-2.2, Na 0.08-1.9, and Br 750-11,300, while those in the alcohol-benzene bitumoids are Au 0.05-0.27, Cu 34-91, As 37-3590, Ag 2-260, Sb 0.56-1.5, Na 9900-17,400, and Ba 1.4-9.9. The bitumoids from deposits of different types contain the same metals, and there are no substantial variations in amount with type of deposit. There is, however, the following trend in the contents for various stages of the hydrothermal systems: the deposition of the ore associations and the related oxidation of organic matter under hydrothermal conditions are accompanied by reduction in the metal contents in the bitumoids, which may indicate that the metals at certain stages exist as complexes with organic compounds, whose oxidative destruction releases the metals and causes them to deposit as mineral phases. The character and amounts of the mineral phases are controlled by the physicochemical conditions, not by the presence or absence of certain metals in the solutions. (Authors' abstract)

BANNIKOVA, L.A. and RYZHENKO, B.N., 1984, Isotopic ratios of carbon and sulfur in the products of redox reactions in hydrothermal conditions (the system of CH_4-Na_2SO_4-NaCl-H_2O): Geokhimiya, 1984, no. 9, p. 1268-1282 (in Russian; English abstract).

Computer simulation of redox interaction in the system of CH_4-Na_2SO_4-NaCl-H_2O at temperatures 100, 200 and 300°C has been made. Calculations have been made using method of minimization of isobaric-isothermic potential of a system consisting of an aqueous solution with various initial concentrations of CH_4 and Na_2SO_4. The aim of the calculations consists of determination of carbonate carbon to sulfide sulfur ratios and values of $\delta^{13}C(CO_2)$ and of $\delta^{34}S(H_2S)$ in the reaction products depending on the ratios of initial concentrations CH_4/Na_2SO_4 both for conditions of isotopic equilibrium of all components and for conditions when isotopic equilibrium between CO_2 and CH_4 in the solution is not reached. The calculation simulated mixing of sulfate-bearing solutions with solutions bearing organic compounds. Some chemical peculiarities of the interaction under study have been revealed. Character of variations of $\delta^{34}S(H_2S)$ and $\delta^{13}C(CO_2)$ and accompanying variations of H_2S contents in the mixing solution are discussed. (Authors' abstract)

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. of Geochem. & Anal. Chem., Acad. Sci., 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 produces conditions favorable to the deposition of cassiterite. The deposition of the sulfide association 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 $\sum S$ in the solution favored the replacement of cassiterite by stannite. (Authors' abstract)

BANSHCHIKOVA, I.V. and OVCHINNIKOV, L.N., 1984, The evolution and physicochemical conditions of the formation of metamorphic complexes at the Kola superdeep borehole (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 13-14 (in English). Authors at Inst. Mineral., Geochem. & Crystal. of Rare Elements of the Ministery Geol. USSR, USSR Acad. Sci., Moscow, USSR.

A systematic thermobarogeochemical study was made of inclusions in various mineral parageneses of different ages in the rocks of the Kola Archean and the Pechenga Middle Precambrian complexes.

1. Aqueous salt solutions of high density remaining in interstitial inclusions took part in the formation of plagiogneisses and amphibolites of the Kola complex. The migmatite-granites are synchronous with the Kola folding and crystallized from anatectic silicate melts at T >830-820°C (crystallized inclusions); migmatite-plagiopegmatites - from silicate-salt melts and salt melts and brines at 810 to 675°C (crystallofluid inclusions) and fluid phase pressure of $6.6\text{-}5.5 \cdot 10^8$ Pa (inclusions with liquid carbon dioxide).

2. The formation of regional metamorphic zones in the rocks of the

Pechenga complex occurred synchronously with the folding and resulted from the action of pore solutions of complex salt composition (multiphase inclusions). The temperature of the solutions at the time of formation of mineral parageneses of the prehnite-pumpellyite facies exceeded 190-340°C, epidote-chlorite facies - 340-455°C, biotite-actinolite facies - 455-560°C. The temperature gradient down the [bore] varied from 100°/km to 60°/km.

3. The early retrograde paragenesis of rocks of the Pechenga complex was formed under the influence of highly concentrated salt solutions (multiphase inclusions) at >260-450°C, with gradient varying from 60°/km to 50°/km.

4. The post-Pechenga porphyry-like granites of the Kola complex originated from a silicate magmatic melt (crystallized inclusions) with initial temperature at the early phases of intrusion 845°C and the late phases - 820°C. The pressure of the accompanying carbon dioxide fluid increased respectively from 6.5•108 [$6.5 \cdot 10^8$?] to $8.0 \cdot 10^8$ Pa.

5. The late retrograde parageneses in the rocks of the cross-section [occurred] at over 250-380°C.

6. The origin of bitumenous substance occurring within cataclastic zones in the inclusions with hydrogen-hydrocarbon solutions is connected with the formation of late faults. (Authors' abstract)

BARANOVA, N.N., ZOTOV, A.V., BANNYKH, L.N., DAR'YINA, T.G. and SAVEL'YEV, B.V., 1983, The effects of redox conditions on the solubility of gold in water at 450°C and 500 atm: Geokhimiya, no. 8, p. 1133-1138 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 4, p. 117-122, 1984).

BARDINTZEFF, J.-M., 1984a Glasses and magmas of 1979 eruption of St. Vincent Soufière volcano (West Indies): Bull. Soc. Géol. France, v. 25, no. 6, p. 811-818 (in French). Author at Lab. de Pétro.-Volcanol., bat. 504, Univ. Paris Sud, 91405 Orsay Cedex, France.

Analyses of glasses (both pumice and inclusions) show wide ranges in composition. It is concluded that two different magmas were involved, the mixing of which triggered the eruption. (E.R.)

BARDINTZEFF, J.-M., 1984b Pyroxenes and their melt inclusions, good witnesses of nuée ardente eruption (St. Vincent, West Indies, 1979): Bull. Minéral., v. 107, p. 41-54 (in French; English abstract). Author at Lab. Petrogr.-Volcano., Bat. 504, Fac. Sci., 91405 Orsay Cedex, France.

Pyroxenes of St. Vincent Soufriere volcano andesito-basaltic nuées ardentes (1979) show clearly three stages of crystallization. 1) Cr-rich diopsides (with chromites and Fo 89 olivines) crystallize early (P >10 kbar) from primary basaltic magma. 2) Salites characterize a second high PH_2O stage (PH_2O = 5 kbar) and occur in cumulate with Al-magnetites, Fo 75 olivines, Ca-plagioclases and amphiboles. 3) Augites and orthopyroxenes appear in the last stage with Na-plagioclases. Primary melt inclusions do not occur in diopsides; their compositions are andesito-basaltic in salites and andesito-dacitic in augites. The different crystallization-stages are displayed in some products of the eruption (cumulates, blocks and ash-matrix of nuées ardentes, domes).

The proposed volcanological interpretation is that of mechanical mixing of residual dacitic magma (in small amount) produced by fractional crystallization with reinjected andesitic magma. This mixing produces sudden variations of thermodynamic conditions, triggering nuees ardentes. (Author's abstract)

BARGAR, K.E. and BEESON, M.H., 1984, Hydrothermal mineralogy of research drill hole Y-3, Yellowstone National Park, Wyoming: Geothermal Resources Council, Transactions, v. 8, p. 111-117. Authors at U.S. Geol. Survey.

The approximate paragenetic sequence of hydrothermal minerals in the Y-3 U.S. Geological Survey research diamond-drill hole in Lower Geyser Basin, Yellowstone National Park, Wyoming, is: hydrothermal chalcedony, hematite, pyrite, quartz, clay minerals (smectite and mixed-layer illite-smectite), calcite, chlorite, fluorite, pyrite, quartz, zeolite minerals (analcime, dachiardite, laumontite, stilbite?, and yugawaralite), and clay minerals (smectite and mixed-layer illite-smectite). A few hydrothermal minerals that were identified in drill core Y-3 (lepidolite, aegirine, pectolite, and truscottite) are rarely found in modern geothermal areas. The alteration minerals occur primarily as vug and fracture fillings that were deposited from cooling thermal water. (Authors' abstract)

BARGAR, K.E., FOURNIER, R.O. and THEODORE, T.G., 1984, Particles resembling bacteria in fluid inclusions from Yellowstone National Park, Wyoming (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, no. 6, p. 436-437. Authors at U.S. Geol. Survey, 345 Middlefield Rd., Menlo Park, CA 94025.

Liquid-rich fluid inclusions in quartz crystals from U.S. Geological Survey research drill hole Y-13 in Yellowstone National Park contain micrometer-sized particles that appear to be microorganisms. Quartz crystals, 1-2 mm long, from depths of 59.5, 102.1, and 102.5 m in the drill core line fractures in late Pleistocene rhyolitic lava flows. About 20 of more than 200 quartz crystals examined from these depths contain between 1 and several hundred threadlike, rodlike, or irregular-shaped particles in pseudosecondary fluid inclusions. These minute particles were noticed only because of their continuous movement, probably Brownian motion. Only 1 to about 10 particle-bearing fluid inclusions (between 10 and 100 µm long) are present per quartz crystal. So far, we have only observed one fluid inclusion cavity, under the scanning electron microscope, that contained a single rod-shaped particle. The morphology of the particle resembles that of a bacterium.

The measured temperature and pressure of 102.1 m depth (at which -99% of the bacteria-like particles were found) is about 190°C and 1.24 MPa, respectively. Homogenization temperatures (189.5° - 275.3°C) of the fluid inclusions at this depth mostly exceed measured temperatures, suggesting that the fluid inclusions probably did not form under present-day conditions. Instead, the fluid inclusions probably formed ~45,000 - 14,000 years B.P. at a higher pressure due to the overburden of at least 490 m of glacial ice. If the particles should prove to be bacteria, then the temperatue-pressure conditions under which these microorganisms can live would approach the extreme conditions (~350°C and 26.9 MPa) at which bacteria have been reported from a black smoker on the East Pacific Rise. (Authors' abstract)

BARKER, C.E. and REYNOLDS, T.J., 1984, Preparing doubly polished sections of temperature sensitive sedimentary rocks: J. Sed. Petrology, v. 54, no. 2, p. 0635-0636. First author at U.S. Geol. Survey, P.O. Box 25046, Denver, CO 80225.

Meaningful temperature measurements on fluid inclusions in sedimentary rocks formed by low-temperature diagenesis require that the sample is not heated during preparation. Heating soft and/or cleavable minerals can cause expansion of inclusion cavities and/or leakage of fluid from inclusion cavities, resulting in an increased Th. We describe here a set of grinding, polishing, and mounting techniques for preparing doubly polished rock sections with a minimum of heating above room temperature. (From the authors' Introduction)

BARKER, Colin and ROBINSON, S.J., 1984, Thermal release of water from natural quartz: Am. Mineral., v. 69, p. 1078-1081. Authors at Dept. Geosci., The Univ. Tulsa, Tulsa, OK 74104.

A mass spectrometer was used to monitor the release of water from quartz samples heated to 1200°C in vacuum. Both hydrothermal quartz and granitic quartz show abundant fluid inclusion ruptures over the temperature range from 100°C to 550°C and, in most cases, a prominent water release at the quartz alpha-beta transition (573°C). Fluid inclusion ruptures above this stage are rare. High temperature water release from hydrothermal quartz is negligible, but it is greater (though more variable) for the quartz from granites. No water release can be related to the quartz-tridymite transition. (Authors' abstract)

BARNES, Ivan, 1984, Volatiles of Mount St. Helens and their origins: J. Volcanol. Geotherm. Res., v. 22, p. 133-146. Author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025, USA.

Analyses have been made of gases in clouds apparently emanating from Mount St. Helens. Despite appearances, most of the water in these clouds does not issue from the volcano. Even directly above a large fumarole δD and $\delta^{18}O$ data indicate that only half the water can come from the volcano. Isotopic and chemical evidence also shows the steam in the volcano (-33.0 per mol[sic] δD) from which a condensate of 0.2 N HCl was obtained is not a major cause of the explosions. The steam in the volcano is derived from a metamorphic brine in the underlying Tertiary meta andesite. The gas that caused the explosive eruptions is carbon dixoide. (Author's abstract)

BARON, C., NORMAN, D.I. and KYLE, P., 1984, Measurement of trace elements, including REE, in fluid inclusion liquids (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 437. Authors at Geosci. Dept., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

In order to better understand concentrations of ore-metals and the general solute chemistry of hydrothermal ore-fluids, a precise and accurate method of measuring trace elements in fluid inclusion waters was developed. Fluids are extracted by thermal decrepitation in a quartz flask and measured by neutron activation. Accuracy is 10-20% depending on the concentration of the element and analysis can be duplicated within the accuracy of the measurement. Elements measured in inclusion waters from the Copper Flat porphyry-copper deposit NM, and from Au-veins associated with the porphyry are: Na, K, Sc, Cr, Fe, Co, Ni, Zn, As, Se, Br, Rb, Sr, Mo, Ag, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, W, Au, Th, and U.

REE are highly enriched in LREE; La concentrations are 100-1 ppm and HREE are 100-10 ppb. Iron concentrations in the range of 1% were measured in copper-porphyry fluids; Mo and Au were 100-10 ppm and 90-40 ppb respectively. Trace elements in Au-vein inclusion-fluids have a similar distribution as elements in the copper-porphyry inclusion-fluids, but are in lower concentration, suggesting Au-vein ore-fluids were dilutions of fluids which mineralized the Copper Flat deposit.

The potential applications of trace element analysis of inclusion fluids are great and include knowledge of the chemistry of ore-fluids which deposit different ores, plus sources of solute and mobility of elements in all types of hydrothermal and metamorphic waters. (Authors' abstract)

BARSUKOV, V.L., BORISOV, M.V. and PEK, A.A., 1984, Hydrothermal solution self-mixing in the production of ore veins and wall-rock alteration aureoles (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 230 (in English). Text: Proc. 27th Int'l. Geol. Cong., v. 11, p. 521-535 (1984). First author at V.I. Vernadsky Inst. Geochem. & Anal. Chem. USSR Acad. Sci., Moscow, USSR.

Computer simulation of chemical interaction between chloride-bicarbonate solutions and liparite has shown that the hydrodynamic process of self-mixing of hydrothermal solutions involves marked geochemical effects. The self-mixing is a recently discovered phenomenon, manifested in recurrent exchange of fissure and pore-space solutions. The simulation procedure was carried out at temperature of 150°C. The results are considered as representative for U-Mo, Pb-Zn, Sb-Hg and other meso- and epithermal deposits. Due to the self-mixing phenomenon, the solutions with constant initial chemical composition can produce in the adjacent segments of the vein system synchronously different mineral parageneses, as well as, different metasomatic alteration aureoles in the wall-rocks. (From the authors' abstract)

BART, A., BART, H. and KHODAKOVSKY, I.L., 1984, Thermodynamics of hydrothermal equilibria in the system Bi_2O_3-SiO_2-H_2O (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 17- (in English).

BARTLETT, M.W., 1984, Petrology and genesis of carbonate-hosted Pb-Zn-Ag ores, San Cristobal district, Department of Junin, Peru: PhD dissertation, Oregon State Univ., Corvallis, OR, 301 pp.

No abstract available; the following extracts are from pages 175, 176, 257 and 258. (E.R.)

The investigation involved a detailed study of inclusions [in sphalerite and quartz] from both vein and manto-type ores. However, emphasis was directed toward inclusions in the manto ores because of the ambiguous origin of these deposits. Fluid inclusions also were found and measured in magmatic phenocrysts of quartz from the Chumpe Quartz Porphyry. These inclusions were highly variable in composition and type, and apparently are different from those reported by Campbell and Rye (1982).

Fluid inclusion data from fractured quartz phenocrysts in the Chumpe Quartz Porphyry indicate that sericitic alteration formed between 325° and 450°C, by reaction of feldspar with fluids having salinities of between 18 and 49 weight percent NaCl equivalent. The dominant chloride species are inferred to have been NaCl, KCl, $CaCl_2$ and HCl. Evidence for periodic boiling of the fluids in the quartz porphyry is abundant, and considered in terms of the NaCl-H_2O system, requires a minimum pressure of 100-250 bars (equivalent to 900-2400 m hydrostatic load). Fluid inclusion data from sphalerite and quartz in the veins and mantos indicate mineralization temperatures of 180°-300°C and fluid salinities of 4 to 8 weight percent NaCl equivalent. Because evidence of boiling is lacking from inclusions in the ores, minimum pressures were between 20 and 100 bars (equivalent to 200-1400 m hydrostatic load). Mixing of the dense magmatic brine derived from the porphyry with cooler meteoric waters at a distance from this intrusive center may account for lower temperatures and salinities of the ore fluids associated with vein and manto ores.

Sulfur isotopic temperature estimates (169°-287°C) determined from coexisting sphalerite-galena mineral pairs are virtually identical to fluid inclusion homogenization temperatures (159°-285°C), and thus document isotopic equilibrium between these minerals. Delta values from pyrite-sphalerite and pyrite-galena pairs give excessively high temperatures indicative of disequilibrium, a relationship that is also corroborated by paragenetic and textural observations.

BARTLETT, M.W. and FIELD, C.Y., 1984, Genesis of carbonate-hosted manto ores, San Cristobal district, Cordillera Occidental, central Peru (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 438. Authors at Dept. Geol., Oregon State Univ., Corvallis, OR 97331.

Mineral deposits at San Cristobal consist of polymetallic vein and strata-bound manto ores in limestones near large through-going veins. Hydrothermal mineralization took place at 5.4 m.y. after intrusion of a small quartz porphyry stock. Vein minerals record three paragenetically distinct assemblages that include early quartz-pyrite-wolframite, intermediate chalcopyrite-sphalerite-galena-sulfosalts, and late barite-manganosiderite-marcasite. Manto ores are massive and exhibit replacement textures, but have mineralogical, paragenetic, and trace metal characteristics similar to nearby vein ores. Alteration of limetsone host rocks was by metasomatic additions of Fe, Mn, and minor SiO_2 to form manganosiderite pervasively and jasperoid locally that enclose the manto ores. The formation of skarn assemblages was inhibited by conditions of low temperature and (or) high fCO_2. Secondary fluid inclusions in quartz porphyry have Th ranging from 300 to 450°C and salinities from 20 to 50 wt % NaCl. Th of primary inclusions in vein and manto quartz range from 270 to 305°C, whereas those in associated sphalerite have a bimodal distribution of 180-210 and 240-280°C, respectively, and salinities vary from 4 to 8 wt % NaCl suggesting dilution by meteoric waters. Sulfur isotope temperature estimates from sphalerite-galena pairs are identical to those of the fluid inclusion data. The mean $\delta^{34}S$ composition of sulfide-sulfur is ~5‰, and suggests a mixing of magmatic sulfur (~0‰) with reduced sulfate-sulfur from evaporites (~13‰) of the Pucara Group. Geologic and geochemical evidence collectively imply an epigenetic hydrothermal replacement orign for these strata-bound manto deposits. (From the authors' abstract)

BARTON, M.D., 1984, Phase relations of minerals in the system $BeO-Al_2O_3-SiO_2-H_2O$: experimental results and petrological applications (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 439. Author at Dept. Earth & Space Sci., U.C.L.A., Los Angeles, CA 90024.

Phase relations and thermodynamic properties of bertrandite, beryl, chrysoberyl, euclase, and phenakite have been evaluated, combining new phase equilibrium and calorimetric experiments with data from the literature. The minerals in this system are perhaps most useful as indicators of metasomatic variables. (From the author's abstract)

BASILONE, Tim, ANDERSON, Thomas and BURRUSS, R.C., 1984, Origin and implications of fluid inclusions from filled fractures, Oriskany Sandstone, Allegheny Plateau, Pennsylvania (abst.): AAPG Bull., v. 68, no. 12, p. 1915. First author at Univ. Pittsburgh, Pittsburgh, PA.

Two cores from the Lower Devonian Oriskany Sandstone underlying the Allegheny Plateau in south-central Somerset County, Pennsylvania, contain fractures that may either be filled with epigenetic minerals or unfilled. The 1 Sipe core, taken from an unproductive well drilled on the crest of an anticlinal structure, is characterized by numerous discontinuous vertical fractures. The 1 Romesburg core, taken from a productive well drilled on the flank of an anticlinal structure, contains numerous fractures that lie parallel with bedding planes. The walls of these fractures consist of smooth slickensided surfaces.

Quartz and ferroan-calcite crystals filling fractures contain numerous hydrocarbon-bearing fluid inclusions. The distribution of these fluid inclusions within most minerals allowed a determination to be made regarding the relative times of migration of fluid hydrocarbon phases in the subsurface with respect to the paragenetic sequence of mineralization events.

Analysis of fluid inclusions indicates that fractures were opened at 22,000 ft (6,700 m) and remained open throughout an extended period of uplift. Furthermore, inclusions contain hydrocarbon-rich fluids that are comparable to reservoir hydrocarbons in the nearby Shamrock field. This relationship implies that hydrocarbons that currently exist in reservoirs were conducted along fractures that were once open.

Fractures crosscut diagenetic features, indicating that diagenesis, for the most part, preceded fracture events. Although they differ in origin and orientation, fractures characterizing Oriskany strata were healed by a consistent sequence of epigenetic minerals. (Authors' abstract)

BASU, N.K. and MRUMA, A.H., 1984, Petrology of the talc-kyanite-yoderite-quartz schist and associated rocks of Mautia Hill, Mpwapwa district, Tanzania (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 257-258. Authors at Univ. Dar es Salaam, Dar es Salaam, Tanzania.

Talc-kyanite-yoderite-quartz schist and associated rocks belonging to the Proterozoic Usagaran System occurring along the western edge of the Mozambique Orogenic Belt (450-600 Ma) were studied using petrographic, X-ray diffraction, electron-microprobe and fluid inclusion methods. Fluid inclusions trapped in kyanite in the talc-kyanite-yoderite-quartz schist are found to be CO_2-rich fluids. This indicates low water fugacity during the formation of talc-kyanite assemblage and so, pressure was probably lower. Primary fluid inclusions could be trapped at pressures between 5.2 to 5.6 Kbars and temperatures ranging from 540°C to 570°C. So, this gives the P-T range of the peak of the first phase of progressive metamorphism. (From the authors' abstract)

BATTINO, Rubin, RETTICH, T.R. and TOMINAGA, Toshihiro, 1984, The solubility of nitrogen and air in liquids: J. Phys. Chem. Ref. Data, v. 13, no. 2, p. 563-601. First author at Dept. Chem., Wright State Univ., Dayton, OH 45435.

This review covers the solubility of nitrogen and air in liquids as a function of temperature and pressure. Solubility data for individual systems were critically evaluated. Recommended or tentative values are presented as smoothing equations and/or in tabular form. Trends in homologous series or related solvents are discussed. Data for the n-alkanes were smoothed with respect to temperature, pressure, and carbon number. Liquids include: water; heavy water; seawater; aqueous salt solutions; mixed solvents; hydrocarbons; organic compounds containing oxygen, halogen, sulfur, nitrogen, or silicon; olive oil; various biological fluids; H_2S; SO_2; NH_3; CO_2; nitrogen oxides; and several halogen and boron containing inorganic solvents. (Authors; abstract)

BATULIN, S.G., GOL'DSHTEIN, P.I., KALINKIN, V.I., NATAL'CHENKO, B.I. and NAUMOV, G.B., 1984, Chemical composition and uranium-bearing capacity of pore solutions in permeable rocks of sedimentary cover: Geokhimiya, 1984, no. 8, p. 1171-1180 (in Russian; English abstract).

BAUMANN, K., BILGRAM, J.H. and KANZIG, W., 1984, Superheated ice: Z. Phys. B-Condensed Matter, v. 56, p. 315-325. Authors at Lab. für Festkorperphysik, Eidgenossische Tech. Hochschule, Zürich, Switzerland.

Ice single crystals are superheated by a pressure jump. Their optical homogeneity is examined by elastic light scattering in order to obtain information about the thermodynamic state in the bulk of the sample. The intensity of the scattered light after the pressure jump remains first unchanged. Only after a time lag τ a steep intensity increase is observed. The dependence of τ on the superheating, on sample size, on the position of the scattering volume in the sample, on crystal orientation, on the scattering angle and on the crystal quality is examined. τ depends only on superheating and crystal quality within experimental sensitivity. After a superheating of more than 5°C the optical appearance of ice is like opalescent glass. The observations are compatible with the assumption that the ice has been superheated with respect to the melt and that homogeneous nucleation occurs in the metastable state. The equilibrium curve ice I_h - water has been determined. (Authors' abstract)

Of possible pertinence to ice in monophase frozen inclusions. (E.R.)

BEANE, R.E., 1984, Evolution of hydrothermal minerals and related fluid characteristics in some porphyry copper deposits of the southwestern United States of America: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 45-51.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 8-9. (E.R.)

BEATY, D.W. and CUNNINGHAM, C.G., 1984, Igneous-related hydrothermal origin of the Deer Trail Pb-Zn-Ag-Au-Cu manto deposits, Marysvale, Utah (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 440-441. First author at Noranda, Box 15638, Lakewood, CO 80215.

The principal Pb-Zn-Ag-Au-Cu manto deposit exposed in the Deer Trail mine, Marysvale district, west-central Utah consists of a semicontinuous group of stratabound bodies (mantos) that replaced as many as 15 beds in the lower part of the Toroweap Formation. The mantos are stacked along a prominent steeply-dipping axial vein, and thin symmetrically away from it. Individual mantos consist almost entirely of sulfides (py-gn-sph-cpy-td), have sharp contacts with the country rocks, and vary in thickness up to 3 m. Hydrothermally altered rocks form indistinct envelopes around the veins and mantos. Mo, As, Sb, Te, Se, Bi, and Hg are important trace constituents. Fluid inclusions in sphalerite homogenize at 250-300°C with 17-22 wt% NaCl. Liquid CO_2 and evidence for boiling were seen locally. Galena, sph, cpy and py average $\delta^{34}S$ = -1.1, 0.6, 2.0, 3.9, respectively ($\Delta^{34}S$(sph-gn) = 245°-265°C) suggesting an igneous source for the sulfur. Preliminary $^{206}Pb/^{204}Pb$ is 18.43, about the same ratio found in igneous rocks throughout the Rocky Mountain region. Quartz in the axial vein has average $\delta^{18}O$ = -1.4, and at 280°C, was precipitated from a fluid with $\delta^{18}O$ = -10, characteristic of somewhat exchanged meteoric water. One km west of the mantos is an area of coincident hydrothermal alteration and radial structural deformation.

The manto deposits thus appear to have formed in a hydrothermal system related to a nearby unexposed igneous intrusion. The transport medium was meteoric water modified by reaction with wallrocks or by addition of as much as 20% magmatic water. Geological and geochemical relations identical to those at Deer Trail are present at many of the economically more important manto deposits in the Western United States (Tintic, Park City, Leadville, Gilman, Pioche), which, by analogy, may have had a similar origin. (Authors' abstract)

BEBOUT, G.E. and CARLSON, W.D., 1984, Carbon and oxygen isotope evidence for fluid heterogeneity during metamorphism, Llano uplift, Texas (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 441. Authors at Dept. Geol. Sci., Univ. Texas, Austin, TX 78713-79709.

A carbon and oxygen isotope study corroborates petrologic evidence that, within the p€ Valley Spring Gneiss, channelized infiltrations of aqueous fluids were responsible for the localized derivation of calc-silicates from (calcite + quartz + feldspar) marbles. (From the authors' abstract)

BECKER, R.H. and PEPIN, R.O, 1984, Martian origin of the shergottite meteorites: Evidence from nitrogen and noble gases (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 2, p. 183. Authors at Sch. Physics & Astronomy, Univ. Minnesota, Minneapolis, MN, USA.

Gases in glassy inclusions from the antarctic shergottite EETA 79001 are distinctly different from normal meteoritic trapped gases, but closely resemble the martian atmospheric composition measured by Viking. Nitrogen trapped in the glass has a $\delta^{15}N$ value at least as high as +190 per mil. Ratios of Ar/N are consistent with dilution of a pure trapped component, characterized by $\delta^{15}N$ and $^{40}Ar/^{14}N$ values in the Mars atmosphere range (620 ± 160 per mil and 0.33 ± 0.03, respectively), with either terrestrial atmosphere adsorbed on the sample or indigenous nitrogen from the minerals of the rock. Elemental and isotopic compositions of trapped noble gases in the glass are within error of the Mars atmosphere compositions whereever such comparisons can be made. The geochemically simplest explanation for the unique noble gases and isotopically heavy nitrogen in the EETA 79001 glass is that they are trapped samples of the martian atmosphere, and that this meteorite, and thus the rest of the shergottites and probably the nakhlites and chassignite as well, have come from Mars.

Isotopic measurements of the small amounts of trapped krypton and xenon in the glassy material are not very precise, but do allow a first-order estimate of isotopic patterns. Krypton, except for a small excess at ^{80}Kr probably generated by neutron capture in bromine, appears to be smoothly mass-fractionated with respect to both terrestrial and chondritic Kr. The xenon composition is consistent with addition of neutron-capture, radiogenic, and fissiogenic isotopes to a base composition resembling terrestrial atmospheric Xe. The elemental $^{84}Kr/^{132}Xe$ ratio of 24 is close to the terrestrial value but very different from the chondritic ratio.

Nitrogen in the nonglassy basaltic matrix surrounding the glass inclusions amounts to less than 0.5 ppm, and has a $\delta^{15}N$ value in the range +5 to -20 per mil. It may represent either adsorbed terrestrial contamination or indigenous (nonatmospheric) nitrogen in the basalt. Trapped noble gases of the type found in the glass are not present in the basaltic material. Spallation noble gases in the matrix suggest a very short exposure to galactic cosmic rays, about 600,000 years. (Authors' abstract)

BEDSON, Peter, 1984, Rare earth element distribution between immiscible silicate and carbonate liquids: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 12-19.

BEGEMANN, F. and JAMBON, A., 1984, Noble gases in mid-Atlantic Ridge basalt (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 2, p. 183-184. First author at Max-Planck-Inst.

Chemie, Mainz, Germany.

Noble gas concentrations have been measured in two Mid Atlantic Ridge Basalt samples from 30°41'N, 41°39'W. Single pieces of 1.36 and 1.85 grams, respectively, were heated for 24 hours at ca. 100°C and subsequently degassed in three steps 1) by heating the samples for 30 min at 600°C; 2) by crushing the chunks at room temperature; and 3) by melting the powder and keeping the melt for 30 min at 1400°C. The three steps were performed without breaking the vacuum so that adsorption on the fresh powder of atmospheric noble gases can be excluded with certainty.

Results: The 600°C-fraction contained 10% of the total He; the heavier noble gases were atmospheric contaminants ($^{40}Ar/^{36}Ar$ was atmospheric). Crushing of the chunks released about the same amounts of gas, presumably from vesicles, as did melting of the powder. The exception was ^{40}Ar which was up to 5 times more abundant in the vesicle fraction. In the vesicle gases $^{40}Ar/^{36}Ar$ ratios went up to 22600, that of the total samples was 9100 (7400) and 12200 (8700), respectively, where the values in brackets are the ratios including the argon from the 600°C step. $^{4}He/^{40}Ar$ ratios are around 6 in the vesicle gas and 3-4 times higher in the melt fraction, with total ratios of 9.2 and 12.5, respectively. The abundance ratios of all non-radiogenic nuclides are the same to within better than a factor of two in the vesicle gas and the gases from the melt. $^{3}He/^{4}He$ is $(1.40 \pm 0.1) \times 10^{-5}$, again indistinguishable within the limits of error in the vesicles and the helium released upon melting. Note, that this may be due to equilibration by diffusion during the 600°C step. The abundance pattern is compared with that of other solar system reservoirs. Taking these data at face value our results confirm that there is no simple way to derive the basalt pattern of the light and heavy noble gases from any other single reservoir. Particularly striking is the "overabundance" of ^{3}He and of ^{20}Ne which, furthermore, cannot be accounted for by admixing "solar" noble gases to any of the other types. What is needed is an admixed component with a $^{3}He/^{20}Ne$ ratio of about unity. Possible explanations will be discussed. (Authors' abstract)

BEHR, H.J. and HORN, E.-E., 1984a, Quartz-forming and the process of silicification in the carbonate-complex of the Rhenish Massif: Postvariscan vein-mineralization in Middle-Europe: Age, genesis and economic importance, GDMB (Ges. dt. Metallhütten und Bergleute), Hersg. - 425 S., 87 Abb., 14 Tab. Weinheim (Bergstrasse), Verlag Chemie 1984. Heft 41 der Schriftreihe der GDMB, p. 27-45 (in German; English abstract).

The post-Variscan deposition of the minerals of non-ferrous metals in the limestone complexes of the Rheinische Schiefergebirge was accompanied by the deposition of large amounts of silica. The silicification also reached into the overlying Cretaceous sediments. Analysis of the different generations of quartz and calcite using fluid inclusions and isotope geochemistry yielded features that allow a distinction of post-Variscan mineralization from Variscan and pre-Variscan mineralization. The following items are discussed: genesis of crystal zoning, origin of mineral-depositing solutions, mixing processes, seismo-tectonic activities controlling solution transport, heat sources and control mechanisms of the mineralization, and involvement of biogenic processes. (Authors' abstract)

BEHR, H.J. and HORN, E.-E., 1984b, Criteria for distinction of Variscan and post-Variscan cycle mineralization using fluid inclusion data: Postvariscan vein-mineralization in Middle-Europe: Age, genesis and economic importance, GDMB (Ges. dt. Metallhütten und Bergleute), Hersg. - 425 S., 87 Abb., 14 Tab. Weinheim (Bergstrasse), Verlag Chemie 1984. Heft 41 der

Schriftreihe der GDMB, p. 255-269 (in German; English abstract).

Analysis of fluid inclusions in fluorite, barite, quartz, calcite, and sphalerite resulted in prominent differences between Variscan and post-Variscan mineralization. Elevated Ca, Na, and K concentrations are responsible for salinity values in the post-Variscan mineralization that are rather high compared to the low values of the Variscan mineralization. The widespread zoning and the rhythmic mineral successions of the younger mineralization are caused by large oscillations in salinity and temperature. This can only be explained by mixing of solutions coming from very different sources. The origin of the highly saline solutions from sedimentary rocks can be substantiated. These solutions have mixed in all possible proportions with low salinity hydrothermal solutions brought up from great depths by "tectonic pumping" through systems of post-Variscan shear and tension fissures. (Authors' abstract)

BEISEYEV, O.B., 1984, Geological and physico-chemical conditions of amphibole asbestos deposit formation (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 7, p. 239-240. Author at Kazakh Res. Inst. Mineral Resources of KazSSR Ministry Geol., Alma-Ata, USSR.

Temperature conditions of the formation of deposits (600 determinaions of Th of gas liquid inclusions, and of mineral decrepitation) correspond to certain stages in the process of enclosing rock alteration: 40-120°C for rhodusite-crocidolite-asbestos, 60-230°C for actinolite-asbestos, 540-90°C for anthophyllite-asbestos. Asbestos proper is formed only under low temperature conditions, either in the beginning of the process, when initial gel is in its most fluid state and predominance of the liquid phase in solutions is considerable (S:L = 1:200, 10 experiments), or else, towards the end of the process, when hydration and decomposition processes take place in the crystalline amphibole rock and ore (800 analyzed samples of amphibole asbestos and its crystalline analogues compared). (From the author's abstract)

BELEVTSEV, Ya.N., KOVAL, V.B. and STRYGHIN, A.I., 1984, Genetic pattern for the deposits of uranium-albitite formation (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 2, p. 332. Authors at Inst. Geochem. & Physics of Minerals of Acad. Sci. UkrSSR, Kiev, USSR.

Through the data on gaseous-liquid inclusions the temperature of albitite formation ranges from 350-150°C, that of uranium mineralization being 200-120°C. Solutions are carbonaceous with the admixture of chlorides and sulphides. Solution concentration varies from 10 to 40 per cent, the ore formation pressure amounting to 600-900 bars. (From the authors' abstract)

BELKIN, H.E., DE VIVO, Benedetto and LATTANZI, Pierfranco, 1983, Fluid inclusion studies on ore deposits of Tuscan Maremma, Italy: Mem. Soc. Geol. It., v. 25, p. 273-284 (in Italian; English abstract). First author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092, USA.

Microthermometric analyses of fluid inclusions in sphalerite, quartz, and calcite from the pyrite and polymetallic deposits of Tuscan Maremma (Italy) are presented along with previously published results. These minerals were formed during the Tertiary Apennine orogenic event in which the assumed Paleozoic-Triassic(?) exhalative-sedimentary massive sulfide deposits were metamorphosed and partly remobilized, and other discordant deposits were emplaced.

Fluid inclusion data (Th, salinity) when plotted in known mineral-paragenetic position reveal simple and complex relationships. These time-temperature-salinity relationships suggest simple and complex mixing of a relatively hot, saline ore forming fluid with a cooler, less saline fluid, probably groundwater. The temperature of homogenization (Th) varies from 200° to 320°C and the salinity varies from near zero to ~16 wt% NaCl equivalent. Freezing data suggest that Ca^{2+} and/or Mg^{2+} may locally be important fluid components, in addition to $Na^{+}(K^{+})$-Cl.

Data available for the Niccioleta A pyrite deposit allow reconstruction of the environment during the various stages of the Apenninic event: 1) regional metamorphism, 2) skarn formation, 3) hydrothermal mineral deposition. Throughout these stages, temperature decreased from 500°C to less than 200°C, and pressure from about 2 kb to less than 500 bars.

Limited fluid inclusion data for quartz associated with Sb mineralization indicate lower average Th and salinities than in the pyrite and polymetallic deposits. (Authors' abstract)

BELKIN, H.E., DE VIVO, Benedetto and VALERA, Roberto, 1984, Fluid inclusion study of some Sarrabus fluorite deposits, Sardinia, Italy: Econ. Geol., v. 79, p. 409-414. First author at U.S. Geol. Survey, Mail Stop 959, National Center, Reston, VA 22092.

Some inclusions contained NaCl dm plus vapor, others were monophase liquid. Birefringent solid inclusions were also seen. P inclusions Th mainly 95-125°C; Tm ice mainly -6 to -16, but superheated ice under negative pressure was formed in some on freezing (Tm ice $<$+5.3°C); Te -38 to -54. (E.R.)

BELKIN, H.E., McGEE, J.J. and TILLING, R.I., 1984, Plagioclase zonation as an indicator of the magmatic history of El Chichon Volcano, Chiapas, Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 442. Authors at U.S. Geol. Survey, Reston, VA 22092.

Detailed petrographic and chemical studies of the eruptive products of El Chichon Volcano document complex zoning behavior in the plagioclase phenocrysts. The plagioclase (An35-80) is characterized by predominant oscillatory zoning (5-20 μm) and superimposed dissolution/growth zones (25-100 μm) that contain silicate-melt and gas inclusions. Etch pits in the dissolution/growth zones are commonly the loci of the silicate-melt and gas inclusions.

Analytical traverses of the plagioclase phenocrysts reveal both regular oscillatory zoning (~2-5 mol% An) and periodic, larger scale calcic compositional spikes (~10-35 mol% An) compared with adjacent areas. These calcic spike zones invariably coincide with the plagioclase dissolution/growth zones and the magnitude of the calcic spike varies with the abundance of inclusions.

The complex systematic zoning in plagioclase records multiple processes in the magma reservoir. Fine-scale oscillatory zoning is assumed to have been produced by local crystallization processes. Available data suggest pressure fluctuation, perhaps caused by stirring in the convecting magma, as the most likely cause of the observed dissolution/growth zones. The association of larger-scale calcic spikes and inclusions suggests episodic interruption of convective stirring by fairly sudden increases in volatile pressure and subsequent explosive loss of pressure during eruption. Repeated cycles of volatile accumulation and eruption from a convecting reservoir may produce the observed zoning pattern. (Authors' abstract)

BELOUS, I.R., KIRIKILITSA, S.I., LEVENSHTELYN, M.L., RODINA, E.K. and FLORINSKAYA, V.N., 1984, Occurrences of mercury in northwestern Donbass salt domes: Sovetskaya Geol., no. 2, p. 40-47 (in Russian; translated in Int'l. Geol. Review, v. 26, no. 5, p. 573-582). Authors at Inst. Mineral Resources, Ministry Geol. Ukrainian SSR.

The article describes an unusual, but theoretically important, concentration of mercury in salt domes. (Authors' abstract)

BELOVA, L.L, KRICHEVETS, G.N. and SHMARIOVICH, Ye.M., 1982, Hydrodynamic conditions of formation of epigenetic mineralization during interaction of formation waters with upward-moving fissure and vein solutions: Dokl. Akad. Nauk SSSR, v. 265, no. 2, p. 393-396 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., v. 265, p. 60-63, 1984).

BELYI, V.M., MIGDISOV, A.A., BARSKAYA, N.V. and GRINENKO, V.A., 1984, Redistribution of sulfur and its isotopes in hydrothermally altered oceanic basalts (Costa Rica rift, Hole 504B): Geokhimiya, 1984, no. 3, p. 390-402 (in Russian; English abstract).

BENTON, L.M., 1984, Ammonium geochemistry of Pb-Zn-Ag sedimentary exhalative ore deposits: a possible exploration tool (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 442-443. Author at Dept. Earth Sci., Dartmouth College, Hanover, NH 03755.

The ammonium (NH_4) concentration in sediments hosting sedimentary exhalative Pb-Zn-Ag deposits is found to increase in the hanging wall over the ore body.

Ammonium was found to be contained in authigenic feldspars, and reached bulk rock concentrations as high as 2000 ppm (30% feldspar). (From the author's abstract)

BERDNIKOV, N.B. and KARSAKOV, L.P., 1984a, Conditions of formation of granulites and amphibolites of the Lapland fault zone, data of thermobarogeochemistry: Akad. Nauk SSSR Doklady, v. 275, no. 6, p. 1450-1454 (in Russian). Authors at Tectonics and Geophysics of Far-East Sci. Center of Acad. Sci., Khabarovsk, USSR.

In the Lapland tectonic zone a granulite complex with very high PT parameters of metamorphism was found (so-called Laplandian type of metamorphism). Mineral equilibria indicate the values $10\text{-}11 \cdot 10^8$ Pa and 900-950°C. Fluid inclusions were studied in quartz, silimanite and hypersthene from hypersthene-sillimanite schist from Palenyi Island and in quartz from garnet-amphibole gneiss from Kochinnyi. Minerals from the schist bear only inclusions of L CO_2; in quartz P and PS inclusions were found, their size 1-20 µm, specific volume of CO_2 0.95-1.38 cm^3/g, melting starts at -56 to -58°C. Sillimanite bears single inclusions 1-5 µm long, specific volume of CO_2 1.00 tol.258 cm^3/g. Hypersthene contains rare small (1-3 µm) single inclusions with specific volume of CO_2 0.95 to 1.30 cm^3/g. Sometimes the inclusions bear also thin layers of water. Th of L CO_2 inclusions are in the following ranges (°C): I -17 to +2, Ia +2 to +10, II +12 to +17, IIa +17 to +26. A limited number of S inclusions filled by water solution of salts plus CO_2 was found in quartz and sillimanite.

Quartz from garnet-amphibole gneiss contains L CO_2 inclusions (1-10 µm) with specific volume 1.14 to 1.33 cm^3/g. P inclusions frequently bear also water phase, PS and S inclusions are filled by L CO_2 or L CO_2 + L H_2O. In certain growth zones inclusions of salt brines were found; they all decrepitated at 400-450°C before homogenization. Such inclusions formed probably due to heterogenization of formerly homogeneous CO_2-H_2O-salt fluid on decreasing P and T. Th of L CO_2 inclusions in the described gneiss range from +6 to +25°C; these inclusions formed at ~570°C (from mineral parageneses), hence P CO_2 at this T reaches $2.2\text{-}3.4 \times 10^8$ Pa.

Inclusions of the group I formed during crystallization of hypersthene-sillimanite paragenesis, inclusions of the group II and those in garnet-amphibole gneiss formed simultaneously, groups Ia and IIa refer to the retrograde stages of the above respective metamorphic processes. Inclusions of pure L CO_2 with Th -27 to -23°C are connected with culmination of the granulite metamorphism at 900-950°C, $7.1\text{-}8.5 \times 10^8$ Pa. (Abstract by A.K.)

BERDNIKOV, N.V. and KARSAKOV, L.P., 1984, Thermobarogeochemistry of metamorphic complexes of the southern Soviet Far East (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 22 (in English). Authors at Inst. Tectonics & Geophy., Far East Sci. Center USSR Acad. Sci., Khabarovsk, USSR.

Within the Stanovoy folded region there occur areally metamorphosed Archean granulitic and amphibolitic complexes, and also a superimposed epidote-amphibolitic complex of suture zones of dislocations. The Chogar granulitic complex is characterized by high-temperature and deep-seated sapphirine-quartz and hypersthene-sillimanite parageneses (T = 1000-1100°C, P = 10-11 kbar) with primary inclusions of liquid CO_2, $\rho = 1.07\text{-}1.13$ g/cm^3, and $\leqslant 7\%$ CH_4. In the Stanovoy amphibolitic complex of "grey gneisses" (T = 600-690°C, P = 6-7 kbar) the primary inclusions are filled with CO_2, $\rho = 0.85\text{-}1.18$ g/cm^3, and lesser H_2O. Relict inclusions of liquefied N_2, $\rho = 0.05\text{-}0.65$ g/cm^3, carrying the information on "pre-Stanovoy" metamorphism, are also found in it. The zonally metamorphosed rocks of the Giluy complex are characterized by garnet-staurolite-kyanite parageneses (T = 600°C, P = 5 kbar) with primary inclusions of aqueous-saline composition. During regressive metamorphism CO_2 appears in them. Three types of CO_2 inclusions are found in shallow granulites of the Khanka median massif (T = 750-800°C, P = 5-6 kbar): relict ($\rho = 1.05\text{-}1.09$ g/cm^3), primary and primary-secondary in the minerals of the main parageneses ($\rho = 0.91\text{-}1.03$ g/cm^3), and those originated as a result of amphibolite-facies retrograde metamorphism ($\rho = 0.80\text{-}0.91$ g/cm^3). In the amphibolite-facies rocks with the features of anatexis, which are exposed in the anticlinorium zone of the Sikhote-Alin folded system, the inclusions are filled with liquid CH_4, as well as are the inclusions in quartz of the granites cutting them. In the gneiss xenoliths from the basement of the folded system, primary fluid composition was CO_2. In the Mesozoic during geosynclinal-folded development of the system, the basement rocks were remobilized and broken by the fluid flow of methane composition. Thus the areally metamorphosed Archean rocks are characterized by CO_2-filled composition, and possibly N_2-specialization is ascertained. In the rocks of young, zonally metamorphosed complexes the fluid has diverse (CO_2, H_2O, CH_4, N_2) specialization. There is revealed the dependence of fluid composition in the rocks of the main crustal elements of the region on the degree of their transformation under the influence of mantle material during geological development. (Authors' abstract)

BERECZ, E. and BALLA-ACHS, M., 1983, Gas hydrates, in Studies in Inorganic Chemistry 4: Elsevier Publ., New York, 343 pp.

An extensive review, including data on all the hydrates that may be expected in fluid inclusions. (E.R.)

BERGMAN, S.C. and DUBESSY, Jean, 1984, CO_2-CO fluid inclusions in a composite peridotite xenolith: implications for upper mantle oxygen fugacity:

Contrib. Mineral. Petrol., v. 85, p. 1-13. First author at ARCO Oil and Gas Co. Res. and Dev. Dept. R208, P.O. Box 2819, Dallas, TX 75221, USA.

Fluid inclusions occur in a composite xenolith from the Lunar Crater Volcanic Field, Nevada, U.S.A. The xenolith is an amphibole-bearing wehrlite that is cut by an andesine-amphibole vein. The compositions of individual fluid inclusions in both portions of the xenolith have been determined using microthermometry and micro Laser-Raman spectroscopy. Fluids in the host wehrlite are nearly pure CO_2 (>99 mol%) whereas those in the vein contain from 8.5 to 12.0 mol% CO in CO_2. Chemical modelling shows that the composition of the vein fluids at T(room) is representative of the composition at the high P, T conditions of trapping. Graphite has not been observed by optical microscopy in any of the fluid inclusions. Graphite is probably absent (although stable at T <800°C) most probably because of the kinetically unfavorable CO decomposition reaction and rapid quenching. By combining the measured fluid compositions with fluid P-V-T data and the chemical equilibrium $CO_2 \rightleftarrows CO + 1/2O_2$, we have calculated the oxygen fugacity of the fluid inclusions at 1200°C: $\log fO_2 \cong 8.6$ (vein) and -6 (host). If the fO_2 of the fluid in the vein represents that in equilibrium with the magma that crystallized to produce the vein, then the fO_2 of the basalt magma is near QFM at 1200°C and 10.3 kbar. This is similar to values reported for extrusive basaltic lavas. If the much lower intrinsic oxygen fugacity-values for olivines and spinels from alkali basalt nodule are representative of upper mantle conditions, then oxidation of basaltic magmas must occur in the upper mantle prior to ascent to the surface. Implications for the origin of CO_2-rich fluids and carbon isotope geochemistry are also discussed. (Authors' abstract)

BERKHEISER, S.W., Jr., 1984, Fetid barite occurrences, western Berks County, Pennsylvania: Mineral Resources Rept. 84, Pennsylvania Geol. Survey, 43 pp.

The barite occurs in zeolite-pumpellyite facies sediments without Pb, Zn, Cu or Ag, but has associated organic matter. (E.R.)

BETHKE, P.M., 1984, Controls on base and precious metal mineralization in deeper epithermal environments: U.S. Geol. Survey Open-File Rpt. 84-890, 14 pp. plus illustrations. Author at U.S. Geol. Survey, Reston, VA 22092.

Two distinct chemical environments are recognized for epithermal mineralization in volcanic settings. In the first, typified by Goldfield, Nevada, mineralization is closely tied to magmatism; the ores are deposited in a chemical environment dominated by disproportionation of magmatic SO_2 and interaction of the resulting acid solutions with wallrock in steep thermal gradients near shallow plutons. In the second, typified by Creede, Colorado, mineralization is controlled by deeply circulating cells analogous to many modern geothermal systems; ores are deposited beneath an interface between deep, near neutral brines and overlying surface waters as a result of cooling and loss of acid volatiles. (Author's abstract)

This paper quotes many studies based at least in part on fluid inclusions. (E.R.)

BEYTH, Michael, STARINSKY, Avraham and LAZAR, Boaz, 1984, Low temperature geothermal waters, Timna, southern Israel: Geol. Survey Israel, Current Research 1983-84, p. 17-20. Authors at Hebrew Univ. of Jerusalem, Dept. Geol.

Like all the brines of the Dead Sea Rift, the Timna geothermal saline waters are of the Ca-chloride type with $mCa/m(HCO_3 + SO_4) > 1$ (Kanfi, 1972). The type locality for the Ca-chloride brines of the Dead Sea Rift is the area of the springs around the Dead Sea, 200 km north of Timna (Starinsky, 1974). The purpose of this work was to study the chemical characteristics of the waters of the seepages of the Timna Copper Mines and to compare them with those of the type locality. (Authors' Introduction)

BIE, Wanlin and LIU, Binglin, 1984, The method determining water in rock and mineral by gas chromatograph: Sci. Geol. Sinica, 1984, no. 1, p. 108-114 (in Chinese; English abstract). Authors at Inst. Geol., Acad. Sinica, Beijing, China.

The method for determining water in rocks and minerals by gas chromatograph has some advantages, such as wide scope, high sensitivity, simplicity, accuracy, rapidity, etc. and contributes to automation of analysis.

The instrument used by the authors was modified to make the water peak narrow. Some measurements were taken to expand the range of analysis and to improve its speed, precision and accuracy, including the use of integrated peak without substracting blank for quantitative analysis and external standards for calculation. This method was used in our laboratory for over one year. (Authors' abstract)

BIONDI, J.C. and FELIPE, R.S., 1984, The Volta Grande fluorite deposit, Cerro Azul, Paraná, Brazil: Anais do XXXIII Congresso Brasileiro de Geol., Rio de Janeiro (Proc. 33rd Brazilian Geol. Congress), p. 3784-3798 (in Portuguese; English abstract). Authors at Mineropar-Minerais do Paraná S.A., Curitiba, PR, Brazil.

The Volta Grande fluorite deposit (Cerro Azul, Paraná - BR) contains two tabular vertical orebodies in a fault cutting the Tres Córregos granite. They are formed by hydrothermal replacement of Proterozoic carbonate metasediments and cataclastic rocks. Field and laboratory data and some fluid inclusion determinations suggest that mineralization is related to the Mesozoic alkali magmatism, which is common in that region.

Fluid inclusion studies in fluorite, barite, and carbonate indicated that the conditions of mineralization decreased from 150/170°C in an aqueous solution of 3.2/5.6 wt.% NaCl equiv. to 60/80°C and meteoric water conditions (0.0/1.4 wt.%). (Authors' abstract modified by K. Fuzikawa)

BIRD, D.K., SCHIFFMAN, Peter, ELDERS, W.A., WILLIAMS, A.E. and McDOWELL, S.D., 1984, Calc-silicte mineralization in active geothermal systems: Econ. Geol., v. 79, p. 671-695. First author at Dept. Geol., Stanford Univ., Stanford, CA 94305.

Calc-silicates in the system $CaO-FeO-MgO-Fe_2O_3-O_3-Al_2O_3-TiO_2-SiO_2-H_2O$ are an important group of rock-forming minerals found in drill hole samples from active geothermal areas worldwide. The most common metasomatic calc-silicates in geothermal systems are heulandite, laumontite, wairakite, prehnite, epidote, garnet, sphene, clinopyroxene, actinolite, and wollastonite. Conditions of temperature, pressure, and the chemical characteristics of hydrothermal fluids associated with the occurrence of these minerals can be readily obtained from drill hole measurements. Observations such as these allow critical evaluation of the relationships between intensive thermodynamic properties and phase relationships of calc-silicates in active magma-hydrothermal systems.

A distinct sequence of calc-silicates is found which, in general, reflects progressive dehydration with increasing temperature. Heulandite and laumontite usually occur at temperatures below 200°C, whereas wairakite, epidote, prehnite, and actinolite occur within the range of temperatures from 200°C to greater than 300°C. Anhydrous phases of garnet, clinopyroxene, and wollastonite typically are found at temperatures greater than

300°C. With the exception of laumontite and wollastonite, hydrothermal calc-silicates exhibit a diverse range of compositions. Alkalis substitute for calcium in heulandite and wairakite, and there is considerable octahedral substitution of ferric iron for aluminum in epidotes, prehnite, and garnet and of ferrous iron for magnesium in clinopyroxenes and actinolites. In some case it can be shown that coexisting compositions of epidote and garnet, and actinolite and clinopyroxene, represent nonequilibrium partitioning of octahedral cations when compared with experimental, theoretical, and natural metamorphic phase relations.

In the Cerro Prieto and Salton Sea geothermal systems there are subtle systematic gradients in the averaged compositions of epidotes with increasing depth and temperature. Discontinuities in these compositional gradients are closely associated with the appearance or disappearance of one or more of the phases calcite, prehnite, wairakite, or biotite. From the available data there is no other obvious systematic correlation between observed compositional trends of calc-silicates and either depth or temperature in most geothermal systems. Bulk rock and fluid compositions appear to be important factors controlling the observed compositional characteristics of these minerals.

Our detailed study of the calc-silicate mineralogy in the Cerro Prieto geothermal system was used to demonstrate examples for thermodynamic evaluation of phase relations among minerals of variable composition and to calculate the chemical characteristics of hydrothermal solutions compatible with the observed calc-silicate assemblages. In general there is a close correlation between calculated and observed fluid compositions. Calculated fugacities of O_2 at about 320°C in the Cerro Prieto geothermal system are about five orders of magnitude less than those at the nearby Salton Sea geothermal system. This observation is consistent with the occurrence of Fe^{+3}-rich epidotes and andradite garnets in the latter system and the presence of prehnite at Cerro Prieto. (Authors' abstract)

BISCHOFF, J.L. and ROSENBAUER, R.J., 1984, Pressure-volume-temperature relations of hydrothermal seawater: experimental determination, mathematical formulation, and calculation of thermochemical parameters: U.S. Geol. Survey Open File Report 84-845, 25 pp. plus 62 pp. tables.

The pressure dependence of the specific volume of seawater (3.2% 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. After extrapolation to 1000 bars, the isotherms were fit to the Tammann compressibility equation. The temperature-dependent parameters of the Tammann equation were then regressed to polynomials of temperature. The result is an empirical equation of state that describes the specific volume, compressibility, and expansivity of seawater as a function of temperature and pressure applicable to seafloor geothermal systems. Using this equation and applying corresponding states theory, enthalpy, entropy, heat capacity, and the isothermal and isenthalpic Joules-Thompson coefficients of seawater as a function of temperature and pressure were calculated. (Authors' abstract)

BLACIC, J.D. and CHRISTIE, J.M., 1984, Plasticity and hydrolytic weakening of quartz single crystals: J. Geophys. Research, v. 89, no. B6, p. 4223-4239. First author at Geophysics Group, Los Alamos Nat'l. Lab.

The historical record and experimental data on the plasticity of quartz crystals are reviewed, including the discovery of the important phenomenon of hydrolytic weakening. Quartz deforms by slip on numerous planes, generally with Burgers vectors 1/3 $\langle 2\bar{1}\bar{1}0 \rangle$ and [0001]; $\langle \underline{c} + \underline{a} \rangle$

slip may be activated when resolved shear stresses on *a* and *c* slip systems are low. Dry natural crystals deformed in an anhydrous environment are very strong, with strengths approaching the intrinsic "theoretical" values, at temperatures up to 1000°C. Synthetic crystals with high OH concentrations and dry crystals heat-treated in a hydrous environment are anomalously weak above a critical temperature (T_C) that varies inversely with OH content. There is a transition in the preferred slip system in crystals equally stressed for *a* and *c* slip that coincides with the hydrolytic weakening temperature (T_C). Yielding and flow in all crystals below their respective critical weakening temperatures appear to be controlled by a lattice resistance mechanism, characterized by a low activation energy and very small activation area. Above the critical temperatures, it appears that crystal flow is facilitated by diffusion of "water," or some related hydroxy defect, to the dislocations, causing hydrolysis of the strong Si-O-Si bonds and aiding bond exchange. This process may assist glide or climb of dislocations--or both--and appears to be rate-limiting. There is evidence that hydrolytic weakening is strongly influenced by confining pressure, possibly through the solubility or diffusivity of H_2O or its components in quartz. The change in slip systems at the weakening temperature is attributable to anisotropy of the diffusivity. Similarly, a discontinuity in the creep rates of synthetic crystals, with a concomitant change of activation energy, at the - transition is consistent with observed changes in diffusivity at the transition temperature. The experimental data are not yet complete enough to construct an adequate microdynamical model of the flow mechanism. (Authors' abstract)

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).

BLAKE, Stephen, 1984, Volatile oversaturation during the evolution of silicic magma chambers as an eruption trigger: J. Geophys. Res., v. 89, no. 110, p. 8237-8244. Author at Research Sch. Earth Sci., The Australian Nat'l. Univ.

Large, shallow silicic magma chambers can apparently generate their own potential to initiate caldera-producing eruptions. Differentiation of an initially water-poor siliceous magma yields a stably graded zone of extremely fractionated low-density liquids of low temperature, low crystallinity, and high water content at the chamber top. After protracted evolution of such a system, the uppermost magma in the chamber will become oversaturated in water, generating an excess pressure. By equating the magma and chamber volumes at some pressure above the stable lithostatic value, this excess magmatic pressure can be evaluated as a function of the magma's compressibility, water content and solubility, lithostatic pressure (chamber depth), and some assumed measure of the chamber's ability to expand. Critical overpressures between 5 and 25 MPa are believed to be sufficient to rupture most chambers, implying that for rhyolite magma at 850°C, the critical water contents are in the range 3-6 wt % for chambers buried at depths of 1.5-7 km. The vesicularities of the magma in the oversaturated layer are calculated to be $\lesssim 1\%$ but may reach $\sim 10\%$ in cases where the oversaturated layer is a small (less than a few percent) part of the chamber and when the chamber can dilate during the increase in pressure. It follows from this study that fractionated magmas evolving at shallow depth cannot attain water contents much above 6 or 7 wt %, since in so doing they become oversaturated and are ultimately erupted. (Author's abstract)

BOCHEK, L.I., SANDOMIRSKAYA, S.M., CHUVIKINA, N.G. and KHVOROSTOV, V.P., 1984, New selenium-bearing sulfide of silver, gold and copper-penzhinite $(Ag,Cu)_4Au(S,Se)_4$: Zapiski Vses. Mineral. Obshch., v. 113, no. 3, p. 356-360 (in Russian). Authors at Central Sci.-Research Geol.-Prosp. Inst. of Precious Metals, Moscow, USSR.

Th of inclusions in quartz paragenetic with penzhinite equals 250-420°C. (A.K.)

BOCTOR, N.Z., NIXON, P.H., BUCKLEY, F. and BOYD, F.R., 1984, Petrology of carbonate tuff from Melkfontein, East Griqualand, southern Africa: Kimberlites I: Kimberlites and Related Rocks, J. Kornprobst, ed., p. 75-82.

Xenocrysts in the tuff are suggested to have come from a metasomatized garnet granulite or to have equilibrated with a LREE-enriched vapor after incorporation in the tuff. (E.R.)

BODNAR, R.J. and BETHKE, P.M., 1984, Systematics of stretching of fluid inclusions I: fluorite and sphalerite at 1 atmosphere confining pressure: Econ. Geol., v. 79, p. 141-161. Authors at U.S. Geol. Survey, Mail Stop 959, National Center, Reston, VA 22092.

Measured homogenization temperatures of fluid inclusions in fluorite and sphalerite may be considerably higher than the true homogenization temperatures if the samples have been previously heated, owing to nonelastic deformation of the inclusion walls in response to the increase in internal pressure as the temperature is raised. This deformation produces a volume increase and a concomitant increase in the fluid inclusion homogenization temperature in subsequent heating tests, without loss of any of the inclusion contents. If this increase is greater than the precision of the temperature measurement, the inclusion is said to have stretched. The amount of stretching is indexed quantitatively by the increase in the homogenization temperature and is expressed in degrees Celsius.

More than 1,300 measurements on fluid inclusions in fluorite and sphalerite indicate that stretching proceeds systematically and predictably. In order to generate internal pressures that are sufficiently high to cause stretching, most inclusions must be heated beyond their initial homogenization temperatures, i.e., overheated. The amount of overheating necessary to initiate stretching depends on the P-V-T-X properties of the inclusion fluid, the inclusion size and shape, physical properties of the host mineral, and the confining pressure. Inclusions having steep isochoric P-T paths and/or high internal pressures at homogenization require smaller amounts of overheating to initiate stretching than do inclusions having less steep isochores and/or low equilibrium vapor pressures at the temperature of homogenization. For a given composition and amount of overheating, regularly shaped inclusions are less likely to stretch than irregularly shaped inclusions in all minerals and, within each of these types, smoothly rounded to subhedral inclusions are more resistant to stretching than are angular or negative crystal-shaped inclusions.

In the range of homogenization temperatures and salinities examined in this study, the amount of overheating necessary to initiate stretching of inclusions in fluorite is inversely related to inclusion volume according to:

$$T_{oh} = 100 - 16 \log_{10}V,$$

where T_{oh} is the amount of overheating in degrees Celsius and V is the inclusion volume in μm^3. Assuming an isochoric slope, dP/dT, of 9 $bars \cdot °C^{-1}$ for the inclusion fluid, the calculated internal pressure necessary to initiate stretching of inclusions in fluorite under a confining pressure of 1 atm is related to inclusion volume as:

$$P_{int} = 900 - 147 \log_{10}V,$$

where P_{int} is the internal pressure in bars and V is the inclusion volume in μm^3. In natural situations where the confining pressure is considerably higher than 1 bar, the internal pressure and corresponding amount of overheating required to initiate stretching is increased. The mechanism of stretching of fluid inclusions in fluorite is probably plastic deformation associated with movement of dislocations in the surrounding host mineral or, less likely, the opening of microfractures in the inclusion walls. Evidence of fracturing was generally not observed at optical mangifications during this study.

Inclusions in sphalerite are generally more resistant to stretching than those in fluorite and the data for sphalerite are less systematic. The amount of overheating required to initiate stretching of inclusions in sphalerite ranged from <8°C for an inclusion several hundred micrometers in diameter to >75°C for a 10-µm-diam inclusion. Fracturing of the inclusion walls is more common for inclusions in sphalerite as compared to fluorite, but the dominant mechanism of stretching of inclusions in sphalerite appears to be plastic deformation.

Reconnaissance studies indicate that inclusions in barite are very susceptible to stretching, doing so with little or no overheating, and suggest that barite is an unreliable host mineral for fluid inclusion studies.

The results of this study show that the measured homogenization temperature of a fluid inclusion may be considerably higher than the true homogenization temperature if the internal pressure reached sufficiently high values during previous testing in the laboratory or, less likely, during postentrapment thermal events in nature. The systematic relationship between the internal pressure necessary to intiate stretching and the inclusion volume provides a means of recognizing previously stretched inclusions and estimating the magnitude of postentrapment thermal events. Furthermore, reproducibility of homogenization temperature measurements, lack of microscopically observable fractures in the inclusion walls, and the lack of noticeable increase in the vapor bubble size after heating are insufficient to prove that an inclusion has not stretched. (Authors' abstract)

BODNAR, J.R. and STERNER, S.M., 1984, Application of synthetic fluid inclusions to phase equilibria studies (abst.): EOS, v. 65, p. 292. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Experimental studies have shown that synthetic fluid inclusions in quartz trap representative samples of the parent solution. Inclusions trapped from a homogeneous, one-phase fluid exhibit uniform phase ratios at room temperature, and temperatures of various phase changes agree with predicted values. Inclusions trapped from immiscible fluids, however, display a wide range in phase ratios at room temperature, with most of the inclusions having phase ratios which suggest entrapment of only end-member compositions. Thus, simple optical examination of inclusions trapped at known P-T-X conditions reveals whether the inclusions formed in a one-fluid-phase field, or in the presence of two or more immiscible fluids. In addition, by performing heating/freezing tests on inclusions which trapped one or the other (but not mixtures) of the two immiscible fluids, end-member compositions may be determined.

Synthetic fluid inclusions have been formed at various P-T conditions from H_2O-NaCl solutions of known bulk composition to test this technique and to extend the range of available data. Inclusions trapped at 700°C and 1100 bars from a 5 wt % NaCl solution exhibit uniform phase ratios at room temperature, indicating entrapment in a one-fluid-phase fluid. However, at 700°C and 1000 bars, a solution of this same bulk composition produces both low salinity, vapor-rich inclusions and high salinity, liquid-rich inclusions containing a halite daughter mineral, indicating the presence of two immiscible fluids at the conditions of entrapment. Thus, the one phase-two phase boundary at 700°C for a bulk composition of 5 wt % NaCl lies between 1000 and 1100 bars, which is in agreement with previously published results. Using this same "bracketing" technique, the maximum pressure at which a 5 wt % NaCl fluid is immiscible is 1200 ± 50 bars at 800-825°C. (Authors' abstract)

BODNAR, J.R. and STERNER, S.M., 1984b Synthetic fluid inclusions in natural quartz (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 448. First author at Chevron Oil Field Res. Co., P.O. Box 446, La Habra, CA 90631.

Synthetic fluid inclusions having a wide range of geologically applicable compositions in the C-O-H-S-Na-K-Ca-Cl-Cu-Fe system have been formed by healing fractures in inclusion-free natural quartz and by precipitating new quartz overgrowths on an original seed crystal. Inclusion types synthesized include: (1) primary and seconary pure H_2O inclusions of various densities, including the critical density, (2) liquid-rich inclusions containing undersaturated aqueous solutions of NaCl or KCl or $CaCl_2$, or mixtures of the three salts, (3) H_2O-NaCl inclusions containing halite daughter minerals, (4) H_2O-NaCl-KCl inclusions containing halite and sylvite daughter minerals, (5) H_2O-CO_2 inclusions of various compositions containing liquid H_2O and either CO_2 vapor or CO_2 liquid, or both, at 25°C, (6) H_2O-CO_2-NaCl inclusions containing an aqueous phase, liquid and vapor CO_2, and halite at 25°C, (7) C-O-H inclusions containing liquid H_2O, a CO_2-CH_4 liquid phase, and graphite at 25°C, (8) H_2O-NaCl inclusions that contain a chalcopyrite daughter mineral, and (9) inclusions representing trapping of the coexisting, immiscible phases in the H_2O-NaCl, H_2O-CO_2-NaCl, and Na-C-O-H systems.

Inclusions trapped in the one-fluid-phase field exhibit uniform phase ratios at room temperature, and the temperatures of various phase changes within individual inclusions agree with those predicted from experimental and theoretical data, indicating that the inclusion fluid has the same composition and density as the parent solution. These 'minature autoclaves' may therefore be used to study numerous problems related to fluid inclusion research, to calibrate the various analytical equipment used to study natural fluid inclusions, and to study phase equilibria, solubility, and PVT relations of a variety of chemical systems. (Authors' abstract)

BOETTCHER, A.L., 1984, The system SiO_2-H_2O-CO_2: melting, solubility mechanisms of carbon, and liquid structure to high pressures: Am. Mineral., v. 69, p. 823-833. Author at Inst. Geophys. & Planet. Phys. and Dept. Earth & Space Sci., Univ. California, Los Angeles, Los Angeles, CA 90024.

To serve as a model for the solubility mechanisms of carbon in silicate liquids and as a model for melting relationships in systems containing multi-component vapors, the system SiO_2-H_2O-CO_2 was investigated to pressures of 27.5 kbar and temperatures from 1000 to 1650°C. The solubility of carbon in the hydrous liquids increases markedly above 10-15 kbar, probably entering the liquid as molecular CO_2, possibly in part as tetrahedral carbon. Phase transformations in the high-pressure liquids, such as quartz ⇆ coesite structure, may enhance the solubility. The amount of carbon in solution is unknown, particularly at the lower pressures, and this precludes calculation of the activity coefficients of H_2O in the H_2O-CO_2 vapors. The solubility mechanisms and data on the liquids in this system may also apply to the more complex, aluminosilicate magmas. (Author's abstract)

BOGASHOVA, L.G., 1984, Consanguinity of ore-forming solutions with salt-originating basins and underlying terrigenous deposits (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 37-38. Author at Moscow State Univ., Geological Faculty, Moscow, USSR.

The genetic analysis of ore-forming thermal brines shows that their source was either evaporable-sea basins, or atmospheric waters and deposits of evaporites. High degree of metamorphism (predominance of Ca over Mg), and higher temperatures of brines indicate that these brines moved from surface salt-originating basins to deep water-bearing horizons through several kilometers of terrigenous-carbonate rocks underlying salt-originating basins. Interstitial solutions can provide information of brine infiltration and formation of their composition in these deposits.

The study of interstitial solutions of salt-bearing and subsalt clay rocks carried out on potash-salt deposits revealed that the frontal subsidence of brines proceeded in extensive areas, and was accompanied by their metamorphism and concentration of heavy metals in them. All studied interstitial brines are metalliferous: the content of heavy metals in them is similar to that in ore-forming hydrotherms and gaseous-liquid inclusions in minerals of stratiform deposits of metals. It has been established that enclosing clay rocks with clark concentrations of metals served a source of heavy metals in interstitial brines. Ore concentrations of heavy metals without higher temperatures owe their origin to a vast area of contiguity and interaction of aggressive chloride brines with dispersed clay rocks (ratio of liquid phase to solid phase ≈ 1:10), and presence of easily soluble compounds of metals in these rocks. The experiments carried out confirmed the possibility of generation of metal ore concentrations in chloride brines by their filtration under pressure through clay rocks containing metals at a clark level. The data obtained enable us to assume that the brines of salt-originating basins [that have] undergone the stage of interstitial solutions in subsalt terrigenous deposits were the source of ore-forming solutions in stratiform deposits. (Author's abstract)

BÖHLKE, J.K., KISTLER, R.W. and MCKEE, E.H., 1984, K-Ar Rb-Sr, and stable isotope data on the ages and fluid sources of gold-quartz veins in the Sierra Nevada foothills metamorphic belt, California (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 448-449.

BOKIY, G.B., NIKITIN, A.V. and PEPIN, S.V., 1982, Chemical transport of carbon by nitrogen-containing "intermediates" in natural diamond synthesis: Dokl. Akad. Nauk SSSR, v. 266, no. 3, p. 711-714 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 266, p. 169-172, 1984).

BOKONBAEV, K.Dzh., 1984, Geological aspect of descending bubbles: Akad. Nauk SSSR Doklady, v. 274, no. 6, p. 1438-1440 (in Russian). Author at Inst. of Geol. of Acad. Sci. Kirgiz SSR, Frunze, Kirgiziya.

The author proposes explanation of mechanism of "squeezing down" of gas bubbles in magmatic chamber: if T gradient occurs in viscous L, it causes a change of surface tension on the phase boundary. This coefficient will be lower on the side of warmer layers of L. Hence this causes a decrease of the Laplace pressure in the opposite point of the bubble, stimulating the bubble motion in viscous L toward the higher T. If lower layers are warmer, the bubble migrates downwards. The author presents results of experiments made in organic liquids. (Abstract by A.K.)

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. Authors at Inst. Geol., Kirgiz Acad. Sci., Frunze.

Calculates the possibilities of movement of bubbles up a temperature gradient (and hence down in a magma chamber). (E.R.)

BONEV, I., 1984, Mechanisms of the hydrothermal ore deposition in the Madan lead-zinc deposits, Central Rhodopes, Bulgaria: Proc. 6th Quadrennial IAGOD Symp., E. Schweizerbart'sche Verlagsbuchhandlung (Nagele u. Obermiller) Stuttgart, Germany, p. 69-73. Author at Geol. Inst., Bulgarian Acad. Sci., 1113 Sofia, Bulgaria.

The ore bodies of the Madan district are formed mainly under the effect of physico-chemical changes in the ore-forming solutions as a result of (a) interaction with pyroxene skarns and occasionally with marbles, (b) interaction with the associated gneiss rocks and (c) boiling of the solutions. (Author's abstract)

Interpretation based in part on previously published fluid inclusion data. See also Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 25-26. (E.R.)

BONEV, I.K., REICHE, M. and MARINOV, M., 1984, Morphology, perfection and growth of natural pyrite whiskers and thin platelets: Phys. Chem. Minerals, v. 12, p. 223-232. First author at Geol. Inst., Bulgarian Acad. Sci., 1113 Sofia, Bulgaria.

Whiskers and thin platelets of pyrite have been found growing coherently on the faces of small cubic pyrite crystals. The thin whiskers are perfect and dislocation-free, although some ribbon-like whiskers and platelets contain internal longitudinal channels and small isometric fluid inclusions. (From the authors' abstract)

BONGDARA, B., GRIVOR'YEV, Ib.F, GROMOV, A.V., DOLOMANOVA, Ye.I. and NOSIK, L.P., 1984, Conditions of formation of tin deposits in the Nam Pa Ten area, Laos, as indicated by thermobarogeochemistry and the isotope composition of carbon in CO_2 and sulfur in sulfides: Geologiya i Razvedka, 1984, no. 8, p. 24-30 (in Russian; translated in Int'l. Geol. Rev., v. 27, no. 1, p. 102-108, 1984). Authors at Inst. Geol. of Ore Deposits, Petrog., Min. & Geochem., USSR Acad. Sci. and Sergo Ordzhonikidze Geol. Explor. Inst., Moscow, USSR.

The tin deposits of the region are located in faults in a clastic sequence. They fall into two types, the cassiterite-quartz and cassiterite-sulfide associations, in terms of mineral composition and geochemical characteristics. The ore bodies of the cassiterite-quartz association (Nong Syn deposit) are quartz veins and veinlets containing cassiterite, microcline, biotite, orthoclase, oligoclase, albite, and less often wolframite, topaz and fluorite. The cassiterite in the ore veins forms short-prismatic and dipyramidal crystals. Arsenopyrite and pyrite are also found. The country rock is silicified and greisenized at vein contacts. The ore bodies of the cassiterite-sulfide association (Phon T'yu and Boneng deposits) have a more complex mineralogical makeup. In addition to cassiterite, they have abundant quantities of such minerals as chalcopyrite, sphalerite, arsenopyrite, pyrrhotite, galena, and less often stannite. Gangue minerals include quartz, chlorite, sericite and muscovite. The cassiterite in the veins forms long-prismatic and pinacoidal-prismatic crystals. Wallrock alteration consists of zones of chloritization, sericitization and slight silicification.

The Nang Syn deposit Th ranged from 130-340°C with mode at 269°C; those from the cassiterite-sulfide association ranged from 134-336°C [from text, but Figs. 3 and 6 reverse these sets of data]. $\delta^{13}C$ from decrepitation of inclusions in both quartz and cassiterite from both types of deposit was measured (-4.85 to -14.75‰PBD), suggesting organic carbon from country rock. $\delta^{34}S$ was also determined on sulfides. (From text and E.R.)

BONHAM, H.F., Jr. and GARSIDE, L.J., 1984, Tonopah summary, *in* Western geological excursions, v. 3, p. 165-169, Lintz, J., Jr., ed.: Publ. by MacKay Sch. Mines, Dep. Geol.

Quotes literature data on fluid inclusion studies. (E.R.)

BONI, Maria, 1984, Fluid inclusions as a contribution to genetic and paleoenvironmental problems for the post-Hercynian karst ores in Iglesiente-Sulcis (southwest Sardinia): Abstracts, 5th European Congress on Sedimentology, Marseille, France, 1984: Int'l. Assoc. Sedimentologists, p. 66-67. Author at Univ. Napoli, Italy.

The fluid inclusions in barite, quartz, calcite, fluorite and dolomite from the karst cavities and vein fillings have been analyzed. In these minerals, with the exception of vein fluorite, the most frequent inclusions are monophase, not even becoming two-phase by freezing. We can therefore suppose that there is at least one major generation with a Th lower than 50°C. A second generation, ranging from 60°C to 110-130°C, is also common to these minerals, with lower values for calcite (mean value 95°C) and fluorite (85°C) and higher for quartz (110°C). The dolomite crystals, belonging to the "geodic" and "yellow" types, both related to the Permo-Triassic dolomitization of the Cambrian lithotypes, show also, apart from monophase inclusions, a two-phase generation with Th ranging from 60 to 120°C (mean 95°C). The vein fluorite differs in having also a well-defined generation at a higher temperature (120-160°C), with a maximum between 140 and 160°C, and is therefore in a field that could be clearly defined as hydrothermal.

Many scattered higher temperature data have been found. In the case of the quartz, it could be theoretically possible to hypothesize a generation with a Th ranging from 160° to 250°C; for fluorite, calcite and especially barite, the more probable explanation is of necking down and leaking phenomena.

Freezing temperatures, if some scattered values (mostly in calcite) ranging from -2°C last melting to 0°C, which are still under investigation, are not taken into account, show a very consistent grouping for quartz, fluorite and dolomite of between -16 and -22°C, for Th between 60 and 130°C. The salinity, therefore, is quite high (20-24 wt.% NaCl). It may be necessary to consider also other salts than NaCl (chemical analyses are still in progress), because first melting temperatures have been found between -57 and -45°C.

The whole series of data on the fluid inclusions seems to be fully in the range of the Mississippi Valley-type ores, both for Th and salinities. They do not explain, however, in an indisputable way, the actual genesis of both the ore and gangue minerals in the post-Hercynian karst- and vein-fillings. At least part of the ore forming fluids have been warm, sometimes hot, and extremely saline. Because of the high salinities, they could be derived from the connate waters of the Permo-Triassic, partly evaporitic, sediments (Campoma series). Instead, the high temperatures common both to the karst fillings and to the dolomitic alteration of the Cambrian host carbonates, might have a double origin: either resulting from late diagenetic exothermic processes involving reduction of sulphate minerals through organic matter and generation of hydrocarbons, or from higher geothermal gradients in an area recently subjected to an intense orogenetic cycle and to granitic intrusions. (From the author's abstract)

BORISENKO, A.S., LEBEDEV, V.I. and TYUL'KIN, V.G., 1984, Formation conditions of hydrothermal cobalt and cobalt-containing deposits: Trans. Inst. Geol. Geophy. Siberian Br. Acad. Sci. USSR, v. 550, 172 pp. (in Russian).

Much attention is paid to the study of gas-liquid inclusions in minerals by methods of homogenization, cryometry, gas chromatography, etc., allowing characterization of P-T conditions, composition, concentration and other physical-chemical parameters of mineral-forming fluids, their evolution in space and time. Analysis of the basic physical-chemical and geologic factors causing deposition of ore and non-metalliferous vein minerals is given. The problems of polygeneous origin of the sources of hydrothermal solutions and ore-forming elements are considered in detail. An important role of vadose waters in the formation of cobalt mineralization is shown. A possible genetic model of the formation of hydrothermal cobalt and cobalt-bearing deposits is suggested. (Authors' abstract)

The paper presents conditions of spatial distribution of cobalt and cobalt-bearing ore formations and their connections with magmatism, and peculiarities of mineral composition of ores. Gas-liquid inclusions were studied mainly in quartz, carbonates and barite from ore bodies. Minerals from the following deposits of the arsenide Ni-Co vein type were investigated: Khovu-Aksy, Askhatiin-Gol, Akol (Tuva, USSR), Abakan (Khakassiya, USSR), Kura-Ozek (Gornyi Altai), Aktepe (Uzbekistan), Bou-Azzer (Maroc). Khovu-Akay: skarn stage garnet bears rare P polyphase inclusions LH_2O + G + 2 or 3 dms, inclusion size ≤5 µm. All dms are soluble, one is halite, inclusions homogenize at 280-350°C (central zones of crystal Th 350-310°C, outer zones 320-280°C. S inclusions yielded Th <200°C. Skarn tourmaline bears similar inclusions with halite dm, Th 250-270°C. Quartz and carbonate of the final skarn stage contain also G + L + dm halite of Th 230-290°C (quartz) and 180-270°C (calcite); by Klevtsov + Lemmlein method P reached 550-700 atm. Post-skarn pre-ore quartz bears inclusions with Th 35-80°C and 50-40°C. Ore bearing quartz (with nickeline and skutterudite) yields Th 40-60°, dolomite 50-80°C. Quartz-rammelsbergite association gave Th 40-100°C, calcite-safflorite 40-110°C (inclusions with trapped halite crystals), late arsenide stage 40-135°C and final calcite-sulfide-sulfosalt stage 60-160°C. Askhatiin-Gol: arsenide mineralization occurs in carbonate and quartz-carbonate veins with siderite, barite and fluorite. Th typical of arsenide stage are in range 105-170°C, inclusions bear halite dm, P determined by Lemmlein + Klevtsov method reaches 120 to 450 atm; P obtained from CO_2 inclusions (Th + 20°C in G phase) equals 100-160 atm. Sulfide stage minerals yielded Th 90-140°C. Similar Th values were obtained for the other studied Co deposits from Tuva, Khakassiya, Central Asia and Maroc.

The deposits of the cobalt sulfoarsenide ore formation are characterized by Th 105-180 (deposit Vladimirovskoe in Gornyi Altai), 80-165°C (deposit Akdzhilga in S. Kirgiziya), 210-700°C (an unnamed Au-Co deposit), 190-280°C (deposit Karakul' in Gornyi Altai).

The minerals of the deposits of Cu-Co sulfoarsenide-sulfosalt and sulfosalt ore formations generally bear inclusions with Th 40-230°C, halite is the common dm (deposits: Kharadzhul', Butrakhta, Uzun-Oy, Ozernoe, Askhatin, Kaat-Taiga etc.). Concentrations of solutions may achieve even 30-35 wt. % of NaCl equiv. (rarely more). Cryometric studies indicate frequent presence of $CaCl_2$ in solutions (Te -50 to -59°C) and possibly $MgCl_2$ and $CaBr_2$ (Te -83°C). Analyses of water leachates confirmed the above composition of inclusion solutions. During cryometric studies one dm was identified as $CaCl_2 \cdot 6H_2O$ (antarcticite). In solutions, NaCl is in conc. ranges 4.5-26.5 wt.%, $CaCl_2$ 3-28 wt.%, KCl up to 4 wt.%. Gas present in inclusions is mostly CO_2 (7-69 mg/kg of sample), unidentified gases (0-6 mg/kg); water content equals 275-1900 mg/kg of sample. (Abstract by A.K.)

BORISOV, M.V., RYZHENKO, B.N. and KRAYNOV, S.R., 1984, Influence of acid-basic properties of rocks on a composition of the equilibrated aqueous solution: Geokhimiya, 1984, no. 5, p. 705-713 (in Russian; English abstract).

Dependences of composition of fluids equilibrated with rocks on the rock bulk chemistry, rock-water ratio, and temperature were studied. It was shown that the chemical type of the rock but not simply the contents of given elements and the variation of their contents in the rock determine the composition of equilibrated aqueous fluid and its acid-basic characteristics. A comparison of calculated and observed contents of alkalies in natural waters was done. (Authors' abstract)

BORNHORST, T.J., KENT, G.R., MANN, K.L. and RICHEY, S.R., 1984, Temperature of mineralization in Mogollon mining district and vicinity, southwest New Mexico: New Mexico Geol., v. 6, no. 3, p. 53-55. Authors at Dept. Geol. & Geol. Engrg., Michigan Tech. Univ., Houghton, MI 49931.

Inclusions in fluorite, calcite, and quartz were studied. Th ranged from 157 to 269°C; salinity = 3.2-3.5% NaCl equiv. Ratios of Na:K:Mg:Mn were determined on four samples by leaching. (E.R.)

BÖTTGER, T., STIEHL, G. and MUHLE, K., 1984, Variations in δD of granite and mica schist in contact rocks of a pluton in the Middle Erzgebrige: ZFI-Mitteilungen, "Isotope in der Natur," no. 85, p. 9-18: Leipzig, Akad. Wissen. der DDR (in German; English abstract). Authors at Akad. Wissen. der DDR, Zentralinstitute Isotopen- & Strahlenforschung, DDR 7050 Leipzig, Permoserstr. 15.

The δD values and hydrogen contents were determined on samples from a profile of granite and mica schists in the area of a pluton in the Middle Erzgebirge Mts. The δD values and hydrogen contents of the wall rock are influenced by the intrusion process. δD values of granite vary from -31 to -102‰ (vs. SMOW). Hydrogen contents and δD values decrease with increasing distance from the granite contact. A model based on the Rayleigh-process is discussed. (Authors' abstract)

BOTTINGA, Y., 1984, Compressibility of silicate liquids (abst.): Terra Cognita, v. 4, no. 3, p. 306-307.

BOULAY, C., 1984, A study of the metalliferous (Cu-Pb-Zn; F-Ba) veins with silicified anhydrite in the Giromagny-Auxelles and Sewen-Urbes regions (southeast Vosges, France): These 3e Cycle, Univ. Nancy, in CRPG Rapport Annuelle 1984-1985, p. 75-76 (in French).

In the Hercynian massifs of Europe, there are numerous metalliferous veins which are partially or totally composed of quartz gangue, in which the cross-hatched structure is classically interpreted as the silicification of a pre-existing barite assemblage. Recent studies of a number of these veins (Arnold and Guillou, 1980), indicate that more commonly there has been a pseudomorphic replacement of anhydrite.

Studies of the quartz gangue and of the mineralization allows one to propose for these vein systems two general types of zones: 1) one zone where the cross-hatched quartz results from the silicification of both $CaSO_4$ and $CaCO_3$. These veins are predominantly mineralized with Cu, and 2) another zone in which the gangue is pseudomorphous after anydrite. In these veins, there is a dominance of Pb.

The basic physical chemistry of anhydrite solubility shows that for the case studied, anhydrite will not precipitate due to evaporation, increase of temperature in a calcium-rich solution, or dilution of this solution. Based on major element analyses of the anhydrites and on partition coefficients between anhydrite and brines, it appears that, for the conditions studied, anhydrite deposition will occur from sulfate solutions which contain magnesium and sodium.

Based on cryometric analyses, it appears that the silicification occurred in a magnesium-rich environment by the mixing of two shallow waters of different salinities.

Continentally-derived water, which has reacted with the rocks through which it flowed, augment the brines in both silica and metal ions. Isotopic relationships between sulfates ($BaSO_4$) and sulfides (PbS, $CuFeS_2$) show differences of +20 to +30‰, which may be explained by bacterial reduction to produce H_2S. The metal ions are deposited when they come into contact with the H_2S-enriched brines. Finally, the Mg-Na character of the brines permits a reconcentration of W mineralization originally tied to the emplacement of the microgranite.

Fractures permit the trapping and ultimately the mixing of two waters of very different chemistries. Their mixing within the fractures, which are connected to underlying evaporites, led to the conditions for the silicification of anhydrite and the deposition of the metals. (Translation courtesy M.J. Logsdon)

BOULEGUE, J., PERSEIL, E.A., BERNAT, M., DUPRE, B., STOUFF, P. and FRACHETEAU, J., 1984, A high-temperature hydrothermal deposit on the East Pacific Rise near 7°N: Earth & Planet. Sci. Letters, v. 70, p. 249-259.

BOURCIER, W.L., GIBSON, E.K., Jr. and KOTRA, R.K., 1984, Characterization and gas analysis of fluid inclusions in Archean barites from the Warrawoona group, northwestern Australia (abst): Lunar and Planet. Sci. XV, p. 82-83. First author at NRC-Res. Assoc., SN-4/NASA-JSC, Houston, TX.

Our examination of the fluid inclusions in 3.4-b.y.-old barites from the North Pole deposit have shown that four coexisting inclusion types are present: (1) large (20-40 micron) irregular, morphologically distinct inclusions which may contain one, two, or three phases, commonly they contain only an aqueous and a vapor phase, but may also contain an aqueous phase plus liquid and vapor CO_2, or only a single phase; (2) smaller (10-30 micron) roughly equant three-phase inclusions having liquid and vapor CO_2, and commonly an additional pale yellow daughter mineral; (3) much smaller (1-10 micron) two phase secondary inclusions aligned along planes in the barites, and (4) intermediate sized (5-15 micron) one-phase inclusions of pale yellow or brown color. The occurrence of this variety of inclusion types indicates that the barites have not been thoroughly recrystallized during a later (2.95-b.y.-old) lower-greenschist facies metamorphic event, as evidenced by the presence of the assemblage calcite+

chlorite+actinolite+prehnite in the surrounding metavolcanic host rocks (Hickman, 1981).

The type (1) inclusions most likely represent primary fluid inclusions in the barite. Textural relationships show no obvious alignment of the inclusions along healed fractures. The variety of liquid/vapor ratios can be explained by leakage of fluids into or out of the inclusions during later tectonism. Although it cannot be assumed with certainty that they formed from the original mineralizing fluid, it is clear that they are older than type (2) and type (3) inclusions.

The high-density type (2) inclusions, which contain both liquid and vapor CO_2, have phase relations consistent with their having formed from fluids generated by the decarbonation/dehydration reactions during the lower greenschist facies metamorphic event.

Textural relations indicate that the type (3) inclusions post-date all the other inclusion types and were likely formed during the waning stages of the metamorphic event. Because the last tectonic event affecting the Pilbara Block, which hosts the barite deposits, is dated at 2.7-b.y.-old (Marston and Groves, 1981), all the inclusion types are at least this old. These observations also imply that although barite is a notoriously 'leaky' mineral for fluid inclusion studies, the North Pole barites have been able to contain CO_2-H_2O fluids at internal pressures of greater than 60 bars (because they contain coexisting liquid+vapor CO_2) for at least 2.7-b.y.

Apparently, replacement of the gypsum by barite took place in a 3.4-b.y.-old hydrothermal event, which coprecipitated galena and sphalerite, a common mineral assemblage in Phanerozoic volcanogenic sulfide deposits. Other workers have shown that the barites formed by replacement of preexisting gypsum, and that H_2S is present in some (as yet unidentified) types of inclusions (Lambert et al., 1978, Rankin and Shepherd, 1978). The presence of H_2S in the inclusions indicates that the fluid inclusion contents have not undergone significant oxidation due to hydrogen gas diffusion out of, or oxygen diffusion into the inclusions, as H_2S is known to readily oxidize to SO_4^{2-} or native sulfur. Common lead dating of galenas intergrown with the barites gives an age of formation of 3.4-b.y., which implies a similar age for the barites.

To further characterize the inclusion types and determine whether or not representative samples of the 3.4-b.y.-old mineralizing fluids are contained in the type (1) inclusions, we are using a laser microprobe-gas chromatograph (Gibson et al. 1982) to identify and measure the gas contents of individual inclusions or groups of inclusions of a common type. Using the microanalyser, CO_2 has been positively identified in the type (2) inclusions, in which the presence of CO_2 was predicted from heating/freezing phase relations. We are examining the various inclusion types for other gases including hydrocarbons, particularly in the type (4) inclusions. Positive identification and quantification of the gas contents is being accomplished both by coinjection of known gas amounts and by analysis of synthetic minerals containing fluid inclusions of known gas contents. If samples of the primary mineralizing fluids can be identified, comparison of the gas contents of more recent analogous hydrothermal fluids with the fluids contained within the barites may help to identify whether or not the redox state of fluids in the upper crust has undergone significant changes since the early Archean. (Authors' abstract)

BOVE, D.J., 1984, Geology and hydrothermal alteration of the Red Mountain alunite deposit, Lake City, Colorado (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 216.

BOWERS, T.S., JACKSON, K.J. and HELGESON, H.C., 1984, Equilibrium activity diagrams for coexisting minerals and aqueous solutions at pressures and temperatures to 5 kb and 600°C: Springer-Verlag, New York, 397 pp.

Presents over 3600 diagrams of phase relations in terms of log activity of various constituents. (E.R.)

BOWERS, T.S. and TAYLOR, H.P., Jr., 1984a, An integrated chemical and stable-isotope model of the origin of Mid-Ocean Ridge hot spring systems (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 452.

See next abstract.

BOWERS, T.S. and TAYLOR, H.P., Jr., 1984b, An integrated chemical and stable-isotope model of the origin of midocean ridge hot spring systems: J. Geophys. Res., v. 90, no. B14, p. 12,583-12,606. First author at Dept. Earth, Atmos. & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA.

Chemical and isotopic changes accompanying seawater-basalt interaction in axial midocean ridge hydrothermal systems are modeled with the aid of chemical equilibria and mass transfer computer programs, incorporating provision of addition and subtraction of a wide-range of reactant and product minerals, as well as cation and oxygen and hydrogen isotopic exchange equilibria. The models involve stepwise introduction of fresh basalt into progressively modified seawater at discrete temperature intervals from 100° to 350°C, with an overall water-rock ratio of about 0.5 being constrained by an assumed $\delta^{18}O(H_2O)$ at 350°C of +2.0 per mil (H. Craig, personal communication, 1984). This is a realistic model because: (1) the grade of hydrothermal metamorphism increases sharply downward in the oceanic crust; (2) the water-rock ratio is high (>50) at low temperatures and low (<0.5) at high temperatures; and (3) it allows for back-reaction of earlier-formed minerals during the course of reaction progress. The results closely match the major-element chemistry (Von Damm et al., 1985) and isotopic compositions (Craig et al., 1980) of the hydrothermal solutions presently emanating from vents at 21°N on the East Pacific Rise. The calculated solution chemistry, for example, correctly predicts complete loss of Mg and SO_4 and substantial increases in Si and Fe; however, discrepancies exist in the predicted pH (5.5 versus 3.5 measured) and state of saturation of the solution with respect to greenschist facies minerals. The calculated $\delta D(H_2O)$ is +2.6 per mil, in excellent agreement with analytical determinations. The calculated chemical, mineralogic, and isotopic changes in the rocks are also in good accord with observations on altered basalts dredged from midocean ridges (Humphris and Thompson, 1978; Stakes and O'Neil, 1982), as well as with data from ophiolites (Gregory and Taylor, 1981). Predicted alteration products include anhydrite and clay minerals at low temperatures and typical albite-epidote-chlorite-tremolite (greenschist) assemblage at 350°C. The models demand that the major portion of the water-rock interaction occur at temperatures of 300°-350°C. Interaction at temperatures below approximately 250°C results in negative $\delta^{18}O(H_2O)$ shifts, contrary to the observed positive $\delta^{18}O$ values of the fluids exiting at midocean ridge vents. Hydrogen isotope fractionation curves by Suzuoki and Epstein (1976), Lambert and Epstein (1980), and Liu and Epstein (1984), among others, are compatible with the model, and require $\delta D(H_2O)$ to increase at all temperatures as a result of seawater-basalt interaction. (Authors' abstract)

BRANDT, S.S. and BRANDT, S.B., 1983, The use of phase diagrams for a presentation of processes of isotopic fractionation (system water-ice-salt):

ZfI-Mitteilungen (papers of the Central Inst. Isotope and Radiation Res. of the Acad. Sci. of the GDR), v. 76, p. 102-104 (in German). Authors at Acad. Sci. USSR, Irkutsk.

With isotopic investigation of waters and brines of Western Yakutia it should be possible to show the effects of isotopic fractionation produced by permafrost.

The fractionation that develops during freezing of fresh water can be figured by means of a phase-diagram for two completely miscible components. The form of the diagram is determined by the known relations of Van-Laar, and depends on the heats of melting of the light and heavy components. Heats of melting of fresh waters with different isotopic compositions were evaluated semi-qualitatively. The phase state of a simple one-component-brine during freezing and the dependence of the chemical composition on the temperature of a brine are given by a eutectic-diagram. To evaluate the isotopic fractionation and the concentration of the brine during the process of freezing and melting, a model in form of a 3-faced prism (H_2O-D_2O-NaCl-Temperature) is suggested.

An experiment to determine the change of D-values with growing salt-content in water has shown that with increasing mineralization the fractionation at freezing/melting decreases monotonously toward zero and the eutectic does not show any extreme isotopic composition. (Translation courtesy H.A. Stalder)

BREARLEY, Mark and SCARFE, C.M., 1984a Amphibole in a spinel lherzolite xenolith: Evidence for volatiles and partial melting in the upper mantle beneath southern British Columbia: Can. J. Earth Sci., v. 21, no. 9, p. 1067-.

BREARLEY, M. and SCARFE, C.M., 1984b Dissolution of upper mantle minerals in alkali basalt melt at 30 kbar: implications for ultramafic xenolith survival (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 454.

BRESKOVSKA, V.V., ILIEV, Z.P., CVETANOV, R.G., PETROV, P.P. and MLADENOVA, V.I., 1984, Geology and mineralogy of Gjurgen Dere, Madzarovo ore field: God. SU "Kl. Ohridski." Geol.-Geogr. Fak., 74, 1980, no. 1, Geologija, 1984, p. 69-96 (in Russian; English abstract).

The paper concerns the ore veins in Gjurgen Dere, the southern part of the Madzarovo ore field (Eastern Rhodope Mts.). Three stages of metasomatic alterations of the wall rocks are distinguished - two pre-ore stages: (1) propylitization (epidote-chlorite-carbonate facies) and (2) potassium-alkaline metasomatism (four facies: potash feldspar, quartz-potash feldspar, quartz-potash feldspar-chlorite, and potash feldspar-chlorite-albite), and a stage of wall rock alteration proper, sericitization, which took place before or during the deposition of the productive sulphide mineralization. Ore formation developed as a multistage process as follows: quartz-pyrite-chalcopyrite, quartz-specularite-chlorite, quartz-polymetallic stage, quartz-chalcedony with barite and specularite, and carbonate stage. Increased contents of Ga, Cd, Sb, and Ag are found in the ore minerals by semiquantitative spectral analysis. Th of gas-fluid inclusions in quartz and sphalerite is between 235 and 245°C. (Authors' abstract)

BRETT, Robin, 1984, Chemical equilibration of the Earth's core and upper mantle: Geochimica Cosmo. Acta, v. 48, p. 1183-1188.

BRIGHAM, R.H. and O'NEIL, J.R., 1984, The movement of water through a cooling pluton: an oxygen isotope study (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 454-455.

BRIMHALL, G.H., 1984, Alteration phase equilibria in porphyries and related epithermal vein systems: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 8-21.

BRIMHALL, G.H. and STOFFREGEN, R.E., 1984, Experimental biotitization of hornblende in H_2SO_4-K_2SO_4-H_2O fluids (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 48. Authors at Dept. Geol. & Geophys., Univ. California, Berkeley, CA 94720.

Preliminary experiments on the biotitization of primary igneous hornblendes have been completed over a temperature range of 300 to 450°C at 1,000 bars argon gas pressure. The experiments were run with .10 and .25m K_2SO_4-H_2SO_4 aqueous solutions, and buffered by a solid assemblage of magnetite, microcline, quartz, and pyrite; this buffer fixed oxygen and sulfur fugacities at values appropriate for a felsic intrusive rock undergoing potassic alteration in the early-stage porphyry copper environment. In these experiments, hornblende is destroyed, producing biotite and anhydrite, presumably by the reaction

$$\text{hb} + K_2SO_4(\text{aq}) + H_2SO_4(\text{aq}) \rightarrow \text{bio} + CaSO_4 + SiO_2(\text{qtz})$$

when Ca liberated from the hornblende goes to make anhydrite. Biotitization of hornblende and reequilibration of primary igneous biotite to a lower T_iO_2, high MgO/FeO composition have been described in high temperature alteration assemblages around the world (Roberts, 1973; Moore and Czmanske, 1973; Titley, 1982). These reactions, in addition to sphene replacement by anhydrite and Fe-Ti oxides, may represent the earliest and most widespread effects in granitic wall rocks as magmatic-sulfate-rich hydrothermal solutions begin convective circulation around porphyries. Many studies in the literature stress the role of HCl as the primary acid component responsible for silicate hydrolysis reacations, notable exceptions being the work of Hemley (1969) on the stability relation of alunite, $KAl_3(SO_4)_2(OH)_6$, and Burnham and Ohmoto (1980). (Authors' abstract)

BROOKS, J.M., DENNICUTT, M.C., II, FAY, R.R., McDONALD, T.J. and SASSEN, Roger, 1984, Thermogenic gas hydrates in the Gulf of Mexico: Science, v. 225, p. 409-411. First author at Dept. Oceanography, Texas A&M Univ., College Station, TX 77843.

Thermogenic gas hydrates were recovered from the upper few meters of bottom sediments in the northwestern Gulf of Mexico. The hydrates were associated with oil-stained cores at a water depth of 530 meters. The hydrates apparently occur sporadically in seismic "wipeout" zones of sediments in a region of the Gulf continental slope at least several hundred square kilometers in area. (Authors' abstract)

BROWN, Grahame, 1984a Australia's first emeralds: J. Gemm., v. 19, no. 4, p. 320-335. Author at Univ. Queensland, Australia.

Mention is made of inclusion characteristics. (E.R.)

BROWN, Grahame, 1984b Inclusions in synthetic corundum by Chatham: The Australian Gemmologist, v. 15, no. 5, p. 149-154.

BROWN, G. and SNOW, J., 1984, Inclusions in Biron® synthetic emeralds: The Australian Gemmologist, v. 15, no. 5, p. 167-170.

BROWN, I.J. and NESBITT, B.E., 1984, Gold-bismuth-copper skarn mineralization in the Marn skarn, Dawson City, Yukon (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 456. Authors at Dept. Geol., Univ. Alberta, Edmonton, Alberta, T6G 2E3, Canada.

Fluid inclusions from skarn silicates and vein quartz indicate that highly saline and chemically complex fluids were involved throughout the development of the skarn. (From the authors' abstract)

BROWN, Louis, 1984, Applications of accelerator mass spectrometry: Ann. Rev. Earth Planet. Sci., v. 12, p. 39-59.

BROWN, P.E., 1984, Mineralization in the Pb-Zn ores of Stevens County, NE Washington State (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 456. Author at Dept. Geol., Univ. Wisconsin, 1215 W. Dayton St., Madison, WI 53706.

Most of the important Pb-Zn producers of Stevens County appear to have Mississippi Valley Type (MVT) affinities. However, most of the smaller deposits that have accounted for 75% of the silver recovered from this district are discordant quartz-veins. Petrographic, fluid inclusion and stable isotope examination of these deposits (in progress) indicates that the quartz veins were introduced later than the conformable limestone replacement bodies and do not represent locally remobilized ores. In addition the ore-bearing fluids were CO_2-rich and had temperatures of 250-325°C. Trapped fluids in the conformable ores occur as small (<15 microns), aqueous, two-phase inclusions. Inclusions in quartz from the veins contain three phases (H_2O, liquid CO_2 and CO_2 vapor) with CO_2 densities usually less than 0.77 g/cc. (From the author's abstract)

BROWN, W.M., KWAK, T.A.P. and ASKINS, P.W., 1984, Geology and geochemistry of a F-Sn-W skarn system -- The Hole 16 deposit, Mt. Garnet, North Queensland, Australia: Australian J. Earth Sci., v. 31, p. 317-340. First author at Western Mining Corp., 168 Greenhill Rd., Parkside, SA 5063, Australia.

The Hole 16 deposit is a small unexposed F-Sn-W exoskarn deposit with underlying associated endoskarn, greisenized granite and largely ungreisenized Carboniferous 'Elizabeth Creek' granite. Sphalerite geobarometry indicates that this was a high level intrusion. The skarn formed above a granite cusp and is mantled by pure marble. Assemblages and textures representing successive stages of skarn genesis are: (1) massive andradite, (2) massive Sn-rich garnet + magnetite ± clinopyroxene ± fluorite, (3) 'wrigglite' which refers to a characteristic fine-grained contorted rhythmically layered texture, consisting of alternating layers of magnetite and fluoro-vesuvianite + fluorite, or cuspidine ± fluorite and magnetite ± Zn-Fe spinel, (4) massive fluoro-vesuvianite + fluorite, (5) Fe-F-amphibole + Fe-F-biotite + Fe-F-phyllosilicate + calcite ± scheelite, (6) chlorite ± hematite ± clay minerals. Assemblages (5) and (6) are found in very minor amounts throughout the skarn. States (1)-(4) also correspond to the skarn types extending upwards from the granite contact. Growth zoned garnets are andradite-rich (And_{100} to $And_{60}Gross_{40}$) with up to 2.46 wt% SnO (0.81 average), vesuvianite is always relatively Fe-rich ($Fe_{90}Mg_{10}$ to $Fe_{40}Mg_{60}$), pyroxene is Mg-rich ($Di_{81}He_{13}$ to $Di_{92}He_{8}$) and powellite-rich scheelite ($Sch_{77}Pow_{23}$) occurs mainly near the outer of the skarn. Tin occurs within the exoskarn mainly near the granite contact in solid solution in garnet, as minute (0.5 µm long) crystals of cassiterite in magnetite and rarely as large cassiterite crystals(<1 mm) associated with retrograde amphibole alteration. The granite is a typical 'A-type' or tin granite, having very high Ga/Al, high SiO_2 and high total alkalis. In the drill core it is variable in appearance, consisting of aplitic, pegmatitic and even-grained areas. The endoskarn consists of fluorite-calcite-quartz-white mica, and the greisen is dominantly white mica. On the basis of a mass balance calculation using bulk chemical analyses, it is suggested that about 10 volumes of granite would have to be altered to greisen and endoskarn to produce the volume of skarn observed, and significant Fe and F would need to be added to the system as well. The data presented here, with fluid inclusion data presented elsewhere, suggest the system was a largely closed circulation system with $FeCl_2$ and CaF_2 derived from the greisenization processes ($FeCl_2 \cdot XH_2O$ and CaF_2 daughter crystals occur in quartz fluid inclusions in the granite) whereas $CaCl_2$ and CO_2 were derived from the skarn-forming process. Temperatures were largely magmatic throughout (≈ 600°C) and very limited meteoric water was involved. (Authors' abstract)

BRUNER, W.M., 1984, Crack growth during unroofing of crustal rocks: effects on thermoelastic behavior and near-surface stresses: J. Geophys. Research, v. 89, no. B6, p. 4167-4184.

BUADZE, V.I., GOGISHVILI, V.G., AREVADZE, D.V., YAROSHEVICH, V.Z., RATMAN, I.P., ZULIASHVILI, T.G., GOGISHVILI, T.Sh. and GUNIAVA, V.D., 1984, Water, sulphur and carbon sources in ore deposits of the Caucasus (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 55. Authors at Caucasian Inst. Min. Resources of USSR Ministry Geol., Tbilisi, USSR.

The isotopic composition of hydrogen of fluid inclusion water and oxygen of mineral crystal lattices indicates the importance of magmatic water in the ore-forming fluids of the majority of the region's high- and medium-temperature deposits. At later medium- and low-temperature stages the fluids are obviously mixed with meteoric water. The source of water in As-Sb-Hg deposits is metamorphogenic without any perceptible seawater component.

The carbon of the ore-forming fluids is predominantly of deep origin, a considerable proportion of crustal (including organic) carbon [is] found only in deposits in carbonate series.

The isotopic investigation results confirm the model of a deep-seated source of fluids for the majority of the Caucasian ore deposits, the genetic diversity of the latter being defined by a number of other factors. (From the authors' abstract)

BUCHANAN, D.L. and JONES, M.J., 1984, Sulphide deposits in mafic and ultramafic rocks: Proc. of IGCP Projects 161 and 91, Third Nickel Sulphide Field Conf., Perth, Western Australia, 23-25 May, 1982, 164 pp.

Of pertinence to inclusions from sulfide immiscibility. (E.R.)

BUL'YENKOV, N.A., BYELYANIN, A.F. and TSINOBER, L.I., 1983, Studies of orientation and habit of inclusions in transparent crystals of quartz and fluorite: Novye Dannye o Mineralakh, v. 31, p. 146-153 (in Russian).

The visual-microscope method was elaborated for studies of habit and orientation of inclusions in transparent crystals. The method is based on determination of angles between projections of linear sections of defects of transparent crystals and the edge of crossing of sample faces, cut from crystal in the shape of parallelepipede. (Authors' abstract translated by A.K.)

BUNKIN, A.Y. and FROLOV, A.A., 1984, The entrapment and migration of liquid inclusions during growth of $FeGe_2$ single crystals from the melt: J. Crys. Growth, v. 69, p. 131-137. Authors at Inst. Physics of Metals, Ural Sci. Center, Acad. Sci. USSR, 620219 Sverdlovsk, USSR.

The processes at the interface leading to the periodic entrapment of flat liquid inclusions are described. The impurity-rich inclusions are migrating towards the interface as liquid zones in temperature gradient zone melting. The parameters of the macrostep structure and the velocity of the inclusions are evaluated. The experiments have shown that different dopants (cobalt, tin) and the variation of the growth rate influence considerably the peculiarities of the crystal microstructure. (Authors' abstract)

BURDE, B.I., 1984, Concentration of bound water in main types of magmatic rocks: Akad. Nauk SSSR Doklady, v. 276, no. 5, p. 1217-1221 (in Russian). Author at Far-East Sci.-Research Inst. of Mineral Raw Materials, Khabarovsk, USSR.

The concentration was determined of bound water $H_2O(+)$, in magmatic rocks, including granites (0.49, 0.50), granodiorites (0.74, 0.83), diorites (0.96, 1.06), gabbros (1.30, 1.55), liparites (0.94, 0.92), dacites (1.22, 1.28), andesites (1.41, 1.39), and basalts (1.62, 1.90 wt.%), respectively, from Priamurya and Aldan-Stanovoi regions of USSR. The $H_2O(+)$ concentration decreases linearly with increased SiO_2 content. The nature of the $H_2O(+)$-SiO_2 interrelation is tested for diverse-age magmatic rocks. The $H_2O(+)$ content is related more to the secondary (than the primary) hydrous minerals. (C.A. 101: 114341w)

BURLINSON, K., 1984, Exploration for gold at Pine Creek and Tennant Creek, N.T. and at Halls Creek, W.A. using the fluid inclusion decrepitation technique: The Australian I.M.M. Conf., Darwin, N.T., v. 13, p. 373-375. Author at Burlinson Geochem. Svc. Pty. Ltd., Darwin, N.T.

The decrepitation technique is a rapid means of measuring abundances, temperatures and to some extent the fluid compositions, of fluid inclusions in transparent and opaque minerals. The method has been used to investigate the hydrothermal fluid systems associated with gold mineralization in the Tennant Creek, Pine Creek and Halls Creek Goldfields. At the Enterprise Mine, Pine Creek, several different stages of quartz veining are distinguished and within these, gradational changes in fluid temperatures and compositions help to define the center and nature of the thermal system responsible for the mineralization. In the surrounding Pine Creek region and at Tennant Creek and Halls Creek, the results were applied on a regional scale to characterize outcrops and aid in the discrimination between potentially mineralized and barren outcrops.

Fluid inclusion data obtained by the decrepitation method have led to a better understanding of the mineralization styles at Halls Creek and assisted in the understanding of the mineralization at the Enterprise Mine. The ability to use ironstones at Tennant Creek leads to the possibility of using decrepitation as an aid in distinguishing the various types of ironstone and their mineralization potential. In the Pine Creek area, these results show that CO_2-rich fluid systems are very frequently mineralized and decrepitation analyses of quartz veins are therefore proposed as a regional screening tool. (From the author's extended abstact)

BURLINSON, K., DUBESSY, J.C., HLADKY, G. and WILKINS, R.W.T., 1983, The use of fluid inclusion decrepitometry to distinguish mineralized and barren quartz veins in the Aberfoyle tin-tungsten mine area, Tasmania, *in* G.R. Parslow, ed., Geochemical Exploration 1982: J. Geochem. Explor., v. 19, p. 319-333. First author at P.O. Box 37134, Winnellie 5789, Australia.

In the Aberfoyle Sn/W district of N.E. Tasmania, mineralization is in quartz veins associated with Devonian granite. The host rocks to the mineralization are folded Silurian quartzites, greywackes and shales and these also contain abundant premineralization quartz veins which can be difficult to distinguish from irregularly mineralized ore veins on geological criteria, especially in drill core. It was found that the decrepitation characteristics of the quartz, chiefly the intensity ratio of high and low temperature peaks, which are developed in all decrepigrams, enable a distinction between the two generations of veins to be readily made. The differences between the fluid inclusions in the two generations of veins are relatively subtle, however it seems clear that "CO_2-rich" inclusions having a wide range of composition and density are the main source of decrepitation events and that the major differences in decrepitation behavior can be correlated with differences in average homogenization temperature of these inclusions. Even those ore veins which have undergone moderate ductile deformation have the typical signature of their origin. The decrepitation results are supported by analyses of inclusion gases by Raman microprobe. These analyses differentiate a third group of veins which are possibly unmineralized veins belonging to a separate hydrothermal system. (Authors' abstract)

BURROWS, D.R. and SPOONER, E.T.C., 1984a, Fluid inclusion evidence for H_2O-CO_2 phase separation associated with magmatically derived MoS_2 mineralization within a post-tectonic Archean granodiorite/trondhjemite intrusion, Mink Lake, N.W. Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 49. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

The 1.5 x 3.25 km Mink Lake stock is an unmetamorphosed, post-tectonic intrusion located 110 km N.E. of Red Lake. It is trondhjemitic in composition, and contains a 350 x 1000 m zone of MoS_2 mineralization within its southern part. MoS_2 mineralization occurs in (i) shallow dipping aplites with hydrothermal alteration selvages, (ii) sub-horizontal, tabular zones of intense carbonate metasomatism up to 3 m in width, and (iii) shallow dipping quartz-carbonate-K-feldspar-chlorite-pyrite veins with carbonate alteration selvages. Hence, MoS_2 mineralization spans a silicate melt-hydrothermal fluid(s) transition. H_2O-CO_2 phase separation is indicated by co-existing primary inclusions in quartz related to MoS_2 (i) showing a complete range of $H_2O:CO_2$ ratios (~5-95 vol. % at 40°C) and (ii) homogenization into both the H_2O-rich and CO_2-rich phases in the same temperature range (260°C-320°C, principally). CO_2 clathrate melting temperatures of +3.5°C to +5.4°C indicate moderate H_2O salinities of 8.4-11.3 equiv. wt. % NaCl. The homogenization temperatures of 260°C-320°C are equal to formation temperatures since inclusion trapping occurred on a solvus. TiO_2, Zr, Rb and Sr variations for 60 samples from the Mink Lake stock indicate that the paragenetic sequence of MoS_2 mineralization developed marginal to an internal zone of crystal fractionation. The occurrence of MoS_2 through a silicate melt-hydrothermal fluid(s) transition, the $\delta^{18}O$ and $\delta^{34}S$ values of hydrothermal components calculated from mineral compositions, and the evidence for internal igneous fractionation spatially related to mineralization indicate a magmatic origin for the hydrothermal H_2O-CO_2 fluid mixture. Hence, a high CO_2 content in Archean hydrothermal fluids is *not* necessarily an indicator of a "metamorphogenic" origin, as has been suggested in the case of some Archean Au deposits. (Authors' abstract) See also next abstract. (E.R.)

BURROWS, D.R. and SPOONER, E.T.C., 1984b, Low-$\delta^{13}C$ carbonate alteration associated with magmatically derived MoS_2 mineralization within a post-tectonic Archean granodiorite/trondhjemite intrusion, Mink Lake, N.W. Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 50. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

MoS_2 mineralization located within the southern part of the 1.5 x 3.25 km Mink Lake intrusion is associated with intense carbonate metasomatism in which the original granodiorite mineralogy was completely replaced through interaction with a hydrothermal H_2O-CO_2 mixture undergoing phase separation at 260°C-320°C (fl. inc. data). Carbonate alteration zones occur as (i) symmetrically developed selvages adjacent to MoS_2 bearing quartz, aplite and rare pegmatite veins, and (ii) as larger, but localized, sub-horizontal, tabular zones up to 3 m in width without obvious internal veins. Since some carbonate alteration occurs marginal to aplites the H_2O-CO_2 mixture was clearly magmatically derived. Biotite is completely replaced by chlorite (± talc), and then by calcite, Mg-chlorite, rutile and pyrite. Plagioclase is replaced by albitic feldspar, muscovite and calcite. The normative plagioclase composition drops from An_{29} to An_9. Alteration is accompanied by (i) significant increases in Na_2O, K_2O, CaO, Al_2O_3, Mo, W, Sn, Pb and S and (ii) significant decreases in Fe, SiO_2, Li, Sr, Rb, B, F, Cu and Co. The $\delta^{13}C$ values of the carbonate define a narrow range from -2.7‰ to -3.9‰ with a mean of -3.1 ± 0.4‰ (1σ; n = 6; PDB). These values lie within a broader range of -2 to -7‰ for carbonatites in Ontario and Quebec (Deines and Gold, 1973) suggesting compatibility with a deep carbon source. The values are also closely similar to the $\delta^{13}C$ values for replacement and vein carbonate associated with Au mineralization from 14 localities in the Timmins area of which 85% (n = 81) lie between -2‰ and -4.5‰ (Fyon et. al., 1982). Since the carbonate in the Mink Lake intrusion is magmatically derived, this carbon isotopic similarity is not inconsistent with a magmatic derivation for the carbonate associated with Archean Au mineralization in the Porcupine Camp. (Authors' abstract) (See also previous abstract.)

BURRUSS, R.C. and RUPERT, R.T., 1984, Chemical and PVT analysis of fluid inclusions in sedimentary rocks: Toward a quantitative tool for studies of petroleum migration and sedimentary diagenesis (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 26-27 (in English). First author at Gulf Research & Dev. Co., Houston, TX.

Microthermometric and chemical analysis of fluid inclusions in diagenetically altered sedimentary rocks can yield estimates of paleo-subsurface temperatures and pressures and the time of petroleum migration. Detailed chemical analysis of the hydrocarbon inclusions is necessry for two reasons: 1) direct comparison with reservoired oils to define pathways and timing of migration and 2) input to an equation of state to calculate isochores for P, T estimates.

We modified a commercially available, cryogenically programmed, capillary column gas chromatograph for analysis of hydrocarbons released from inclusions in small samples (2-4 mg.) of diagenetic minerals. The small sample size allows detailed petrographic characterization of the inclusions to be analyzed. Inclusions are opened by decrepitation at 300°C, and the contents are directly injected on the column via a switching valve. The system is microprocessor controlled to insure reproducible retention times and quantitative calculations of compositional parameters. All individual saturated and aromatic hyrdrocarbons from C_1 to C_8 are resolved, with high resolution separation out to $C_{28}+$. Initial experiments with inclusions in carbonate minerals show good correlation of hydrocarbon yields with the abundance of inclusions observed by fluorescence microscopy. Decrepitation of inclusions in fluorite and halite is less efficient due to "stretching;" therefore, the system was modified to allow crushing of samples. Chromatograms of inclusion contents compare well with macroscopic samples of reservoired oils.

The high resolution analysis allows calculation of the mole fractions of the C_1 through C_7+ hydrocarbons. This composition is used with a reservoir engineering equation of state to calculate isochores for the hydrocarbon inclusions. In samples where both two-phase aqueous inclusions and distinct two-phase hydrocarbon inclusions can be demonstrated to be trapped contemporaneously (Narr and Burruss, 1982, 1984), both fluids have intersecting isochores which uniquely define paleo-pressure and temperature. Thus, combined chemcial analysis and PVT modelling can yield quantitative information on the P, T history of diagenetically altered sediments. (Authors' abstract)

BURT, D.M., 1984, Alteration-phase equilibria in skarns, greisens, and epithermal deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 22-27.

BUSSINK, R.W., 1984, Geochemistry of the Panasqueira tungsten-tin deposit, Portugal: Geologica Ultraiectina, no. 33, 170 pp.

A major part of this investigation is dedicated to the physical conditions under which the mineralization of Panasqueira was formed (Chapter 5). Th of fluid inclusions in the minerals of Panasqueira point to an interval between 325 and 250°C for the early stages; salinities are between 5 and 10 wt% NaCl. In the final hydrothermal stage Th dropped to about 100°C; the salinity is also lower, down to 3 wt% or less. Due to trapping of CO_2-rich fluids against an impermeable granite-schist contact fluid pressures point to an 'overpressure' of about 1 kbar before opening of the joint system. Opening of this joint system caused vigorous boiling of the fluids in the ore veins at a depth of about 1800 m.

Gas chromatographic analyses show next to CO_2 the presence of CH_4 and N_2. The presence of CH_4 suggests a reducing environment during ore deposition. The origin of the CH_4 and N_2 is possibly found by assimilation of schist containing organic matter.

Stable isotopes of carbon, oxygen and nitrogen indicate a homogeneous isotopic source for the early fluids. High overpressures in the earliest stage and about constant oxygen, carbon and nitrogen isotopes strongly favor a 'magmatic' origin for the initial mineralizing fluids. Oxygen and carbon isotopes of the fluids differ strongly in the latest stage and point to a large influx of meteoric water. (From the author's abstract)

BUSSINK, R.W., KREULEN, Rob and de JONG, A.R.M., 1984, Gas analyses, fluid inclusions and stable isotopes of the Panasqueira W-Sn deposits, Portugal: Bull. Minéral., v. 107, p. 703-713. Authors at Inst. Earth Sci., Dept. Geochem., P.O. Box 80.021, 3508 TA Utreht, The Netherlands.

Fluid pressures up to 1000 bars higher than the lithostatic pressure existed in the early stage before formation of the Panasqueira W-Sn deposits. Opening of the sub-horizontal joint system resulted in a drastic pressure drop and boiling of the ore fluids. Ore deposits were formed from 'magmatic' fluids, which contained substantial amounts of N_2 and CH_4 from assimilated sediments in the magma. Only in the latest stage an apparent influx of meteoric water changed the 'magmatic' composition of the fluid. (Authors' abstract)

BYERS, C.D., CHRISTIE, D.M., MUENOW, D.W. and SINTON, J.M., 1984, Volatile contents and ferric-ferrous ratios of basalt, ferrobasalt, andesite and rhyodacite glasses from the Galapagos 95.5°W propagating rift: Geochimica Cosmo. Acta, v. 48, p. 2239-2245. First author at Chem. Dept. and Hawaii Inst. Geophys., Univ. Hawaii, Honolulu, HI 96822.

Volatiles and major elements in abyssal glasses ranging in composition from basalt, ferrobasalt, andesite to rhyodacite from the Galapagos Spreading Center (GSC) near 95°W were analyzed using electron microprobe and high temperature mass spectrometry. Total volatile content ranged from 0.32 wt.% to 2.74 wt.%. Volatile abundances of MORB glasses from the 95.5°W propagating rift are similar to those from the adjacent normal rift (avg. 0.34 wt.%) and lower than those of N-type MORB from the Mid-Atlantic Ridge (avg. 0.49 wt.%). Although both propagating and non-propagating rift glasses contain trace amounts of methane (<0.01 wt.%) and carbon monoxide (0.04 wt.%), significantly higher 100 $Fe_2O_3/FeO + Fe_2O_3$ ratios are observed for the primitive propagating rift glasses. Water contents of the most primitive GSC glasses are ~0.09 wt.% suggesting a water content for the mantle source of ~0.02 wt.% which indicates that source masses with very low water content can be involved in the generation of MORB.

In fractionated ferrobasalt, andesite and rhyodacite glasses from the 95.5°W propagating rift, increasing abundances of H_2O, Cl and F indicate highly incompatible behavior, whereas CO_2 and reduced carbon species appear to decrease in abundance with increasing differentiation. Ferric-ferrous ratios increase from basalt to andesite and reduce to near zero in the rhyodacite. These values are not distinguishable from those previously reported for similar fractionated glasses from the Galapagos 85°W propagating rift, despite the apparent suppression of oxide precipitation in the 85°W suite. (Authors' abstract)

CAI, Yuanji, 1984, Experimental study on the transformation of anhydrite into pyrite: anhydrite as a sulphur source for pyrite formation under hydrothermal conditions: Bull. Nanjing Inst. Geol. M.R., Chinese Acad. Geol. Sci., v. 5, no. 4, p. 36-53 (in Chinese; English abstract).

CALAS, G., BASSETT, W.A., PETIAU, J., STEINBERG, M., TCHOUBAR, D. and ZARKA, A., 1984, Some mineralogical applications of synchrotron radiation: Phys. Chem. Minerals, v. 11, p. 17-36. First author at Lab. Min.-Cristal., Univ. Paris 6 et 7, LA CNRS 09, 75230 Paris Cedex 05, France.

Synchrotron radiation offers several advantages over the conventional X-ray sources, among which the most important are its high intensity, broad spectral range and natural collimation. Among the numerous techniques which have been recently developed we present a review of the results concerning more specifically mineralogical systems: X-ray absorption spectroscopy concerning high-resolution edge spectra and Extended X-ray absorption fine structure (EXAFS), X-ray diffraction under high P-high T conditions, small-angle scattering, X-ray microanalysis and X-ray topography.

For each technique the basic principles are described together with the experimental devices used, before mineralogical examples are given. Two main applications may be pointed out: chemical and structural characterization of disordered systems and kinetic studies (phase transitions and evolution). Many other techniques (photoelectron spectroscopy, X-ray fluorescence analysis ...) which are actually under development as a result of the rapid increase of the use of storage rings are not covered in the present review but will possibly also be used in the near future in Earth Sciences. (Authors' abstract)

CAMPBELL, A.R., HACKBARTH, C.J., PLUMLEE, G.S. and PETERSEN, Ulrich, 1984, Internal features of ore minerals seen with the infrared microscope: Econ. Geol., v. 79, p. 1387-1392. First author at Dept. Geosci., New Mexico Inst. Mining & Tech., Soccorro, NM 87801.

See abstract (by Plumlee et al.) in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 206, 1983. (E.R.)

CAMPBELL, Andrew, RYE, Danny and PETERSEN, Ulrich, 1984, A hydrogen and oxygen isotope study of the San Cristobal Mine, Peru: implications of the role of water to rock ratio for the genesis of wolframite deposits: Econ. Geol., v. 79, p. 1818-1832. First author at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Oxygen and hydrogen isotope ratios were measured from vein minerals and extracted fluid inclusion waters from the San Cristobal wolframite-base metal deposit in Peru. Oxygen isotope values for quartz range from 9.8 to 14.4 per mil and for wolframite from 0.6 to 4.6 per mil. The calculated δ values at 300°C for water in equilibrium with quartz and wolframite are $\delta^{18}O = 2.8$ to 7.3 per mil for quartz and 1.4 to 5.4 per mil for wolframite. Hydrogen isotope values show an overall range of $\delta D = -58$ to -148 per mil, but the range for any given mineral is much smaller. These data are interpreted in light of a model which examines the effect of temperature and water to rock ratio on the isotopic compositions of meteoric waters exchanging with granite. In a rock-dominated system an isotopically exchanged water becomes depleted in $\delta^{18}O$ and enriched in δD as the temperature of exchange decreases. When the water to rock ratio is also allowed to vary, a wide variety of water compositions is generated. The isotopic composition of minerals from San Cristobal can be interpreted as the result of deposition from a meteoric water which has undergone isotopic exchange with a granite at 400°C, with a water to rock ratio ranging from 0.01 to 0.003. Isotopic data taken from two other wolframite deposits, Pasto Bueno (Landis, 1972) and Panasquiera (Kelly and Rye, 1979) are reinterpreted using the model developed for San Cristobal. Both sets of data are consistent with the hypothesis that wolframite deposits are formed by meteroric waters which have experienced exchange at very low water to rock ratios (<0.05). The importance of the low water to rock ratio may be related to the way in which tungsten is leached from a crystallized pluton. (Authors' abstract)

CANDELA, P.A., 1984, A partitioning model for the rare earth elements and other polyvalent, chloride-complexed metals in melt-vapor systems (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 462. Author at Dept. Geol., Univ. Maryland, College Park, MD 20742.

The partitioning of polyvalent, chloride-complexed metals between a magma and a fractionating aqueous fluid can be modeled assuming either isobaric fractional cyrstallization, or polybaric decompression of the magma body. During fractional crystallization, and at water concentrations in the melt ($c\{H_2O\}$) <2.5 wt%, the chlorine concentration increases in the evolving vapor as crystallization proceeds. This leads to high effective vapor/melt partition coefficients (PC) at low $c\{H_2O\}$ for M^{n+} where $n>1$. However, the amount of metal removed from the melt necessarily decreases to zero as the $c\{H_2O\}$ goes to zero. The PC for most REE is a function of the <u>cube</u> of the Cl concentration and therefore, depending on the Cl <u>concentration</u> of the fluid, the PC for a REE can be quite high for $c\{H_2O\} \approx 1.0$ wt%. These calculations suggest a significant amount (10-40%) of cerium can be removed into an evolving magmatic aqueous fluid at low $c\{H_2O\}$, $\{Cl/H_2O\} \approx 0.1$, and for bulk solid/melt partition coefficients on the order of $0.1 \rightarrow 0.25$. The proportion of Ce removed from the magma falls as higher or lower c{H_2O} are approached. For divalent elements such as Zn the effect is similar; however for univalent cations (e.g. Cu, Rb, Na) the efficiency of removal decreases monotonically as c{H_2O} decreases. Considering these effects alone, it can be concluded that significant REE removal (L>H) can occur at shallow depths, and the ratio Zn/Cu in a magmatic fluid increases as the depth of vapor evolution decreases from e.g. 2 kb to a few hundred bars. In the case of polybaric decompression, the rise of a water-saturated magma can lead to a rather efficient stripping of Ce, Cu, Zn + Mn by vapor evolution with the proportion of Ce removed reaching 20% (with a Cl concentration in the melt ≈3000 ppm) when 2% H_2O is evolved. (Author's abstract)

CANDELA, P.A. and HOLLAND, H.D., 1984, The partitioning of copper and molybdenum between silicate melts and aqueous fluids: Geochimica Cosmo. Acta, v. 48, p. 373-380. First author at Dept. Geol., Univ. Maryland, College Park, MD.

The partitioning of copper and molybdenum between silicate melts and aqueous fluids has been determined at 750°C and 1.4 Kb. The experiments were conducted in a 1/2 inch ID, rapid quench, cold seal pressure vessel. The aqueous and glass phase run products were analyzed by atomic absorption spectrophotometry and ion microprobe, respectively. The vapor/melt partition coefficient for copper, $D_{Cu}^{v/l}$, defined as the ratio of the concentrations of copper in the vapor to copper in the melt was found to be $D_{Cu}^{v/l} = (9.1 \pm 2.5)m_{Cl}^{v}$ at NNO up to at least 4.5 moles of chlorine per kg of solution. The partition coefficient for molybdenum is equal to 2.5 ± 1.6 at NNO and QFM; its value is independent of the fluorine concentration of the melt up to at least 1.7 wt. percent fluorine, and of the chlorine concentation up to at least 4.5 moles of chlorine per kg of solution. Copper is probably present in the univalent state in both the silicate melt and in the associated aqueous phase at NNO; the most important aqueous complex of copper is probably $CuCl^0$. Molybdenum is probably present in the aqueous phase as one or more molybdate species. (Authors' abstract)

CANDIA, M.A.F., 1983, Petrology of the Mangabal I and Mangabal II mafic-ultramafic complexes, Sanclerlandia, Goiás, Brazil: Doctoral thesis, The Univ. Sao Paulo, Brazil, 400 pp. (in Portuguese).

The Mangabal I and Mangabal II mafic-ultramafic complexes consisting of two differentiated bodies, were formed in separate chambers by a low pressure crystallization fractionation process of a tholeiitic basaltic magma. They intruded a level of the sialic basement, represented in the area of gneissic and calc-silicate rocks, which are interpreted as belonging to the Goiás Basal Complex.

... The study of the fluid phase composition, based mainly on fluid inclusion analyses, indicated the coexistence of a more hydrated paragenesis under the influence of an aqueous phase with another coronitic and relict igneous associations due to a CO_2-rich phase. (Author's abstract modified and shortened by K. Fuzikawa)

CARROLL, M.R. and RUTHERFORD, M.J., 1984, Sulfur solubility and anhydrite saturation in hydrous magmas (abst): Lunar and Planet. Sci. XV, p. 139-140.

CASSEDANNE, J.P. and SAUER, D.A., 1984, The Santa Terezinha de Goiás emerald deposit: Gems & Gemology, v. 20, p. 4-13. First author at Geosci. Inst. of the Fed. Univ. of Rio de Janeiro, Brazil.

Only pyrite, chromite, and calcite are found as inclusions in the emeralds (in talc schist). (E.R.)

CATHLES, L.M., 1984, The role of hydrodynamics in understanding ore deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 28-29.

CERCONE, K.R. and LOHMANN, K.C., 1984, Tracking diagenetic fluids: isotope and fluid inclusion evidence from Silurian reefs of northern Michigan (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 466. First author at Dept. Earth & Space Sci., SUNY at Stony Brook, Stony Brook, NY 11794.

Fluid inclusion and petrographic data indicate two fluid sources: nearby upper Silurian evaporites and deep basin sediments. Migration of evaporite-derived fluids into reefs always occurred at a specific point in their burial history, corresponding to the temperature-controlled dehydration of gypsum. These fluids predated the migration of liquid hydrocarbons, appear to have neomorphosed metastable carbonates which survived shallow burial, and precipitated a regionally extensive calcite cement of consistent oxygen composition (-7.0% $\delta^{18}O$) but variable carbon composition (+1.5 to +5.0% $\delta^{13}C$). Since ony one of the two aquifers in the system is organic-rich, carbon enrichment caused by anaerobic fermentation of organic matter was controlled by fluid pathways into the reef and modified by rates of fluid circulation and degree of water-rock interaction in the reefs themselves. Some pinnacle reefs recorded the influx of later, basin-derived fluids which postdated the migration of liquid hydrocarbons. These fluids caused dissolution and, depending on flow pathway, precipitation of either baroque dolomite (-5.0% $\delta^{18}O$/+5.0% $\delta^{13}C$) or calcite cement of a distinct isotopic composition (-8.0% $\delta^{18}O$/+1.0% $\delta^{13}C$). The chemical similarity of these fluids to brines currently circulating through the Michigan Basin, as well as the timing of their interaction with reefs, suggests that they represent the onset of cross-formational flow in the basin as subsidence ended in the late Paleozoic. (From the authors' abstract)

CHANGKAKOTI, A and MORTON, R.D., 1984, New observations on the silver deposits of the Great Bear Lake region, N.W.T. (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 51. Authors at Dept. Geol., Univ. Alberta, Edmonton, Alberta, T6G 2E3, Canada.

Nine silver-bearing vein deposits within Proterozoic roof-pendants in the Great Bear Batholithic Complex are the subject of ongoing studies. In the Camsell River Sector, deposits at the Terra (Silver Bear) mine are hosted by calcargillites and andesitic metapyroclastics with fahlbands, those of the former Silver Bay (Northrim) mine are within basaltic-flows and -volcaniclastics, those of the Norex mine cut metaandesitic-flows and -pyroclastics, whilst those of the Smallwood prospect were found in high-level quartz porphyries of the Complex.

Electron-microprobe analyses of the native silvers, (Ni-, Co- and Fe-) arsenides, sulfarsenides and sulfides from all the deposits have been performed. The native silvers contain significant amounts of Hg, Bi, Sb and occasionally Te. Silvers from the Camsell River Sector are more enriched in Hg than those of the Echo Bay Sector; (up to a max. of 4.3 wt.%). Nickelines, cobaltites and gersdorffites in ores of the Camsell River Sector are enriched as As, compared with those minerals in the deposits of the Echo Bay Sector. These regional variations in mineral chemistry are not related to host-rock lithology and possibly reflect epigenetic, magmatic-hydrothermal systems.

Fluid-inclusion studies have so far revealed salinities of 27.4 to 34.0 wt.% equiv. NaCl and homogenization temperatures of 120° to 235°C.

C- and O-isotope analyses of calcites and dolomites, together with H- and D-analyses of inclusion fluids from quartz, calcites, arsenides and sulfides so far suggest that there was no common fluid regime for the deposits of the two sectors of the Complex and that systems were unique to individual vein-systems. (Authors' abstract)

CHANYSHEV, I.S. and FELDMAN, A.A., 1984, The relationship of miogeosyncline-associated gold mineralization with magmatism, composition of substratum and ore formation environment (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 2, p. 203. Authors at Central Res. Inst. Geol. Explor. for Base and Precious Metals, Moscow, USSR.

Mentions fluid inclusion data. (E.R.)

CHAPMAN, N.A. and SAVAGE, David, 1984, Mineralogical aspects of the safe disposal of high level radioactive waste: Fortschritte der Mineralogie, v. 62, no. 1, p. 17-32. First author at Fluid Processes Res. Group, British Geol. Survey, Nicker Hill, Great Britain.

Any reasonable approach to the solution of the safe disposal of high-level radioactive waste is necessarily multidisciplinary in nature. Among these diverse scientific and technological disciplines, mineralogy has a significant role in all aspects of a multi-barrier concept of disposal.

First, a number of mineral phases, particularly titanates, have excellent potential for immobilizing and encapsulating radioactive waste species. However, it is essential that the solid-solution characteristics, thermodynamic stability, and dissolution kinetics of such waste forms be accurately determined and be confidently predictable over the timescale of 10^4 - 10^5 years. In addition, many noncrystalline wasteforms (e.g. glass) break down under aqueous attack to produce a "secondary wasteform" consisting of an assemblage of poorly soluble mineral phases which may govern the solubility, and hence rate of release of radiologically significant radionuclides. In this case the dissolution mechanism is of less importance than solubility limiting equilibria in a closed-system near-field.

Second, engineered barriers should possess low permeability, and longevity during the thermal period of the wastes. Again, it is necessary that the physical and mineralogical properties of candidate materials (e.g., bentonites, concretes) be predictable in the repository lifetime.

Third, within the geological barrier, detailed mineralogical studies are relevant to evaluate: changes in the properties of the rock mass in response to thermal gradients and radiation fluxes imposed by the emplacement of waste canisters; geochemical behavior under thermal load, such as irreversible rock-water interactions, the de-watering and transformation of clays, and the decrepitation and migration of fluid inclusions (particularly concerning repositories in salt deposits); and the radioelement sorptive capacity of mineral phases lining fractures and fluid pathways.

Throughout all these mineralogical aspects of radioactive waste management, there is a consistent need for a combination of descriptive and predictive analysis, the former requiring the full range of mineralogical expertise and technology currently available, and the latter being derived through thermodynamic and kinetic modelling coupled with geological precedent. (Authors' abstract)

CHAROY, Bernard and GONZALEZ-PARTIDA, Eduardo, 1984, Analysis of fluid phases associated with genesis of massive sulphide deposit and Au-Ag veins from Taxco-Guanajuato (Mexico): Bull. Minéral, v. 107, p. 285-305 (in French; English abstract). First author at Ecole Nat'l. Supérieure Géol., Appliquée, B.P. 452, 54001 Nancy Cedex, France.

Two principal types of sulphide occurrences have been recognized in the Taxco-Guanajuato province: 1) Exhalative-like massive sulphide deposits enclosed in the metamorphic Tizapa sequence and, 2) Quartz veins with sulphide concentrations spatially related with intrusive monzogranite stocks. The characteristics of the hydrothermal solutions genetically responsible for the mineralizations are determined using fluid inclusion studies. 3 different types of solutions are identified:

1) Hypersaline brines (bulk salinity up to 67 wt %) close to halite saturation at elevated temperature (≈500°C) with boiling point around 420°C; they are related with the volcanism associated with the massive sulphide occurrences;

2) Essentially complex carbonic solutions related with the epizonal metamorphism of the Tizapa sequence; and

3) Aqueous solutions associated with ore veins with salinity decreasing with Th from 10 to 1 eq. wt % NaCl and 350 to 150°C; K/Na at. ratio is high, near 0.3. There is no evidence for boiling. Geothermal gradient is estimated around 80°C/km. All these characteristics are close to those encountered in other deposits of the same type.

The genetic model postulated from sulfur isotope data supports a selective remobilization of the massive or disseminated sulphides initially trapped in the Tizapa sequence by circulation of meteoric water in relation with the granitic intrusions. (Authors' abstract)

CHATTERJEE, N.D., JOHANNES, Wilhelm and LEISTNER, Hans, 1984, The system $CaO-Al_2O_3-SiO_2-H_2O$: new phase equilibria data, some calculated phase relations, and their petrological applications: Contrib. Mineral. Petrol., v. 88, p. 1-13.

CHEILLETZ, Alain, 1984, Geochemistry and thermobarometry of fluids associated with scheelite and quartz from the Jbel Aouam tungsten occurrences - Central Morocco: Bull. Minéral., v. 107, p. 255-272 (in French; English abstract). Author at C.R.P.G., B.P. 20, 54501 Vandoeuvre Cedex, France.

Fluid inclusions from quartz and scheelite associated with Jbel Aouam vein-type tungsten occurrences in Central Morocco are studied by microthermometric, Raman spectroscopic and scanning electron microprobe techniques. Global composition of two different types of inclusion (V and L) and isothermal molar volume/CO_2 molar fraction diagrams allow the determination of trapping conditions at T = 400-450°C and P = 1 kbar for fluids associated with tungsten deposition. Subcritical evolution with dilution by aqueous fluids of CO_2-rich early fluids is the main mechanism proposed at the time of trapping. (Author's abstract)

This is a brief version of the Thèse Doctorat d'Etat, Nancy, Institut National Polytechnique de Lorraine, 273 pp., 1984. (E.R.)

CHEILLETZ, Alain, DUBESSY, Jean, KOSZTOLANYI, Charles, MASSON-PEREZ, Nicole, RAMBOZ, Claire and ZIMMERMANN, J.-L., 1984, Molecular fluids in an hydrothermal quartz vein: comparison of punctual and bulk analysis techniques, contamination of inclusion fluids by carbonaceous compounds: Bull. Minéral., v. 107, p. 169-180 (in French; English abstract). First author at CRPG, 15, rue Notre-Dame des Pauvres, 54501 Vandoeuvre-Lés-Nancy, France.

Four techniques have been selected to analyze molecular fluid phases in crystals: microthermometry (M.) and Raman Spectrometry (R.S.), non-destructive punctual techniques available only for transparent minerals;

mass spectrometery (M.S.) and gas chromatography (G.C.) available for the bulk analysis of fluids released by crushing or heating of all kinds of minerals. High temperature vein quartz from the scheelite-wolframite deposit of Jbel Aouam (Central Morocco) has been selected to be analyzed by the four techniques because it contains a homogenous generation of fluids. (1) Within the uncertainty on the measurements, molar fraction of H_2O in the fluids from quartz is consistently measured by the four techniques. (2) The CO_2/CH_4 molar ratio obtained by R.S. is consistent with the analytical data from G.C.; it is superior by one or two orders of magnitude to that obtained by M.S. (3) Small and constant amount of H_2 is detected only M.S. (4) Heavy carbonaceous species are systematically identified by M.S. and with less quantities by G.C.; they are not in fluid inclusions where only CO_2 and CH_4 are detected by R.S. (5) However dark particles are visible under the microscope in fissures of quartz; their Raman scattering spectrum is similar to that of coal, therefore they still can yield hydrocarbons on heating. (Authors' abstract)

CHEN, Lüan, 1984, The Eh-pH diagram of the stability field of mercury minerals and the predominance field of their soluble species in the HgS-Cl^--H_2O versus 25°-200°C system and their geological significance: Geol. Review, v. 30, p. 114-125 (in Chinese; English abstract). Author at Inst. Geol., Guizhou Bureau Geol. & Min. Resources, PRC.

According to the theory of the formation of hot brine ore deposits and data concerning the salinity of quartz inclusions associated with cinnabar in mercury deposits and the formation temperature of the minerals, this paper presents an Eh-pH diagram of the stability field of mercury minerals and the predominant field of their soluble species under certain conditions, and discusses physico-chemical conditions of transport of mercury as chloride complexes and hydrogen-sulfide comlexes respectively. (From the author's abstract)

CHEN, Wenming, 1984, Internal relations in mineralization between the Yulong porphyry copper deposit and stratiform copper desposits of the sandstone-shale type: Dizhi Lunp'ing, Geol. Review, v. 30, no. 3, p. 239-252 (in Chinese; English abstract). Author at Inst. Mineral Deposits, Chinese Acad. Geol. Sci.

This paper deals with the internal relations between endogenic porphyry copper deposits and exogenic stratiform copper deposits of sandstone-shale type in the light of the temporal and spatial distribution, material composition, textures and structures and some other characteristics of the Yulong porphyry copper deposit. In spatial distribution, the two types of copper deposits lie adjacent to each other, occur in the strata of the same ages and exhibit the same "rock formation," and are both controlled by "lithofacies and paleogeography" and paleostructure; in chemical composition, they contain similar ore-forming elements: Mo, Co, Ag, (Au), Pb and Zn. The ore-bearing porphyry bodies in the Yulong porphyry copper deposit have some noticeable pecularities: they are rich in K, Cl and Al and poor in Ca and Na; their REE contents are close to those in sedimentary rocks but apparently different from those in chondrite; the water in their inclusions obviously have lower hydrogen and oxygen isotope (δO^{18}% and δD%) values than "magmatic crystallization water," δS^{34}% values of their sulfides vary considerably, as is the case with stratiform copper deposits of sedimentary-metamorphic type; they contain numerous remnants of country rocks which quite agree with the country rocks in composition and mode of occurrence; various kinds of "palimpset texture" and "porphyroblastic texture" are frequently observed in their phenocrysts.

Based on the above-mentioned geologic facts, the author holds that the valuable mineral substances of the Yulong porphyry copper deposit were derived predominantly from country rocks and that porphyry copper deposits might be formed as a result of the evolution of stratiform copper deposits of sandstone-shale type or copper-rich sandstone-shale through palingenesis. (Author's abstract)

CHEN, Xianpei and GAO, Jiyuan, 1984, Geology-geochemistry of barite deposits in China, in Academia Sinica, Developments in Geoscience, Contrib. 27th Int'l. Geol. Congress, 1984, Moscow: Science Press, Beijing, China, p. 375-383. Authors at Inst. Geochem., Academia Sinica.

China's barite deposits are classified into stratiform and vein types. Stratiform barite deposits occur mainly in the Cambrian, Devonian, Carboniferous systems, particularly in the lower Cambrian series. Barite deposits are formed under diverse geotectonic conditions and sedimentary environments, but there are many similar characteristics, in regard to their country rocks, sedimentary textures, associated minerals, earlier replacement and temperatures of fluid inclusions. It is considered that barite strata and country-rock silicilith (chert) are deposited from hot springs. Barite veins occur mainly in the Ordovician, Devonian and Triassic Systems. Vein barite was formed by thermal water, or resulted from barite-bearing rocks through reworking. (Authors' abstract)

CHEN, Yinhang, 1984, Study of the mineral inclusion of middle-late Yanshan magma-minerogenetic series (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 28 (in English). Author at Geol. Inst., Ministry of Chem. Industry, Hebei Province, PRC.

The mineral inclusions of the middle-late Yanshan magma-minerogenetic series, in the northern margin of the North China stable block, are classified into three main types and five subtypes according to their trapping state, composition, and evolution process: 1. crystal inclusions (apatite, zircon, titanite); 2. melt inclusions, a. simple (silicate) glassy inclusions and melt-crystal inclusions, b. complex (silicate + sulfide or oxide, halide or sulfate) melt-crystal inclusions; 3. fluid inclusions, a. molten fluid (transitional type), b. simple fluid (vapor, vapor-liquid and pure liquid) inclusions, c. complex fluid (containing LCO_2 or H_2S) inclusions. Fractional melting, fractional distillation and defluidization happen during the evolution process of the complex melt-crystal inclusions. The temperature, pressure, components and phase state of volcanic, subvolcanic, intrusive and mineralization inclusions have continuity and succession. (Author's abstract)

CHEPIKOV, K.R., KLUBOVA, T.T., MEDVEDEVA, A.M. and SURKOVA, G.I., 1984, Lithological-palynological criteria for oil and gas migration (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 2, p. 234-235. Authors at Inst. Geol. & Explor. of Combustible Fuels, Moscow, USSR.

One of several criteria is based on inclusions. The nature of morphological relationships between oil and mineral neogeneses at different stages of lithogenesis (presence or absence of oil inclusions in authigenic minerals) and also the character of oil inclusions in cavities of different genesis are the time indicators of oil infiltration to the collector layer. Comparison of mineral-forming and other post-sedimentary transformations in oil-bearing and water-bearing parts of one and the same productive layer is another time criterion. (From the authors' abstract)

CHEREPANOV, A.N., SKARAPOV, V.N. and MILOVA, L.V., 1984, Dynamics of retrograde separation of volatile components in the crystallization of cotectic magmas: Geologiya i Geofizika, v. 25, no. 11, p. 42-49 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 11, p. 40-47, 1984).

The first solution is obtained for describing the dynamics of the separation of volatile constituents in the solidification of cotectic melts, with allowance for the permeability of the host and intrusive rocks. (Authors' abstract)

CHERNYSHOV, A.V., 1984, Datolite is a perspective mineral for boron (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 7, p. 252-253. Author at Industrial Assoc. "Bor," Dalnegorsk, USSR.

The datolite skarn deposit has been worked effectively in the course of more than twenty years. It is localized in the southern part of the East-Sikhote-Alin belt (Chukotskaya-Katasiatskaya system of the marginal volcanic belts). Skarns formed along a subvertical extensive bed of pure limestones at the exocontact with granitoid intrusion at a depth of 2.0 to 2.5 km under volcanic rock cover. Wollastonite, hedenbergite, and andradite, forming conformable metasomatic zones, as well as calcite and quartz prevail in the skarns. Useful minerals - datolite and to a lesser extent danburite - are distributed irregularly. Skarn (Th 680 to 400°C), borosilicate (Th 420 to 265°C), and quartz-calcite (Th 365 to 180°C) stages are distinguished. The deposit formed 10 to 14 millions of years after the intrusive (age 42 to 48 m.y.) formed. In contrast with skarns connected spatially and genetically with subsurface granitoid intrusive, the boron source is suggested to be a mantle one. Neutron-alpha-radiography analysis shows syngenetic absence [of boron] within the intrusion and the enclosing sedimentary rocks of the deposit. Borosilicate mineralization is related paragenetically with a minor intrusion complex (alkaline-potassic series) originated at a great depth. (From the author's abstract)

CHERSKIY, A.N.V., GROYSMAN, A.G., NIKITINA, L.M. and TSEREV, V.P., 1982, First experimental determination of heats of decomposition of natural-gas hydrates: Dokl. Akad. Nauk SSSR, v. 265, no. 1, p. 185-189 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 265, p. 163-167, 1984).

CHOPRA, P.N. and PATERSON, M.S., 1984, The role of water in the deformation of dunite: J. Geophys. Res., v. 89, no. B9, p. 7861-7876. Authors at Res. Sch. Earth Sci., Australian Nat'l. Univ., Canberra, Australia.

Specimens of two natural dunites (Anita Bay, of 100 μm grain size, and Aheim, of 900 μm grain size) have been deformed in experiments at temperatures between 1200° and 1400°C and constant strain rates between 10^{-4} and 10^{-6} s^{-1} in a gas-medium deformation apparatus at 300 MPa confining pressure. Prior to these experiments the specimens were given a heat treatment in a controlled oxygen fugacity furnace at 1200°C for >60 hours to dehydrate the trace layer silicate minerals present and drive off adsorbed water. The predried specimens are much stronger than specimens tested under wet conditions in an earlier study. The predried specimens also do not show the apparent grain size dependence seen under wet conditions. Infrared absorption measurements on the present specimens and those of the earlier study indicate that for a given rock, flow stress can be correlated with the intensity of a residual "water related" broad absorption. The addition of water to a predried specimen results in both a mechanical reweakening and an intensifying of the broadband infrared component. The weakening of the dunites under wet conditions is probably strongly influenced by the presence of small amounts of a water-related species in the grain boundaries, but intragranular weakening may also be contributing. It is suggested that the concentration of the water-related species in the grain boundaries is governed by its concentration in the small melt fraction present. The amounts of water that have been found to be of importance for the strength of these dunites are of the order of 0.01 wt%, amounts much less than most estimates of the water content of the Earth's undepleted upper mantle. Such water may have an important role in determining upper mantle flow behavior. (Authors' abstract)

CHU, Xuelei, CHEN, Jinshi and WANG, Shouxin, 1984, Several diagrams of sulfur isotope evolution in equilibrium with hydrothermal system: Scientia Geologica Sinica, no. 2, p. 186-200 (in Chinese; English abstract).

CIRLIN, E.-H. and TAYLOR, L.A., 1984, Glass in chondrules: effects of alteration on the apparent distribution coefficient K_D of Fe & Mg at olivine/glass interfaces (abst): Lunar and Planet. Sci. XV, p. 164-165.

CLAESSON, T.J.P. and RONGE, B.S.H., 1984, Rate-controlling factors when granite, granodiorite and gabbro are interacted with water in the temperature range 50-150°C (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 243-244 (in English).

CLEMENS, J.D., 1984a Generation of fluorine-bearing fluids in hydrothermal experiments: Geochimica Cosmo. Acta, v. 48, p. 2393-2395.

CLEMENS, J.D., 1984b Water contents of silicic to intermediate magmas: Lithos, v. 17, p. 273-287. Author at Chem. Dept., Arizona State Univ., Tempe, AZ 85287, USA.

Silicic to intermediate magmas have water contents that range from <1 wt. % to around 7 wt. % depending on the character and depth of the magma source, type of melting reaction and the degree of differentiation. The condition of water saturation is rare, implying that crustal magma genesis generally takes place under fluid-absent conditions or that any fluid present must contain volatile species other than H_2O. The source and quantity of water present during partial melting profoundly affect the types of melting reactions, residues and magmas as well as subsequent magma evolution. For S-type granitic magmas, melting reactions involving muscovite breakdown in pelites yield low-temperature, "wet" melts that form veins, pockets and small plutons in regional metamorphic terranes. Biotite breakdown in pelites near the amphibolite-granulite facies transition yields hotter magmas with variable water contents. These are emplaced at medium to high levels. Under granulite facies conditions, biotite breakdown in quartzofeldspathic rocks yields high-temperature, "dry" magmas emplaced as subvolcanic batholiths and volcanics. (Author's abstract)

CLIFTON, C.G., 1984, Primary gas dispersion halos in disseminated gold deposits: examples from Nevada and California (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 42.

CLOCCHIATTI, Robert and NATIVEL, Pierre, 1984, Mineralogical study and discovery of hydrated and silica-sodic magma residues in the quartz phenocrysts of the syenite of Cilaos (Reunion Island, Indian Ocean): C.R. Acad. Sci. Paris, v. 299, no. 8, p. 451-456 (in French; English abstract).

The syenite of Cilaos corresponds to a magma with strong alkaline features and sodic dominance and with a high fluid enrichment. It represents the ultimate product of differentiation by fractional crystallization accumulated at the top of the magmatic chamber and then injected into curved fractures which affect it. Evidence of magma residues of an unusual composition (SiO_2 = 60 to 68%, Na_2O = 8 to 16%, fluid phase, H_2O, Cl, F >12%) has been found. The study of glass and fluid inclusions leads us to think that this syenite has crystallized under vey low pressure conditions, and temperatures ranging from 750 to 120°C. (Authors' abstract)

CLYNNE, M.A. and POTTER, R.W., 1984, NaCl solubility in NBT-6 and WIPP-A, 0-100°C: U.S. Geol. Survey Open-File Rpt. 84-217, 8 pp. Authors at Occidental Res. Corp., P.O. Box 19601, Irvine, CA 92713.

Solubility of NaCl in complex bitterns NBT-6 and WIPP-A from near 0°C to near 100°C are reported. The experimental data and coefficients of an equation for a smoothed curve describing each system are listed in tables. (Authors' abstract)

COLE, D.R. and RAVINSKY, L.I., 1984, Hydrothermal alteration zoning in the Beowave geothermal system, Eureka and Lander counties, Nevada: Econ. Geol., v. 79, p. 759-767.

COLEMAN, M., COX, M. and TAYLOR, R., 1984, Isotopic evidence for the nature and extent of fluid involvement in metasomatism of the St. Lawrence Granite (Newfoundland, Canada): Chem. Geol., v. 45, p. 289-298. First author at Isotope Geol. Unit, Inst. Geol. Sci., London WC1X 8NG, Great Britain.

Stable isotope analyses have been made on samples of intensely metasomatized St. Lawrence Granite at its contact with impermeable sediments. The $\delta^{18}O$(SMOW) of silicate components range from +3.7 to +7.2‰ while for carbonate, from +13.1 to +18.7‰; $\delta^{13}C$(PDB) for carbonate ranges from -8.4 to -6.0‰. The depletion of ^{18}O in the silicates was caused by high-temperature interaction with CO_2 which had previously been in isotopic equilibrium with the main granite body. The effective CO_2/rock ratio was ~ 2/3 at a distance of 1.2 m from the contact, but was about twice that value at the contact. In detail, the $\delta^{13}C$ and $\delta^{18}O$ for the carbonate indicate loss of some CO_2 from the system and additions of further small amounts of carbonate at lower temperatures. (Authors' abstract)

COMSTI, E.C. and TAYLOR, G.R., 1984, Implications of fluid inclusion data on the origin of the Hillgrove gold-antimony deposits, N.S.W.: AIMM Proc., v. 289, p. 195-203. Authors at Univ. New South Wales, Australia.

Fluid inclusions within quartz accompanying several stages of mineralization at Hillgrove (New South Wales) are described. Pyrite-arsenopyrite-Au mineralization shows uncorrected Th of 195-250°. Later stibnite-antimonide-siderite and stibnite-calcite mineralization had Th 100-195° and a bimodal distribution of temperatures peaking at 175 and 145°. Secondary included fluids within an earlier generation of deformed quartz veins were derived from hydrothermal fluids contemporaneously with the main-stage mineralizing fluids. A correlation between Th and salinities indicates that mineralization accompanied the mixing of a hot, partly saline fluid (at 5% equiv. NaCl) with cooler, less saline meteoric or connate water. Results suggest that the metals were transported by S-poor, relatively low-temperature, low-salinity solutions, possibly as carbonate complexes, and that a vertical zonation of the W-Sb-Au mineralization is compatible with the mixing of this hydrothermal fluid with cooler groundwater. The ore minerals possibly derived from the remobilization of deep-seated strata-bound deposits or from metamorphic fluids expelled from deep-seated volcaniclastic sediments. (C.A. 102: 81915b) See also Taylor and Comsti, 1984, this issue.

CONNELLY, M.P. and BOWMAN, J.R., 1984, Petrologic and fluid inclusion studies of copper skarns, Rocky Range, SW Utah (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 476. Authors at Dept. Geol. & Geophs., Univ. Utah, Salt Lake City, UT 84112-1183.

Three types of fluid inclusions occur in the skarns. Both Stage I garnets and Stage II quartz contain fluid dominated (<50% vapor), multiphase fluid inclusions with halite daughter salts (Type I). These inclusions are closely associated with vapor-dominated inclusions (Type II) in both minerals, suggesting that the skarn fluids were boiling through both stages of skarn development. Liquid Th for Type I inclusions in garnet range from 545 to >600°C (the limit of the heating apparatus), while Tm NaCl give NaCl equiv. salinities from 50 to 61 wt%. Th measurements for Type I inclusions in Stage II quartz range from 260° to 405°C (mean = 360°C), while Tm NaCl give NaCl equiv. salinities of 30-45 wt%. In some of these inclusions, halite is still present after l-v homogenization. Th values of Type III inclusions in quartz, fluid-dominated without daughter salts, also are in the range 270-400°C and Tm indicate NaCl equiv. salinities of 5 to 20 wt%. Estimates of P(H_2O) based on these T-salinity data are 500-600 bars and 150-180 bars for Stage I and II, respectively. Estimates of minimum lithostatic load (Pt ≈ 400-500 bars) suggest that fluid pressure changed from lithostatic to essentially hydrostatic during evolution of the skarn. Application of phase equilibria to observed skarn assemblages and temperature results from fluid inclusion data restrict early skarn formation to T = 550-600°C, $-18.5<\log f(O_2)<-17.0$, and $\log f(S_2)<-2.0$. (From the authors' abstract)

CONNOLLY, J.A.D. and KERRICK, D.M., 1984, Analysis of thermochemical data and phase equilibria for the system lime-alumina-silica-water-carbon dioxide (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 476.

CONSTANTINESCU, Emile and SUBAU, Gavril, 1984, Mineralogy of Alpine veins from the Romanian Carpathians (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 31 (in English). First author at Univ. Bucharest, Bucharest, Romania.

The Alpine veins, which are less known in the Romanian Carpathians, are described in the present paper as occurrences in different types of metamorphic rocks: in migmatites and laminated granites with quartz-adularia-ripidolite-apatite paragenesis; in amphibolites and amphibole schists with quartz-albite-chlorite-actinolite-calcite-hematite paragenesis; in chlorite-sericite schists with epidote with quartz-albite-chlorite-actinolite-epidote paragenesis; in chloritoid pyrophyllite schists with quartz-chlorite-pyrophyllite-paragonite/muscovite-chloritoid paragenesis. In all cases, the mineralogical composition of the Alpine veins is directly related to that of adjacent rocks and points to the generation of the former by lateral secretion. The veins exhibit a deposition sequence which starts with an alkaline phase (quartz + adularia or albite) and continues with a calcic-alkaline phase (actinolite, epidote, calcite). The morphology of crystals, the chemical-structural features (order/disorder) and the homogenization temperatures of fluid inclusions point to generation temperatures of 50-200°C. The Alpine veins represent the final, post-deformation fabrics within regional metamorphism processes in the Romanian Carpathians. (From the authors' abstract)

COOKE, B.J. and GODWIN, C.I., 1984, Geology, mineral equilibria, and isotopic studies of the McDame tungsten skarn prospect, north-central British Columbia: Econ. Geol., v. 79, p. 826-847. First author at Mindat Consultants, 2095 West 44th Ave., Vancouver, BC V6M 2T1, Canada.

The McDame tungsten skarn prospect occurs in Hadrynian to Ordovician clastic and carbonate metasediments near Cretaceous felsic stocks. Three prograde skarn and ore facies and one retrograde facies are lithologically and structurally controlled. Prograde massive calc-silicate W-Mo-Fe facies, characterized by garnet skarn with disseminated scheelite and molybdenite, has replaced graphitic marble in contact wiht biotite hornfels; it is thicker near a northeast-striking fault. Layered calc-silicate Fe facies, typified by quartz skarn with minor pyrrhotite, has replaced biotite hornfels as envelopes around fractures. Layered oxide Fe-W-Mo facies, distinguished by magnetite skarn with laminations of molybdoscheelite, has replaced graphitic dolomite as veins within fractures. Retrograde massive sulfide Fe-Zn-Cu-W facies, identified by pyrrhotite skarn with disseminated sphalerite, chalcopyrite, and scheelite, has replaced the other skarn facies, and locally graphitic marble, in veins and pods.

Lithostatic pressure during formation of McDame skarns was on the order of 1,500 bars. Temperature (T) and CO_2 mole fraction (X) conditions of the metasomatic fluid are estimated for the different skarn facies by assuming an idealized iron-free system. Massive garnet skarn was stable to T(max) = 555°C and X(max) = 0.14; garnet-bearing quartz skarn formed below T(max) = 475°C and X(max) = 0.08; feldspar-bearing magnetite skarn formed above T(max) = 430°C and X(max) = 0.06; and massive pyrrhotite skarn altered previously formed skarns at lower T and XCO_2. Calc-silicate mineral zoning resulted from dissolution, infiltration-diffusion, and deposition of SiO_2, CaO, Al_2O_3, MgO, H_2O, and CO_2 in the skarn protoliths. Metallic mineral zoning, on the other hand, formed from W-, Mo-, O_2-, and S_2-bearing magmatic fluids that reacted with country rocks to produce prograde facies and mixed with Fe-, Zn-, and Cu-bearing formational waters to form retrograde skarn.

Sulfur isotope data from McDame porphyry, skarn, and hornfels from six discrete groups (skarn average $\delta^{34}S = 7.7$) between ordinary magmatic sulfur ($\delta^{34}S = 0$) and Cambrian sedimentary sulfate ($\delta^{34}S = 30$). Their distribution can be explained by fractionation of magmatic sulfur through reaction of metasomatic fluids with wall rocks to form porphyry pyrite, skarn pyrite, and skarn pyrrhotite and mixing with formational sulfur in connate waters to produce skarn pyrrhotite-sphalerite-chalcopyrite and porphyry pyrrhotite. Rubidium-strontium isotopes from Kuhn stock quartz feldspar porphyry define a 69 ± 2 m.y. isochron with a high initial ratio of 0.712, indicating that the Kuhn stock had a sialic crustal component. Isotopic disequilibria among mineral phases suggest progressive contamination of the granitic melt by continental crust during magma ascent and crystallization. Lead isotope data from vein and skarn deposits near Cassiar cluster around the upper crustal shale curve for the Canadian Cordillera, indicating an upper crustal source for the lead. Thus, anatexis and assimilation of continental crust produced granitic melts rich in lithophile elements. The Kuhn stock is an oxidized granitoid of sedimentary origin, geochemically specialized in K_2O, K/Rb, U, and U/Th and anomalous in W and Mo. Differentiation processes have concentrated these lithophile elements in magmatic fluids that produced the McDame tungsten skarn deposit. (Authors' abstract)

Numerous fluid inclusions in fluorite from garnet skarn contain one or more dms; Te -21 to -49; Tm (phase?) -3.3 to -7.8 (but $CaCl_2$ given as "solid composition" for many inclusions); wt % salt 6.5 to 12.5; Th(P) 272-334; (S) 127°C. (E.R.)

COONS, W.E., MEYER, D., OLSEN, R.L. and REGISTER, J.K., 1984, The geochemistry of the Castile brines: implications for their origin and impact on the WIPP site: Mat. Res. Soc. Symp. Proc., v. 26, p. 49. Authors at D'Appolonia Consulting Engrs., 2340 Alamo SE, Suite 306, Albuquerque, NM 87106.

Pressurized brine reservoirs have been found in the Castile anhydrite which underlies the proposed Waste Isolation Pilot Plant. The major and minor component chemistry of the brines and the isotopic abundances of the brines and coexisting minerals have been determined and evaluated. Thermodynamic calculations indicate that the brines approach saturation with all major minerals in their host horizon. The brines, therefore, appear to be in equilibrium with their geologic environment and do not have the capacity for substantially degrading the integrity of the site. When analyzed through solute versus bromide plots, the data indicate that the most likely origin for the brines is Permian seawater. As a result, the reservoirs appear to have been derived from waters no longer being introduced into the rock (i.e., they have a finite source). (Authors' abstract)

CORREIA NEVES, J.M., MONTEIRO, R.L.B.B. and DUTRA, C.V., 1984, Chemical composition of pegmatitic beryl of Brazil and their petrologic and metallogenetic significance: Revista Brasileria de Geociencias, v. 14, no. 3, p. 137-146 (in Portuguese; English abstract). First author at Centro de Pesquisas Prof. Manoel Teixeira da Costa, CX. Postal 6208, CEP 30.000, Belo Horizonte, MG, Brazil.

Infrared [spectra] revealed H_2O, CO_2 and CH_4 occluded in channels of the beryl structure and/or present in fluid inclusions of the same mineral. The petrologic and metallogenetic implications of the chemical composition, mainly the variation in the alkali contents, of the studied beryls are discussed and interpreted. Above critical levels, the alkali contents can be used to disclose the potentiality of the pegmatite to become ore bodies for Li, Cs and Ta. (From the authors' abstract)

CORTI, H.R. and FERNANDEZ-PRINI, Roberto, 1984, Thermodynamics of solution of gypsum and anhydrite in water over a wide temperature range: Can. J. Chem., v. 62, p. 484-

COSTA, U.R., BARNETT, R.L. and KERRICH, R., 1984, the Mattagami Lake mine Archean Zn-Cu sulfide deposit, Quebec: Hydrothermal coprecipitation of talc and sulfides in a sea-floor brine pool -- evidence from geochemistry, $^{18}O/^{16}O$, and mineral chemistry -- a reply: Econ. Geol., v. 79, p. 1953-1955. First author at Programa de Pesquisa Pos-Graduacao em Geopfisica, Inst. Geosci. Univ. Federal Bahia, Federacao, Salvador, Bahia 40.000, Brazil.

A reply to a discussion by Zierenberg (this volume). (E.R.)

COX, D.P. and OHTA, Eijun, 1984, Maps showing rock types, hydrothermal alteration and distribution of fluid inclusions in the Cornelia Pluton, Ajo mining district, Pima County, Arizona: U.S. Geol. Survey Open-File Rpt. 84-388, 9 pp.

Tm NaCl 200-600+°C; Th L-V(L) 50-500°C; Th L-V(V) 300-600+°C. (E.R.)

CRAIG, H., KIM, K.-R. and RISON, W., 1984, Easter Island hotspot: I. Bathymetry, helium isotopes, and hydrothermal methane and helium (abst.): EOS, v. 65, no. 45, p. 1140. Authors at Scripps Inst. Oceanography, La Jolla, CA 92093. Continued next page.

Morgan (1972) proposed an Easter hotspot on the East Pacific Rise at 27°S, 114°W, to account for the Sala y Gomez chain and conjugate Tuamotu and Nazca Ridges. A number of authors: Pilger and Handschumacher (1981) and previously Chase, Hey et al., and Minster et al., have fixed the hotspot location on the East margin of the Easter microplate within a roughly 30 (N-S) by 60 (E-W) n-mile ellipse centered on 26°35'S, 111°40'W, based on plate-motion models and a 3-m.y. age for Easter Island. On Expedition PASCUA (1983) we used a Seabeam swath to sample basalts at two sites exactly on the East margin at the proposed hotspot latitude, as well as at 9 other sites on the EPR from 25°S to 34°S. At 26°26'S, the "East Ridge" of the microplate rises 750 meters above the seafloor to 2080 meters depth, with a width of 15 nm centered at 112°37'W. Basalts at the hotspot site have a very strong He-3/He-4 anomaly: the 3/4 ratio (R) = 10.5 to 11 x R(atm), similar to Society and Austral hotspot ratios. All other measured EPR, Juan de Fuca, and Galapagos basalts (44 samples) have normal MORB He: R = 9 R(atm) [range: 6.9-8.8]. Thus the Easter hotspot is a "High He-3" hotspot (R >8), in the class of the Austral, Society, Samoan, Hawaiian, Reunion, and Icelandic oceanic hotspots. The chemistry of these basalts is orthodox MORB, but Macdougall & Tanzer (next paper) find strong Sr & Nd anomalies vs. EPR basalts.

In addition to a mantle plume, a "hotspot" hydrothermal plume, 5 = 40 m above bottom was observed, with a 3/4 ratio anomaly of 317% (!) and a He-3 vs. He-4 slope showing R (added He) = 10.65 R(atm), as in the basalts. CH_4 was 55.6 μcc/kg in the plume. The CH_4/He-3 ratio is 0.19 E6, exactly similar to Loihi Seamount plumes (0.18 E6), but much lower than MORB hydrothermal plumes and vents at 21°N, 19-21°S, and Galapagos (range: 3-20 E6). Thus CH_4/He-3 in hotspot basalts is only 2% of the MORB ratio. (Authors' abstract)

CRAWFORD, M.L., STOUT, M.Z. and GHENT, E.D., 1984, P-T-X (fluid) evolution in Al_2SiO_5-bearing schist, Mica Creek B.C.: fluid inclusion evidence (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 478-479. First author at Dept. Geol., Bryn Mawr College, Bryn Mawr, PA 19010.

Metamorphosed pelitic rocks from Mica Creek, British Columbia contain kyanite with minor fibrolite and andalusite-bearing quartz pods. Mineral compositions were used to infer peak P-T conditions and fluid compositions in equilibrium with the solid phases. Fluid inclusions in three schist samples prove to be good indicators of conditions affecting those rocks during and after peak metamorphic conditions. In samples from two localities fluid inclusions from schist and quartz-rich segregations have densitites appropriate to the peak metamorphic conditions. The observed fluid compositions (low salinity aqueous with <12 mol% dissolved CO_2) agree well with calculated X H_2O values of .90-.98. The fluids unmixed as the schists were uplifted and cooled; fluid inclusions trapped during this stage outline a solvus in the CO_2-H_2O-NaCl system. A later influx of fluid (immiscible low salinity aqueous and mixed CO_2-CH_4) accompanied formation of andalusite-bearing plagioclase-rich segregations. The restricted association of andalusite-bearing pods and low density fluids suggest a localized but pervasive fluid influx during uplift. The P-T conditions and fluid compositions at this stage require that the andalusite-plagioclase-quartz pods form by segregation in the presence of aqueous fluids, rather than by anatexis. (Authors' abstract)

CRERAR, D.A., WOOD, S.A., BRANTLEY, S.L. and BOCARSLY, A.B., 1984, Chemical controls on solubility of minerals in hydrothermal solutions (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p.

55. First author at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544.

The transport, deposition and zoning of hydrothermal ores is 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 metal species. Recent solubility and spectroscopic data from our own and other laboratories permit the following generalizations on the chemistry of transition metal complexes at elevated temperatures. Bonding changes from primarily ionic to covalent across each transition row. The d^{10} transition metals behave more as Pearson soft bases, preferentially complexing with soft acids (electron donors) such as HS^-, while 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 towards covalent bonding down each vertical group of elements; this in part explains the preference of Au and Hg for HS^- complexes and the anomalous behavior of Sb and Bi. It has become increasingly apparent that ligation numbers decrease with temperature such that neutral complexes like $FeCl_2^0$ may predominate above roughly 250°C. This can be attributed to some or all of the following changes observed at increasing temperatures: decreasing dielectric constant of water; descent from octahedral to tetrahedral complex symmetry; pronounced decrease in activity coefficients of anionic ligands; increasing importance of hydrolysis. Increased solubility of ore minerals at higher temperatures can be attributed to many of the above effects; a previously overlooked and equally important explanation is the rise in pH buffering capacity of the solvent which dramatically increases corrosive capability. (Authors' abstract)

CROCKET, J.H. and LAVIGNE, M.J., Jr., 1984, Sulphur sources in the Dickenson gold mine as suggested by sulphur isotopes, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 417-433.

CUNNINGHAM, C.G. and BARTON, P.B., Jr., 1984, Recognition and use of paleothermal anomalies as a new exploration tool (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 481.

CUNNINGHAM, C.G., RYE, R.O., STEVEN, T.A. and MEHNERT, H.H., 1984, Origins and exploration significance of replacement and vein-type alunite deposits in the Marysvale volcanic field, west central Utah: Econ. Geol., v. 79, no. 1, p. 50-71. First author at U.S. Geol. Survey, Mail Stop 913, National Center, Reston, VA 22092.

Replacement and vein-type alunite deposits formed in two significantly different epithermal environments in the Marysvale volcanic field of Utah. Alunite deposits, replacing intermediate composition lava flows, formed 23 m.y. ago in near-surface, highly oxidizing conditions at the tops of hydrothermal plumes that were spaced at 3- to 4-km intervals around a monzonite stock. The deposits are horizontally zoned outward, from alunitic cores to kaolinitic and propylitic envelopes, and are vertically zoned from a lower pyrite-propylite assemblage upward through assemblages dominated by alunite, jarosite, and hematite to a flooded silica cap. The $\delta^{34}S$ values of 11.5 to 15.4 per mil for replacement alunite along with geologic constraints indicate that sulfate sulfur was derived from underlying Mesozoic evaporites. The δ^{34}S values of -15.3 to +5.1 per mil of underlying pyrite, however indicate that reduced sulfur, necessary to produce low pH during oxidation, either was produced by partial reduction of the evaporite sulfate or came from another source. The transition from the pyrite-propylite zone to the alunite zone probably marks the paleoground-water surface.

In some localities, deposits of natroalunite, the sodium-rich analog of alunite, are superimposed upon the alunite deposits. In each case, the δ^{34}S values of the natroalunite (-5.5 to 0.7‰) are distinctly lower than those of the alunites and indicate a nonevaporitic source of sulfur. Field relations and radiometric ages indicate that the natroalunite is significantly younger than the alunite and related to entirely separate thermal events. The source of high Na/K in solutions that is required to form natroalunite may have been halite-rich evaporites in the underlying Mesozoic sedimentary rocks.

Vein-type alunite deposits formed 14 m.y. ago as open-space fillings in extension fractures above a concealed stock. Crystals of alunite grew inward from the walls, forming veins of nearly pure alunite as much as 20 m thick. Fluid inclusions in the alunite contain low density vapor indicating crystallization in a wet-steam geothermal system. The δ^{34}S values near zero per mil indicate that the vein-type alunite sulfur probably had a magmatic source, and it appears that the sulfur may have been present as SO_2 shortly after degassing from the magma. Similar δ^{34}S values (near 0%) characterize sulfide minerals in base and precious metal deposits surrounding the alunite deposits.

The presence of sedimentary sulfur in the replacement alunite deposits indicates that the fluids involved in hydrothermal systems related to the 23-m.y.-old stock interacted with the sedimentary rocks beneath the volcanic field where they may have formed skarn and replacement deposits. Although they have a different sulfur source, deposits of a similar type may be related to the systems that formed the later natroalunite deposits. The probable magmatic orign for sulfur in the 14-m.y.-old vein-type alunite and its deposition from vapor-rich fluids, as well as the probable magmatic origin for sulfur in the surrounding base and precious metal deposits, suggest that the underlying stock may host porphyry-type deposits. (Authors' abstract)

CURRIE, K.L., 1984, A note on the solubility of quartz in supercritical water; in Current Research, Part B: Geol. Surv. Canada, Paper 84-1B, p. 369-372.

d'ANGELO, W.D., DORRZAPF, A.F., Jr. and DOUGHTEN, M.W., 1984, Analysis of fluid inclusions by inductively coupled plasma atomic-emission spectroscopy and ion chromatography (abst.): 26th Rocky Mountain Conf., Denver, Colorado, Aug. 5-9, 1984, Rocky Mountain Sec., Soc. for Applied Spectroscopy and the Rocky Mountain Chromatography Discussion Group, Progam and Abstracts, p. 144. Authors at U.S. Geol. Survey, 923 National Center, Reston, VA 22092.

Inductively coupled plasma atomic emission spectroscopy (ICP-AES) and ion chromatography (IC) were used to determine the cationic and anionic composition of 27 fluid inclusions from salt from the Palo Duro basin in Texas. Sample sizes ranged from 0.21 to 40 μl. Each sample was diluted to 1-ml with distilled water. Half of the 1-ml diluted sample was further diluted 1:1 with 10% (v /v) HCl and analyzed by ICP-AES for Na, K, Mg, and Ca. The remaining half of the 1-ml sample was diluted 1:1 with a mixture of 0.006 M $NaHCO_3$ and 0.0048 M Na_2CO_3 to give a final concentration of

HCO_3^- and CO_3^{2-} in the sample equal to that of the IC eluent, thus eliminating the water dip. This aliquot then was analyzed by IC for F^-, Cl^-, Br^-, and SO_4^{2-}. Because of the multi-element capabilities of ICP-AES and IC, a smaller amount of sample was used than is required for single-element determinations, and the dilution was kept to a minimum. For 14 of the samples, the average charge balance (anions/cations) was 1.06 ± 0.10, and the range was 0.86 to 1.19. (Authors' abstract)

DARDENNE, M.A. and SAVI, C.N., 1984, Geology and geochemistry of fluorite veins of Segunda Linha Torrens e Cocal-SC: Revista Brasileira de Geoci., v. 14, no. 2, p. 120-127 (in Portuguese). First author at Dept. Geoci., Univ. Brasilia. CEP 70910, Brasilia, DF, Brasil.

In the fluorite province of Southern Brazil (Santa Catarina State), the mineralized veins are positioned in open NS to N30E trending faults. Those faults are open fractures in the crystalline basement (granites and quartz-monzonites of the Upper Proterozoic), that form a paleogeographic high, limiting the eastern edge of Paraná Basin. The mineralized faults also cut across Eocambrian porphyry-quartz dikes, Upper Carboniferous sediments of Itararé Group and Upper Cretaceous diabase dikes. The fluorite veins show a symmetrical and/or assymmetrical simple zonation, characterized by banded fluorite, fine and coarse breccias, "cocardes" and associated geodes. Fluorite samples are green, light-yellow and white in color, and are found associated with chalcedony, quartz, barite, pyrite, kaolinite and more rarely galena. Precipitation of fluorite occurred in melange zone between rising hydrothermal fluids and connate water in sediments of the Itararé Group, that is underlain by crystalline basement. The formation of fluorite veins is linked to the evolution of the rifting event that separated the South American and African continents, probably from the end of Cretaceous to the beginning of Tertiary. The origin of fluids investigated by oxygen and sulphur isotope studies in barite, fluid inclusions in fluorite and rare earth distribution in various types of fluorite samples, is related to convective circulation of superficial waters percolating at depth, which are then heated, starting the leaching of fluorine from basement rocks and depositing fluorite during the ascending process towards the surface. (Authors' abstract)

DARIMONT, Anne, 1984, Fluid inclusion study of Ba, F(Zn, Pb) mineralizations from the metallogenic district in south Belgium: Bull. Minéral., v. 107, p. 227-232 (in French; English abstract). Author at Lab. Géol. Appliquée, 45, avenue des Tilleuls, B 4000 Liège, Belgique.

Vein-type mineralizations of Ba, F(Zn-Pb) in Devonian (Frasnian, Givetian) carbonate host rocks from the metallogenetic district of South Belgium, are studied by fluid inclusions. The paragenetic sequence determined by petrographic studies at Beauraing is listed as follows: sphalerite-fluorite I, calcite-fluorite II, barite-galena. Te values are lower than -50°C. Th and Tm ice are: sphalerite (110°C, -15°C), fluorite I (75°C, -23°C), calcite (140°C, -4°C), fluorite II (125°C, -2°C) and barite (<50°C, -6°C). $NaCl-CaCl_2-H_2O$ solutions represent fairly well the composition of the mineralizing brines; in sphalerite, the molality in Cl^- ions is around 4.4; and the salinity is comprised between 10 and 14% NaCl with 10 and 6% $CaCl_2$.

The observations on fluorite II, characterized by Th = 125°C and Tm = -2°C, in the whole district attests to the regional distribution of the fluid responsible for this episode. This study enables the reconstitution of thermobarometric evolution. The crystallization of sphalerite and fluorite I takes place around 1000 bars and 180°C, as shown by the intersection of their respective isochores in P-T diagram. Deposition of calcite and fluorite II, characterized by the highest filling temperatures is suggested as a consequence of later reopening of veins, with subsequent decrease in pressure. Barite and galena represent the low temperature final stage. (Author's abstract)

DAVIDSON, D.W., HANDA, Y.P., RATCLIFFE, C.I., TSE, J.S. and POWELL, B.M., 1984, The ability of small molecules to form clathrate hydrates of structure II: Nature, v. 311, p. 142-143. First author at Div. Chem., Nat'l. Res. Council of Canada, Ottawa, Canada K1A 0R9.

Since gas hydrates were shown in the mid-1950s to be water clathrates of two distinct crystallographic structures, it has been generally accepted that structure I hydrates are formed by molecules with maximum van der Waals diameters of up to about 5.8 A while structure II hydrates are formed by larger molecules, up to about 7.0 A in size. No exception to this general rule has been observed among more than 100 individual species of molecules known to form clathrate hydrates. From X-ray and neutron diffraction studies we now find, however, that the two smallest molecules which form clathrate hydrates - argon and krypton - do so in the structure II modification. This finding supports a suggestion of Holder and Manganiello. (Authors' abstract)

DAVINA, O.A., YEFIMOV, M.Ye., MEDVEDEV, V.A. and KHODAKOVSKIY, I.L., 1983, Thermochemical determination of the stability constant of $UO_2(CO_3)^{4-}_{3(sol)}$ at 25-200°C: Geokhimiya, no. 5, p. 677-684 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 3, p. 10-   , 1984).

DAWSON, J.B., 1984a, Contrasting types of upper-mantle metasomatism?, *in* Kimberlites, v. II: The mantle and crust-mantle relationships, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 289-294.

Metasomatism is now well-recognized in upper-mantle peridotite xenoliths in kimberlites and basalts. It is patent when petrographically recognizable by development of hydrous phases rich in incompatible elements, usually by replacement of anhydrous phases and sometimes associated with injection of fluids into channelways. The case is examined for a more subtle cryptic metasomatism causing incompatible-element enrichment in the absence of replacement and injection features. More chronological data are needed to assess whether the chemical and physical effects of metasomatism (enhanced heat production, lowering of the solidus, decreased gravitational stability) can be correlated with known magmatic and tectonic events. (Author's abstract)

DAWSON, J.B., 1984b, Xenoliths in kimberlites: clues to the Earth's upper mantle: Sci. Prog., v. 69, no. 273, p. 65-81. Author at Dept. Geol., The Univ., Sheffield S1 3JD, England.

Blocks of the upper mantle, brought to the Earth's surface during kimberlite eruptions, indicate that this deep layer of the Earth is lithologically complex. Although olivine-rich peridotites predominate, there are many mineralogical and textural variants. Eclogites, although relatively rare, confirm the complexities observed in the peridotites. Some of the complexities have been caused by kinetic deformation, fluid migration and magma intrusion. Although these processes have largely obliterated old fabrics and isotopic ages, the xenolith suites include some ancient relicts from the early stages of the Earth's history. (Author's abstract)

DEICHA, G.A. and PROUVOST, J., 1984, Scanning electron microscopy applied to crystallogenetic disequilibrium in the evolution of veils of fluid inclusions: 27th Int'l. Geol. Congress, Abstracts, v. 5, p. 33 (in French). First author at Univ. P. & M. Curie, Lab. Géol. Appliquée, Paris, France.

Nonequilibrium processes typically apply to the trapping of fluids during the healing of fractures, leaving evidence of both corrosion and deposition in the fluid inclusions. Scanning electron microscopy is well suited to studying the factors which may control the number, dimensions, morphology and other characteristics of cavities formed by such dynamic processes. The case studies reported address the relationships between "pseudo-primary" and "pseudo-secondary" inclusions, with special reference to porphyry copper deposits. (From the authors' abstract, translation courtesy M.J. Logsdon)

DEINES, Peter, GURNEY, J.J. and HARRIS, J.W., 1984, Associated chemical and carbon isotopic composition variations in diamonds from Finsch and Premier kimberlite, South Africa: Geochimica Cosmo. Acta, v. 48, p. 325-342. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

The carbon isotopic composition of 66 inclusion-containing diamonds from the Premier kimberlite, South Africa, 93 inclusion-containing diamonds and four diamonds of two diamond-bearing peridotite xenoliths from the Finsch kimberlite, South Africa was measured. The data suggest a relationship between the carbon isotopic composition of the diamonds and the chemical composition of the associated silicates. For both kimberlites similar trends are noted for diamonds containing peridotite-suite inclusions (P-type) and for diamonds containing eclogite-suite inclusions (E-type): Higher $\delta^{13}C$ P-type diamonds tend to have inclusions lower in SiO_2 (ol), Al_2O_3 (opx, gt), Cr_2O_3, MgO, Mg/(Mg + Fe) (ol, opx, gt) and higher in FeO (ol, opx, gt) and CaO (gt). Higher $\delta^{13}C$ E-type diamonds tend to have inclusions lower in SiO_2, Al_2O_3 (gt, cpx), MgO, Mg/(Mg + Fe) (gt), Na_2O, K_2O, TiO_2 (cpx) and higher in CaO, Ca/(Ca + Mg) (gt, cpx).

Consideration of a number of different models that have been proposed for the genesis of kimberlites, their xenoliths and diamonds shows that they are all consistent with the conclusion that in the mantle, regions exist that are characterized by different mean carbon isotopic compositions. (Authors' abstract)

DE JONG, A.F.M. and SALEMINK, J., 1984, O-18/O-16 and fluid inclusion data from skarn and ore deposits at Seriphos, Greece (abst.): Terra Cognita, v. 4, no. 2, p. 216-217. Authors at Inst. Earth Sci., P.O. Box 80021, 3508 TA Utrecht, The Netherlands.

On the island of Seriphos, Cyclades, Greece, the intrusion of a granodiorite produced extensive skarn and (iron) ore deposits. The occurrence of bleached zones along fractures in the magmatic rocks indicates that the skarn and ore components were leached from the granodiorite and deposited in the adjacent country rocks. Oxygen isotopes and fluid inclusions were studied to unravel the chronological evolution in the metasomatic solutions during the progressive hydrothermal cooling of the intrusive systems.

Melting relations in primary fluid inclusions in quartz grains from unaltered hornblende-biotite-granodiorite indicate that the 'primary magmatic fluids' were hydrous $NaCl-KCl-CaCl_2-MgCl_2$ solutions with a total salt content of 45-40 eq.wt.% NaCl. Quartz grains from quartz-albite-sericite assemblages of the bleached granodiorite contain fluid inclusions with a very similar composition and a total salt content of 40-35 eq.wt.%

NaCl. In both rock types the homogenization temperatures of the fluid inclusions are T(h) = 250-300°C. The comparable whole rock $\delta^{18}O$-values of 9.3‰ for the unaltered granodiorite to 10.0% for the altered rocks suggests that the leaching occurred at a low water/rock ratio (fig. 2).

In early formed hedenbergite-andradite skarns primary fluid inclusions in coexisting quartzes contain 'magmatic' $NaCl$-KCl-$CaCl_2$-$MgCl_2$ solutions with a total salt content of about 35-30 eq.wt.% NaCl and T(h) = 300-350°C. Isotopic data indicate a formation of these skarns at temperatures around 550°C from hydrous solutions with $\delta^{18}O$ = 10-12‰.

In medium temperature quartz-epidote assemblages fluid inclusions contain total salt concentrations of 25-23 eq.wt.% NaCl. Quartzes coexisting with actinolite-calcite-magnetite/hematite parageneses have primary fluid inclusions with 20-18 eq.wt.% NaCl and T(h) = 300°C. The $\delta^{18}O$-values of coexisting pairs of magnetite and quartz from these MT-skarns point to equilibrium formation temperatures of about 400°C and to an isotopic composition of the water phase between 9.0 and 6.0‰.

In late stage pyrite-quartz, fluorite and barite deposits the total salt content of the primary fluid inclusions further decreases from around 20 eq.wt.% NaCl to less than 15 eq.wt.% NaCl. The homogenization temperatures of the inclusions at the same time decrease from around 250°C to some 100°C. The isotopic composition of the coexisting water phase gradually decreases from $\delta^{18}O$ = 6‰ to $\delta^{18}O$-values approaching 0‰.

The uniform homogenization temperatures of around T(h) = 300°C of the fluid inclusions in the magmatic rocks as well as in the HT- and MT-skarns evidence a formation process whereby the hydrothermal solutions remained largely along the same isochore (ρ = 0.75 gr/cm^3) as the formation temperatures dropped. The gradually decreasing total salt content and $\delta^{18}O$-values of the metasomatic solutions confirm that the metasomatic mass exchange system at Seriphos was a largely closed system; there was a continuous reequilibration of the fluids as metasomatism progressed.

We conclude that the skarn and ore deposits at Seriphos were formed from a limited amount of solutions that percolated along the cracks and fractures in the solid rocks. The fluids originated from degassing of the granodioritic magma. (Authors' abstract)

DELANO, J.W., 1984, Vesicles in four varieties of Apollo 15 volcanic glass (abst): Lunar and Planet. Sci. XV, p. 218-219.

DEMIN, Yu.I., 1984, Thermal regime of granitoids and their associated mineralization: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 281-287. Author at Moscow State Univ., Moscow, USSR.

Includes some discussion of Th for melt inclusions in quartz and feldspar (from the literature?).

See also Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 53. (E.R.)

DENNIS, P.F., 1984, Oxygen self-diffusion in quartz under hydrothermal conditions: J. Geophys. Research, v. 89, no. B6, p. 4047-4057. Author at Dept. Geol., Imperial College.

Oxygen self-diffusion, D_{Ox}, has been monitored in single-crystal quartz in the temperature range 515°-850°C under hydrothermal conditions. In the beta field, between 700° and 850°C, the data are represented by two linear Arrhenius relations for transport parallel and perpendicular to c. Values for D_0 ($m^2\ s^{-1}$) are 2.09×10^{-11} parallel to c and 3.16×10^{-10} perpendicular to $(10\bar{1}0)$. Values for ΔH ($kJ\ mol^{-1}$) are 138.54 parallel to c and 203.72 perpendicular to $(10\bar{1}0)$. At 700°C, in the total presusre range 11.5-100 MPa, D_{Ox} is independent of water ($f(H_2O)$) and oxygen ($f(O_2)$) fugacities between the Ni-NiO and Fe_3O_4-Fe_2O_3 buffers. The results are consistent with diffusion via a simple charged vacancy mechanism under an extrinsic point defect regime. Further experiments are required to confirm the nature of the mobile oxygen defect. A key aspect of the results is the observation that at the low water fugacities of the present experiments a hydrogen-containing defect appears to play no role in the oxygen transport mechanism. This is in contrast to other published sets of data and leads directly to the requirement for detailed interlaboratory comparisons. (Author's abstract)

DENNIS, P.F., 1984, Oxygen self diffusion in quartz: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 260-265. (See previous item.)

DES MARAIS, D.J., 1984, Isotopically light carbon in midocean ridge basalts - fact or artifact (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 486-487.

DES MARAIS, D.J. and MOORE, J.G., 1984, Carbon and its isotopes in midoceanic basaltic glasses: Earth & Planet. Sci. Letters, v. 69, p. 43-57. First author at NASA-Ames Res. Center, Moffett Field, CA 94035, USA.

Three carbon components are evident in eleven analyzed mid-oceanic basalts: carbon on sample surfaces (resembling adsorbed gases, organic matter, or other non-magmatic carbon species acquired by the glasses subsequent to their eruption), mantle carbon dioxide in vesicles, and mantle carbon dissolved in the glasses. The dissolved carbon concentration (measured in vesicle-free glass) increases with the eruption depth of the spreading ridge, and is consistent with earlier data which show that magma carbon solubility increases with pressure. The total glass carbon content (dissolved plus vesicular carbon) may be controlled by the depth of the shallowest ridge magma chamber. Carbon isotopic fractionation accompanies magma degassing; vesicle CO_2 is about 3.8‰ enriched in ^{13}C, relative to dissolved carbon. Despite this fractionation, $\delta^{13}C$(PDB) values for all spreading ridge glasses lie within the range -5.6 and -7.5, and the $\delta^{13}C$ (PDB) of mantle carbon likely lies between -5 and -7. The carbon abundances and $\delta^{13}C$(PDB) values of Kilauea East Rift glasses apparently are inflenced by the differentiation and movement of magma within that Hawaiian volcano. Using ^3He and carbon data for submarine hydrothermal fluids, the present-day mid-oceanic ridge mantle carbon flux is estimated very roughly to be about 1.0×10^{13} gC/yr. Such a flux requires 8 Gyr to accumulate the earth's present crustal carbon inventory. (Authors' abstract)

DEVINA, O.A., KUYUNKO, N.S., YEFIMOV, M.Ye., MEDVEDEV, V.A. and KHODAKOVSKIY, I.L., 1983, The thermodynamic parameters of BF_4^- and boron hydroxyfluoride complexes in aqueous solution at 25-300°C: Geokhimiya, no. 8, p. 1150-1159 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 4, p. 132-142, 1984). Authors at Vernadskiy Inst. Geochem. and Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Measurements have been made on the enthalpy of solution of $KBF_{4(c)}$ in NaF solutions up to $\mu = 0.7$ in an LKB-8700 solution calorimeter at 25, 35, 45, and 60°C. The measurements and published data have been used to calculate the thermodynamic parameters of $BF^-_{4(sol)}$ and of boron hydroxyfluoride complexes at 25-300°C. (Authors' abstract)

DE VIVO, Benedetto, 1984, Inclusion fluids in minerals: Le Scienze, No. 186, Feb. 1984, p. 30-40 (in Italian).

A review of fluid inclusion research. (E.R.)

DE VIVO, Benedetto and LATTANZI, Pierfranco, 1984, Applications of the study of fluid inclusions to the investigations of geothermal fields: Rendiconti della Societa Italiana di Mineral. & Petrol., v. 39, p. 393-400 (in Italian; English abstract). First author at Centro di Geocronologia e Geochim. della Formazioni recenti del C.N.R., Citta Univ., Piazza Aldo Moro, 00185, Rome.

The fluid inclusions in minerals are the most direct witness of the fluid phase with which the minerals interacted at the moment of their formation (primary inclusions) or in a subsequent age (secondary inclusions). Hence, fluid inclusion studies in minerals formed by interaction between hydrothermal fluids and wall rocks in geothermal fields make possible the reconstruction of the fluid characteristics present in the past in the geothermal field. By comparing such characteristics with those of present geothermal fluids, the past evolution of the geothermal fluids and the past evolution of the geothermal field can be traced and hypotheses about its future evolution formulated.

As examples, results obtained on the geothermal fields of Broadlands (New Zealand), Los Alamos (New Mexico) and Larderello (Tuscany) are reported. In particular, the data obtained on the fluid inclusions of Larderello show that the present fluid, in agreement with the generally accepted models, made up essentially of superheated steam, may derive from the boiling of a liquid phase initially dominant. (Authors' abstract)

DIDENKO, A.V., 1984, Formation conditions of carbonaceous matter and minerals in mercury deposits of Transcarpathia (based on results from study of inclusions): Deposited Doc. 1984, VINITI 4926-84, p. 119-125 (in Russian).

Th and pH of gas-liquid inclusions in elongate prismatic quartz from the Hg ore deposits are 170-160° and 7.0-7.1, respectively, in crystals with a hexagonal cross section and ~260° and 6.6-6.7, respectively, in crystals with a trigonal cross section. In the inclusions, liquid carbonaceous matter (CM) envelops gas bubbles or occurs as droplets in aqueous solutions. In UV light these droplets luminesce yellowish brown and are classified as heavy petroleum. Liquid CM filling voids in altered quartz diorite porphyries has the elemental composition C 85.2, H 8.35, O + N + S 6.45%. IR spectra of liquid CM indicate the presence of arom. compounds, carbonyl compounds, and aliph. compounds with CH_2- and CH_3-groups. Mass spectrometric studies of the gas phase in inclusions determined the range in composition. CO_2 49.5-94.01, N_2 2.83-33.45, CH_4 2.8-28.8, H_2 0.34-41.6, and $C_2H_6 \leq 1.81\%$. The CM and Hg ore mineralization are closely related and were transported together in fluids, possibly in organometallic complexes. The Hg ore-forming minerals were derived from neutral-slightly alkaline solutions, with cinnabar, marcasite, and calcite crystallizing at 160-120°. The CM, including parafins, idrialite, and karpatite, formed after the deposition of cinnabar, from slightly alkaline solutions at 120 to 60°. (C.A. 103: 56981h)

DILLES, J.H., 1984, The petrology and geochemistry of the Yerington batholith and the Ann-Mason porphyry copper deposit, western Nevada: Ph.D. thesis, Stanford Univ., Stanford, CA, 462 pp.

Field, petrologic, and geochemical data presented herein constrain the origin of porphyry copper mineralization in the Jurassic Yerington batholith. The batholith, with 58-68% SiO_2, Peacock index ~56, high K_2O (3.0 wt% at 60% SiO_2), high strontium (~1100 ppm), and low initial strontium isotopic composition (0.7040), is similar to high-K orogenic andesites. Three major units were emplaced, from oldest to youngest: granodiorite, quartz monzonite, and porphyritic quartz monzonite (PQM), including porphyry. They show progressive decrease in volume, increase in depth of roof emplacement (<1, 1-2, >3 km, respectively), increase in grain size, and increase in silica content (~60, ~66, ~68 wt% SiO_2, respectively). Two concordant U-Pb zircon dates of 169 m.y.b.p. on granodiorite and 168 m.y.b.p. on mineralized quartz monzonite porphyry (QMP) indicate the batholith was emplaced within one million years. Phase petrology, stable isotopes, and both iron-titanium oxide and biotite compositional data indicate each plutonic unit crystallized while water-saturated at relatively high oxygen fugacities to the solidus at 700 ± 25°C, and that minerals reequilibrated to 500 ± 50°C during cooling in the presence of a magmatic water phase.

Hydrothermal alteration affected ~25 km^3 of rock at the Ann-Mason porphyry copper deposit. Main stage biotite (potassic) alteration and copper mineralization was contemporaneous with a central QMP dike swarm and was accompanied by flanking/deeper oligoclase-actinolite (sodic-calcic) alteration. Both alterations contain high salinity fluid inclusions trapped at 300-480+°C, but field relations, petrology, and stable isotope data suggest that magmatic fluids caused potassic alteration, whereas largely non-magmatic fluids, flowing up a temperature gradient, caused sodic-calcic alteration. Late stage albite-chlorite and lesser sericitic alterations cut main stage alteration, have pyritic mineralization, and contain low salinity fluid inclusions that homogenize at 150-250+°C. Stable isotope data and phase petrology suggest that late stage fluids were either ocean water or isotopically heavy meteoric water. I propose that most of the copper in the deposit came from a high salinity, water-rich magmatic fluid that separated from the crystallizing PQM/QMP magma, but that up to 16% may have been derived from leaching during sodic-calcic alteration. (Author's abstract)

DING, T. and REES, C.E., 1984, The sulphur isotope systematics of the Taolin lead-zinc ore deposit, China: Geochimica Cosmo. Acta, v. 48, p. 2381-2392. First author at Inst. Geol. of Mineral Deposits, Chinese Acad. Geol. Sci., Baiwanchuan Fuchenmen Wai, Beijing, PRC.

See next item. (E.R.)

DING, T.P., REES, C.E., SCHWARCZ, H.P., YONGE, C. and McMASTER, D., 1984, Stable isotope studies of the Taolin Pb-Zn deposit China (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 490. First author at Inst. Geol. & Mineral Deposits, Chinese Acad. Sci., Beijing, China.

The Taolin deposit consists of a series of hydrothermal veins. Taken together with δD of fluid inclusions, the data show that hydrothermal fluid was initially of magmatic composition but, as it cooled, it mixed with meteoric waters. A post-ore calcite-quartz assemblage was precipitated from essentially pure meteoric water. (From the authors' abstract)

DING, T.P. and RYE, R.O., 1984, Stable isotope studies of the Xihuashan tungsten ore deposit, Jiangxi, China (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 250-251 (in English). First author at Inst. Mineral Deposits, Chinese Acad. Geol. Sci., Beijing, China.

The Xihuashan quartz-wolframite deposit in Jiangxi, China, consists of over 600 steeply dipping quartz veins in the upper part of a complex biotite granite stock that intrudes Cambrian pelitic rocks.

The granite has an isochron age of 157 ± 13 m.y. and initial $^{87}Sr/^{86}Sr$ ratio of 0.7199. The $\delta^{18}O$ data on the stock indicate post-crystallization exchange with $\delta^{18}O$-depleted meteoric water. Whole rock and quartz $\delta^{18}O$ values suggest that the biotite granite may have S-type characteristics. The $\delta^{18}O$ data on quartz, wolframite, sericitized potassium feldspar, and muscovite from the veins and associated greisen envelopes, indicate deposition from fluids displaying a remarkable narrow range of $\delta^{18}O$ H_2O and temperature throughout vein formation and greisenization. The $\delta^{18}O$ H_2O of the hydrothermal fluids can be calculated to have been 3.14 ± 1.6. It is likely that the fluids contained an observable component of highly exchanged meteoric water. Most of the δD-H_2O values of the fluids are in the range typical of magmatic fluids and therefore cannot be used to sort out magmatic and meteoric water components without a more detailed study. Sulfur isotope data on sulfides, however, indicate that sulfide sulfur was derived from a deep seated igneous source. (Authors' abstract)

DINGWELL, D.B., HARRIS, D.M. and SCARFE, C.M., 1984, The solubility of H_2O in melts in the system SiO_2-Al_2O_3-Na_2O-K_2O at 1 to 2 kbars: J. Geol., v. 92, no. 4, p. 387-395. First author at Exper. Petrol. Lab., Dept. Geol., Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

The solubilities of water in six melts in the system K_2O-Na_2O-Al_2O_3-SiO_2 were determined at 970-1630 bars and 800°C. Melts were synthesized hydrothermally in Pt capsules in cold-seal vessels and then quenched isobarically. The solubilities were determined by micromanometric measurement of H_2O evolved during vacuum fusion of vesicle-free glass wafers and are reproducible to ±2.8% (2 s.d.) of the concentration. The solubilities at 970 bars for the granitic and phonolitic minimum melts are 2.88 ± 0.10 wt % and 5.01 ± 0.14 wt %, respectively. Both peralkaline and peraluminous granitic melts have higher H_2O solubilities than the 1 kbar $P(H_2O)$ minimum melt and indicate the existence of minima in solubilities at molar (Na = K)/Al = 1 along joins of constant SiO_2. Two melts at constant SiO_2 and (Na + K)/Al ratio, but varying in Na/(Na + K) (0.57, 0.69 molar), have the same solubility (2.88 ± 0.10, 7.64 ± 0.10 wt %). The compositional dependence of solubilities for peralkaline and peraluminous melts is not predicted by the solubility mechanism and calculation method of Burnham (1975, 1979, 1981) that was developed for metaluminous melts. The pressure dependence of solubility was investigated for a peralkaline melt with six determinations at four pressures from 970 to 1620 bars. The mole fraction of dissolved water (based on 8 moles of O) for this melt is proportional to the square root of the fugacity of water; the root mean square deviation from linearity is 1.4% and is equal to the analytical precision (1 s.d.). Our data for the haplogranite minimum are lower than some other determinations; however, the limitations of the various methods for determining solubilities in melts make detailed comparisons with our data difficult. The solubility of water in a Bishop Tuff melt was estimated from our measurements and used with direct measurements of H_2O in rhyolitic melt inclusions (4.9 ± 0.5 wt %, Druitt et al. 1982) to obtain the minimum pressure of water (2100 ± 300 bars) and a minimum depth (8 ± 1 km) of crystallization. (Authors' abstract)

DOBRETSOV, N.L., LITVINOVSKY, B.A. and REYF, F.G., 1984, The model of the fluid syntexis and ore-bearing granitoidal magmas (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 294. Authors at Geol. Inst. Buryat Div. of Siberian Br. USSR Acad. Sci., Ulan-Ude, USSR. Continued next page.

The data of the thermobarometry, geology and mineralogy show that only those intrusions or their parts bear W-Mo mineralization, in which the distillation begins at an early magmatic stage. In such hypabyssal and mesoabyssal intrusions the magma contains not 2-3% of H_2O, as usually, but 4.5-5%, in the late phases the content of H_2O increases up to 7%. Th of the melt inclusions in the intratelluric phenocrysts is 700-800°C, that determines the lower temperature limit of the formation of the magma. (From the authors' abstract)

DOBSON, D.C., 1984, Geology and geochemical evolution of the Lost River, Alaska, tin deposit: Ph.D. thesis, Stanford Univ., Stanford, CA, 162 pp.

Sn-W-Be-F and base metal mineralization at Lost River occurs in stockwork vein skarn, greisen and breccia within and above the cupola of a late Cretaceous granite which intrudes Ordovician limestone. The stock was emplaced at a shallow level in a setting characterized by minor normal faulting, but without metamorphism or major deformation. Major and minor element analyses indicate that mineralized intrusions at Lost River, and elsewhere on the northern Seward Peninsula, were highly evolved granites derived from sialic crust. The earliest partial melts were apparently felsic plutons which fractionated, probably by volatile-related mechanisms, to yield volumetrically small tin-bearing stocks.

Alteration in the limestone commenced with "anhydrous" skarn assemblages characterized in sequence by: (1) andradite; (2) fluorite + idocrase + magnetite; and (3) idocrase + subcalcic garnet ± fluorite and hornblende. Quartz + topaz + tourmaline + cassiterite + sulfide greisen within the granite was contemporaneous with fluorite + biotite + hornblende + sulfide + cassiterite vein formation in skarn. Further evolution resulted in deposition of mica-rich greisens at the apex of the cupola and margarite + muscovite + plagioclase alteration in the carbonates and skarn. Two breccia types cut all earlier assemblages. The first barely post-dated mica greisen, and consists of fragments of skarn, limestone and igneous rocks in a muscovite + zinnwaldite matrix. Kaolinite-matrix breccias are the last hydrothermal event noted.

Fluid inclusion studies suggest that early skarns formed from fluids at 350-400°C with salinities declining from 15-18 wt % NaCl to 9-15 wt %. Approximately isothermal boiling of the fluids resulted in greisenization of the granite; concomitantly, residual fluids with enhanced salinity (18-21% NaCl) caused hydrous silicate (biotite or hornblende) deposition in skarn. Pressures indicatd by boiling inclusions are roughly 250-400 bars. Phase equilibria require that initial fluids were characterized by extremely low XCO_2, moderate to low fO_2 and fS_2 and relatively high fHF/fH_2O. Following greisen and hydrous skarn alteration, declining temperatures, and increases in XCO_2 and fO_2, resulted in the formation of margarite and plagioclase in veins in limestone and skarn. Late clay alteration probably occurred at $T < 250°C$.

Data from Lost River and other Sn-deposits suggests that sudden pressure variations, accompanied by fluid boiling, are a common prerequisite of Sn-mineralization. Thus, the search for Sn-deposits can probably be restricted largely to shallow environments, where rapid pressure fluctuation (with boiling) can occur via fracturing, and fluid communication with the surface. In the case of Sn-skarns, shallow levels are especially critical because early silicates (e.g., andradite and idocrase) may contain significant Sn. The deposition of recoverable Sn is therefore dependent on the destruction of those phases by later alteration which is best accomplished at shallow levels, as "deep" skarns seldom show significant retrograde alteration. (Author's abstract)

DOLGOV, Yu.A., BAKUMENKO, I.T., TOMILENKO, A.A. and CHUPIN, V.P., 1984, Metamorphic and magmatic mineral formation according to the thermobarogeochemical data: Geologiya i Geofizika, v. 25, no. 12, p. 41-54 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 12, p. 41-52, 1984).

This article synthesizes the results of thermobarogeochemical studies of inclusions in the minerals of metamorphic and igneous rocks. The compositions of the metamorphosing fluids and the PT-conditions of formation of the metamorphic rocks of different series of facies and of certain metamorphogenic ore deposits are established. In the case of the Kholodninskoe pyritic-polymetallic ore deposit, it was found that there is a regular change in composition of the fluid (from methane to carbon dioxide) along with a pressure drop from $(7.0\text{-}7.5)\cdot 10^8$ Pa in the ore-free host rocks to $(3.0\text{-}3.5)\cdot 10^8$ Pa in the ore bodies. Information is presented on the use of inclusions in impactites to study the processes and products of impact shock metamorphism. Examples of the use of solidified melt inclusions to ascertain the nature and conditions of formation of such genetically complex bodies as anatectites, granites, pegmatites, and alkalic rocks are cited. Cases of the liberation of gases from magmas of different compositions in various geologic situations have been established on the basis of the accompanying fluid inclusions. (Authors' abstract)

DOLGOV, Yu.A, TOMILENKO, A.A. and CHUPIN, V.P., 1984a Anatexis and metamorphism conditions according to inclusions in minerals (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 35-36 (in English). Authors at Inst. Geol. & Geophy. Siberian Br. USSR Acad. Sci., Novosibirsk, USSR.

1. Fluid composition and evolution in metamorphism and anatexis and P-T parameters of these processes during the formation of a number of migmatite-gneiss complexes of the Soviet Union, Mongolia, the GDR and India are determined by thermobarogeochemical methods. During granulite formation of the Aldan shield, Khan-Khukh-Ei ridge (Mongolia), and charnockites and gneisses of Kansk granulite complex (the Yenisei ridge), fluid pressure was 6-8 kbar. Higher fluid pressures (>15 kbar) are obtained for eclogite of Eastern Siberia and the GDR. Low-temperature generations and crystallization of anatectic melts under the conditions of amphibolite facies of Mama mica-bearing region in Trans-Baikal region (about 640°C), Mymchukur block in the Dzhungarsky Alatau and Gorny Altai series in the South Chuisky ridge (about 700°C), comparing to amphibolitic and granulitic facies of the Western part of the Aldan shield (for Upper Aldan suite accordingly 830-780 and 900-820°C) are obtained when studying inclusions of crystallized granitoid melts by the homogenization method. In the granulite facies melting low water content (about 2-3 weight %) and rather high CO_2 content (up to 0.6 weight %) are established. The data on the conditions of volatiles separation during anatectic melts crystallization are obtained. 2. Craters on the Moon, Venus, Mercury and Mars surfaces are of impact origin. On the Earth similar craters are mainly wiped out by exogenous processes. Several tens of young preserved craters have peculiar structure and minerals, characterizing the influence of high pressures and high temperatures. Target rocks undergo local impact metamorphism and transform into impact-metamorphic ones. Minerals develop jointing at impact. Higher pressure and temperature develop near joints, and that leads to the formation of melting inclusions in joints, having a ladder-like pattern and gas bubbles appearing at cooling. Such inclusions allow usual procedures for determining homogenization temperature. (Authors' abstract)

DOLGOV, Yu.A., TOMILENKO, A.A. and CHUPIN, V.P., 1984b Conditions of anatexis and metamorphism (according to the data on inclusions in minerals): Geologiya i Geofizika, v. 25, no. 8, p. 91-98 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 8, p. 82-88, 1984).

On the basis of a study of metamorphogenic inclusions (H_2O, CO_2, CH_4, N_2, and their mixtures) and of crystallized melt inclusions in the minerals of Precambrian migmatite-gneiss complexes, this article presents information on the PT-characteristics and evolution of the composition of fluids in metamorphism and anatexis in the deeper zones of the Earth's crust. The temperatures at which anatectic melts are generated and crystallized were found to be higher (900-810°C) in the granulite than in the amphibolite (830-640°C) facies. It is shown that in addition to essentially aqueous-saline and carbon-dioxide fluids, in certain geologic environments fluids of essentially hydrogen-hydrocarbon and nitrogen composition can be of independent significance in metamorphism. (Authors' abstract)

DONALDSON, C.H., 1984a Crystal dissolution rates in a basaltic melt: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 174-175.

DONALDSON, C.H., 1984b Textures resulting from partial crystal dissolution in basaltic melt: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 175-177.

DOROBEK, S.L., 1984, Evidence for post-cementation migration of high-temperture, high-pressure fluids--Siluro-Devonian Helderberg Group, central Appalachians (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Author at Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.

Fluid inclusion data and fracture-filling cements in carbonate and siliciclastic rocks of the Siluro-Devonian Helderberg Group, central Appalachians, indicate post-cementation, late Paleozoic migration of high-pressure, high-temperature fluids.

Void-filling quartz and calcite cements contain secondary, 2-phase fluid inclusions that give freezing temperatures of -20 to -25°C (-4 to -13°F) (salinity >22 wt. % NaCl). Homogenization temperatures are 200 to 300+°C (392 to 572°F) (temperatures calibrated and pressure corrected) and greatly exceed maximum paleotemperatures (120 to 160°C; 248 to 320°F) given by conodont color-alteration index values or calculated from known sedimentary overburden. High homogenization temperatures suggest rapid movement of metamorphic fluids so that ambient burial temperature was not raised for long enough periods of time to affect conodont CAI values. These fluids probably came from Blue Ridge-Piedmont thrust sheets that were undergoing metamorphism during late Paleozoic deformation. These fluids migrated more than 75 km (47 mi) during thrusting.

Well-cemented sandstone and limestone have multiple crosscutting trains of secondary hydrocarbon inclusions. Some trains crosscut cement-filled fractures. Hydrocarbons also occur as thin films along cement crystal boundaries and as secondary inclusions trapped along calcite deformation twins. These inclusions indicate geopressured fluids moved along intercrystalline boundaries and along deformation twin planes in calcite under deep burial conditions either during or after deformation.

Rare fractures contain transported skeletal grains, "exotic" clasts, recemented clasts of fracture-filling cement, and mud. Cement clasts contain included mud and skeletal grains, and indicate several episodes of particle transport, cementation, and refracturing prior to final fracture filling. Primary(?) 2-phase fluid inclusions in vein-filling calcite give homogenization temperatures of 120 to 150°C (248 to 302°F). Coarse-grained "clastic" fracture fills indicate migration of rapidly moving fluids capable of transporting clasts through fracture conduits under deep burial conditions. (Author's abstract)

DOSTAL, J, DUPUY, C. and BOIVIN, P.A., 1984, Geochemistry and petrology of ultramafic xenoliths and their host basalts from Tallante, southern Spain (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 58. First author at Dept. Geol., St. Mary's Univ., Halifax, Nova Scotia, B3H 3C3, Canada.

Ultramafic xenoliths enclosed in Plio-Quaternary alkali basalts from the Tallante volcanic massif near Cartagne, southern Spain are composed mainly of spinel peridotites or pyroxenites, which typically show granular textures. In the abundant composite xenoliths, the spinel peridotite is cut by pyroxenite or diorite veinlets generally 0.2-0.3 cm thick. Spinel peridotites are made up of olivine (Fo 90-91), enstatite (En 90 Fs 9 Wo 1) with 3.5% Al_2O_3, diopside (En 48 Fs 4 Wo 48) with 5% Al_2O_3 and Cr-spinel. These rocks underwent subsolidus reequilibration at about 850°C. Spinel lherzolites are probably mantle residues modified to variable degrees by metasomatic fluid. Pyroxenites are composed of dominant clinopyroxene (En 43 Fs 10 Wo 47) and subordinate amounts of olivine, amphibole, phlogopite and plagioclase. Clinopyroxenites have both major and trace element compositions intermediate between spinel peridotites and hot basalts. Their origin involved crystal segregation from alkali basalt magmas formed earlier than the host basalts. Close to the contact with the veinlets, the spinel lherzolites are enriched in Ca, Fe and some incompatible elements including light REE. The concentrations of incompatible elements are generally decreasing with distance from the veinlets. Such variations probably resulted from the migration of a fluid from the veinlets into the surrounding lherzolites. The source for the host alkali basalts had a concentration of transition elements similar to those of the associated peridotite xenoliths but had significantly higher abundances of some incompatible elements particularly light REE. The alkali basalts were derived from a heterogeneous incompatible element-enriched upper mantle source probably similar in composition to the composite xenoliths. (Authors' abstract)

DREIBUS, G., JAGOUTZ, E. and WANKE, H., 1984, Halogen inventory in the Earth's mantle - crust system (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 254 (in English). Authors at Max-Planck-Inst. für Chemie, Mainz, FRG.

Analyses of primitive and unaltered spinel-lherzolites from different continental localities yielded very low concentrations of Cl, Br, and I. Spinel- and garnet-lherzolites as well as crustal composites contain Cl, Br, and I in chondritic (C 1) abundance ratios, which seem to be valid for the Earth as a whole. Today most of the Earth's inventory of Cl, Br and I resides in the crust; most of Cl and Br (in C 1 ratio) dissolved in seawater and I to 90% in sediments.

The very low I concentration in seawater makes the Cl/I and Br/I ratios to an indicator for rock/seawater interaction on a local and global scale. Halogens with the seawater pattern were found in alkali basalts, island basalts, kimberlites, ancient subaerial tholeiites and komatiites.

The corresponding I/La ratios in ancient subaerial basalts from Isua and modern submarine tholeiites indicate constant halogen concentrations in their source regions over geologic times. However, contrary to oceanic tholeiites the highly fractionated modern alkali basalts have about a factor 10 to 100 lower I/La ratios.

The extremely low concentrations of halogens observed in the mantle seems to support the proposition that after accretion the Earth's mantle acted as a sink and not as a source for volatiles. (Authors' abstract)

DREW, G.J. and BOTH, R.A., 1984, The carbonate-hosted silver-lead deposits of the Ediacara mineral field, South Australia: petrological, fluid inclusion and sulphur isotope studies: Australian J. Earth Sci., v. 31, p. 177-201. First author at Dept. Mines & Energy, 191 Greenhill Road, Parkside, SA 5063, Australia.

The Ediacara mineral field is situated 30 km W of Beltana on the western margins of the Flinders Ranges, South Australia, and consists of silver-lead and copper deposits in lower Cambrian carbonate rocks that contain anomalous base-metal contents throughout the Adelaide Geosyncline. The lower Cambrian rocks, which consist of the basal Parachilna Formation and overlying Ajax Limestone, rest disconformably on the Precambrian, and at Ediacara occupy a shallow N-S elongate syncline near the hinge zone of the Adelaide Geosyncline. The main primary ore minerals of the silver-lead mineralization are galena and pyrite, with very minor chalcopyrite and sphalerite, and rare tetrahedrite and pearceite. The gangue consists mainly of silica (both chalcedony and quartz), with minor dolomite and rare barite. The mineralization is stratabound and occurs in conformable zones, the lowest of which commences about 30-50 m above the base of the Cambrian sequence. The host to the silver-lead mineralization, the Ajax Limestone, can be subdivided into three units which represent a set of lithologies, structures and organic traces indicative of a shallow near-shore carbonate environment. The silver-lead mineralization is mainly present in sandy and laminated dolomites which are deposited in an environment ranging from sub-tidal to bar and channel and tidal flat, respectively. Four types of mineralization have been recognized: disseminated sulphides of syngenetic and/or diagenetic origin and epigenetic concentrations along stylolites, in veins and as breccia fillings. Post-depositional solution activity has affected a large proportion of the carbonate sequence. The effects of this activity range from stylolites through stylobreccias to solution collapse breccias. The epigenetic concentrations of mineralizations have apparently been formed by the remobilization of the disseminated sulphides during solution activity. The ore and gangue minerals of the epigenetic mineralization display both euhedral forms and distinct colloform banding, and framboidal textures have also been observed in both pyrite and galena. There is evidence of repeated episodic precipitation and no simple paragenetic sequence can be recognized. Fluid inclusions in silica and dolomite associated with the epigenetic mineralization have homogenization temperatures of 159 to 199°C and freezing temperatures that indicate the fluids to be saline brines containing NaCl with $CaCl_2$ and/or $MgCl_2$. Sulphur isotope analyses show a range of $\delta^{34}S$ values from -12.5 to -8.6 per mil, with no evidence of significant differences between the four types of mineralization. The data suggest deposition of the disseminated sulphides as a result of biological reduction of seawater sulphate in a system partially open with respect to sulphate supply. Subsequent remobilization of sulphides apparently involved little or no sulphur isotope fractionation. The Ediacara silver-lead deposits have many features in common with Mississippi Valley-type lead-zinc deposits and appear to have similarities in terms of genesis, in that the epigenetic mineralization has been formed as a result of post-depositional solution activity during diagenesis in a sedimentary basin. The scale of transport of the metals deposited as the epigenetic mineralization at Ediacara appears, however, to have been very much less than that of the metals in other Mississippi Valley-type deposits. (Authors' abstract)

DU, Shengbao, 1983, Distribution regularity and ore genesis of rock crystal deposits in Guangxi: Min. Deposits, v. 2, no. 1, p. 66-74 (in Chinese; English abstract). Author at Geol. Team No. 8, Geol. Bureau of Guangxi.

Apart from a few ores in the pegmatites within granites and in the contact zones of skarns, a substantial number of rock crystal deposits in Guangxi occur in various sedimentary rocks, especially in quartz veins and calcite veins in Upper Carboniferous carbonate rocks. The deposits are controlled by a combination of the latitudinal tectonic system, neocathaysian tectonic system and a NW trending structural zone, showing a distribution characterized by orientation, symmetry, equidistance and mosaic pattern. Of all inclusions, liquid inclusions are best developed, and a certain number of gaseous inclusions have also been recognized in some deposits. This implies that ores were formed mostly in an environment dominated by hydrothermal solutions and partly in the boiling state. Some inclusions contain a substantial amount of liquid carbonic acid, sometimes reaching as much as 30%; some have in them a lot of organisms of gas or liquid phase[sic]. Th are determined to be in the range of 107-420°C, salinities (NaCl wt%) 2.65-10.9, pressures 200-600 bar, and pH 7.04-7.16. Lead isotopes of certain deposits fall into anomalous limits, while δS^{34}, $\delta O^{18}_{H_2O}$ have the values of +18.18 - -10.37%., 6.00 - 24.02%. and 1.9 - 2.4%. respectively. The above characteristics and data vary with regularity in keeping with the different geological settings of the deposits. The rock crystal deposits in Guangxi are thus divided genetically into three types: postmagmatic pneumato-hydrothermal deposits, deposits from underground hot waters, and transitional deposits formed by above two solutions mixed at various ratios. (Author's abstract)

DUBESSY, Jean, 1984, Simulation of chemical equilibria in the C-O-H system. Methodological consequences for fluid inclusions: Bull. Minéral., v. 107, p. 155-168 (in French; English abstract). Author at Centre de Recherches sur la Géol. de l'Uranium, B.P. 23, 54501 Vandoeuvre-lès-Nancy, France.

$\bar{V}$-X properties of fossil fluids trapped in fluid inclusions do not differ more than a few percent from the initial $\bar{V}$-X properties of the fluid at high pressure and temperature conditions of trapping. During cooling of a fluid inclusion containing graphite, the change of the $\bar{V}$-X properties of the fluid in equilibrium with graphite are related to the initial composition of the trapped fluid. No significant modification of the $\bar{V}$-X properties of the trapped fluid is observed if less than 30% of atomic hydrogen of the system is lost. (Author's abstract)

DUBESSY, Jean, GUILHAUMOU, Nicole, MULLIS, Joseph and PAGEL, Maurice, 1984, Identification, in fluid inclusions, of solid H_2S and CO_2 with similar melting temperature: Bull. Minéral., v. 107, p. 189-192 (in French; English abstract). First author at Centre de Recherches sur la Géol. de l'Uranium, B.P. 23, 54501 Vandoeuvre-lès-Nancy, France.

In fluid inclusions from Lastourville (Gabon), Col d'Allos (France), Perry County (USA) and Val d'Illiez (Switzerland), melting of a solid phase was observed between -92°C and -103°C. Identification by Raman microspectrometry shows these phases are solid CO_2 and H_2S. These spectroscopic determinations are necessary for interpretations of microthermometric measurements. (Authors' abstract)

DUJON, S.-C. and LAGACHE, Martine, 1984, Exchanges between plagioclases and aqueous Na-Ca chloride solutions at different pressures and temperatures (400° to 800°C, 1 to 3 kb): Bull. Minéral., v. 107, p. 553-569 (in French; English abstract).

DUNCAN, I.J., 1984, Is pressure solution a major creep mechanism in orogenic belts? (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 83.

DUNCAN, I.J. and GWINN, C.J., 1984, Isotopic evolution of deep basinal brines in the Gulf Coast: the role of shale compaction and diagenesis (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 83. Authors at Dept. Geol. Sci., Southern Methodist Univ., Dallas, TX 75275.

Mass balance constraints suggest that fluids from compaction and dewatering of shales should be an important and perhaps dominant component of deep basinal brines. Stable isotope data provide critical evidence for distinguishing brine origin. The D/H evolution of shale formation waters can be modeled as a mixture of detrital clays, with δD initially in the range -70 to -85‰ relative to SMOW, and pore water with δD initially 0‰. The observed change in clay D/H ratios with depth and the D/H of water in equilibrium with the finest-grained clay fractions allows estimation of the D/H ratio of water evolved from shale compaction. Modification of the D/H ratio during fluid migration in clastic and carbonate aquifers is probably small. These calculations are in striking agreement with measured D/H ratios of Gulf Coast brines. These D/H data are incompatible with evaporated seawater forming even a small component of Gulf Coast brines. As was originally shown by Clay et al., the $^{18}O/^{16}O$ ratios of the Gulf Coast brines appear to be rock-dominated. Our calculations suggest brines in lower carbonate cements. The oxygen, and presumably carbon, isotope ratios of these brines are dominated by recrystallization and reprecipitation of detrial and cement phases. If the D/H data preclude formation water evolving from an original evaporative brine (the "Louann brine"), an alternative explanation must be found for the high observed chloride molarities. A reverse chemical osmosis mechanism has been recently suggested but has not been documented by field data. An alternative model is the dissolution of evaporative halite, deep in the section, by water migrating updip from compacting deep basinal shales. However, only Edwards brines have Br/Cl ratios consistent with halite dissolution. Fractionation of halogens by equilibration with diagenetic chlorites and/or clays may affect Br/Cl ratios in other aquifers. (Authors' abstract)

DUNNING, G.R., 1984, A sulfur isotopic, ore textural, chemical, and experimental study on the formation of the Kuroko deposits, Hokuroku district, Japan: Ph.D. dissertation, Memorial Univ. Newfoundland, Canada.

DUNNING, J.D., PETROVSKI, D., SCHUYLER, J. and OWENS, A., 1984, The effects of aqueous chemical environments on crack propagation in quartz: J. Geophys. Research, v. 89, no. B6, p. 4115-4123. Authors at Dept. Geol., Indiana Univ.

The chemical role of water and other aqueous environments in crack propagation was examined in a series of crack propagation tests in natural and synthetic quartz. The potential roles of surface free energy reduction and zeta potential (surface electrostatic potential) in chemical weakening were specifically examined by running the crack propagation tests in the presence of six surface active aqueous environments which varied substantially in these parameters with respect to quartz. Calorimetric and electrophoresis tests were also undertaken in order to determine the degree of reduction of the surface energy of quartz produced by each chemical environment and the zeta potential between each environment and quartz. It was found that there was a moderate correlation between reduction of the crack propagation stress of quartz and the degree by which the surface energy was reduced in the presence of a particular environment. No such correlation was found with respect to zeta potential. It was also observed that some of the chemical environments appeared to produce highly branched cracks in quartz. This branching effect is probably related to the velocity of crack propagation. (Authors' abstract)

DURAK, Bernard, PAGEL, Maurice and POTY, Bernard, 1984, Temperatures and salinities of fluids related to diagenetic silicifications of a sandstone formation overlying a uranium deposit located in the basement: Examples from the Kombolgie Sandstone (Australia): C.R. Acad. Sc. Paris, Ser. II, v. 296, p. 571-574 (in French; translated in U.S. Geol. Open-File Rpt. 84-155, 6 pp.).

Microthermometric studies have been performed on fluid inclusions localized in quartz overgrowths and quartz veins of the Kombolgie Sandstone. Minimum temperatures of formation lie between +65 and +210°C. Salinities are variable, and melting temperatures range from -45 to -6.3°C. An inverse relationship exists between salinity and minimum temperature of formation, where salinity increases and minimum formation temperature decreases with progressive silicification. Quartz overgrowths are therefore characterized by higher salinity and lower formation temperature than related detrital quartz grains. Silicification began at a temperature higher than 150°C. Comparable results have been obtained from studies of gangue minerals from the Jabiluka deposit. These data are essential for the interpretation of uranium deposits spacially associated wtih Proterozoic unconformities. (Authors' abstract translated by L.M. Bithell)

ĎURIŠOVÁ, Jana, 1984a Origin of greisen assemblages in the western Krusné hory Mts.: Vestnik Ustredniho ústavu geologického, v. 59, no. 3, p. 141-152 (in Czech; English abstract). Author at Ustredni ústav geol., Malostranské nám. 19, 118 21 Praha 1, Czechoslovakia.

The origin of tin and tungsten-bearing greisens at Bozi Dar, Vykmanov and Prebuz was studied by fluid inclusion method. Topaz and quartz from the ore assemblages were examined. The beginning of the greisenization process is characterized by the temperature interval 470-500°C and high salinity of solutions. In the course of greisenization, the gaseous and liquid phases of ore-bearing solutions separated. The proper greisenization process took place at 400-300°C from chloride solutions of low salinity (less than 10 mass %). (Author's abstract)

ĎURIŠOVÁ, Jana, 1984b Thermobarogeochemical research - methods and possibilities of its application: Acta Mont., v. 68, p. 197-204 (in Czechoslovakian). Author at Ústřed. Ústav, Geol., Prague, Czechoslovakia.

A review of ČSSR work on fluid-inclusions in Sn-W deposits of Krushne Hory, ČSSR. (E.R.)

DYMKIN, A.M., PURTOV, V.K. and YATLUK, G.M., 1984a Solubility of iron in high-temperature hydrothermal solutions: Akad. Nauk SSSR Doklady, v. 274, no. 1, p. 179-182 (in Russian). Authors at Inst. Geol. & Geochem. of Urals Sci. Center, Sverdlovsk, USSR. Continued next page.

Experiments were performed with iron extraction by NaOH, Na_2CO_3, K_2CO_3 and HCl solutions from gabbro-norite, dunite, amphibole, biotite, liparite and basalt at 600-800°C and P 101 MPa. (A.K.)

DYMKIN, A.M., PURTOV, V.K. and YATLUK, G.M., 1984, Transport of iron in high-temperature hydrothermal solutions: Dokl. AN SSSR, 1984, v. 274, no. 1, p. 179-182 (in Russian, English abstract; translated in Int'l. Geol. Rev., v. 26, p. 1180-1184, 1984).

Presents the results of experiments on the mobility of iron resulting from the action of solutions of HCl, NaOH, Na_2CO_3, and K_2CO_3 on rocks and minerals at 600°C and 800°C and pressure 101 MPa, and interpretation of the probable conditions of formation of magnetite skarn deposits. (Authors' abstract)

EADINGTON, P.J., 1984, Redox controls in the hydrothermal reactions of tin (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 255 (in English). Author at CSIRO Div. Mineralogy, North Ryde, Australia.

Tin may occur with high concentrations (to 5%) in some silicate minerals as well as in cassiterite or stannite. The behavior of tin in hydrothermal systems depends on the substitution schemes of tin in silicate minerals as much as the solubility of cassiterite and stannite. Each of these processes is sensitive to redox conditions (or oxygen fugacity).

The solubility of cassiterite as chloro and fluoro complexes of tin increases with decreasing oxygen fugacity. Diadochic substitution of tin in silicate minerals should decrease with decreasing oxygen fugacity (and Fe^{3+}/Fe^{2+} ratio), since a 2 Fe^{3+}(oct) = Sn^{4+}(oct) + Fe^{2+}(oct) substitution scheme has been demonstrated for some minerals, and is suggested by compositional data for others.

In both granites and skarns, hydrothermal concentrations of cassiterite are favored by low oxygen fugacities. Less tin is immobilized by substitution in silicate minerals and there are larger temperature- and pH-dependent-coefficients of solubility for cassiterite. (Author's abstract)

EDGAR, A.D., 1984, Metasomatism in the mantle: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 22.

EDGAR, A.D. and ARIMA, Makoto, 1984, Experimental studies on K-metasomatism of a model pyrolite mantle and their bearing on the genesis of ultrapotassic magmas: Proc. 27th Int'l. Geol. Congr., v. 9, p. 509-541. Authors at Dept. Geol., Univ. Western Ontario, London, Canada N6A 5B7.

Experiments at 20 and 30 kb, and 850-950°C on pyrolite with various concentrations of K_2O in aqueous solution have been used to model K-metasomatism in the upper mantle. (From the authors' abstract)

EDMUNDS, W.M., ANDREWS, J.N., BURGESS, W.G., KAY, R.L.F. and LEE, D.J., 1984, The evolution of saline and thermal groundwaters in the Carnmenellis granite: Mineralogical Mag., v. 48, p. 407-424. First author at British Geol. Survey, Hydrogeology Unit, Wallingford, Oxon OX10 8BB, England.

The Carnmenellis granite and its aureole contain the only recorded thermal groundwaters (up to 52°C) in British granites. They occur as springs in tin mines at depths between 200 and 700 m and most are saline (maximum mineralization 19,310 mg l^{-1}). Mining activity has disturbed the groundwater circulation pattern developed over a geological time-scale and levels of bomb-produced tritium (>4 TU) indicate that a significant component (up to 65%) of the most saline waters are of recent origin. All components of all the mine waters are of meteoric origin. Radiogenic ^{4}He contents, ^{40}Ar/^{36}Ar ratios, and uranium series geochemistry suggest that the thermal component has a likely residence time of at least 5 x 10^4 years and probably of order 10^6 years.

The thermal waters have molar Na^+/Cl^- ratios considerably less than 1 but they are enriched relative to sea water in all major cations except Mg. The groundwater is also particularly enriched in Li with contents ranging up to 125 mg l^{-1}. The groundwater salinity, which may reach a maximum of 30,000 mg l^{-1}, is shown to result from weathering reactions of biotite (probably through a chloritization step) and plagioclase feldspar, to kaolinite. On volumetric considerations, fluid inclusions cannot contribute significantly to the groundwater salinity, and stable isotope ratios rule out any contribution from sea water.

Groundwater silica contents and molar Na^+/K^+ ratios suggest that the likely equilibration temperature is 54°C, which would imply a depth of circulation of about 1.2 km. (Authors' abstract)

EFIMOVA, M.I., MALAKHOV, V.V., CHERNYSHEV, A.V. and NOSENKO, N.A., 1984, Genetic features of the borosilicate deposit, Dalnegorsk (according to thermobarogeochemical data) (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 38-39 (in English). First author at Far East Geol. Inst. Far East Sci. Center USSR Acad. Sci., Vladivostok, USSR.

The skarn deposit was formed at the contact of Mesozoic terrigenous-carbonaceous rocks with an andesitic granitoid intrusion. We distinguish two phases: the first one - 50.5 to 56.5 my - diorites, quartz-diorites, Th of crystallized inclusions is 980 to 990°C; the second one - 32 to 56.5 my - adamellites, aplites, granites, Th of melt inclusions is 770 to 820°C. Salt inclusions in granitoid quartz originated at 290 to 550°C. Analysis of mineral gas phase supports the temperature value of the start of crystallization. The deposit is zoned: inner zones - wollastonite (Th 560 to 690°C), median ones - hedenbergite (Th 550 to 420°C), marginal ones - andradite (Th 460 to 420°C). Kidney-shaped and globe-shaped formations with concentric zonal structures characterize the deposit. Borosilicate mineralization superimposed on all zones is represented by datolite, danburite, axinite; datolite is of principal importance. We distinguish three generations: datolite I (Th 365 to 320°C) composes lines in skarns replacing wollastonite; datolite II (Th 280 to 260°C) develops along fractures in skarn together with quartz I replacing hedenbergite and datolite I; datolite [III] (Th 240 to 220°C) is drusy, associates with apophyllite and quartz II (Th 260 to 220°C). We relate the skarn formation to the action of highly concentrated and high temperature fluids during active tectonic movements. Considerable increase of fault channels and rapid loss of solvent favored the formation of colloidal systems. Irregular crystallization of these systems explains the skarn texture variation. Bicarbonate-sodic solutions deposited productive association; CH_4 and CO_2 prevailed in gas phase. Borosilicate mineralization associates through time with the formation of minor intrusions of contrast[ing] alkaline-potassium series (36 to 27 millions of years). Isotope analysis of carbonaceous minerals confirms the endogenous source of [carbon] dioxide during mineralization. (Authors' abstract)

EGGLER, D.H. and BURNHAM, C.W., 1984, Solution of H_2O in diopside melts: A thermodynamic model: Contrib. Mineral. Petrol., v. 85, p. 58-66.

EGGLESTON, T.L. and NORMAN, D.I., 1984, Geochemistry and origin of rhyolite-hosted tin deposits, southwestern New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 499. Authors at Geosci. Dept., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Tertiary-age topaz-rhyolite domes in New Mexico host Sn mineralization. Total Cl plus F varies from 1.4 to 0.2% with Cl/F = 2 to 4 and as much as 1.2% Cl. The $\delta^{18}O$ is +8 permil. REE patterns are flat with slight enrichment of LREE and deep Eu anomalies.

Sn mineralization is restricted to the flanks of intensely vapor phase recrystallized zones (VPRZ) just below the carapace of the domes. The general paragenesis is: quartz-topaz; hematite-cassiterite; and quartz-calcite-fluorite-wood tin. Studies of 5-phase, hydrous fluid inclusions containing a glass-like phase that melts at 350°C in the VPRZ indicate fluids with temperatures >600°C, calculated $\delta^{18}O$ of +6 to +10 permil, and 70 eq. wt. % NaCl. Cassiterite was deposited at 150 to 200°C from boiling fluids with a calculated $\delta^{18}O$ of -6 to 0 permil.

These data suggest that both magmatic and meteoric fluid were important to Sn deposition. Quartz and topaz were deposited by magmatic fluids evolved during cooling of the rhyolite. Later, wood-tin was deposited from short-lived, meteoric water-dominated, epithermal systems. Cassiterite was deposited at intermediate temperatures and salinities, suggesting mixed magmatic and meteoric water. The source of the Sn was the host rhyolites. The Cl content of these rhyolites is significantly higher than reported topaz rhyolites which contain no tin mineralization, suggesting that Cl is important in the formation of these Sn deposits. In addition, these rhyolites are similar in age and geochemistry to the nearby Iron Mt. granite which generated W-Sn-F skarns suggesting that the rhyolites are surface expressions of deeper W-Sn systems. (From the authors' abstract)

ELDERS, W.A., 1984, Continental scientific drilling to 5.5 km in the Salton Sea geothermal field, California, USA (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 1, p. 123-124.

ELLIOT, W.P., 1984, The pre-1958 atmospheric concentration of carbon dioxide: EOS, v. 65, no. 26, p. 416-417.

ELPHICK, S., 1984, Oxygen isotope diffusion studies: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 141-143.

ELTHON, D., HANSON, R., ALLEN, R. and VERGARA, H., 1984, Unusual ocellar textures in diabases from the Sarmiento ophiolite complex, Chile: Can. J. Earth Sci., v. 21, p. 376-378. First author at Dept. Geosci., Univ. Houston, University Park, Houston, TX 77004, USA.

Unusual ocellar textures from the base of the sheeted dikes unit in the Sarmiento ophiolite are described. There are significant chemical differences between these ocelli and the surrounding diabasic matrix. The mesoscopic textural evidence and the chemical evidence suggest an origin of these ocelli by liquid immiscibility or magma mixing. (Authors' abstract)

ENGELDER, Terry, 1984, The role of pore water circulation during the deformation of foreland fold and thrust belts: J. Geophys. Research, v. 89, no. B6, p. 4319-4325. Author at Lamont-Doherty Geol. Observ., Columbia

Univ.

Volume-loss strain accompanying pressure solution of calcite occurred within both the Umbria-Marches Apennines of Italy and the Appalachian Mountains of western New York. Data from strain markers show that volume-loss strain was greater within the shallow portions of the Apennines than within the Appalachians. Within the deeper portions of both fold and thrust belts, strain was nearly volume-constant. Calcite solubility data suggest that downward circulation of meteoric water is necessary for the 35% volume-loss strain of the limestones within the Apennines. Strain at a depth of about 1 km was volume-constant and is interpreted as indicative of restricted pore fluid circulation. In the Appalachians, calcite comprises less than 1% of the clastic rocks, and a 10% volume-loss of this calcite may occur during circulation of connate or dehydration water derived from dewatering of the shales but in an environment that restricts the circulation of meteoric water. Here, the volume of calcite removed (0.1% of the total rock) is so small that circulation of meteoric water is not necessary for strain by pressure solution. (Author's abstract)

ENTOV, V.M., ZAK, S.A. and CHEN-SIN, E., 1984, On two-phase flow in porous environment with microheterogeneous wetting: Akad. Nauk SSSR Doklady, v. 274, no. 6, p. 1334-1337 (in Russian). Authors at Inst. of Problems of Mechanics, Moscow, USSR.

Pertinent to mineral- and inclusion formation from heterogeneous fluids. (A.K.)

EPATKO, Y.M. and LITVINSKAYA, M.E., 1984, Static magnetic field effect in ore-forming processes: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 85-90. Authors at Inst. Geochem. & Physics of Minerals, Acad. Sci. of the Ukrainian SSR, Kiev, USSR.

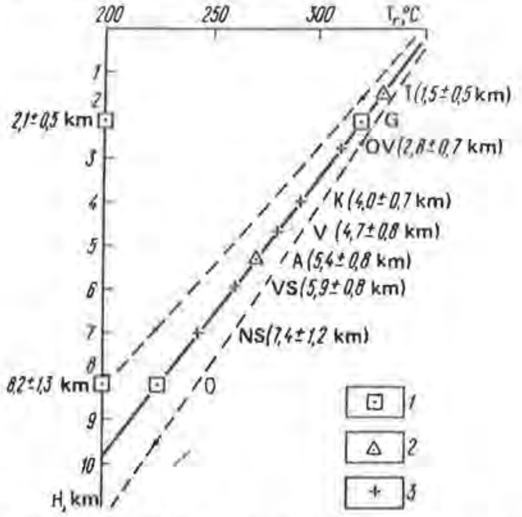
An external magnetic field can induce changes in the properties of salt aqueous solutions. An experimental research on the magnetic field effects on the migration ability of silica in the systems: quartz-H_2O; quartz-H_2O-CO_2; carbonaceous-magnetic* quartzite-H_2O; carbonaceous-magnetitic* quartzite-H_2O-CO_2 has been carried out. The experimental results present a cogent argument for the effect of rather weak magnetic fields on the chemical reaction kinetics. (Authors' abstract) *Sic.

EPEL'BAUM, M.B. and BUKHTIYAROV, P.G., 1983, Studies of immiscibility in the system diopside-nepheline-fluorapatite with admixtures of salts of hydrofluoric and phosphoric acids, in Experimental studies of endogeneous ore formation: "Nauka" Publ. House, Moscow, p. 220-229 (in Russian).

In the system diopside-nepheline-fluorapatite the admixtures of $Na_6P_6O_{18}$ and MgF_2 cause a distinct decrease of T of melting and extension of immiscibility over a wide area including average composition of the Khibiny apatite-ijolite intrusion. The immiscibility remains also under high H_2O or $H_2O + CO_2$ pressures. The inversion of densities of silicate and phosphate phases may be expected under influence of water dissolved in melts. (A.K.)

EPSHTEYN, Ye.M. and KABAN'KOV, V.Ya., 1984, The depth of emplacement and mineral potential of ultramafic, ijolite, and carbonatite plutons: Sovetskaya geologiya, 1984, no. 8, p. 85-98 (in Russian, English abstract; translated in Int'l. Geol. Rev., v. 26, no. 12, p. 1402-1415). First author at All-Union Inst. Min. Resources (VIMS).

The authors use Th of fluid inclusions to estimate the depth of formation of the UIC (ultramafic, ijolite, and carbonatite) plutons. They plot data from Samoylov (Fluid Inclusion Research--Proceedings of COFFI, v. 10, 1977, p. 243) as shown below. (E.R.)



Graph showing relations between mean homogenization temperatures (Th) of fluid inclusions in minerals of quartz-bearing rocks of the dolomite-ankerite phase and the emplacement depth of the UIC plutons: 1) standard; 2) control; 3) "test case": O) Ozernyy, NS) Nizhnesayansk, VS) Verkhnesayansk, A) Afrikanda, V) Vuorijarvi, K) Kovdor, OV) Ozernaya Varaka, G) Guli, T) Turyy.

ERMAKOV, N.P. See also YERMAKOV, N.P.

ETHERIDGE, M.A., WALL, V.J., COX, S.F. and VERNON, R.H., 1984, High fluid pressures during regional metamorphism and deformation: implications for mass transport and deformation mechanisms: J. Geophys. Research, v. 89, no. B6, p. 4344-4358. First author at Bureau of Mineral Resources.

Evidence is presented to support the conclusion that pore fluid pressures P_F during regional metamorphism are generally greater than or equal to the minimum principal compressive stress S_3. The resultant very low effective stresses σ lead to significantly increased porosity and permeability, even at moderate to high metamorphic temperatures. Permeabilities between 10^{-18} and 10^{-15} m^2 are considered to be common, resulting in rapid fluid migration and the dominance of advective (infiltrative) over diffusive mass transport, even over relatively small distances. In view of the importance of intergranular mass transport to rock deformation during metamorphism, a mobile, high-pressure fluid will have substantial rheological effects, especially in polyphase rocks. The fluid is capable of influencing the rate of dislocation creep in a number of ways. More importantly, advective mass transport along fluid pressure gradients can give rise to a solution transfer deformation mechanism that competes with conventional pressure solution. The rate of deformation by advective mass transport could be controlled by a number of processes, including dissolution kinetics, advective transport rates, and the rate of crack growth. A specific deformation model, based on advective transport rate control, is developed, which can produce strain at competitive rates but with stress and temperature dependences of unusual form. (Authors' abstract)

EVANS, Brian, 1984, The effect of temperature and impurity content on indentation hardness of quartz: J. Geophys. Research, v. 89, no. B6, p. 4213-4222.

FABRICIUS, J., 1984a Formation temperature and chemistry of brine inclusions in euhedral quartz crystals from Permian salt in the Danish Trough: Bull. Minéral., v. 107, p. 203-216. Author at Geol. Survey of Denmark, 31, Thoravej, DK 2400 Copenhagen NV, Denmark.

Classic microthermometry has been carried out on fluid inclusions in euhedral quartz from the Batum saltdome in the dome area of N. Jutland, Denmark. The salt studied is of Zechstein 1 and 2 age. The fluid inclusions are either isolated regular inclusions or populations of irregular thin inclusions on an internal crystal face. The inclusions are either fluid-gas inclusions or inclusions also containing a solid phase of NaCl.

The salinity and the $CaCl_2$:$MgCl_2$ ratio have been measured using phase diagrams of the system ($CaCl_2$ + $MgCl_2$)-NaCl-H_2O, the Ca:Mg ratios 3:1, 1:1 and 1:3. The salinity determined is from c.35 weight % to more than 45 weight % and the Ca:Mg ratio from 3:1 to 1:4.

Th of 231 fluid-gas inclusions give a mean of 98.1°C indicating a formation of the quartz crystals late in Zechstein 3. The formation temperatures (115°C - 180°C) and pressures (15 MPA - 90 MPa) have been measured/calculated on 14 quartz crystals indicating an individual crystallization in the period Early Triassic-Early Jurassic times. The calculated Rayleigh numbers indicate conditions of thermal convection in Late Triassic-Early Jurassic times. Both the Zechstein 1 salt and the Zechstein 2 salt were sedimented under uniform conditions. (Author's abstract)

FABRICIUS, Johannes, 1984b, Microthermometry, Vol. IV in Zechstein salt Denmark, Salt Research Project EFP-81, DGU Series C no. 1, 83 pp.

Fluid inclusions in quartz crystals from Danish salt domes have been studied in order to determine the chemistry of the brines present in the salt.

The crystallization temperatures and the corresponding pressures of several quartz crystals have been measured and calculated. These P-T conditions reflect the diapiric evolution: pillow stage, diapiric penetration phase and post-diapiric phase. Some of the P-T measurements give strong evidence of thermal convection conditions in the bedded rock salt.

Carnallite-bearing fluid inclusions have been studied in order to establish the dehydration conditions of natural carnallite in cognate geological environmetns. The inclusions are natural visual autoclaves and they represent a chemically closed system. Several dehydration temperatures have been measured and the corresponding pressures calculated. (Author's abstract)

FARFEL', L.S., SAVEL'YEVA, N.I. and MIRONOVA, O.F., 1983, Hydrothermal solutions at the Aksu gold-ore deposit: Geokhimiya, 1983, no. 12, p. 1781-1786 (in Russian; translated in Geochem. Int'l., v. 21, no. 1, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 72, 1983. (E.R.)

FELDMAN, M.D. and KNAUTH, L.P., 1984, Hydrogen isotope geochemistry of trace water in sedimentary dolomite (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 507. Authors at Dept. Geol., Arizona State Univ., Tempe, AZ 85287.

The trace water content of sedimentary dolomite has been investigated using a stepwise heating technique combined with hydrogen isotope measurements of the evolved water. Four types of water are sequentially evolved from dolomite: surface water (25-200°C); fluid inclusion water (200-

500°C); clay mineral contaminant water (500-1000°C); and structural water (540-720°C).

Comparison of the dolomite data with stepwise heating experiments on sedimentary calcite and hydrothermal dolomite suggest that the presence of structural water in sedimentary dolomite is related to the hydration of aqueous Mg^{++} ions. The structural water content of carbonates may also depend on whether the mineral formed as a primary precipitate or as a replacement of a preexisting carbonate.

The D/H ratios of fluid inclusion water extracted from whole rock carbonates by stepwise heating and vacuum crushing may be significantly different due to the presence of large fluid inclusions in cements which are eliminated by grinding prior to stepwise heating. Thermal extraction is better suited than vacuum crushing for the isotopic analysis of fluid inclusion water in carbonates.

Exchange experiments show that surface water exchanges rapidly at room temperature. The other types of water exchange much more slowly suggesting that they may preserve their D/H ratios over geologic time.

The isotopic composition of fluid inclusion water in dolomite has applications for geothermometry and for determining the types of water involved in dolomitization. The structural water content of dolomite may serve as an indicator of a replacement vs. primary origin. (Authors' abstract)

FENG, Zhiwen, WANG, Siyuan, HUANG, Yongke, YU, Hengweng and HU, Huyan, 1984, Lithofacies features and mechanism of formation of "Zihe-type" time- and strata-bound iron ore deposits in central Shandong province: Geochemistry, v. 3, no. 4, p. 384-395. First author at Wuhan College of Geology.

The Lower Palaeozoic system is a series of iron-bearing rocks consisting mainly of shallow sea-facies carbonates. On the basis of microfacies analysis of the carbonate rocks, the Lower Palaeozoic sedimentary sea basin is divided into two broad sedimentary-tectonic regions of sedimentary facies and eight subfacies. The original iron-rich carbonates were deposited in salt-lakes, lagoons, etc. of the resticted basins. Over the long geological history, the original iron formations were reconstructed to various extents by late tectonic processes. Geological observations and studies on the equilibrium mechanism of oxygen/sulfur isotopic fractionation and the composition and temperature of fluid inclusions in the minerals indicate that thermal brines played an important role in reworking of the original iron-rich carbonate rocks, which led to the formation of sedimentary-reworked strata-bound ore deposit. (Authors' abstract)

FENG, Zhongyan, YU, Fang and WEI, Qiying, 1984a The geologic characteristics of the contact metasomatic copper deposits in northern Taihang mountains, China and the properties and origin of their ore-forming solution: Acta Geologica Sinica, v. 58, no. 2, p. 143-152 (in Chinese; English abstract). Authors at Dept. Geol., Beijing Univ., China.

There are a number of contact metasomatic copper ore deposits in northern Taihang mountains, China. They are associated with intermediate-acid small-sized stocks and cupolas intruded during the Late Jurassic at a depth of no more than 2000 meters. Three successive stages of alteration and mineralization can be distinguished: garnet-pyroxene stage, quartz-iron oxides stage and quartz-sulphides stage. All the alteration and mineralization took place at a temperature of less than 400°C, lower than the critical temperature of the hydrothermal solutions. The solution not only consists of magmatic water but also of a great amount of meteoric water. The temperature interval of the first stage is about 400-285°C;

of the second stage, between 385-255°C; of the third stage, below 290°C. Inclusion liquids contain Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-} and F^{-}, hence it belongs to Na^{+} - $Ca^{++}/Cl^{-}(F)$ - HCO_3^{-} saline water type. The properties of the ore-forming solutions are different depending on their temperature, pressure, and water component, as well as on the composition of the liquid inclusions and of stable isotopic elements in different alteration and mineralization stages. The writers came to a conclusion that the metals were derived from the magama. (Authors' abstract)

FENG, Zhongyan, YU, Fang and WEI, Qiying, 1984, The properties and origin of the ore-forming solution of the contact metasomatic copper deposits in northern Thai-Huang-Shan, China (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 93-94. Authors at Dept. Geol., Peking Univ., Peking, China.

There are a number of contact metasomatic copper ore deposits in northern Thai-Huang-Shan, China. Three successive stages of alteration and mineralization can be distinguished: garnet-diopside stage, iron oxides stage and quartz-sulphides stage. All the alteration and mineralization took place below 400°C, lower than the critical temperature of the hydrothermal solutions; the water of the solutions consisted of magmatic water and ground water. The temperature of the first stage [was] between 400°-300°C, with ground water about 15%; the second stage between 380°-250°C, with ground water about 40%; the third stage between 290°-140°C, with ground water up to 60%. Inclusion liquids contain Ca^{++}, Mg^{++}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-} and F^{-}. They are saline waters, belong to Na^{+}-$Ca^{++}/Cl^{-}(F^{-})$-HCO_3^{-} type. The above information [does] not coincide with the traditional idea about the alteration and mineralization of contact metasomatic ore deposits. (Authors' abstract)

FERGUSON, J., 1984, The methane content of some Carboniferous limestones from the northern Pennines and its relationship to mineralization: Proc. of Yorkshire Geol. Soc., v. 45, pts. 1 & 2, p. 67-69.

Anomalous amounts of methane gas have been detected in Carboniferous limestones collected in an area to the south-east of Rookhope in the northern Pennines. The significance of this discovery is discussed in relation to the geology of the area. Two origins for the gas are postulated: either it has been generated as a direct result of the mineralization or it is a consequence of the prolonged existence of a high geothermal gradient in the area. It is argued that, since these two events are likely to be related, the location of methane anomalies might prove a useful technique for mineral exploration in similar geological settings. (Author's Summary)

FERRY, J.M., 1984, A biotite isograd in south-central Maine, U.S.A.: mineral reactions, fluid transfer, and heat transfer: J. Petrology, v. 25, p. 871-893. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218, USA.

The biotite isograd in pelitic schists of the Waterville Formation involved reaction of muscovite + ankerite + rutile + pyrite + graphite + siderite or calcite to form biotite + plagioclase + ilmenite. P-T conditions at the biotite isograd were near 3500 bars and 400°C. C-O-H-S fluids in equilibrium with the petlitic rocks were close to binary CO_2-H_2O mixtures with XCO_2 - 0·02-0·04. During the biotite-forming reaction, pelitic rocks (a) decreased by 2-5 per cent in volume, (b) performed - (4-11) kcal/liter P-V work on their surroundings, (c) absorbed 38-85 kcal/liter heat from their surroundings, and (d) were infiltrated by at least

0·9-2·2 rock volumes H_2O fluid.

The biotite isograd sharply marks the limit of a decarbonation front that passed through the terrane during regional metamorphism. Decabonation converted meta-shales with 6-10 per cent carbonate to carbonate-free pelitic schists. One essential cause of the decarbonation event was pervasive infiltration of the terrane by at least 1-2 rock volumes H_2O fluid early in the metamorphic event under P-T conditions of the biotite isograd. Average shale contains 4-13 per cent siderite, ankerite, and/or calcite, but average pelitic schist is devoid of carbonate minerals. If the Waterville Formation serves as a general model for the metamorphism of pelitic rocks, it is likely that worldwide many pelitic schists developed by decarbonation of shale caused, in part, by pervasive infiltration of metamorphic terranes by several rock volumes of aqueous fluid during an early stage of the metamorphic event. (Author's abstract)

FERSHTATER, G.B., CHASHCHUKHINA, V.A. and VILISOV, V.A., 1984, Fluorine and chlorine distribution in apatite embedded in different rock-forming minerals of magmatic rocks: Dokl. Akad. Nauk SSSR, v. 276, no. 5, p. 1228-1233 (in Russian).

FINN, D.R. and BUCHANAN, L.J., 1984, Hayden Hill, California: epithermal Au-Ag mineralization associated with Cascade volcanism (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 509. First author at Mackay Sch. Mines, Univ. Nevada Reno, Reno, NV 89557.

Fluid inclusions from late quartz + adularia veins typically exhibit boiling textures. Preliminary measurements yield Th of 210°-295°C. These data strongly suggest that the mineralization formed at depths in excess of 500 meters and thus is not a "hot springs" deposit. (From the authors' abstract)

FISHER, D.E., 1984, Radiogenic rare gases in MORB and depleted mantle degassing (abst.): EOS, v. 65, no. 45, p. 1139. Author at School of Marine & Atmospheric Sci., Univ. Miami, Miami, FL 33149.

K, U, and rare gas isotopic abundances were measured in several MORB glasses, allowing calculation of U, Th/He, K/Ar, and U/Xe radiogenic ages. Fission track dating of the same glasses was carried out, giving ages orders of magnitude younger, as do sea floor spreading rates; the rare gas ages therefore indicate times of mantle accumulation, with internal patterns indicating mass fractionation effects. An upper limit to the rare gas accumulation time is $\lesssim 600 \times 10^8$ years, indicating the mantle source regions of MORB have not remained closed to degassing losses since early in earth history. Model calculations based on I/Xe xenology are shown to be in agreement with this interpretation. A stable, layered mantle is not suggested by these data. (Author's abstract)

FOLEY, S.F., 1984, Liquid immiscibility and melt segregation in alkaline lamprophyres from Labrador: Lithos, v. 17, p. 127-137. Author at Dept. Geol., Univ. Tasmania, Hobart, Tasmania 7001, Australia.

Sannaites (alkaline lamprophyres with Ti-rich mica and/or amphibole and K-feldspar) forming part of the Aillik Bay alkaline dyke swarm contain two varieties of leucocratic globular structures. Type I are interpreted to represent immiscible silicate liquids, whereas type II are caused by segregation of late-stage melt. Type I globules are characterized by enrichment in Al_2O_3, SiO_2, Na_2O and K_2O, and depletion in CaO, MgO, FeO (total Fe), TiO_2 and P_2O_5 relative to the sannaite groundmass. Mafic minerals inside and outside the type I globules have cores of similar composition, but rims which follow different trends. Type II globular structures are commonly zoned; they have a carbonate-analcite inner zone interpreted as the site of a former gas bubble, and an outer zone representing late-stage liquid. Minerals in the outer zones show extreme zonation along chemical trends similar to those in the groundmass, but contrasting with those in type I globules. Boundary nucleation is common in type II but rare in type I.

The Aillik Bay sannaites are believed to lie at the alkali + alumina-rich extremity of the miscibility gap. Rocks with type II structures frequently have a two-stage groundmass which may be caused by metastable immiscibility compositionally adjacent to the stable miscibility gap. (Author's abstract)

FONTES, J.C., BRISSAUD, I. and MICHELOT, J.L., 1984, Hydrological implications of deep production of chlorine-36, in Proc. Third Int'l. Symp. on Accelerator Mass Spectrometry, H.H. Andersen and S.T. Picraux, eds.: Zurich, Switzerland, April 10-13, 1984, Nuclear Instruments & Methods in Phys. Res., Sec. B: Beam Interactions with Materials and Atoms [B5]: 2, p. 303-307.

Indexed under Fluid Inclusions. (E.R.)

FORSLUND, Bertil and JELINSKI, Bohdan, 1984, A simple mini-furnace for thermo-microscopy and crystal growth experiments: Mat. Res. Bull., v. 19, p. 1031-1036. Authors at Dept. Inorganic Chem., Arrhenius Lab., Univ. Stockholm, S-106 91 Stockholm, Sweden.

A fairly simple and inexpensive device for the preparation of single crystals (mm dimensions) from a melt is described. This is a mini-furnace, permitting atmosphere control as well as continuous visual inspection of the sample through a stereomicroscope. A method to separate the crystals from the melt is also described. The device has been used for the preparation of crystals of several ternary compounds and for phase analysis studies in the $\underline{A}_2O$-V_2O_5-V_2O_3 systems ($\underline{A}$ = Rb, Cs) in the temperature range 400-800°C and the O_2 pressure range 1-10^{-25} atm. The oxygen activity which is crucial for these experiments, was controlled by the use of a $ZrO_2(Y_2O_3)$ solid electrolyte EMF-cell. (Authors' abstract)

FORSMAN, N.F., 1984, Durability and alteration of some Cretaceous and Paleocene pyroclastic glasses in North Dakota: J. Non-Crystalline Solids, v. 67, p. 449-461. Author at Dept. Geol., Univ. North Dakota, Grand Forks, ND, USA.

The presence and character of a Paleocene and two Upper Cretaceous volcanic ash deposits in North Dakota validates other workers' suggestions that natural glasses are stable for long periods of geologic time. Except for superhydration,* glass grains from each deposit are commonly unaltered. Grains which have altered to montmorillonite follow the same pattern of chemical change commonly reported for the origin of bentonites. (Author's abstract)

*Refers to formation of liquid H_2O-filled vesicles in hydrated glass. See Roedder and Smith, GSA Spec. Pap. 82, p. 164 (1964). (E.R.)

FORSTER, Hansgeorg, 1984, Physico-chemical criteria for the evolution of magmatic iron ore deposits at low pressure (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 105-106. Author at Inst. f. Mineral. u. Lagerstättenlehre RWTH, Aachen, FRG.

Thermochemical experiments were performed, verifying that Fe_2O_3 and sodium silicate melts are immiscible. These experiments were performed to understand the apatite-magnetite ores of Kiruna, Sweden, and Central Iran. (E.R.)

FORTEY, N.J., INGHAM, J.D., SKILTON, B.R.H., YOUNG, B. and SHEPHERD, T.J., 1984, Antimony mineralization at Wet Swine Gill, Caldbeck Fells, Cumbria: Proc. Yorkshire Geol. Soc., v. 45, pts. 1 & 2, p. 59-65.

A previously unrecorded quartz-antimony vein is described from Wet Swine Gill, a tributary of the River Caldew in the northern Lake District. Deposition of quartz gangue preceded that of metalliferous minerals, which include an early stibnite-berthierite assemblage, zinckenite and later-formed fülöppite and semseyite. Weathering products include bindheimite and stibiconite. The high antimony content in arsenopyrite (up to 7% Sb by weight) supports fluid inclusion data and a comparison with antimony deposits in the Massif Central, France, in pointing to deposition of the early assemblage at relatively high temperatures (above 200°C), and it is inferred that the vein is an expression of the nearby Early Devonian Carrock W-As deposit. The Pb-sulphantimonides may have formed by redeposition of antimony involving lead-bearing fluids during the Early Carboniferous. (Authors' Summary)

FOSTER, R.P., 1984, Gold '82: the geology, geochemistry and genesis of gold deposits: Proc. of the Symp. Gold '82, Univ. Zimbabwe, 24-28 May 1982, 753 pp., Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1).

FRANCE-LANORD, C., LE FORT, P., PECHER, A. and SHEPPARD, S.M.F., 1984, Microthermometry and carbon and oxygen isotope studies of fluid samples from the MCT Zone, central Nepal: 10e Reunion Ann. des Sci. de la Terre, Bordeaux, 1984, Abstracts, p. 232 (in French). First author at C.R.P.G., B.P. no. 20, 54501 Vandoeuvre-Nancy, France.

The MCT Zone is a thick (10 km), crustal shear zone which superposes high temperature terrains (la Dalle (thrust sheet) du Tibet) over low temperature terrains (formations of the Moyen pays Nepalais (Nepalese Middle Lands)), introducing an inverse, prograde metamorphism in the low-temperature rocks (Le Fort, 1975). The metamorphism, which locally reaches the kyanite isograd in the formations of the Middle Lands, is accompanied by major liberation of fluids. Fluid inclusions contained in numerous quartz lenses in the MCT Zone provide direct evidence of these fluids. A microthermometric study of five new samples confirms three earlier results of Pechner (1978): 1) within a single lens, the fluid inclusions are very homogeneous; 2) fluids are generally ternary mixtures of CO_2, H_2O, and salts; and 3) in the Middle Lands, the CO_2 concentration increases toward the MCT Zone.

The carbon-isotope composition of CO_2 extracted from four samples collected close to the MCT Zone is highly variable ($\delta^{13}C$: +1.2‰ to -15‰). This range of values implies contributions from several processes, particularly decarbonation and oxidation. As shown in the accompanying figure, one can hypothesize production of CO_2 in a variety of locations as well as several types of fluid circulation to account for the carbon isotope data.

The work currently in progress is directed toward understanding both the role of lithology in controlling the composition of the fluids and the scale of fluid circulation. (Authors' abstract, translation courtesy M.J. Logsdon)

Continued next page.

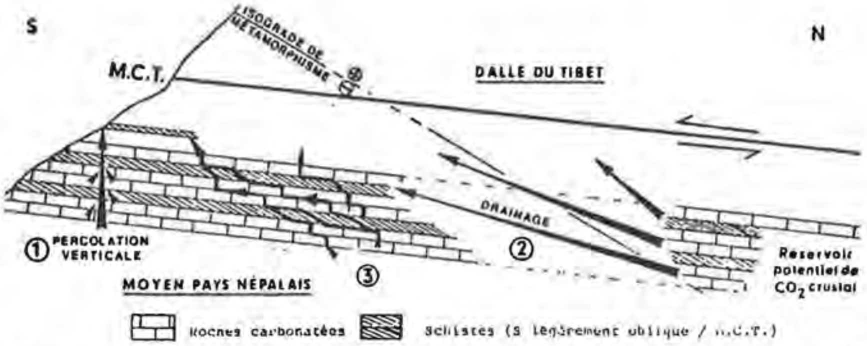


Figure caption: A sketch of the circulation of CO_2 below the MCT Zone. 1) Vertical flow on a scale of 100's of meters; 2) Long-distance flow of CO_2, originating in similar, but higher-grade terrains; 3) Percolation of CO_2 from intermediate distances along lithologic and tectonic discontinuities. N.B.: The figure is not to scale.

FRANKLIN, J.M. and SCOTT, S.D., 1984, Silver veins in the Thunder Bay area, Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 63. First author at Geol. Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada.

These silver-bearing veins occupy two separate fault zones that parallel the axis of the Keweenawan mid-continent rift zone. Each vein set is geologically distinct. The "island" veins, typified by the Silver Islet mine, are mercury rich, and contain native silver, acanthite, niccolite, gersdorfitte, and base metal sulphides, in a calcite-dolomite-quartz-barite-fluorite matrix. These occur in fractures normal to olivine diabase dykes (Ca 1045 Ma) and terminate in Aphebian Rove Shale. The "inland" veins occur almost entirely in Rove Shale, within the most westerly Keweeawan fault zone. These veins extend up to, but rarely cut, Logan diabase dykes (Ca 1100 Ma). They contain a relatively simple assemblage of native silver, acanthite, base metal sulphides, barite, fluorite, calcite and quartz.

Preliminary fluid inclusion data indicate a wide range of depositional temperatures, typically in the range of 277 ± 30°C to 320 ± 42°C. There is some evidence that boiling occurred. Galena from each vein set has a distinctive lead isotopic composition. The Silver Islet samples are homogeneous, and slightly more radiogenic, compared with compositions for the inland veins. The latter define a good secondary isochron, indicating a source age of Ca 2200 Ma if mineralization occurred at Ca 1200 Ma. Both vein sets are thought to have formed due to release of metamorphic water during the thermal events associated with Keweenawan rifting. Fluids migrated up marginal faults, and precipitation of vein constituents was due to adiabatic cooling, possibly accompanied by boiling, at high crustal levels. (Authors' abstract)

FRANKS, S.G. and FORESTER, R.W., 1984, Relationships among carbon dioxide, pore-fluid chemistry, and secondary porosity, Texas Gulf Coast (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). First author at ARCO Alaska, Inc., Anchorage, AK.

Sequences of diagenetic minerals associated with secondary porosity show striking similarities. The formation of quartz overgrowths on detrital quartz grains is followed generally by carbonate cementation. The dissolution of this carbonate is the main secondary porosity-forming event, which commonly precedes kaolinite precipitation and iron-rich carbonate cementation. In the Texas Gulf Coast, oxygen isotopic analyses provide temperature estimates of authigenic phases that predate and postdate secondary porosity development: quartz, ≥80°C (176°F); kaolinite, ≥70°C (158°F); albite, 100°-150°C (212°-302°F); late carbonate, >100°C (212°F). These data suggest that secondary porosity in the Tertiary Gulf Coast forms at temperatures of about 100° ± 25°C (212° ± 45°F).

Correlations among calcite saturation indices in pore fluids, abnormally high permeabilities, and mole % CO_2 in natural gases of the Eocene Wilcox Group imply a strong interrelationship between CO_2 and secondary porosity development in clastic reservoirs. The CO_2 content of gases varies systematically with both the reservoir age and temperature, which suggests a kinetic control on generation. The amount of CO_2 in natural gases increases rapidly at approximately 100°C (212°F); this coincides with a rapid increase in the ratio of secondary to primary porosity in associated sandstones. Stable isotopic analyses of carbonate cements indicate a strong component of organically derived carbon and therefore cycling of carbon between inorganic and organic systems. The type, amount and distribution of organic matter, and early carbonate in both shales and sandstones control the quantity of CO_2 available for generating secondary porosity. (Authors' abstract)

FRANTZ, J.D. and MARSHALL, W.L., 1984, Electrical conductances and ionization constants of salts, acids, and bases in supercritical aqueous fluids: I. Hydrochloric acid from 100° to 700°C and at pressures to 4000 bars: Am. J. Sci., v. 284, p. 651-667.

FRANZOSI, P., SALVIATI, G., COCITO, M., TAIARIOL, F. and GHLEZZI, C., 1984, Inclusion-like defects in Czochralski grown InP single crystals: J. Crystal Growth, v. 69, p. 388-398. First author at MASPEC-CNR, Via Chiavari 18/A, I-43100 Parma, Italy.

X-ray topography using both reflection and transmission geometry and scanning electron microscopy in the transmission cathodoluminescence mode have been used for studying a characteristic inclusion-like defect in InP single crystals grown by the liquid encapsulated Czochralski technique. The experiments were performed on a number of crystals which differed from each other in their doping and crystal orientation. The images confirm a previously postulated model which assumes that the defect consists of a central core from which prismatic dislocation loops are punched out in the (110) directions. The possible role of gaseous inclusions as being responsible for the observed defect is discussed. (Authors' abstract)

FRAPE, S.K., FRITZ, P. and McNUTT, R.H., 1984, Water-rock interaction and chemistry of groundwaters from the Canadian Shield: Geochimica Cosmo. Acta, v. 48, p. 1617-1627. First author at Dept. Earth Sci., Univ. Waterloo, Waterloo, Ontario, Canada N2L 3G1.

The chemical and isotopic compositions of groundwaters in the crystalline rocks of the Canadian Shield reflect different degrees of rock-water interactions. The chemistry of the shallow, geochemically immature groundwaters and especially of the major cations is controlled by local rock compositions, whereby dissolution reactions dominate. Conservative constituents, such as chloride and bromide, however, are not entirely a result of such reactions but appear to be readily added from leachable salts during the initial stages of the geochemical evolution of these waters. Their concentration changes little as major cations increase, until concentrations of Total Dissolved Solids (TDS) reach 3000 to 5000 mg l^{-1}. The isotopic composition of these shallow waters reflects local, present day precipitations.

In contrast to the shallow groundwaters, the isotopic and chemical compositions of the deep, saline waters and brines are determined by extensive, low-temperature rock-water interactions. This is documented in major ion chemistries, ^{18}O contents and strontium isotopic compositions. These data indicate that the deep brines have been contained in hydrologically isolated "pockets." The almost total loss of primary compositions make discussions on the origin of these brines very speculative. However, all brines from across the Canadian Shield have a very similar chemical composition, which probably reflects a common geochemical history. The concentrations of some major and most minor elements in these fluids appear to be governed by reactions with secondary mineral assemblages. (Authors' abstract)

FREIMAN, S.W., 1984, Effects of chemical environments on slow crack growth in glasses and ceramics: J. Geophys. Research, v. 89, no. B6, p. 4072-4076. Author at Inorganic Materials Div., Nat'l. Bureau of Standards.

This paper presents a review of our current understanding of environmentally induced slow crack growth in glasses, single crystals, and polycrystalline ceramics. It is shown that the rate of crack growth is controlled by the chemical activity of the active species in the environment as well as by the stress intensity at the crack tip. A recently developed molecular model of stress-induced chemical reaction between vitreous silica and water is described. The implications of this model for the effects of other chemical species on crack growth are discussed. Finally, the complications introduced by the presence of grain boundaries in polycrystalline ceramics are pointed out. (Author's abstract)

Note - Other papers on the same subject are in the same issue - see Kirby and Scholz, 1981, this volume. (E.R.)

FREUND, F., 1984, Volume instabilities in the mantle as a possible source for kimberlite formation, *in* Kimberlites, v. I: Kimberlites and related rocks, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 405-415.

Dissolved H_2O in nominally anhydrous minerals such as olivine is shown to form not only OH^- anions but peroxy anions plus hydrogen, O_2^{2-} + H_2 by an internal charge transfer (CT) process. If H_2 is lost by diffusion the system retains excess oxygen in the (1-) valence state. Dissolved CO_2 in non-carbonate minerals is shown to form $O_2^{2-} + CO_2^{2-}$ rather than the carbonate anion, CO_3^{2-} widely believed to be the only solute species derived from CO_2. The CO_2^{2-} configuration has unusual bonding features. The carbon diffusion is fast and sensitive to stress. The possibility of long-range carbon diffusion in the mantle is predicted to occur below a certain depth where the carbon diffusion is anticipated to follow tectonic stress patterns related to plate motion leading to lateral inhomogeneities in the mantle. High carbon concentrations are expected for regions under tensile stress. A model is developed which is based on peroxy decay reactions predicted to occur in a given rock volume when O_2^{2-} dissociates upon decompression, leading to electrical potentials which in turn cause an electrochemically driven cation influx. This then causes in-situ melting and a self-amplifying gravitational instability. (Author's abstract)

FRICKE, A., SCHREYER, W. and MENDENBACH, O., 1984, Recrystallization, planar elements and fluid inclusions in quartz of the core crystallines in the Vredefort ring in South Africa (abst.): Fortschritte der Mineralogie, Beiheft 62, no. 1, p. 61-63 (in German).

See also Schreyer and Medenbach, 1981, Fluid Inclusion Research--

Proceedings of COFFI, v. 14, p. 184, 1981. (E.R.)

FRIDLEIFSSON, G.O., 1984, Mineralogical evolution of a hydrothermal system. II. Heat sources - fluid interactions: Geothermal Resources Council, Transactions, v. 8, p. 119-123. Author at Nat'l. Energy Authority, Geothermal Div., Grensasvegi 9, 108 Reykjavik, Iceland.

Interaction between hot intrusive rocks and hydrous fluids establish and maintain high-temperature hydrothermal activity. Mineralogical evidence from the Geitafell Central Volcano SE-Iceland shows that heat extraction from hot intrusive rocks may proceed via supercritical and/or superheated fluid layers into the hydrostatically controlled hydrothermal system hosted by the basaltic volcanics. In the case example two types of metamorphic and hydrothermal mineral assemblages resulted:

A. The development of an inner aureole of hornfels and an outer aureole of skarn minerals at the contacts of large intrusive bodies (gabbros); the skarn minerals being produced from supercritical fluid ($T \geqslant 400°C$, $P(\text{fluid}) \cong P(\text{load}) \leqslant 0.3$ kbar) and,

B. The development of secondary mineral assemblages within shallow level intrusives, of higher grade than those existing within the host rocks at the same depths; apparently produced from superheated steam within the intrusive rocks ($T \geqslant 300°C$, $P(\text{fluid}) < 0.1$ kbar). (Author's abstract)

FRIEDMAN, G.M., CATTAFE, Joseph and BORAK, Barry, 1984, Deep-burial diagenesis of the Hunton (Late Ordovician to Early Devonian) carbonates in the Anadarko basin, *in* Limestones of the Mid-Continent, N.J. Hyne, ed.: Tulsa Geol. Soc., p. 183-199. First author at Dept. Geol, Rensselaer Polytech. Inst., Troy, NY 12181.

Carbonate rocks buried to depths of 20,000 to 30,000 feet exhibit characteristics that are diagnostic of deep-burial diagenesis. The rocks were sampled from depths where temperatures are about 210°C and pressures are about 2.5 kilobars. The thermal alteration of vitrinite present in well cuttings demonstrates that the maximum paleotemperatures were essentially the same as the measured, present-day, deep burial temperatures. These conditions have subjected the carbonates to structural deformation and diagenesis approaching metamorphism. The diagnostic textures observed seem to be due, primarily, to the pressure of 20,000 to 30,000 feet of overburden, whereas, the high temperatures appear to have had little visible effect. (From the authors' abstract)

FRIEDMAN, Irving, and GLEASON, J.D., 1984, Deuterium and water content of eruptive rocks (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 264 (in English). Authors at U.S. Geol. Survey, Denver Fed. Center, Denver, CO, USA.

Rhyolitic volcanic glass (obsidian) is a chilled sample of lava and might provide a sample of the water in the magma suitable for deuterium analysis. Previous attempts to use the deuterium content of phenocrystic biotite failed because of the oxidation reactions that biotite undergoes during cooling of the magma.

Samples of obsidian and perlite from drill cores taken through several rhyolite domes at the No Aqua, New Mexico, perlite deposits were analyzed for % H_2O and δD. The δD of the perlite is relatively constant within each core, and varies little between cores. This constancy is in keeping with the secondary origin from meteoric water of the perlite water. The obsidian δD varied by as much as 30% in a single core. There is a relation between δD and % H_2O, but not between δD and position in the core or cooling zones.

The obsidian with higher water content (.2 to .3% H_2O) has a higher deuterium content (-115 to -120) than the obsidian with low water content (.1 to .15% H_2O) $\delta D = -120$ to -150. These variations are not due to cooling or crystallization, and represent differences present during eruption. The implications of this to eruption mechanisms will be discussed. (Authors' abstract)

FRIEDMAN, M., DULA, W.F., GANGI, A.F. and GAZONAS, G.A., 1984, Structural petrology of experimentally deformed synthetic rocksalt: Proc. of First Conf. on The Mechanical Behavior of Salt, H.R. Hardy and M. Langer, eds., The Pennsylvania State Univ, Nov. 9-11, 1981, University Park, PA, p. 19-36. Authors at Center for Tectonophysics, Texas A&M Univ., College Station, TX, USA.

Warm-pressed cylinders of synthetic rocksalt, shortened 10% at $10^{-4}s^{-1}$, confining pressure (P_c) from 0 to 200 MPa, and temperatures from 25° to 300°C are studied microscopically to characterize their mechanical behavior. Upon deformation (1) a-axis fabrics are not altered; (2) grain-boundary bubbles and tubes tend to become aligned along the boundaries particularly when allowed to stress relax at 200° and 300°C; (3) their connectivity increases in part by hydraulic fracturing; (4) intragranular cubic fluid inclusions are complexly modified in size, abundance, and distribution under different sets of P and T conditions; (5) slip occurs on $\{110\}\langle 110\rangle$; and (6) subgrain size (d, μm) is inversely proportional to steady-state stress (σ, MPa) as: $d = (146 \pm 27)\sigma^{-1}$ with rms error = ± 3.5 μm. This relation is independent of P_c (20 to 200 MPa), and probably also of temperature (100 to 300°C), stress relaxation (to 1800 s) and the addition of data from experimentally deformed natural rocksalt. Synthetic and natural rocksalt deform by similar deformation mechanisms despite differences in grain size (0.30 mm versus 1.0 to 20 cm, respectively) and impurity content. (Authors' abstract)

FRITZ, P., FRAPE, S.K. and CLARK, W.B., 1984, Methane in the rocks of the Canadian Shield (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 2, p. 55-56. First author at Univ. Waterloo, Waterloo, Ontario, Canada.

A discussion of the geochemical and isotopic evidence as to the origin of the N_2-CH_4 gases found, along with high-Ca brines, in crystalline rocks. (E.R.)

FU, Jiamo and JIA, Rongfen, 1984, Main forms of disseminated organic matter in carbonate rocks, their evolutionary characteristics and significance in oil-gas evaluation: Geochimica, no. 1, p. 1-9.

FUJINO, Toshio and YAMASAKI, Tatsuo, 1984, Geologic and geothermal structure of the Hatchobaru field, central Kyushu, Japan: Geothermal Resources Council, Transactions, v. 8, p. 425-430. First author at WJEC-West Japan Engrg. Consultants, Inc., Fukuoka, Japan.

Recent investigations and explorations in the Hatchobaru geothermal field have confirmed the up-flow of thermal fluids along 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. Furthermore, there is a large possibility of finding high temperature reservoirs of 290-300°C in the Basement. (Authors' abstract)

FUZIKAWA, K. and ALVES, J.V., 1984, Stretching of fluid inclusions in plagioclases from Lagoa Real uranium province, Caetité, BA: Anais do XXXIII Congresso Brasileiro de Geol., Rio de Janeiro (Proc. 33rd Brazilian Geol. Congress), p. 4453-4461 (in Portuguese; English abstract). Authors at the Nuclebrás, Av. Uruguai 531, Belo Horizonte, Minas Gerais, Brazil.

The main host rocks of the Cachoeira uranium deposit are albite-gneisses (albitites), formed by strong Na-metasomatism associated to the mineralization.

During the fluid inclusion microthermometry of Na-rich plagioclases, an increase in the homogenization temperatures (Th) was noticed in several inclusions when they were overheated.

Stretching phenomena have already been studied in fluorite and sphalerite samples subjected to overheating. Data on the stretching of fluid inclusions in plagioclases seem to have not been published yet.

To study these phenomena, mineralized and unmineralized plagioclases have been tested by several heating runs. The resulting data confirmed the stretching but with no constancy in the overheating/stretching ratio. No clear distinction could be made between uraniferous and non-uraniferous samples.

Testing of associated pyroxene indicated only minor stretching in the range of temperatures studied. (Authors' abstract)

FYFE, W.S., 1984, Chemical transport processes, plate tectonics and ore deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 30-31.

FYFE, W.S. and KERRICH, R., 1984, Gold: Natural concentration pressures, *in* Gold '82: the geology, geochemistry and genesis of gold deposits, ed. R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 99-127.

Reviews the various types of gold deposits and the evidence for the nature of the transporting fluids. (E.R.)

FYON, J.A., SCHWARCZ, H.P. and CROCKET, J.H., 1984, Carbonatization and gold mineralization in the Timmins area Abitibi greenstone belt: genetic links with Archean mantle CO_2 -- degassing and lower crustal granulitization (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 65. Authors at Dept. Geol., McMaster Univ., Hamilton, Ontario, L8S 4M1, Canada.

Locally, volcanic rocks have been intensely carbonatized, and largely replaced by a mixture of quartz and ferroan dolomite. The $\delta^{13}C$ of this dolomite is -4.2 ± 0.7%* (PDB), regardless of the size, stratigraphic position or gold tenor of the carbonatization zone, except where graphitic sediments are present. The replacement dolomites would have precipitated from CO_2-bearing fluids having a $\delta^{13}C$ (ΣC) of -3 to -5%* (PDB). While such an isotopic composition could represent a 30:70 mixture of marine carbonate or metamorphic CO_2 with mantle-derived (magmatic) CO_2, the uniformity of the ^{13}C value suggests that the replacement carbon is from a single source (mantle).

The carbonatized volcanic rocks are enriched in certain large-ion-lithophile (LIL) elements (K, Li, Rb, B). Precambrian granulites are

depleted in these elements as well as gold. Newton et al. (1979) proposed that such granulites formed by permeation by mantle-derived CO_2-rich fluids. Partitioning of the LIL suite as well as gold into the CO_2 fluid during granulitization would allow transfer of these elements from the lower crust to the supracrustal sequences by escaping along deeply-penetrating crustal structures (Destor-Porcupine fault). The temporal coherence during Early Precambrian between gold deposits associated with carbonatized volcanic rocks and regional granulitization of lower crust rocks may reflect a genetic link via the mechanism of extensive CO_2 outgassing during this phase of the earth's history. (Authors' abstact)
*Sic; ‰ meant?

GALIMOV, E.M., 1984a $^{13}C/^{12}C$ of diamonds. Vertical zonality of diamond formation in the lithosphere (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 266 (in English). Text: Proc. 27th Int'l. Geol. Cong., v. 11, p. 279-307 (1984).

GALIMOV, E.M., 1984b Variations of isotopic composition of diamonds and their relation to conditions of diamond-formation: Geokhimiya, 1984, no. 8, p. 1091-1118 (in Russian; English abstract).

GALIMOV, E.M. and KVENVOLDEN, K., 1984, Geochemistry of gases in the gas-hydrate-bearing sediments of the Blake Outer Ridge area, Atlantic Ocean: Geokhimiya, 1984, no. 7, p. 1075-1082 (in Russian; English abstract).

Distribution and isotopic composition of carbon of CH_4 and CO_2 in the sedimentary sequence of the sea floor at the Blake Outer Ridge area, Atlantic Ocean, have been studied. Gas sampling was made in the process of drilling of the hole 533 during 76 leg of the drillship Glomar Challenger (DSDP). Some evidences of presence of the gases in the gashydrate form were obtained. Isotopic composition of carbon of CH_4 varies from -95‰ in the near-surface sediments to -66‰ in lower part of the 400-meters sequence. In parallel with this variation the isotopic composition of CO_2 varies from -25 to -4‰ . The observed values of $\delta^{13}C$ of the gases and close parallelism of their variations are in accordance with the concept of formation of CH_4 as the result of microbiological reduction of CO_2 which was derived from organic matter. Thus gashydrates in the studied sea-floor sequence are formed by biogenic CH_4 and CO_2. (Authors' abstract)

GALLINATTI, B.C., 1984, Initiation and collapse of active circulation in a hydrothermal system at the Mid-Atlantic Ridge, 23°N: J. Geophys. Res., v. 89, no. B5, p. 3275-3289. Author at Union Oil Geothermal.

Gabbro and basalt, collected from an area south of the Kane Fracture Zone along the Mid-Atlantic Ridge, have three stages of alteration which record the cooling of a hydrothermal system: (1) Stage 1. Penetration of seawater began between 400° and 550°C, altering pyroxene to fibrous green amphibole. (2) Stage 2. Propylitic alteration formed along connected fractures between 250° and 300°C. As fracture density increased, the Fe/Mg ratio of chlorite increased, the final result being an Fe chlorite - quartz - sulfide breccia. (3) Stage 3. Late smectite veinlets formed at low temperatures (<200°C) after active circulation ceased. The study focuses on stage 2 alteration. By assuming local equilibrium between alteration minerals and the hydrothermal fluid, constaints can be placed on the fluid composition responsible for stage 2 alteration, the stage associated with deposition of sulfides. The following activities of species in solution were determined for the system $FeO-Na_2O-CaO-MgO-Al_2O_3$-

SiO_2-H_2O at 350 bars and 250°C: $\log a(Ca^{++})/a^2(H^+) = 8.0$, $\log a(Na^+)/a(H^+) = 5.0$, $\log a(Fe^{++})/a^2(H^+) = 1.7$, $\log a(Mg^{++})/a^2(H^+) = 6.0$. Log $a(SiO_2)$ was set at quartz saturation (-2.3 at 350 bars and 250°C). Fluid inclusions record the introduction of a low temperature, seawater-salinity fluid during formation of the latest quartz veins associated with stage 2 alteration. Mixing of this and the hydrothermal fluid caused a drop in temperature and increase in oxidation state, resulting in increased precipitation of quartz, pyrite and chalcopyrite. The salinities of fluid inclusions trapped in quartz during stage 2 alteration are as much as 3 times that of seawater. Concentration of a fluid initially of seawater salinity may be the result of boiling at $\geqslant$350°C and $\leqslant$3000 m depth. (Author's abstract)

GANEEV, I.G., 1984, Physico-chemical model of the joint migration of vein and ore substance in hydrothermal solutions: Akad. Nauk SSSR Doklady, v. 274, no. 5, p. 1189-1192 (in Russian). Author at Inst. of Lithosphere, Moscow, USSR.

The proposed model suggests that there exist physico-chemical conditions of joint migration of essential components of vein and ore minerals in weakly alkaline to weakly acid hydrothermal solutions, that is caused by the unlimited buffering capacity of wall rocks. The transport of substance takes place in the form of hydroxocomplexes of various complexity, heteropolyanions, decomposition of which and crystallization of minerals are caused by acid hydrolysis in anisotropic heat field with presence of acid-alkaline differentiation of solutions. (A.K.)

GANZEYEV, A.A., SOTSKAV, Yu.P. and LYAPUNOV, S.M., 1983, Geochemical specialization of ore-bearing solutions in relation to rare-earth elements: Geokhimiya, no. 8, p. 1179-1183 (in Russian, English abstract; translated in Geochem. Int'l., v. 30, no. 4, p. 160-164, 1984). Authors at Inst. Rarer-Element Mineral., Geochem., and Crystal., Moscow, USSR.

The distribution of REE in metasomatites surrounding ores is considered in relation to that in the unaltered parent rocks. It has been found that the original REE composition varies very slightly during skarning, greisenization, and beresitization of silicate rocks, in spite of the considerable alteration in the rock. Newly formed minerals such as apatite and fluorite take up the REE released by the substitution processes because of their high distribution coefficients for the lanthanoids. Therefore, the REE compositions in the hydrothermal minerals may be independent of the depth specialization of the mineralizing solutions and may be determined by the local redistribution. It is concluded that mineralizing solutions show no specialization in relation to REE in particular cases. (Authors' abstract)

GARANIN, V.K., KROT, A.N. and KUDRYAVTSEVA, G.P., 1983, The evolution of peridotite and eclogite magmas in kimberlite pipes: Geol. rudnykh mestor., no. 4, p. 14-28 (in Russian; translated in Int'l. Geol. Rev., v. 26, no. 1, p. 82-97, 1984). Authors at M.V. Lomonosov Univ., Moscow, USSR.

Includes a review of published data on volatiles in kimberlite and in diamond. (E.R.)

GARVEN, Grant, 1984, Theoretical study of regional mass transport in the genesis of carbonate-hosted lead-zinc deposits (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 66. Author at The Johns Hopkins Univ., Baltimore, MD 21218. Continued next page.

Epigenetic ore deposits in sedimentary basins have received a large amount of research, yet the quantitative relationship between fluid flow and geochemical mass transfer has only begun to be unravelled. The extent to which water-rock interactions occur along a flow path will depend on the mineralogy, pore structure, temperature, fluid composition, and rates of fluid flow. At the regional scale, however, it is the flow patterns and dispersive properties of the flow systems that control the focusing of mass through a ore-forming site. Quantitative analysis of ore genesis must therefore account for processes of fluid flow, heat flow, solute mass transport, and geochemical mass transfer.

Numerical modelling of transport phenomena can be used to provide a heuristic analysis of ore formation in sedimentary basins. Finite-element solutions of the fluid- and heat-flow equations are incorporated into a probabilistic model that predicts advection and dispersion of a single ore-forming component. Geochemical mass transfer is computed with the code EQ3/EQ6, but this is restricted to providing scenarios at the ore site and it is uncoupled from the regional transport modelling. A suite of generic simulations are used to quantify: the effects of hydrodynamics in focusing flow, the role of dispersion, and the comparison of precipitation mechanisms for lead-zinc ores in carbonate strata. Basinwide transport (100-300 km) of metal with sulfide is probably unimportant in ore genesis because dispersion dilutes the low equilibrium concentrations even lower. Hydrodynamic conditions that might result in ore formation through mixing of regional flow systems are rare, in which case a model of metal and sulfate being transported in the same fluid is more defensible. (Author's abstract)

GAUPP, R., MOLLER, P. and MORTEANI, G., 1984, Tantalum pegmatites: Berlin, Gebruder Borntraeger, 124 pp. (in German).

GAUTHIER-LAFAYE, Francois and WEBER, Francis, 1984, Effects of post-burial siliceous diagenesis deformations on the microthermometric behavior of fluid inclusions: an example in the Francevillian uraniferous sandstone reservoir (Gabon): C.R. Acad. Sci. Paris, v. 299, Ser. II, no. 9, p. 555-560 (in French; English abstract).

New data on fluid inclusions associated with siliceous diagenesis show that deformation in the first stage of catagenesis disturbed their microthermometric behavior. Nevertheless, T and P of fluids associated with the uraniferous paragensis and contemporary with the Oklo natural reactors are estimated at 140-160°C and 250-500 bar. (Authors' abstract)

GEGUZIN, Ya.Ye., DZYUBA, A.S. and IONGZU, Yu., 1984, Distribution of an impurity during the crystallization of a melt with macroscopic inclusions (the shadow effect): Akad. Nauk SSSR Doklady, v. 277, no. 3, p. 597-600 (in Russian). Authors at Khar'kov State Univ., Khar'kov, USSR.

The authors discuss the case when during crystallization admixed materials accumulate in front of the face of a growing crystal, indicating that similar considerations may be made for the case of formation of a zone poor in such admixture. If a screen (permeable to heat but impermeable to atoms) is placed in the way of the crystallization front with a static distribution of admixture, behind the screen the static distribution should reestablish. Experiments were made with air-saturated water crystallizing in a thin layer in a constant T gradient = 100 K/cm causing a crystallization rate of ~10^{-3} cm/sec. Screens were of copper, Cu + Ni alloy, plastic and porous paraffin in the shape of a slab or sphere. Crystallization of water causes segregation of air bubbles when local gas concentration exceeds the critical supersaturation level, and then certain typical shadow structures appear. If a flat screen is used, the width of shadow does not depend on the material of the screen. When the size of the screen is small, shadows have peculiar features caused by the existence of admixture reservoirs (gas bubbles) at the edges of screen. (Abstract by A.K.)

GENKIN, A.D., SAFONOV, Yu.G., BORONIKHIN, V.A., NAUMOV, V.B., VASUDEV, V.N., RAO, B.K., CHERNYSHEV, I.V. and NOSIK, L.P., 1984, New data on the mineralogy and geochemistry of a gold ore field of Kolar, India in F.V. Chukhrov, ed., Geol. Polezn. Iskop. Drevnikh Platform, Mater. Indo-Sov. Simp. Nauke Zemle, 4th 1981, p. 82-99 (in Russian).

Two types of Au-bearing veins occur in the Kolar Au ore deposit: Au-quartz (Champion Reef) and Au-sulfide-quartz (Oriental, Mactaegart). Fluid inclusion studies in quartz show that the lithostatic pressure during mineralization was 270 bars/km. The $\delta^{34}S$ data yielded a formation temp. of 210-240° (for the Champion Reef) and 405° (for Oriental). (Abstracted from CA 101: 114252t)

GENSHAFT, Yu.S. and SALTYKOVSKIY, A.Ya., 1984, Peculiarities of basaltoid volcanic manifestations in intracontinental tectonic structures: Akad. Nauk SSSR Doklady, v. 275, no. 3, p. 688-691 (in Russian). Authors at Inst. Earth's Physics, Moscow, USSR.

Temperatures (Th?) of basaltoid magmas of the Baikal-Mongolia region equal 1000-1250°C. (A.K.)

GERASIMOV, M.V. and MUKHIN, L.M., 1984, Studies of the chemical composition of gaseous phase released from laser pulse evaporated rocks and meteorite materials (abst): Lunar and Planet. Sci. XV, p. 298-299. Authors at Space Res. Inst., Acad. Sci. USSR, Moscow, USSR.

This paper presents 12 GC-MS (LKB-9000) analyses of the chemical composition of gases that originate as a result of sample evaporation by laser pulses of variable intensities in a He or H atmosphere. A highly nonequilibrium mixture of H_2, O_2, CH_4, CO, CO_2, SO_2, H_2S, CS_2, H_2O, HHC (up to C_6), C_2H_4O, HCN, CH_3CN, etc. was formed. (E.R.)

GERDENICH, M.J., LAUBACHER, R.C. and PRIDE, D.E., 1984, Regional study of mineralizing fluids, Breckenridge mining district, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 517. Authors at Dept. Geol. & Mineral., The Ohio State Univ., Columbus, OH 43210.

Tertiary base- and precious-metal mineralization, plus quartz-pyrite-molybdenite mineralization in the Breckenridge district developed during evolution of the composite Breckenridge stock. District-wide characteristics of the mineralizing fluids have been examined by means of a reconnaissance fluid inclusion study of 128 sections (506 inclusions) of quartz (vein, phenocryst), sphalerite, and calcite. Four centers of hydrothermal activity ("hydrothermal cells") have been identified, based on the presence of high salinity inclusions, elevated fluid temperatures, and evidence of boiling. Ranges in Th for Type I (L-V) and Type III (L-V-NaCl±KCl) inclusions, and in salinities for the Type III inclusions are as follows: 230-467°C; 210-525°C; 32-65 wt %. Pressure determinations from the fluid inclusion data indicate mineralization depths of .8 to .9 km, corresponding perhaps to the upper part of one or more porphyry-metal systems. (From the authors' abstract)

GERLACH, T.M., 1984a, The volatile budget of Kilauea Volcano (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 517. (See next item.)

GERLACH, T.M., 1984b The degassing of Kilauea Volcano (abst.): EOS, v. 65, no. 45, p. 1131. Author at Sandia Nat'l. Labs., Albuquerque, NM 87185.

A quantitative model has been formulated for the degassing of Kilauea Volcano. The model is constrained by matrix glass, glass inclusion, and volcanic gas analytical data and by summit chamber volume changes as inferred from the Uwekahuna summit tiltmeter. The primary volatile influxes into the chamber in tons/μrad inflationary tilt are 2500 (H_2O), 5400 (CO_2), 1100 (S), 75 (Cl), and 295 (F). Sustained Halemaumau eruptions can degas primary volatiles directly and produce volcanic gases characterized by (vol %) 50% CO_2, 38% H_2O, and 12% SO_2; such eruptions, however, have been rare during the past 60 years. More typically, primary volatiles are fractionated between a chamber gas phase (90% CO_2, 10% SO_2) and chamber equilibrated melt. Average chamber gas discharges of CO_2 to the atmosphere are 3670 tons/day. Discharges of chamber equilibrated melt into rift zones give volatile outfluxes in tons/μrad, which implies 19000-20000 tons of SO_2 emission. The volcanic gases emitted during eruptions of chamber equilibrated melt are characterized by 5% CO, 80% H_2O, 15% SO_2. The model provides a conceptual basis for geochemical monitoring procedures, which have been largely empirical in approach up to the present time. It also establishes a natural standard against which to compare anthropogenic sources of atmospheric pollution for CO_2, SO_2, HCl, and HF. (Author's abstract)

GIBSON, E.K., Jr., CRONIN, J.R., KOTRA, R.K., PRIMUS, T.M. and MOORE, C.B., 1984, Amino acids, carbon and sulfur abundances in Antarctic carbonaceous chondrites (abst): Lunar and Planet. Sci. XV, p. 300-301.

GIBSON, E.K., Jr. and KOTRA, R.K., 1984, Chemical analysis of fluid inclusions using laser microprobe-gas chromatography (abst.): Abstracts of the Am. Chem. Soc. Meeting, April 1984, St. Louis, Div. of Geochemistry (unpaginated). First author at SN4, NASA Johnson Space Center, Houston, TX 77058.

The composition of volatiles present in fluid inclusions may represent the volatiles present at the time of formation of the host material. Direct chemical analysis of volatiles in fluid inclusions as opposed to bulk volatile measurements may provide more accurate information on conditions of formation and subsequent alteration. Due to the minute amounts of volatiles present in inclusions their direct analysis is a difficult task.

We have developed a laser microprobe technique which provides quantitative information complementary to that derived from non-destructive techniques and in cases with very small quantities of volatiles, unique information. A laser microprobe is utilized to "open" the fluid inclusions or to release gases from the host mineral. A stream of high-purity helium is used to sweep the released gases into a chromatograph system with an ultra-sensitive helium ionization detector. We have examined over twenty different materials such as volcanic glasses, tektites, terrestrial basalts, sedimentary rocks and meteorites. The compositional data agree reasonably well with previous estimates, when they exist. The application of the laser microprobe-gas chromatographic technique to the study of fluid inclusions in geological samples will be illustrated. (Authors' abstract)

GIBSON, E.K., Jr., PRESLEY, B.J. and HATFIELD, J., 1984, Salts in the dry valleys of Antarctica (abst): Lunar and Planet. Sci. XV, p. 302-303.

GIBSON, E.K., PRIMUS, T.M. and KOTRA, R.K., 1984, Carbon and sulfur abundances in Antarctic carbonaceous chondrites, ordinary chondrites, eucrites, and the Martian shergottite (abst): Lunar and Planet. Sci. XV, p. 304-305.

GIGGENBACH, W.F., 1984, Mass transfer in hydrothermal alteration systems--A conceptual approach: Geochimica Cosmo. Acta, v. 48, p. 2693-2711. Author at Chem. Div., DSIR, Private Bag, Petone, New Zealand.

At very low fluid/rock mass ratios the hydrothermal alteration process corresponds to isochemical recrystallization of the primary rock. The resulting full equilibrium assemblage with the composition of an average crustal rock contains the phases albite, K-feldspar, K-mica, biotite, quartz and (depending on temperature) epidote, prehnite or one of the Ca-zeolites. Relative Na^+, K^+, Mg^{2+} and Ca^{2+}--solution activities in such a rock-dominated alteration system are uniquely fixed and provide useful reference points with regard to the degree of attainment of full fluid/rock equilibrium. With increasing fluid/rock mass ratios the composition of now increasingly fluid-dominated alteration assemblages is determined by the interplay of three major processes: hydrogen metasomatism as a function of CO_2 reactivity increasing with the horizontal distance from major fluid upflow zones and leading to the formation of Al-enriched alteration assemblages; potassium metasomatism accompanied by silicification in or close to major fluid upflow zones leading to potassic and phyllic alteration; sodium, magnesium, calcium metasomatism associated with descending and heating solutions leading to propylytic alteration of recharge zones. Two new parameters, reactivity and exchangeability, determining the effectiveness of fluid components with respect to hydrothermal alteration are introduced. (Author's abstract)

GILETTI, B.J. and YUND, R.A., 1984, Oxygen diffusion in quartz: J. Geophys. Research, v. 89, no. B6, p. 4039-4046. Authors at Dept. Geol. Sci., Brown Univ.

Diffusional oxygen exchange between quartz and water was studied by determining ^{18}O profiles in the quartz using an ion microprobe. Inverse error function plots of the data are linear as required for a diffusion mechanism. One natural and two synthetic samples were used, and although they had different impurity concentrations (OH^-, Na, and Al per 10^6 Si atoms are 7-4000, 35-835, and 67-127, respectively), the D values were the same within experimental uncertainty. Diffusion parallel to c is about 2 orders of magnitude faster than that normal to c at 700°C, and diffusion normal to the rhombohedron is intermediate. The data indicate a change in slope on an Arrhenius plot at the α-β boundary. At 100-MPa (1 kbar) water pressure the preexponential factors (D_0, in square centimeters per second) and activation energies (Q, in Kilojoules per mole) for α quartz (500°-550°C) are as follows: $D_0 = 190$ and $Q = 284$ parallel to c, and $D_0 = 8 \times 10^{-2}$ and $Q = 238$ normal to the rhombohedron. For β quartz (600°-800°C), $D_0 = 4 \times 10^{-7}$ and $Q = 142$ parallel to c, $C_0 = 9 \times 10^{-7}$ and $Q = 155$ normal to the rhombohedron; and $D_0 = 1 \times 10^{-4}$ and $Q = 234$ normal to c. D increases with PH_2O and between 25 and 350 MPa log D versus log fH_2O has a slope of approximately 1.1. These D values are all several orders of magnitude larger than previously reported values for oxygen diffusion in water-free systems. (Authors' abstract)

GINZBURG, A.I., 1983, Genesis of rare-metal granitic pegmatites, in Geology and Genesis of Pegmatites, "Nauka," Leningrad, p. 96-133 (In Russian).

Quotes many Th values for pegmatite minerals from published works of others. (A.K.)

GIULIANI, G., 1984, Vein concentrations of tungsten-tin in the granitic massif of Zaër (Central Morocco): Mineralization and associated liquid phase: Mineral. Deposita, v. 19, p. 193-201 (in French; English abstract). Author at Allée des Bruyères, 83700 Boulouris, France.

The Sokhret Allal tungsten-tin deposit is located in the southern part of the two-mica Zaër granite (Central Morocco). The mineralization occurs in a swarm of subparallel quartz veins striking N 100-110°E. The veins are spatially associated with feldspathic episyenite-veins that seem to control their emplacement. The paragenesis is divided in three stages: I. oxide stage; II. intermediate stage; III. late sulphide stage. Fluid inclusions have been studied in the massive quartz of stage I. using microthermometric and Raman analyses: it is characterized by fluids evolving from aqueous-carbonic vapors (75 to 90 mole% H_2O, 17 to 12 mole% CO_2, 0.5 mole% CH_4, 5 to 3 mole% N_2, 2.5 to 2 mole% eq. NaCl; $T \simeq 450-500°C$, $P \simeq 800$ to 850 bar) to aqueous solutions (98 to 99 mole% H_2O, 2 to 1 mole% eq. NaCl traces of CO_2, CH_4, N_2; $T \simeq 300°C$, $P \simeq 300$ bar). Their evolution corresponds to the mixing of early carbonaceous fluid by an aqueous solution. Ore deposition would occur during this process of dilution. The early CO_2 bearing fluid seems to play an important role in tungsten transport. (Author's abstract)

GLASSLEY, W.E., BRIDGWATER, David and KONNERUP-MADSEN, Jens, 1984, Nitrogen in fluids effecting retrogression of granulite facies gneisses: a debatable mantle connection: Earth & Planet. Sci. Letters, v. 70, p. 417-425. First author at Dept. Geol., Middlebury College, Middlebury, VT 05753, USA.

The abundance patterns of nitrogen, and chlorine in retrogressed granulite facies gneisses from southern East Greenland exhibit strong enrichment in the vicinity of small-scale shear zones. Sulfur in the shear zones occurs at the same concentration levels as in the adjacent country rock, but is depleted in the transition zone between shear zone and country rock. Within the shear zone sulfur occurs as sulfate, whereas in the country rock granulites it occurs as sulfide. Recrystallization of rock in the shear zone to scapolite-bearing, hornblende-absent assemblages, along with changes in the major element chemistry, demonstrates that these zones define migration pathways of chemically reactive fluids. Consideration of the computed fluid compositions, and of the mass ratios of chlorine/sulfur and nitrogen/sulfur demonstrate that the fluid equilibrated with continental crust prior to its passage through gneisses in the study area. Previous suggestions have been made that the mantle may act as a source region for nitrogen-rich fluids. However, equilibration of these S-, N- and Cl-rich fluids with crustal material precludes the use of element abundances to identify a mantle signature; the bulk of these fluid constituents must be considered crustal derived. (Authors' abstract)

GODOVIKOV, A.A., MARKOV, V.G., BELITSKIY, I.A., BOGDANOVA, V.I. and PAVLYUCHENKO, V.S., 1984, About hypogene thenardite: Akad. Nauk SSSR Doklady, v. 274, no. 1, p. 167-169 (in Russian). Authors at Inst. Geol. & Geophys. Siberian Br. Acad. Sci. USSR, Novosibirsk, USSR.

Thenardite found as lenses and veinlets in underground pits of the "Slepaya" mine in nepheline syenite of the Vishnevye Mts. proves the more extensive role of SO_4 in hypogene processes than it is commonly supposed. (A.K.)

GOFFÉ, Bruno and VILLEY, Michel, 1984, Textural study of carbonaceous matter in a high-pressure - low-temperature metamorphic terrane (French Alps). Do the high pressures influence the coalification?: Bull. Minéral., v. 107, p. 81-91 (in French; English abstract). First author at ER 224, Lab.

Géol., Ecole Normale Superieure - 46, rue d'Ulm, 75005 Paris, France.

In high-pressure, low-temperature metamorphic areas (6 kbar - 300°C) of the internal part of Brianconnais zone, organic matter-bearing metasediments contain hydrocarbon compounds (oils and wet gas) as inclusions in metamorphic minerals (quartz, lawsonite ...). In contrast with the metamorphic conditions, the degree of transformation of the organic matter is much less than that predicted by classical models of organic matter evolution during metamorphism.

The textural study of solid organic matter in these metasediments indicates the coexistence of two phases: I has a structure similar to a kerogen of deep catagenesis. The degree of organization is compatible with the existence of associated hydrocarbon compounds; and II has a structure similar to anthracite. Its degree of organization is more compatible with the thermal conditions of metamorphism, but seems to [be the] result of shearing effects.

An hypothesis is proposed: at a given temperature, the kinetics of organic matter evolution is considerably slowed by increasing static pressures (hydrostatic type). This inhibiting effect of pressure is locally cancelled, in the case of carbonification, by shear stress, which promotes the transformation of kerogen. (Authors' abstract)

GOLDFARB, Richard, PICKTHORN, William and TRIPP, Richard, 1984, The distribution of epigenetic gold-quartz lodes and base metal lodes within the Valdez Group, Alaska (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 286. Authors at U.S. Geol. Survey, Box 25046, MS 973, Denver, CO 80225.

Two distinct epigenetic, mineralized vein systems can be recognized within rocks of the Cretaceous Valdez Group. The Valdez Group is the major component of the Chugach terrane, a large sedimentary wedge accreted to the Gulf of Alaska margin during Late Cretaceous to early Tertiary time.

Gold-quartz lodes are localized within fissures in middle to upper-grade greenschist facies rocks. Fluid-inclusion and stable-isotope data from the Port Valdez district show that a mixture of metamorphic and meteoric waters deposited the auriferous veins at a minimum temperature of 240°C. The lodes are neither evenly nor randomly distributed, but group into 12 distinct regions. Quartz veins containing mainly gold, arsenopyrite, pyrite, calcite, and scheelite cluster on the northern Kenai Peninsula, near Coghill Lake, north of Miners River, and both north and southeast of Port Valdez. Similar lodes, which additionally contain abundant chalcopyrite, are localized around Cleave Creek Glacier, Schwan and Woodworth Glaciers, Portage Pass, western Port Wells, Kenai Lake, Port Nellie Juan, and the southern Sargent Icefield. (While the last two localities are mapped as younger Tertiary Orca Group, they seem to have many similarities with the Valdez Group.) Wall rock alteration was not observed at any of the above localities, and fresh K-feldspar was found next to many of the mineralized veins.

In contrast with these occurrences are lodes that are rich in galena, sphalerite, barite, arsenopyrite, chalcopyrite, and pyrite, but contain little gold. These lodes group north of College Fiord and from Harriman glacier northwest to Goat Mountain, as well as in Orca Group rocks south of Miners River. Extensive alteration of the adjacent country rock indicates that these veins formed under conditions quite different than those responsible for the gold-quartz lodes. (Authors' abstract)

GONCHARENKO, A.I. and SIMONOV, V.A., 1984, Fluid inclusions in plastically deformed olivines in alpine type hyperbasic rocks: Akad. Nauk SSSR

Doklady, v. 276, no. 1, p. 228-231 (in Russian). First author at Tomsk State Univ., Tomsk, USSR.

Olivines (Fa_5) from dunites of the Srednetersinskiy massif (Kuznetskiy Alatau) have dimensions 10 x 2 mm and are surrounded by smaller (3 x 2 to 2 x 1 mm) grains oriented in agreement with the large ones. Olivines bear signs of plastic deformation. Fluid inclusions were found in olivine tectonites of early plastic deformation, and identified as inclusions of methane and nitrogen. Inclusions of methane (size 2-5 μm) occur together with polyphase (L + crystals) and one-phase inclusions. Triple point of inclusions of L methane equals -182.5°C, Th of such inclusions in dunites are from -135 to -145°C, in dunite-pegmatites from -120 to -122°C, specific volumes 2.5 - 2.6 cm^3/g. Methane presence is confirmed by gas chromatography. Inclusions of nitrogen (size about 5 μm) are one-phase, transparent, and occur in olivines of dunites but not in dunite pegmatites. Their heterogenization takes place at about -190°C, Th -194.3 to -194.9°C, specific volume of L nitrogen equals 1.25 cm^3/g. Both kinds of inclusions form regular zones in olivine, up to 0.5 mm wide. Formation of methane inclusions at ~1000°C needed P 8-8.7 kbar, nitrogen inclusions - up to 11.5 kbar. High pressures and reduced gases indicate their deep origin. (Abstract by A.K.)

GONCHAROV, V.I., 1983, Hydrothermal ore formation in the marginal volcanic belts, 216 pp, "Nauka" Publ. House, Moscow, 700 copies printed, price 2 rbls. 50 kopecks (in Russian). Author at North-East Complex Sci.-Research Inst. of Far-East Sci. Center of Acad. Sci., Magadan, USSR.

The book characterizes the conditions of ore formation in the complex ferric-sialic Okhotsk-Chukotka volcanic belt. The author was interested in Au and Ag ore mineralization; he distinguishes gold-silver ore formation by deposit types: Ag-argentite, Au-sulfoantimonite, Au-argentite, Au-sphalerite-galena and Au-pyrite; Au-As-Sb formation, Au-Cu-Mo formation, Au-low-sulfide formation, Au-rare metal formation with Au-tetradymite-Bi and Au-cobaltite deposit types, and Sb-Hg ore formation. Section presenting fluid inclusion studies describes methods of investigation (thermometric and P determinations, analysis of water leachates and gas composition in individual inclusions, salt concentrations and pH of inclusion solutions), theoretical foundations of inclusion use and inclusion data for the Au-Ag deposits from Okhotsk-Chukotka belt. Ag-argentite type: inclusions in quartz of early quartz-chlorite association homogenize in L or G at 350-240°C (Td 420-240°C), solutions of Cl-Na-K type, total concentration >260-300 g per l, gases consist essentially of N_2 and CO_2. The following sulfide-polymetal association yielded the data: Th 395-240°C (quartz) and 320-315°C (sphalerite), Td 350-320 and 300-260°C (quartz), 330-220°C (galena), solution of Cl-Na-K type, concentration <20%, gases - CO_2 + N_2; commerical Ag-argentite association - Th 385-260°C (quartz), but ores precipitated at (Th) 270-260°C, Td 440-430, 360-340 and 300-240°C, solutions of HCO_3-Cl-Na-K type from high concentrations (dm halite and sylvite in inclusions) to 43 g per l; gases N_2 + CO_2 + occasionally O_2; rhodonite-rhodochrosite association - Th 370-260°C, solutions of Cl-K-HCO_3-Mg-Na, salt concentration 40 g per l; helvite-garnet association formed from Cl-HCO_3-Na-Mg solutions. Au-sulfoantimonite type: pre-ore quartz-sulfide association - Th 130-160°C, quartz-kaolinite metasomatites Th 130-240°C, quartz-adularia association Th 180-200°C to 290-300°C (for geodes) at shallow levels, to 290-345°C at deep levels, solutions were of HCO_3>> (SO_4+F+Cl)-Ca-Na-K type with concentration 105-195 g per l; gases N_2 + CO_2 (+ scarce O_2, CO, H_2), post-ore calcite-adularia association - Th 130-140°C and 120-290°C (two types of quartz), P 5-75 atm, solutions of HCO_3-Ca-Na-K type with concentration 90-93 g per l (in dried precipitate of water leachate from calcite Au makes up 0.01 wt.%, Ag 0.001 to 0.03 wt.%); gases N_2 + CO_2 (plus up to 14 vol.% of CO). Au-argentite type: Th 225-400°C, Te -18 to -31°C, salt concentration 7.2-10.5 wt.% of NaCl equiv., P 112-280 atm, HCO_3-Cl-Na-K-(Mg) solutions; gases CO_2+N_2(±O_2). Au-sphalerite-galena type: Th 50-365°C, Te -16 to -24°C, salt conc. 6.2-9.3 wt.%, P 25-190 atm, HCO_3-Cl-Na-K solutions; gases CO_2+N_2(±O_2). Au-pyrite type: Th 100-445°C, Cl-Na-K solutions; gases CO_2+N_2(+CO+"acid gases"). Au-As-Sb formation: Th 100-400°C, P 170-1400 atm, parent solutions are concentrated chloride brines; gases - prevaling CO_2. Au-Cu-Mo formation: Th 50-700°C, P 455 to >1000 atm, Cl-HCO_3-Na-K-Ca-Mg solutions, concentration 66 to 2933[sic] g per l; CO_2 is the main gas. Au-low-sulfide formation: 80-360°C, P 111-1100 atm, Cl-Na-K solutions with conc. 12-30 g per l; main gas - CO_2. Au-rare metal formation: Th 200 to 4800°C, very conc. solutions (brines). Sb-Hg formation: Th 150-250°C. The book contains also results of experiments made for elucidation of the state of Au and Ag in hydrothermal solutions. Note: literature quotations and reference list bear a number of errors. (Abstract by A.K.)

GONZALEZ PARTIDA, Eduardo, 1983a, Fluid inclusions and genetic characteristics of polymetallic mineralization in Tierra Caliente: Geomimet, v. 123, p. 35-55 (in Spanish). Author at Univ. Nac. Auton. Mex., Mexico.

Fluid inclusions of the polymetallic mineralization of Tierra-Caliente were studied. The physico-chemical conditions of the different episodes of mineralization are fundamentally different.

The first, presumably contemporaneous with exhalative phenomenon associated with submarine volcanism and massive sulfide precipitation, was from extremely concentrated brines of 57-67 equiv. wt. percent NaCl at 400-500°C.

Next, development of regional metamorphism in the rocks during two episodes of mineralization created essentially a complex carbon-rich phase where CO_2 + CH_4 + N_2 coexisted with H_2O. The mean composition of the carbon-rich fluid mixture was measured directly in place (Raman microprobe).

The third and final episode of mineralization produced polymetallic veins. The fluids of these veins are classic: low salinity of 1-10 equiv. wt. % NaCl and 150-350°C, formed from solutions of meteoric origin, which selectively remobilized sulfur and metals initially present in the metamorphosed rock section. (From the author's abstract, translation courtesy G.P. Landis) (See also Gonzalez Partida 1983b and 1983c.)

Note: Numerous aspects of the fluid inclusion studies reported in this paper are not in the above author's abstract, so G.P. Landis has provided the following more detailed abstract. Apparently much of this material is given in an earlier paper, cited there as: Gonalez Partida, E., 1981, The Gold-silver vein province of Taxco-Guanajuato: Characteristics of the hydrothermal solutions, sulfur isotopic compositions, and proposal of a metallogenetic model, with examples from the Miahuatlan, Sultepec, and Temascaltepec veins. [Thesis for Dr. of Engineering] I.N.P.L.-E.N.S.C. (France). Edited by C.R.P.G./C.N.R.S. (in French) 234 p.

There are three main styles of mineralization in the province, in chronologic order of development: a) massive sulfide bodies genetically associated with volcano-sedimentary sequence (of Plio-Quaternary age), including neovolcanic ejecta, b) metamorphic quartz segregation veins, from the episode of regional metamorphism, and c) mineralized hydrothermal quartz veins. The massive sulfide mineralization is not Kuroko-type in any sense of the concept, but as the author suggests, is perhaps an intermediate case between Kuroko and Kupferschiefer-type in a submarine volcano-sedimentary sequence. Estimated fluid temperature of 450 deg.C, and 250 bars, and approximately 15 mole percent CH_4 (Raman microprobe) are proposed.

The regional metamorphism produced a green schist country rock which consists of biotite-quartz-feldspar at the lowest exposure to two-mica biotite/chlorite with leucoxene at the top. Celadonite-paragonite substitution permits an estimate of 540 deg.C and 4 kb at the base, to 470 deg.C and 2.5 kb at the top. In zones of intense hydrothermal alteration, near sulfide accumulations, fluid inclusions are abundant but very small (5-20 microns). Fluid density ranges from 0.50 - 0.75 g/cm^3, estimated from CO_2 content. Mole fraction in the gas phase of CO_2 is XCO_2 = 0.93-0.95, that for XCH_4 = 0.013-0.019, and that for XN_2 = 0.03-0.12. CO_2 hydrate clathrate melting is +5 to +9 deg.C, making the salinities of 2-8 eq.wt.% NaCl overestimated. This effect is offset by the CH_4 presence. N_2 is an important component of the metamorphic fluids. The presence of pure CO_2 fluids with CO_2-H_2O fluids (plus CH_4 + N_2 + NaCl) suggests several explanations: a) dilution of pure CO_2 fluids by an externally derived mixed fluid, b) immiscible segregation of a homogeneous fluid of CO_2 + CH_4 + H_2O-NaCl(+N_2) at a temperature of 350-400 deg.C. The author does not suggest a choice.

At Miahuatlan, quartz veins associated with a lower Miocene monzonite stock have been studied in detail. These veins cut andesite and the alteration is quartz, chlorite, epidote, sericite, calcite, pyrite, and chalcopyrite. In contrast the Sultepec district no intrusion is present to give rise to the mineralization. Selvage alteration next to the veins is principally sericite. Three main stages of mineralization are characterized by the following mineral parageneses: Early - sphalerite with chalcopyrite exsolutions, pyrite, chalcopyrite, arsentite, proustite, polybasite, native silver generally in low concentrations, but with some rich pods; Middle - arsenopyrite, sphalerite without exsolution, and marcasite; Late - stibnite, cinnabar, marcasite, pyrite, chalcopyrite, and covellite. Gangue minerals are principally quartz with minor sericite and calcite. Fluid inclusions are 10-30 microns, generally irregular in shape, with few negative crystals, the early stage hosts the most inclusions, and single phase inclusions (liquid) are seen in the late stage minerals. Gas phase is 10-25 percent. The following general conclusions are possible: a) the salinity is low, on the order of 1-10 percent eq.wt.% NaCl, and universally decreases with temperature, b) Th uniformly decreases through each stage to the late stage mineralization, a median range of 150-350 deg.C is observed, with 150-250 deg.C dominant for the late stage. An exception to the direct relation between salinity and temperature is seen in the Middle stage sphalerite which exhibits relatively high salinities with relatively low temperatures. This observation is explained by either the presence of other solutes such as $FeCl_2$, or errors in measuring the freezing point depression in sphalerite-hosted inclusions because of poor visibility of ice at the melting point. Approximately, the minimum pressure to prevent boiling of a 0.80 g/cm^3 fluid at 280 deg.C is 62 bars, which is 720 meters depth hydrostatic, or 200 meters lithostatic. Based upon measurements at two elevations in the Sultepec vein, using temperature and salinity, an estimated geothermal gradient of 8 deg./100 meters is obtained. Leachate analyses from Temascaltepec and Miahuatlan quartz illustrate different chemical compositions at different stages of mineralization: for the former, K/Na = 0.33, Ca/Na = 0.43 and Ca/Mg = 2.19, for the later, K/Na = 0.27, Ca/Na 0.17, and Ca/Mg = 0.57. The results of 88 sulfur isotope analyses of pyrite, sphalerite, and stibnite from Sultepec, Miahuatlan, Zacualpan, Temascaltepec, and Tizapa-Santa Rosa range from -8.0 to -2.9 permil and show no relation to massive sulfide versus hydrothermal vein genetic settings. Sulfur isotope values are generally uniform in the diverse geologic environments, are lower in the veins than in the enclosing sediments, and not typical of magmatic sources. (Abstract courtesy G.P. Landis)

GONZALEZ PARTIDA, Eduardo, 1983b, Study of the fluid phase and its relations with the gold-silver vein mineralization in Miahautlan-Ixtapan del Oro, state of Mexico: Geomimet, v. 125, p. 89-100 (in Spanish). Author at Univ. Nac. Auton. Mex., Mexico.

The polymetallic sulfide mineralization of Miahuatlan-Ixtapan del Oro forms part of a Tertiary metallogenic province in which the auriferous-arsentiferous mineralization occurs as veins.

The Miocene emplacement of a monzonite stock into andesites gave rise to a propylitic hydrothermal alteration characterized by the association of chlorite, epidote, calcite, sericite, and quartz, accompanied by pyrite and chalcopyrite.

The sulfide stage mineral paragenesis (mineral assemblage) is represented by gold, native silver, argentite, sphalerite, galena, chalcopyrite, pyrite, pyrrhotite, marcasite, arsenopyrite, and secondarily emplaced covellite, in a quartz gangue with minor sericite and calcite.

The fluid phase is characterized by a salinity that varies from 0.0 to 7.85 eq. wt. % NaCl. The temperature of formation for the hydrothermal alteration varies from 400°C to 260°C, and for the sulfide mineral stage from 280°C to 140°C (without pressure corrections).

Isotopic analyses of D/H and $^{18}O/^{16}O$ permit [are compatible with] an origin of mineralizing fluids from within a meteoric water convection cell circulating at about 350°C and of low water-rock ratio. (Author's abstract, translation courtesy G.P. Landis).

Mineralization is in quartz veins that cut the andesites at Miahuatlan, whereas in Ixtapan del Oro veins are encased in Upper Cretaceous sediments. Intense propylitic alteration of the andesite is present near the stock. Less abundant phyllitic alteration exists likewise, which is represented by chlorite spherules, sericite and quartz, with a little pyrite.

From microscopic study of inclusions throughout the diverse stages of mineralization a population of more common two-phase inclusions and a population of multiphase inclusions are observed. Multiphase inclusions occur earlier than two-phase inclusions and have an average of 30 percent vapor, and typically a small solid phase exhibiting Brownian motion. A very common solid phase is an anisotropic, fibrous, multiradiating star. The vapor/liquid ratio varies from 30% to 10% from first to last stage of mineralization. AA-analyses of K, Na, Ca, Mg, and Cl leached from quartz-hosted inclusion fluids were performed, and show NaCl to be the predominant solute responsible for the -0.2 to -5.0°C freezing point depression of ice in the fluids. K/Na atomic ratios of 0.27 in andesite hosted veins, to 0.21, 0.32 for veins in calcareous sediments, show no consistent difference (each number is average of 4 analyses). δD and $\delta^{18}O$ are approximately -45 to -60 per mil and 3 to 5 per mil respectively, and show no relation to different host rocks of the quartz veins. (Added data from text, translated by G.P. Landis) (See also preceding item.)

GONZALEZ PARTIDA, Eduardo, 1983c, Petrographic, crystallochemical, and fluid inclusion analysis of the Paleozoic metamorphic series in Tierra Caliente: Geomimet, v. 124, p. 61-71 (in Spanish). Author at Univ. Nac. Auton. Mex., Mexico.

The metamorphic series at the base of the lithostratographic units in the region of Tierra Caliente are characterized by a mineral assemblage of quartz, biotite, muscovite, and detrital tourmaline.

Crystal-chemical analysis of white micas show a temperature of formation that varies from 540°C at the base of the unit to 470°C at the top, and a pressure of 4.0 to 2.5 kb.

Carbon-bearing components, CO_2, and CH_2-N_2, included in the fluid phase, resulted from the transformation of dispersed organic material initially in the pelitic sediments. (Author's abstract, translation courtesy G.P. Landis) (See also preceding items.)

GOODRICH, C.A., 1984, The formation of metallic iron in mafic magmas: the role of carbon (clues from native iron in Kisko Island basalts) (abst): Lunar and Planet. Sci. XV, p. 312-313.

GORBATYI, Yu.K. and DEM'YANETS, Yu.N., 1984, Pressure influence on near ordering in liquid water: Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 903-906 (in Russian). Authors at Inst. Experimental Mineralogy, Chernogolovska near Moscow, USSR.

P causes bending of hydrogen bonds and change of angles, initially close to that of tetrahedron, and density increment due to decrease of distance between closest molecules and increase of coordination number; pertinent to physics of inclusion fluids. (A.K.)

GOSTYAYEVA, N.M. and DIMITROV, G.Kh., 1984, Temperature conditions for the formation of metasomatic prehnite rock (from inclusion study): Geokhimiya i Rudoobrazovaniye, v. 12, p. 33-35 (in Russian). Authors at Inst. Geochem. & Physics of Minerals of Acad. Sci. of Ukrainian SSSR, Kiev, Ukraine.

The studied prehnite metasomatic rocks occur in a tectonic zone in Precambrian rocks of the Kirovograd block, Ukrainian shield. Thickness of stratabound prehnite body reaches 14 m. Wall-rocks are amphibolites, amphibole-biotite gneisses and granites. Prehnite content in metasomatites ranges from 55 to 90% [by vol.? - A.K.], plus clinozoisite, quartz, albite and chlorite. Grain size of rock varies from 0.03 to 2 mm. Prehnite bears azonal P inclusions. Cracking and decrepitation of some of these inclusions occurred at T >300°C, but most inclusions did not leak. Naturally decrepitated inclusions were not found in prehnite. Hence the obtained results of inclusion studies are valid. Size of inclusions ranges from 3 to 20 µm, filling degree from 70 to 90 vol. %. Inclusions homogenize in L phase at 380-100°C, but most of them at 280-120°C. Remnant quartz bears S L and G/L inclusions (3-15 µm long) with filling degree 70-100 vol. % and Th 370-100°C (most inclusions Th 370-120°C), all in L phase. By cryometry, inclusion fluids are Cl-Ca solutions of concentration 8-12 wt. %, rarely only 2.5 wt. %. Triple water leachates yielded the following composition of inclusion solutions: Na 67.5, Ca 31, K 1.5, HCO_3 73.5, Cl+F 35, SO_4 1.5; composition of gases (analysis of individual inclusions) is as follows (vol. %): N_2+rare gases 40-80, CO_2 8-42, acid gases 13-28, CO 6-20, CO_2 concentration in fluid ~1 mole/1 1 of water. (Abstract by A.K.)

GÖTZINGER, M.A., 1984a, The quantification of fluid inclusions in crystals by means of infrared spectroscopy, for example in fluorite: Fortschr. Mineral., v. 62, Beiheft 1, p. 74-76 (in German).

An infrared analysis of doubly polished fluorite plates, and cleavage plates, showed a positive correlation between the NaCl- resp. water-content and the sum of the absorption attributed to the 3400 cm^{-1} OH^- stretch vibration band.

To verify the use of the Lambert-Beer law, a series of fluorite plates of different thicknesses were made from samples of light-green fluorite from Stulln Hermine mine, BRD. These show, under the microscope, a homogeneous distribution of inclusions. The thickness of the plates varied from 0.2 to 0.78 mm. A 2-mm diaphragm permitted identical illuminated areas. Fig. 1 shows a satisfactory linearity between extinction and plate thickness at a constant concentration of fluid inclusions. For quantitative measurements, the range between 0.3 and 0.6 mm of plate thickness seems applicable; differences between polished plates and cleavage plates have not been observed.

The following basic specimen requirements should be observed: 1) the inclusions must be distributed homogeneously in the crystal; 2) the inclusions should not be larger than 0.05 mm diam.; 3) domains with solid inclusions and fissures must be avoided; 4) the plates must be plane parallel.

The content of water does not depend on the genesis, and younger formations generally have less inclusions, or none. The same can be said for the CO_2-content, which can also be detected quantitatively by this method (absorption band at 2340 cm^{-1}). The turbidity of the crystals generally correlates with the water content. Organic substances (C-H-absorption band at about 2900 cm^{-1}) appear in sedimentary fluorites and in those from alpine fissures; they can often be positively correlated with the water content. (Author's abstract, translation courtesy H.A. Stalder).

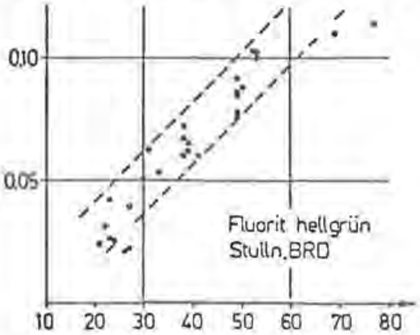


Fig. 1: Linear dependence of the extinction (ordinate = log I_0/I; OH-absorption-band at 3400 cm^{-1}) on the thickness of plates in fluorite (abcissa; mm/100), at the same concentration of H_2O-inclusions.

GÖTZINGER, A., 1984b, Sedimentary fluorite mineralization in Triassic carbonate rocks from the Drau area, Kärnten, Austria: Aufschluss, v. 35, p. 351-358 (in German).

A compilation on the fluorites in Triassic carbonate rocks. Fluid inclusions are mentioned, as well as REE-spectra. (Abstract courtesy H.A. Stalder)

GÖTZINGER, M.A. and WEINKE, H.H., 1984, Trace-element contents and genesis of fluorite mineralizations in the Gutensteiner-Schichten (Anis - Mid-Triassic), Northern Calcareous Alps, Austria: TMPM Tschermaks Min. Petr. Mitt., v. 33, p. 101-119.

Fluorite mineralization in fissures of the Gutenstein Strata (Anis - Mid-Triassic) is located in tectonic zones, near evaporites. The trace-element contents (including REE) of fluorite, calcite and dolomitic limestone have been determined by neutron activation analysis (NAA). Na- and Cl-contents have been measured by short-time-NAA. In fluorites with high Na- and Cl-contents three-phase inclusions are observed by microscope and are characterized by specific IR-spectra. Both the low trace-elements contents, especially in REE, and the distribution patterns of REE suggest an origin of the fluorites in a sedimentary environment. The inclusions in the fluorite suggest that the fluorites in the fissures of the Gutenstein Strata have been deposited from brines; evaporites occur in the immediate vicinity. The origin of fluorite is ascribed to fluorine-rich parts of Gutensteiner Kalk and/or dolomite. Dispersed fluorite occurs in bituminous carbonate sediments. (Authors' abstract)

GOW, A.J., 1984, Crystalline structure of urea ice sheets used in modeling experiments in the CRREL test basin: CRREL Report 84-24, ILIR Project No. DA4A161101A91D, Work Unit 347, 55 pp. Author at U.S. Army Cold Regions Res. & Engrg. Lab., Hanover, NH 03755.

This report describes the growth characteristics and crystalline textures of urea ice sheets which are now used extensively in the CRREL test basin for modeling sea ice. The aims of the report are to describe the different kinds of crystalline texture encountered in urea ice sheets and to show that even small variations in texture can drastically influence the mechanical behavior of urea ice sheets. Standard petrographic techniques for studying microstructure in thin sections were used on 24 urea ice sheets. These investigations entailed observations of the crystalline texture of the ice (including details of the subgrain structure), grain size measurements, and studies of the nature and extent of urea entrapment and drainage patterns in the ice. Increased knowledge of the factors controlling the crystalline characteristics of urea ice sheets has progressed to the point where test basin researchers at CRREL are now able to fabricate ice sheets with prescribed structures leading to predictable mechanical properties. (Author's abstract)

Contains numerous photographs showing the changes in fluid inclusions during recrystallization of the host. (E.R.)

GRAF, J.L., Jr., 1984, Effects of Mississippi Valley-type mineralization on REE patterns of carbonate rocks and minerals, Viburnum Trend, southeast Missouri: J. Geol., v. 92, p. 307-324.

GRAHAM, C.M., ATKINSON, Janet and HARMON, R.S., 1984, Hydrogen isotope fractionation in the system chlorite-water: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 139-140.

GRAHAM, C.M., HARMON, R.S. and SHEPPARD, M.F., 1984, Experimental hydrogen isotope studies: Hydrogen isotope exchange between amphibole and water: Am. Mineralogist, v. 69, p. 128-138. First author at Dept. Geol., Edinburgh Univ., Edinburgh, Scotland EH9 3JW.

Equilibrium hydrogen isotope fractionation factors (α^e(min-H_2O)) were determined experimentally for various amphiboles over the temperature range 350 to 950°C.

The water content of ferroan pargasitic hornblende (in equilibrium with water) decreased from 2.1 wt.% at 350°C to 1.2 wt.% at 950°C, probably because of oxy-hornblende reactions.

A consequence of the low activation energies calculated for hydrogen diffusion is that amphiboles in volcanic rocks may readily quench in their high-temperature hydrogen isotopic compositions, whereas amphiboles in slowly-cooled metamorphic and hydrothermal environments may continue to exchange hydrogen with a coexisting fluid down to temperatures much lower than those of initial amphibole crystallization. (From the authors' abstract)

GRANOVSKAYA, N.V., 1984, Mineralogy and thermobarogeochemistry of the Belaya Reka barite deposit (North-West Caucasus): Zapiski Vses. Mineral. Obshch., v. 113, no. 4, p. 454-463 (in Russian). Author at Rostov Univ., Rostov, USSR.

Two main commercial mineral associations were distinguished in the studied deposits: quartz-barite and galena-barite with fluorite (the latter subordinate). All described barite veins and stratiform bodies formed from Ca-Na-HCO_3-Cl solutions under P<40 MPa. Th of inclusions in barites of the first and second generation (of commerical value) are 180-140 and 90-70°C, respectively. Cooling of solutions is accompanied by increment of Ca/Na ratio in fluids. CO_2 occurs in inclusions in subordinate amounts. (Abstract by A.K.)

GRATIER, J.P. and JENATTON, L., 1984, Deformation by solution-deposition, and reequilibration of fluid inclusions in crystals depending on temperature, internal pressure and stress: J. Structural Geol., v. 6, no. 1/2, p. 189-200. Authors at I.R.I.G.M., BP 68, 38402 Saint Martin d'Hères Cédex, France.

Changes of shape and density of fluid inclusions in crystals were demonstrated when these crystals were subjected to temperatures and internal pressures greater than those of their growth. Experimental relations have been established between the rate of length-change of the inclusions and the different parameters of the experiment: nature of the crystal, temperature and internal pressure, state of stress on the crystal, geometric characters of the inclusion (length, width), orientation of the inclusion with respect to the optical axes of host mineral. It is essentially the effect of the variation of surface energy with the curvature around the cavity which causes a mass transfer of the host crystal by diffusion through the fluid under pressure. The rate of length-change is limited by the rate of dissolution at the median part of elongate inclusions. This change of shape and density is known to occur in naturally deformed crystals. An example of such a behavior is given which allowed us to use the inclusions as markers of the conditions of temperature and pressure subsequent to the growth of crystal. (Authors' abstract)

GREEN, H.W., II, 1984, "Pressure solution" creep: some causes and mechanisms: J. Geophys. Research, v. 89, no. B6, p. 4313-4318. Author at Dept. Geol., Univ. California, Davis.

Despite the widespread evidence of stress-controlled dissolution and precipitation in diagenetically altered and low-grade metamorphic rocks, a great deal of controversy remains concerning the driving forces and transport mechanism involved. To clarify the various driving forces, the free enthalpy equation is expanded here to allow identification of different terms contributing to the overall phenomenon. It is argued that under diagenetic conditions, stress concentrations at grain-to-grain contacts will be the largest source of chemical potential gradients and that upon burial and cementation these inhomogeneities decline and the orientation dependence of normal stress in a quasi-homogeneous stress field becomes important as well. These mechanisms operate efficiently enough under these relatively cold, H_2O-rich conditions that stresses can remain below the threshold for crystal plastic deformation. Water on grain boundaries provides at the very least a high diffusivity path and in cases of large volume losses must also contribute directly through fluid flow. Most experimental work on this phenomenon has not distinguished carefully between stress-enhanced solubility and solubility enhancement due to plastic deformation or microcracking. A new thermodynamic analysis of the results of some experiments by Sprunt and Nur suggests that in at least some of their experiments, true pressure solution creep has been activated. A related phenomenon, volume transfer creep during phase transformations which involve significant volume change, displays many of the characteristics of pressure solution. (Author's abstract)

GRIB, E.N. and SHUGUROVA, N.A., 1984, Gas-phase composition of the acid lavas of Uzon-Geyserny region (according to the results of a minor inclusion study): Vulkanol. Seismol. 1984, no. 3, p. 87-90 (in Russian). Authors at Inst. Vulkanol., Petropavlovsk-Kamchataskii, USSR.

During the Quaternary, three cycles of magmatic activity are recognized in the area each of which commenced with the extrusion of andesites and dacites and culminated with the formation of rhyolitic flows. The acidic rhyolite lavas consist of orthopyroxenes, clinopyroxenes, magnetite, rare olivine, etc. During the magma crystallization, mineral phenocrysts captured residual melts and gases (as bubbles). Results are presented of the microchemical estimation of CO_2, H_2S (+ SO_2 + SO_3 + HCl +HF), hydrocarbons, CO, H_2 and N_2 (+ rare gases) in the gas phase in plagioclase and in the glassy groundmass. (C.A. 101: 76310a)

GRICHUK, D.V. and BORISOV, M.V., 1983, A thermodynamic model of a hydrothermal system in the oceanic crust: Dokl. Akad. Nauk SSSR, v. 270, no. 2, p. 424-426 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 158-160, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 94, 1983. (E.R.)

GRIFFIN, W.L., WASS, S.Y. and HOLLIS, J.D., 1984, Ultramafic xenoliths from Bullenmerri and Gnotuk Maars, Victoria, Australia: Petrology of a sub-continental crust-mantle transition: J. Petrol., v. 25, Part 1, p. 53-87. First author at Min.-Geol. Museum, Sarsgt. 1, Oslo 5, Norway.

The basanite tuffs of Bullenmerri and Gnotuk maars, Victoria, enclose abundant xenoliths of spinel lherzolites, many of which contain amphibole ± phlogopite. The xenolith suite also includes cumulate wehrlites, spinel metapyroxenites and garnet metapyroxenites. All xenolith types contain abundant large CO_2-rich fluid inclusions. Microstructural evidence suggests that all the metapyroxenites have formed from cumulates by exsolution and recrystallization during cooling to the ambient geotherm. Garnet pyroxenites show a series of reactions to successively finer-grained, lower-P mineral assemblages, which imply a relatively slow initial upward transport of the xenoliths in the magma, prior to explosive eruption. The same process has allowed crystallization of phenocrysts from small patches of interstitial melt within xenoliths of lherzolite, wehrlite and metapyroxenite. (From the authors' abstract)

GRIGORYAN, S.V. and OVCHINNIKOV, L.N., 1984, Geochemical exploration methods for concealed mineralization (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 279-280 (in English). Authors at Inst. Mineralogy, Geochem. & Crystal. of Rare Elements USSR Ministry Geol. and Acad. Sci., Moscow, USSR.

The following types of concealed mineralization are distinguished: deposits covered by autochthonous formations; blind ore bodies with primary halos* exposed in the present erosion surface; blind-covered ore bodies, combining the features of the first two groups of deposits; buried-stripped by the ancient erosion surface and later overlapped by allochthonous sediments; blind-buried - occurring under allochthonous sediments. Prospecting of the first group of mineralization is based on their secondary halo detection. However, reliable evaluation of the revealed anomalies is possible only in case of satisfactory correlation between primary and secondary halos, when parameters of adequate primary halos are used for determination of the erosion level and the approximate scale of the concealed mineralization including distinguishing of zones with non-commerical dispersed mineralization. Prospecting of blind mineralization is carried out by revealing their primary halos exposed in the present erosion surface. During prospecting of blind-covered ore bodies, the degree of correlation between primary halos and secondary dispersion halos, formed during their hypergene decomposition, is preliminarily determined. Prospecting of buried and blind-buried mineralizations is carried out by detection of their superimposed halos (including gaseous ones) in overlapping allochthonous sediments. In recent years, increasing efficiency of prospecting of concealed ore bodies in the USSR depended on the successfully used universal geochemical zoning established for primary halos of sulphide-bearing hydrothermal deposits as well as on the application of halos multiplicative parameters, mineralogical-geochemical criteria and considering metasomatic zoning of the anomaly. (Authors' abstract) [*I.e., fluid inclusion features? Ed.]

GRINENKO, L.N., 1984, Hydrogen sulfide gas accumulations as a source of sulfur for sulfidation of magma in the commerical ore bearing intrusions of the Noril'sk region: Dokl. Akad. Nauk SSSR, v. 278, no. 3, p. 730-732 (in Russian). Author at Moscow State Univ., Moscow, USSR.

Gas samples from gabbro-dolerites of the Noril'sk intrusion, depth 880.9 m bear 47% H_2S, and from the depth 975 m - up to 67% H_2S. The author supposes that H_2S comes from H_2S-hydrocarbon deposits in underlying beds of the Tunguska oil-gas province. Sulfidation of magma might occur in the intermediate magma chamber. (A.K.)

GRINENKO, L.N., ARTEMENKO, V.M. and PONOMAREV, V.G., 1984, Sulfur isotope composition of rocks and ores of the Gorevskoye lead-zinc ore deposit: Geokhimiya, 1984, no. 5, p. 653-667 (in Russian; English abstract).

GRISHINA, S.N., 1984, Effect of CH_4 contents on the final melting temperature of CO_2 in the system CO_2-CH_4 (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 52-53 (in English). Author at Inst. Geol. & Geophy. Siberian Br. USSR Acad. Sci., Novosibirsk, USSR.

Liquid methane-CO_2 inclusions in halite from Dneprovsk-Donetsk depression are convenient for studying the system CO_2-CH_4 with various ratios of the components (to $X(CH_4) = 0.6$). The binary composition of the inclusions has been fixed by means of four independent methods. The presence of isolated groups of inclusions of similar types, high density of filling of the vacuoles and low temperature of their destruction permitted one to apply gas chromatography with various regimes of destruction, mass-spectrometry, freezing stage, crushing stage and Raman microprobe analysis to study the composition of the inclusions.

All methods have shown the presence of practically pure methane-CO_2 mixture in the studied inclusions. In several inclusions insignificant amounts of nitrogen ($X(N_2) \leq 0.005$) were found by Raman microprobe analysis and mass-spectrometry. Comparisons of various regimes of destruction for chromatographic determination has shown the change in the component composition at elevated temperature over 400°C.

The study of the same inclusions on the freezing stage and crushing stage permitted one to fix the correlation between the final melting temperature of CO_2 and the CH_4 contents. The obtained correlation makes it possible to evaluate the relationship of the components contained in methane-CO_2 inclusions found in minerals of various geological origin providing valuable information of physico-chemical parameters of the mineral-forming solutions. (Author's abstract)

GROVES, D.I., PHILLIPS, G.N., HO, S.E., HENDERSON, C.A., CLARK, M.E. and WOAD, G.M., 1984, Controls on distribution of Archaean hydrothermal gold deposits in western Australia, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 689-712. First author at Geol. Dept., Kambalda Nickel Operations, Kambalda, W.A.

Gold production from the Archaean of Western Australia (2100 tonnes Au) has come predominantly from discordant, epigenetic, but essentially stratabound deposits, mainly within tholeiitic metabasalt/metadolerite but also within BIF hosts in greenstone belts of the Yilgarn Block. Integration of presently-available data on the nature of auriferous veins and wall rock alteration, the association of gold with sulphide-rich, vein-related alteration, the predominantly syn- to post-peak metamorphic timing of mineralization, and the nature of primary fluid inclusions from auriferous quartz veins allows formulation of a genetic model for gold mineralization.

Gold appears to have been transported as reduced sulphur complexes in a hot, alkaline, reduced H_2O-CO_2 fluid of low salinity derived by metamorphic dehydration and decarbonation of greenstone sequences at upper amphibolite-granulite facies deep in the greenstone pile. These fluids were channeled along fault zones and access to a large volume of reactive host rock was provided by hydraulic fracture at high fluid pressures within or adjacent to the zones of fluid-access. Deposition over a P-T range of c. 0.8-2.0 kb and 300-450°C was largely related to fluid-wall rock interaction, which lowered total dissolved sulphur and changed pH and fO_2 of the fluid. The preferred host rocks -- tholeiites and BIF -- appear important because they provide Fe for pyritization (rarely pyrrhotization) reactions, determine Fe-related redox reactions, and are relatively competent and thus susceptible to hydraulic fracture. Apart from the reduction of dissolved gold species to elemental gold, there is no universal reaction leading to gold deposition. Therefore other rock types may also host gold mineralization and there are numerous small deposits in all rock types as well as the few large deposits in a more limited range of lithologies.

A number of regional controls of gold mineralization appear consequent on the metamorphic model for gold genesis. Most of the larger deposits occur in greenschist to amphibolite transition facies metamorphic domains, presumably reflecting a broad temperature interval (300-450°C) over which gold solubility decreased to levels where deposition could be readily induced by fluid-wall rock reactions. In many areas, vein-type mineralization is associated with broad, fault-bounded, anticlinal zones in which the hosts to gold mineralization are uplifted relative to flanking zones. Such a control is consistent with the initiation of hydraulic fracture in zones of high fluid pressure where lowering of confining pressure accompanied selective uplift.

The age of greenstone belts also appears to exert an important, albeit an indirect, control on the abundance and type of gold mineralization. Possible causes of much lower gold production from the older Pilbara terrain (c. 3.5 Ga) include unsuitable, sulphide- and gold-depleted source-rocks, early removal of gold by silicification, absence of suitable fluid components, and unfavorable metamorphic style. BIF-hosted deposits are important in the apparently older (c. 2.9-3.0 Ga) Murchison Province, whereas tholeiite-hosted deposits dominate the younger (c. 2.8 Ga) Eastern Goldfields Province. The apparent changes in the nature and abundance of gold deposits may reflect fundamental temporal changes in the magmatic, tectonic, and metamorphic evolution of greenstone belts. This can only be established when the province-scale setting of the gold deposits, the alteration and metamorphic histories of the greenstones, and the gold distribution in them are more fully understood. (Authors' abstract)

GUGUSHVILI, V.I., APKHAZAVA, M.A. and BAGDASARYAN, G.P., 1984, Conditions of formation of pyrite-barite-polymetallic deposits of the South-East Georgia: Sovetskaya Geologiya, no. 11, p. 48-56 (in Russian). First author at Geol. Inst. of Georgian Acad. Sci., Tbilisi, Georgia.

At the Madneuli deposit Th for chalcopyrite and pyrite ores is about 370°C and decreases for Cu-polymetallic, barite-polymetallic and quartz-barite - the latter 120-60°C. (A.K.)

GUIJARRO, U., HOYOS, M.A., CASA, J. and MARTIN DE VIDALES, J.L., 1984, Study of the fluid inclusions in the veins of the stockwork of Cerro de San Cristobal (Logrosan, Spain): Bol. Geol. Min. (Madrid), v. 94, no. 6, p. 521-529 (in Spanish; English abstract). First author at Dept. Geol. & Geoquimica. Facultad de Ciencias. Univ. Autonoma de Madrid.

In the stockwork running across the adamellitic apex of Cerro de San Cristobal (Logrosan, Spain) we have distinguished four generations of fractures which were refilled by mineralizing solutions. This process originated veins whose appearing order is: Type I veins, unproductive with NW-SE direction; Type II veins, with N-S direction slightly mineralized in sulphides; Type III veins with NE-SW direction and strongly mineralized in sulphides and cassiterite; Type IV veins, E-W direction and unproductive.

Homogenization temperatures of the primary fluid inclusions increase from Type I veins (228-242°C) to Type II (332-345°C) and reached in Type III veins a temperature up to 350°C. Thereinafter temperature falls in Type IV veins (318-338°C).

Relative homogenization temperatures of the secondary fluid inclusions are quite similar in the diverse vein generations because they are ranging between 236 and 254°C. (Authors' abstract)

GUILHAUMOU, Nicole, VELDE, Bruce and BENY, Claire, 1984, Raman microprobe analysis of gaseous inclusion in diagenetically recrystallized calcites: Bull. Minéral., v. 107, p. 193-202. First author at E.N.S. 46, rue d'Ulm, 75230 Paris Cedex, France.

Raman microprobe studies have been made on two core samples from the Smackover formation (Jurassic) Perry County Mississippi, at about 6.5 kilometers depth. Inclusions were found in calcite cements. Among other interesting aspects, one can see following gaseous inclusion assemblages - H_2S, CH_4, CO_2, carbon; H_2S, CH_4, CO_2, H_2O, carbon; and H_2S, CH_4, carbon where a characteristic low temperature behavior is noted for the CH_4-H_2S system. The solid phase appears to be a very poorly ordered form of graphite, similar to that found in the earliest stages of the kerogengraphite transition found in metagenesis. Other series of inclusions are calcic saline aqueous. Corrected Th for these inclusions are near those of the samples in situ. This indicates that the inclusions have readjusted to present conditions, those of present day bottom hole temperatures and pressures. Considering the importance of early decrepitation one can assume that a readjustment occurred between early entrapment conditions and those currently prevalent at depth.

The observations suggest either an evolution of gaseous inclusions up to the conditions of the upper stability of methane and methane-CO_2 mixtures in the presence of H_2O or the evolution of trapped hydrocarbon liquids which evolved to produce a gas-kerogen assemblage exempt of any organic molecules more complex than CH_4. (Authors' abstract)

GUMENYUK, V.A. and GLYUK, D.S., 1983, The ore-metamorphic zoning of gold-silver deposits: Dokl. Akad. Nauk SSSR, v. 269, no. 1, p. 179-184 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 41-44, 1984).
Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 97, 1983. (E.R.)

GUMENYUK, V.A., GRANOVSKIY, A.G., IVANISHENKO, A.K. and PROKOPOV, N.S., 1984, Relative role of thermobaric and geochemical factors in the formation of ore and metasomatic zoning (as exemplified by a gold-polymetallic deposit in the Priamur'ye): Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 979-984 (in Russian). First author at Far-East Sci.-Research Inst. Mineral Raw Materials, Khabarovsk, USSR.

The deposit occurs in the Lower Proterozoic granodiorite basement of a Mesozoic volcanic structure. It formed under 700-1000 m overburden of coal-bearing lake sediments, now mostly eroded together with the upper 500-meter-thick part of the deposit. The sediments prevented the influence of meteoric O_2 and CO_2, [permitting the] introduction of non-oxidizing Ca(Cl,B) solutions into the deposit formation zone. The deposit has vertical and asymmetric lateral zoning, in the following sequence from north to south and from the present-day surface to the bottom: 1. Sericite + quartz + chlorite + garnet + pyrite + sphalerite + pyrrhotite + Zn-spinel; 2. Sericite + quartz + garnet + pyrite + sphalerite; 3. Quartz + sericite + garnet + pyrite + sphalerite + galena; 4. Quartz + K-spar + sericite + garnet + pyrite; 5. Quartz + sericite + gold + argentite. The paper presents 158 determinations of Td by thermovacuum method for 11 minerals and Th values for inclusions in quartz; they show that all minerals, including Fe-Mn-Ca garnet and Zn-spinel, formed over the wide T interval 180-360°C, and for a number of samples at 160-400°C. T varies in vertical section by 100°C, and laterally by 20-80°C. Water leachates (15 determinations) yielded the composition of solutions: Ca, K, Fe, NH_3 (± Mg), Cl, sulfur ions, $HSiO_3$, F, B and admixtures of Na and HCO_3. The decrepitation of inclusions in the ranges of lower-T peak A (230 ± 20°C) released CO, CO_2 (the ratio $CO:CO_2$ ranges from 140 to 0.7), N_2 (and CH_4 in spinel), but in the ranges of higher-T peak B (320 ± 20°C) - CO, CO_2 ($CO:CO_2$ ratio 17-0.5), CH_4, NH_3, H_2S. The probable reactions producing these gases and influencing the $CO:CO_2$ ratio, are indicated. Pressures of formation are estimated for 0.2-0.5 kbar. (Abstract by A.K.)

GUNAWARDENE, Mahinda, 1984a Inclusions in taaffeites from Sri Lanka: Gems & Gemology, v. 20, p. 159-163. Author at Lanka Foundation for the Research of Gemstones, Colombo, Sri Lanka.

This article reports on a gemological and mineralogical study of inclusions in taaffeites from Sri Lanka, with photomicrographs of some of the most characteristic occurrences. The presence of minerals such as apatite, phlogopite, spinel, and muscovite is noted and their significance in the genesis of taaffeite is discussed. (Authors' abstract)

GUNAWARDENE, M., 1984b The internal paragenesis of taaffeite from Sri Lanka: Z. Dt. Gemmol. Ges., v. 33, no. 3/4, p. 91-95 (in German; English abstract).

Gemmological and mineralogical studies of the internal paragenesis of taaffeites from Sri Lanka are described. Photomicrographs of the most characteristic inclusions of taaffeites are given. The presence of such minerals as apatite, phlogopite, spinel, muscovite as well as the rare occurrence of zircon and garnet within the gem contribute to the knowledge of its origin. (Author's abstract)

GUNNESCH, M. and JAKSCH, H., 1984, Fluid inclusion studies in fluorite at Milpo Mine (Atacocha district), Central Peru, in Syngenesis and Epigenesis in the Formation of Mineral Deposits, A. Wauschkuhn, C. Kluth and R.A. Zimmerman, eds.: Springer, Heidelberg, p. 328-341. First author at Min.-Petrogr. Inst., Im Neuenheimer Feld 236, 6900 Heidelberg, FRG.

Fluid inclusions in fluorite from Milpo mine (Atacocha district) Central Peru provide interesting observations on the hydrothermal phase in these deposits. The inclusions can be divided into four compositionally distinct types. Type I (liquid + vapor + halite ± sylvite) shows homogenization temperatures between 415° and 345°C and salinities of 35-59 wt.% NaCl equiv. The evolution of this type takes place in the succession as follows: $I_a \rightarrow I_b \rightarrow I_c$. All inclusions for type I_a homogenize by halite disappearance. Type II (liquid + vapor) homogenizes to vapor in the same temperature range as type I_a. This fact suggests boiling conditions. Type III (liquid + vapor + halite) homogenizes between 190° and 350°C and contains 30-37.5 wt.% NaCl. Type IV homogenizes between 160° and 300°C and has low salinities of 6-18 wt.% NaCl. Type I inclusions occupy a compositionally distinct field in the NaCl-KCl-H_2O system and correspond to a fluid A of magmatic origin. The inclusions of type III and type IV occupy a very small field along the NaCl-H_2O boundary and represent a fluid B which initially had low salinity. The fluid A has gross densities of 1.10-1.05 g/cm^3 and the fluid B densities of 0.8-0.93 g/cm^3. Mixing phenomena of these fluids with different densities occur. The approximated pressure at the time of trapping is low, from 140 to 200 bars. (Authors' abstract)

GURAU, Andrei, 1984, Mineralization of fluorite in the Valea Caselor basin, Leaota Mountains (Arges County) [Romania]: Stud. Cercet. Geol., Geofiz., Geogr. Geol., v. 29, p. 55-60 (in Romanian). Author at Intreprinderea Prospectiuni Geol. Geofiz., Bucharest, Romania.

Fluorite occurs as vein and tectonic-breccia deposits associated with a pre-Jurassic fracture system in crystallized rocks (Leaota series) of the Voinesti-Papusa quartzofeldspathic complex. Associated minerals are galena, sphalerite, chalcopyrite, and auriferrous quartz. The fluorite crystals are 96.69% CaF_2; trace-element contents are Cu ∼100, Y 121-150, Yb ∼2, Sr 26-30, and Rb 17 ppm. Decrepitation and Th studies of fluid inclusions in fluorites indicate hydrothermal mineralization at 310-350°. Silicic magmatic activity at depth is the probable source of the mineralizing fluids. Textural and paragenetic relations suggest mineralization in several pulses related to repeated movement along a major fracture zone. (C.A. 102: 65085a)

GURNEY, J.J., HARRIS, J.W. and RICKARD, R.S., 1984a, Minerals associated with diamonds from the Roberts Victor mine, in Kimberlites, v. II: The mantle and crust-mantle relationships, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 25-32.

GURNEY, J.J., HARRIS, J.W. and RICKARD, R.S., 1984b, Silicate and oxide inclusions in diamonds from the Orapa mine, Botswana, in Kimberlites, v. II: The mantle and crust-mantle relationships, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 3-9.

GURULEV, S.A., 1983, Conditions of formation of basic layered intrusions: "Nauka," Moscow, 249 pp., 700 copies printed, price 2 rbls. 90 kopecks (in Russian).

The book describes varieties of layered intrusions, their structure, magma reactions with wall rocks, minerals of layered intrusions and conditions of formation of such intrusions. (A.K.)

GUTIERREZ, G.N. and KYLE, J.R., 1984, Nature and controls of sandstone-hosted lead deposits, Indian Creek district, southeast Missouri (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 526. Authors at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78713.

Fluid inclusion data for sphalerite from the Indian Creek mine indicate that the mineralizing fluid was a Na-Ca-Cl brine ranging in temperature from 100 to 120°C. The Lamotte served as the aquifer that channeled the metalliferous brines into the Bonneterre near depositional pinchouts. (From the authors' abstract)

GUTSALO, L.K., 1984a A new method for evaluating the helium isotopic balance in contemporaneous hydrotherms: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 985-987 (in Russian).

GUTSALO, L.K., 1984b Mantle helium, neon, and argon in cold waters of the Sinegorsk Springs (Sakhalin): Dokl. Akad. Nauk SSSR, v. 274, no. 6, p. 1457-1462 (in Russian).

HAGNI, R.D., 1984, Precambrian silver-tungsten-tin mineralization and its relationship to granitic magmatism in southeastern Missouri, USA: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 345-347.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 91, 1980. (E.R.)

HALAS, S., 1984, Isotope analysis on nano-mole gas samples: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 103-106: Leipzig, Akad. Wissen. der DDR (in English). Author at Inst. Physics, Maria Curie-Sklodowska Univ., 20-031 Lublin, Poland.

The technique of isotope analysis developed by Halas and Krouse has recently been adopted for extremely small-size samples at Maria Curie-Sklodowska University. 50-100 nmol of CO_2 extracted from gaseous inclusions in natural quartz shows $\delta^{13}C$ values around -24‰ which indicate an organic origin of this gas, while dispersed hydrocarbons extracted from Permian sediments (mainly CH_4) have $\delta^{13}C$ below -40‰. (Author's abstract)

HALFMAN, S.E., LIPPMANN, M.J., ZELWER, R. and HOWARD, J.H., 1984, Geologic interpretation of geothermal fluid movement in Cerro Prieto field, Baja California, Mexico: Am. Assoc. Petrol. Geol. Bull., v. 68, no. 1, p. 18-30.

HALL, W.E., SCHMIDT, E.A., HOWE, S.S. and BROCH, M.J., 1984, The Thompson Creek, Idaho, porphyry molydenum deposit - an example of a fluorine-deficient molybdenum granodiorite system: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 349-357. First author at U.S. Geol. Survey, Menlo Park, CA, USA.

The Thompson Creek molybdenite deposit is in a belt of I-type granitoid plutons extending from southeastern California to southeastern Alaska that host porphyry molybdenum systems. Molybdenite is associated with a composite biotite granodiorite/biotite granite stock of Late Cretaceous age that is near the east side of the Idaho batholith. Quartz-molybdenite stockwork veins occur within the stock in an elongate tabular body, closely associated with strong potassic alteration, that trends N 45° W and plunges 23° NW.

The geologic, fluid-inclusion, and isotopic data are consistent with a genetic model wherein magmatic fluids that evolved from differentiation of a granodioritic parent magma and caused extensive potassic alteration of the core and crest of a dome-shaped stock mixed with heated meteoric water during quartz-molybdenite deposition. Such mixing resulted in fluids with temperatures of 250° to 300°C, salinities of 6 to 11 wt % NaCl equivalent, and varying amounts of carbon dioxide. Lead-isotopic analyses and heavy $\delta^{34}S$ values indicate a deep crustal source from a 2.1-b.y.-old basement for the lead and sulfur. (Authors' abstract)

HALLBAUER, D.K., 1984, Characterization of pyrite by microinclusions and trace element content (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 54-55 (in English). Author at Chamber of Mines of S.A. Research Organization, Johannesburg, RSA.

As the most common ore mineral pyrite is present in many deposits, often as more than one generation. Mineragraphic differences are usually subtle or ambiguous and often absent. Characteristic differences between pyrites of diverse origin could, however, be obtained by comparing and correlating the type and nature of microinclusions with the trace elements contained in single pyrite grains. For this purpose between 10 and 30 pyrite grains per locality and of about 1 mm or more in diameter were split mechanically. Using electrothermal atomic absorption spectrophotometry one half of each grain was analyzed for 25 to 27 trace elements. The other half was mounted in a SEM to study and analyze the microinclusions and fluid inclusions. The most common microinclusions were found to be quartz, various phyllosilicates and feldspar in different combinations and proportions, and of different composition. Specific inclusions with regard to a classification were carbonates, anhydrite, magnetite and various sulphide minerals. Factor analysis and multivariate discriminant analysis of the trace element contents and their correlation [in a] particular inclusion finally completed the classification. Detrital pyrites from Witwatersrand conglomerates could thus be differentiated according to primary sources and their distribution mapped. (Author's abstract)

HALLEY, S., SOLOMON, M. and HIGGINS, N.C., 1984, Pressure, temperature and source conditions for the fluids of the Aberfoyle (Tasmania) tin-tungsten vein system (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 55-56 (in English). First author at Australian Nat'l. Univ., Canberra, Australia.

The Lutwyche sheeted vein system lies between the Aberfoyle and Storys Creek systems in NE Tasmania. The Lutwyche veins strike NW, N or NE, dip westerly, and cut folded pre-Devonian quartzwackes and shales. The veins are largely milky quartz with wolframite, cassiterite, sphalerite, chalcopyrite, pyrrhotite, pyrite, muscovite, topaz, fluorite and carbonates. Slices of country rock in the veins testify to repeated opening, and faulting and fine-scale fracturing is both pre- and post-vein formation. Poorly defined textures indicate quartz grew inward from the walls. Fluid inclusions in quartz are of five types: A, 3-phase with L-CO_2, V-CO_2 and aqueous solution of about 3.5 equiv. wt.% NaCl; B, 2-phase with V-CO_2 and aq. solution; C, 2-phase with aq. solution and vapor; D, multiphase with aq. solution, vapor and daughter salts; E, vapor with aq. solution. In types A and B Th (270-360°C) and compositional data (mole % CO_2) define CO_2-H_2O-NaCl solvii. Pressures estimated from experimental data are between 200 and 500 bars. Types D and E are relatively late and higher temperature (Th = 304 to 489°C) and represent the components of a CO_2-poor, two-phase H_2O-NaCl system. $S^{34}\delta$ values of sulphides range from -3.3 to +1.3‰ and $\delta^{18}O$ values of quartz from +13.94 to +14.90‰. Calculated fluid compositions indicate mainly magmatic solutions throughout vein history. Early solutions were near 350°C, with CO_2/CH_4 molar ratio >100:1 (R.W.T. Wilkins, pers. comm.), neutral to 1.5 units acid, total sulphur $>10^{-2}$ m, and $fO_2 \approx 10^{-31}$ or lower. Later solutions were higher temperature and CO_2-poor. The veins grew by rapid precipitation during repeated phases of fracture dilation. The pressure range recorded may reflect oscillation from lithostatic to hydrostatic. Gas loss during phases of fluid immiscibility developed during pressure drop possibly led to fall in temperature, and increase in pH and fO_2; these were probably the major factors in mineral precipitation. (Authors' abstract)

HAMPTON, C.M. and BAILEY, D.K., 1984, Gas extraction experiments on volcanic glasses: J. Non-Crystalline Solids, v. 67, p. 147-168. Authors at Dept. Geol., Univ. Reading, Whiteknights, Reading, RG6 2AB, England.

Glasses from a range of geological environments and of various compositions, were heated through the range 600-1250°C, and the released gases were continuously analyzed by mass spectrometer. Gas release-temperature profiles fall into two broad groups. Felsic glasses (>60 wt% SiO_2) have simple gas emissions, where the gas species peak at the melting temperature; this is controlled by a simple viscosity-temperature relationship. Mafic glasses (<50 wt% SiO_2) have complex gas release profiles where gases peak at different temperatures. H_2O emitted ~200°C below the main release of the other gases. These glasses have a complex viscosity-temperature relationship which is affected by nucleation and crystallization induced by heating. The felsic/mafic division depends on the ratio of network forming to network modifying ions. It appears that the mafic glasses, which have a large excess of network modifying ions, over those required to maintain charge balance in the silica-alumina framework, produce a more open glass structure which enables easier diffusion of gases and less strongly bonded ions. Gas emissions often accompany structural changes such as glass transformation, nucleation, liquid exsolution, and phenocryst melting. Temperatures of release suggest that CO_2 occurs in molecular form as CO_3^{2-}, while H_2O occurs as OH^- in the glass/melt. (Authors' abstract)

HANNAH, J.L. and STEIN, H.J., 1984, Evidence for changing ore fluid composition: stable isotope analyses of secondary carbonates, Bonneterre Formation, Missouri: Econ. Geol., v. 79, p. 1930-1935.

HANOR, J.S., 1984a Variation in the chemical composition of oil-field brines with depth in northern Louisiana and southern Arkansas: implications for mechanisms and rates of mass transport and diagenetic reaction: Transactions - Gulf Coast Assoc. Geol. Soc., v. 34, p. 55-61.

HANOR, J.S., 1984b Determining pore-water salinities from SP response: a thermodynamic reevaluation (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Author at Louisiana State Univ., Baton Rouge, LA.

Quantitative knowledge of the salinity of deep formation waters is critical in assessing the degree of hydrocarbon saturation in sands, in predicting methane solubility, and in deducing pathways of fluid migration. Calculation of salinity from the spontaneous potential (SP) response of borehole logs using conventional algorithms can yield inaccurate values, particularly for geopressured waters. Thus, a theoretical reevaluation has been made of the relation between pore-water salinity in NaCl-dominated waters and SP response, taking into account pressure as a variable and recently-developed, improved, thermodynamic models for brines.

The following expression satisfactorily relates pore-water salinity, as molality of total dissolved NaCl, to the static spontaneous potential (SSP) over P-T-salinity conditions of sedimentary interest:

$$\log m\ \text{NaCl (pore water)} = (\text{SSP} \times F)/(2.303\ RT \times b \times t) + \log m\ \text{NaCl (mud filtrate)}$$

where m = molality, F = faraday constant, R = gas constant, and T = absolute temperature. The complex, non-ideal behavior of NaCl solutions can be described by a single, pressure-temperature dependent, concentration independent variable, b. The term t accounts for the differential mobility of Na^+ and Cl^- ions through sands and shales.

Use of the equation provides several important advantages over conventional techniques: (1) pore water salinity is given explicitly as a dependent variable, facilitating analysis of error; (2) the expression is simple and avoids use of electrical resistivities, which have no direct theoretical role in the relation between SP and salinity; (3) the improved thermodynamic base provides a more rigorous means of assessing the effects of grain size, mineralogy, and streaming potential on SP response. (Author's abstract)

HANSEN, E.C., NEWTON, R.C. and JANARDHAN, A.S., 1984a Fluid inclusions in rocks from the amphibolite-facies gneiss to charnockite progression in southern Karnataka, India: direct evidence concerning the fluids of granulite metamorphism: J. Metamorphic Geol., v. 2, p. 249-264. First author at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL 60637, USA.

Fluid inclusion studies of rocks from the late Archaean amphibolite-facies to granulite-facies transition zone of southern India provide support for the hypothesis that CO_2-rich H_2O-poor fluids were a major factor in the origin of the high-grade terrain. Charnockites, closely associated leucogranites and quartzo-feldspathic veins contain vast numbers of large CO_2-rich inclusions in planar arrays in quartz and feldspar, whereas amphibole-bearing gray gneissses of essentially the same compositions as adjacent charnockites in mixed-facies quarries contain no large fluid inclusions. Inclusions in the northern-most incipient charnockites, as at Kabbal, Karnataka, occasionally contain about 25 mol. % of immiscible H_2O lining cavity walls, whereas inclusions from the charnockite massif terrane farther south do not have visible H_2O.

Microthermometry of CO_2 inclusions shows that miscible CH_4 and N_2 must be small, probably less than 10 mol. % combined. Densities of CO_2 increase steadily from north to south across the transitional terrane. Entrapment pressures calculated from the CO_2 equation of state range from 5 kbar in the north to 7.5 kbar in the south at the mineralogically inferred average metamorphic temperature of 750°C, in quantitative agreement with mineralogic geobarometry. This agreement leads to the inference that the fluid inclusions were trapped at or near peak metamorphic conditions.

Calculations on the stability of the charnockite assemblage biotite-orthopyroxene-K-feldspar-quartz show that an associated fluid phase must have less than 0.35 H_2O activity at the inferred P and T conditions, which agrees with the petrographic observations. High TiO_2 content of biotite stabilizes it to lower H_2O activities, and the steady increase of biotite

TiO_2 southward in the area suggests progressive decrease of aH_2O with increasing grade. Oxygen fugacities calculate from orthopyroxene-magnetic-quartz are considerably higher than the graphite CO_2-O_2 buffer, which explains the absence of graphite in the charnockites.

The present study quantifies the nature of the vapors in the southern India granulite metamorphism. It remains to be determined whether CO_2-flushing of the crust can, by itself, create large terranes of large-ion lithophile-depleted granulites, or whether removal of H_2O-bearing anatectic melts is essential. (Authors' abstract)

HANSEN, E.C., NEWTON, R.C. and JANARDHAN, A.S., 1984b, Pressures, temperatures and metamorphic fluids across an unbroken amphibolite facies to granulite facies transition in southern Karnataka, India: Archaean Geochem., 1984, p. 161-181. Authors at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL 60637, USA.

Geobarometry based on the indicator assemblage garnet-pyroxene-plagioclase-quartz indicates regular increase in pressure of metamorphism from ~5 near Channapatna (12°40'N) to 7.5 kbar in the highest-grade rocks, near 12°00'N. Geobarometry based on densities of CO_2 fluid inclusions in quartz, determined from Th measurements from seven localities, agrees quant. with the mineralogic geobarometry. The average temperature in the transition zone is 750°, as determined by the Fe and Mg distribution between garnet and pyroxene pairs. The K/Rb whole-rock ratios of charnockites and gray gneisses are ~300 (normal upper crust values) in the northern half of the traverse and increase southward to very high values, indicating extreme Rb depletion, where charnockite becomes the dominant country rock. This depletion is patchy, even in the southernmost high-grade massif areas. Continuous prograde transition south of Kabbal is established. A depth-zone arrangement of amphibolite facies and granulite facies is indicated. The source of CO_2 in inclusions was deep-seated and streaming of CO_2-rich fluid was an important process in charnockite formation. (C.A. 102: 98676x)

HARDIE, L.A., 1984, Evaporites: Marine or non-marine?: Am. J. Sci., v. 284, p. 193-240. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218.

It is imperative to find criteria to distinguish marine from non-marine evaporites, particularly in view of the growing recognition of the significance of salt deposits in global tectonics. It is crucial to recognize that a marine depositional setting does not guarantee that the salts were derived mainly or exclusively from seawater, but that the extreme hydrologic restriction necessary for evaporite formation means that there could be a significant, perhaps even dominant, non-marine water input, as demonstrated by many modern sabkhas.

The specific criteria for making these distinctions are the following: (1) kinds of fossils, (2) sedimentology of the associated non-saline facies, (3) kinds of primary saline minerals, (4) association of such saline minerals, both in qualitative and quantitative terms, (5) trace element, isotope, and fluid inclusion geochemistry of such saline minerals. The first two tell us mainly about the depositional setting while the third and fourth are the most reliable signatures of parent water chemistry. The last criterion, involving geochemical tracers such as Br, contrary to widely held belief, is not an unequivocal one for distinguishing between marine and non-marine parent waters and in fact can yield misleading results if sampling and interpretation are not guided by petrographic study. (From the author's abstract)

HARDWICK, J.F., Jr., 1984a Epithermal vein and carbonate replacement mineralization related to caldera development, Cunningham Gulch, Silverton, Colorado: MS thesis, Univ. Texas at Austin, Austin, TX.

Epithermal vein and carbonate replacement deposits in Cunningham Gulch are located within the western San Juan Tertiary volcanic field in southwestern Colorado.

Regional propylitic alteration of the hosting volcanics to a chlorite-calcite-pyrite assemblage preceded vein-associated alteration and mineralization. The veins are enveloped by a narrow phyllic alteration assemblage of quartz, sericite, illite, kaolinite, and pyrite. The veins are comprised of sphalerite, galena, chalcopyrite, pyrite, hematite, magnetite, quartz, pyroxmangite, calcite, and minor barite. Substantial bodies of replacement ore are present where the vein structures intersect the limestone blocks; the mineral assemblages of the replacement deposits are identical to those of the feeding vein structures. Commonly, replacement textures are spectacular concentrations, especially the "zebra ore" which primarily consists of regularly spaced, alternating bands of sulfides and quartz. These "zebra" laminations are stratigraphically controlled and appear to represent replacement of a depositional or diagenetic fabric. Main ore-stage mineralization began with widespread deposition of quartz with or without pyrite, followed by sphalerite, chalcopyrite, and galena. Post ore-stage brecciation and silicification events are evident and were followed by deposition of calcite and minor barite during the waning stages of the hydrothermal system.

The distibutions of Fe, Mn, Pb, and Ca suggest a lateral component of fluid flow from northwest the southeast, away from the structural margin of the Silverton Caldera. Fluid inclusion data from both vein and replacement-type sphalerite and quartz indicate that mineral deposition occurred over a range of 200 to 312°C (mean 243°C) from solutions containing 1 to 5% total salts. The high base metal to precious metal content of the ore, the phyllic alteration assemblage, and the temperature and composition of the ore-forming fluid indicate that the mine workings are within the lower portion of a fossil geothermal system. (From the author's abstract)

HARDWICK, J.F., 1984b Epithermal vein and carbonate replacement mineralization in Cunningham Gulch, Silverton, Colorado (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 224. Author at Dept. Geol. Sci., The Univ. Texas at Austin, Austin, TX 78712.

Vein and carbonate replacement ore deposits occur in the area and are largely hosted by the caldera-collapse breccia. Veins are comprised of sphalerite, galena, chalcopyrite, pyrite, hematite, magnetite, quartz, pyroxmangite, calcite, and minor barite. Substantial bodies of replacement "zebra" ore are present where the carbonate blocks are intersected by feeder veins. Although the major flux of fluid flow was probably directed upward within this highly fractured area, the distribution of Fe, Mn, Pb, and Ca suggests a lateral component of fluid flow from northwest to southeast along the vein system, away from the structural margin of the Silverton Caldera. Fluid inclusion data indicate that mineral deposition occurred over a range of 201-312°C from solutions containing 1-5% NaCl eq. These features indicate that the mine workings are within the lower portion of a fossil geothermal system. (From the author's abstract)

HARRIS, D.M. and ANDERSON, A.T., Jr., 1984, Volatiles H_2O, CO_2 and Cl in a subduction related basalt: Contrib. Mineral. Petrol., v. 87, p. 120-128. First author at Dept. Geol., Univ. Oregon, Eugene, OR 97403-1272, USA.

The products of the 1974 eruption of Fuego, a subduction zone volcano in Guatemala, have been investigated through study of silicate melt inclusions in olivine. The melt inclusions sampled liquids in regions where olivine, plagioclase, magnetite, and augite were precipitating. Comparisons of the erupted ash, groundmass, and melt inclusion compositions suggest that the inclusions represent samples of liquids present in a thermal boundary layer of the magma body. The concentrations of H_2O and CO_2 in glass inclusions were determined by a vacuum fusion manometric technique using individual olivine crystals (Fo77 to Fo71) with glass inclusion compositions that ranged from high-alumina basalt to basaltic andesite. Water, Cl, and K_2O concentrations increased by a factor of two as the olivine crystals became more iron-rich (Fo77 to Fo71) and as the glass inclusions increased in SiO_2 from 51 to 54 wt.% SiO_2. The concentration of H_2O in the melt increased from 1.6 wt.% in the least differentiated liquid to about 3.5% in a more differentiated liquid. Carbon dioxide is about an order of magnitude less abundant than H_2O in these inclusions. The gas saturation pressures for pure H_2O in equilibrium with the melt inclusions, which were calculated from the glass inclusion compositions using the solubility model of Burnham (1979), are given approximately by $P(H_2O)(Pa) = (SiO_2 - 48.5 \text{ wt.\%}) \times 1.45 \times 10^7$. The concentrations of water in the melt and the gas saturation pressures increased from about 1.5% to 3.5% and from 300 to 850 bars, respectively, during pre-eruption crystallization. (Authors' abstract)

HART, Roger and HOGAN, Lewis, 1984, Solar noble gas component in glassy submarine basalts (abst): Lunar and Planet. Sci. XV, p. 347.

HART, S.R., 1984a Studies of temporal variations of lead isotopes in ore fluids related to Mississipi-Valley-type ore deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 32-39.

HART, S.R., 1984b He diffusion in olivine: Earth & Planet. Sci. Letters, v. 70, p. 297-302. Author at Center for Geoalchemy, Dept. Earth, Atmospheric & Planet. Sci., Mass. Inst. Tech., Cambridge, MA 02139, USA.

Helium diffusion in olivine (dunite xenolith) has been measured in the temperature range 1180-1460°C; a linear Arrhenius function was obtained with an activation energy of 120^{+32}_{-27} kcal/mole, and a pre-exponential factor $(D_0) = 2.2 \times 10^8$ cm^2/s.

Diffusion mechanisms are not a viable means of degassing He from the mantle. Olivine phenocrysts can be expected to retain previously trapped He, during cooling in extrusive basalts, provided the flow units are thinner than $\approx$ 50 m; xenoliths will retain mantle He signatures only if magma transport times are less than $\approx$ 50 years, or if the He fugacity in the magma is high enough to prevent xenolith degassing. The lower oceanic crust is probably substantially degassed of He. Trapped He will be qualitatively retained in quenched submarine basalt glass only if the cooling rate is faster than $\sim 5 \times 10^{14}$°C/m.y.; glass at several centimeters depth in a basalt flow (near the spherulite zone) will have cooling rates lower than this, so He loss may be significant in many basalt glass samples. (Author's abstract)

HARWOOD, A., 1984, Geothermometric studies at the Chojlla mine, Bolivia (abst.): J. Geol. Soc., v. 141, part 2, p. 391-392. Author at Univ. Cardiff.

The Chojlla tin tungsten deposit is situated in the Cordillera Real to the NE of La Paz, Bolivia. The mine is the most important tungsten producer in Bolivia, and ranks ninth in world producers. The deposit is closely associated with the contact of the Taquesi batholith, of Triassic age, part of which is exposed as dyke-like genetic apophyses in the lower levels of the mine. It is enclosed within a thick pile of Upper Ordovician slates, which have been metamorphosed and metasomatically tourmalinized. The slates dip uniformly NE and are cut at right angles by a system of parallel en-echelon ore-bearing quartz veins which dip to the SW.

The deposit is of the hydrothermal type (high temperature) with ore minerals wolframite and cassiterite, with minor sulphide minerals in veins consisting of over 95% quartz.

Detailed mineralogical studies revealed a single prolonged hydrothermal history, divided into a number of phases:

1. Greisen stage: alteration phase associated with some tungsten mineralization in the granite apophyses;
2. Early vein stage: dominated by deposition of quartz, cassiterite, wolframite, arsenopyrite and apatite;
3. Main vein stage: deposition of quartz and sulphides; Pyrite chalcopyrite, sphalerite, pyrrhotite and minor stannite;
4. Late vein stage: alteration of pyrrhotite to 'Bird's eye' pyrite and marcasite aggregates, deposition of galena, fluorite and siderite.

Fluid inclusion data for quartz, cassiterite, fluorite and siderite were obtained from vein sections and various veins from the different levels of the mine. These revealed decreasing Th with vein paragenesis from 400°C (Greisen stage) to 280°C (Late vein stage). This also corresponded to a rise and fall in salinity from 20 wt% NaCl (Greisen stage) to 24 wt% NaCl (Early vein stage) down to 14 wt% NaCl in the Late vein stage. Data from vein sections revealed a dramatic decrease in salinity between the ore-bearing Early vein stage to the sulphide Main and Late vein stages. Some boiling is also evident in the fluid inclusions from the Greisen and Early vein stage.

Detailed E.P.M.A. studies were also performed on the validity of the arsenopyrite and wolframite geothermometers; the former revealed a similar picture to the fluid inclusion data. Sphalerite geobarometric studies were applied to resolve problems in depth of burial and pressure corrections--these proved erratic.

Sulphur isotope geothermometry was also applied to sulphide pairs (sphalerite-pyrrhotite and sphalerite, chalcopyrite) appearing to coexist; the study revealed that, in fact, pairs were not in isotopic equilibrium when deposited. (Author's abstract)

HASELTON, H.T., Jr., 1984, Solubility of quartz in dilute HF solutions at 600°C and 1 kbar (abst.): EOS, v. 65, p. 308.

HASZELDINE, R.S., SAMSON, I.M. and CORNFORD, C., 1984a Dating diagenesis in a petroleum basin, a new fluid inclusion method: Nature, v. 307, p. 354-357. First author at Britoil PLC Stratigraphic Lab., 150 St. Vincent St., Glasgow G2 5LJ, UK.

The final porosity and permeability of sandstone petroleum reservoirs is greatly affected by the diagenetic growth of minerals after deposition. For example a sand may be deposited with a porosity of 25% and a permeability of 5,000 mdarcy (mD); diagenetic growth of quartz around detrital sand grains may leave a rock with only 10% porosity, and later growth of clays may partly fill these remaining pores and block inter-pore connections, reducing permeability to 100 mD. If the depth and timing of such diagenetic alteration can be measured and the extent of diagenesis estimated, then prediction of the diagenetic state of undrilled sandstones may become possible and diagenesis related more closely to the timing of hydrocarbon migration and the formation of hydrocarbon traps. We present an example of a new method for estimating the date of quartz diagenesis using a combination of techniques from thin section petrogaphy, fluid inclusion thermometry, organic geochemical thermometry and sedimentary basin stratigraphic analysis. These results suggest that quartz in the Beatrice oil field was precipitated from moving and cooling pore fluids, at a temperature between 68°C and 94°C in the late Jurassic. (Authors' abstract)

HASZELDINE, R.S., SAMSON, I.M. and CORNFORD, C., 1984b, Quartz diagenesis and convective fluid movement: Beatrice oilfield, UK North Sea: Clay Minerals, v. 19, p. 391-402. First author at Stratigraphic Lab., Britoil, 150 St. Vincent St., Glasgow G2 5LJ.

The extent of diagenesis in Lower Jurassic shoreline sandstones of the Beatrice oilfield was controlled primarily by their detrital clay content. Sandstones rich in detrital clay had low depositional permeabilities; these show preservation of detrital feldspars to the present day and have no extensive diagenetic quartz overgrowths. Sandstones poor in detrital clay had high permeabilities and show large quartz overgrowths as part of a normal sub-arkosic diagenetic sequence. Such quartz occurs preferentially below, but not above, impermeable mudstones. These low- and high-permeability features suggest that pore-fluid flow was important during diagenesis. Fluid inclusions trapped in diagenetic quartz overgrowths formed between 68° and 94°C. This silica was probably supplied in solution from the temperature-driven illitization of smectitic clays surrounding these sandstones deeper in the basin. Fluid volumes from clay dewatering, from mechanical compaction, or from influx of overlying seawater were too small to transport diagenetic silica volumes. Silica-rich fluids were probably transported up-dip by convective cells within the sandstones and authigenic quartz precipitated as these fluids cooled. This episode of quartz diagenesis could not have been completed within $1{\cdot}6 \times 10^6$ yr if fluid velocities were 3·1 m/yr. Similar convective fluid flows could have transported the fluids responsible for secondary porosity development and the hydrocarbons expelled from mudstones later in the basin burial history. (Authors' abstract)

Salinity of inclusions in quartz overgrowths was 8-17 wt.% NaCl equiv. Organic isomer measurements on associated mudrocks yielded a maximum temperature of 78-94°C. Pressure estimates are also made. (E.R.)

HAWKSWORTH, M.A. and MEINERT, L.D., 1984, Fluid inclusion characteristics and mineral zoning in the Groundhog vein system, Central district, New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 532-533. First author at FMC Corp., Suite 2720, City Center 4, 1801 California St., Denver, CO 80202.

In the upper 300 m of the Groundhog Mine, Zn-Pb-Ag-Cu mineralization associated with quartz veins has been deposited in open fissures along faulted diorite sill-granodiorite porphyry dike contacts. Vein ore bodies extend to within 2.5 km of the Santa Rita porphyry Cu deposit, and overlie extensive skarn mineralization deeper in the Groundhog Mine. Th for 600 inclusions show: primary inclusions in quartz 270-405°C, with a peak near 313°C, and evidence for local boiling at 390°C. Primary Type I inclusions in sphalerite 270-340°C, with a peak at 305°C. Paragenetic relations show sphalerite deposited later and at lower temperatures than most quartz stages. 134 salinity determinations indicate that hydrothermal fluids contained an average of 7 wt.% NaCl equiv. during sulfide deposition, within a range of 1 to 11 wt.%. Daughter minerals, possibly dawsonite, anhydrite, and carbonate, are present in some inclusions. Based on evidence of boiling, a pressure estimate of 220 to 250 bars has been determined. This implies mineralization occurred at a depth between 1000 m (lithostatic est.) and 3600 m (hydrostatic est.), and suggests a pressure correction of 10 to 20°C should be added to Th. Fluid inclusion characteristics are similar to those in the underlying skarn, the phyllic alteration stage at Santa Rita, and the deep root zones below some epithermal Au-Ag vein systems. (From the authors' abstract)

HAYBA, D.O., 1984, Documentation of thermal and salinity gradients and interpretation of the hydrologic conditions in the OH vein, Creede, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 534. Author at U.S. Geol. Suvey, MS-959, Reston, VA 22092.

Detailed fluid inclusion studies (Roedder, 1977, IAGOD, v. 2) on growth banded sphalerite from the OH vein showed that the color variations of growth zones correspond to abrupt changes in the nature of the ore fluids. The base of a distinct orange-brown growth zone marks a sharp increase in both temperature and salinity relative to the preceding yellow-white zone and provides a useful time line throughout the vein. Along this marker horizon, temperatures and salinities of fluid inclusions show a gradual decrease from about 280°C and 12 wt.% NaCl eq. at the basal, northern end of the vein to 250°C and 8 wt.% NaCl eq. at localities 200m higher and 1000m further to the south. This thermal and salinity gradient, which matches the fluid flow path inferred from metal zoning, is interpreted as the progressive mixing of deeper, saline hydrothermal fluids with overlying, dilute ground waters that have been preheated to ~160°C. The greater density of the overlying ground water promoted convective mixing, resulting in solutions that were >30% ground water in the upper parts of the vein. Occasionally, these upper levels were totally engulfed by these overlying waters (Foley et al., 1982, GSA Abs., v. 14, no. 7). Localities in the lower vein levels show discrete salinity variations, which suggest that the hydrothermal component may have undergone an earlier (deeper) period of mixing before mixing with ground water high in the system.

Where it is possible to establish a time line, thermal and salinity gradients provide a means of distinguishing among cooling due to conduction, boiling, or mixing. Whereas boiling is an effective depositional mechanism and has been documented in the upper levels of the OH vein, this study shows that at least some of the coarse-grained sphalerite deposition resulted from mixing high in the system of a deep, hot, saline fluid with an overlying, dilute water. (Author's abstract)

HAYBA, D.O., FOLEY, N.K. and HEALD-WETALUFER, P., 1984, Characteristics that distinguish types of epithermal deposits (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 21. Authors at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

Three distinctive groupings of epithermal deposits were recognized from a literature study of fifteen well-described precious- and base-metal epithermal districts, supplemented by L.J. Buchanan's 1981 compilation of data from 47 less-completely documented deposits. The three groups are distinguished primarily by the type of alteration and the sulfur fugacity indicated by the vein mineral assemblage. Additional discriminating criteria include composition of the host rock, timing of ore deposition relative to emplacement of the host, and relative abundances of gold, silver, and base-metals. The first group, typified by Goldfield, Nevada, has advanced argillic alteration and a vein mineral assemblage (enargite + pyrite ± covellite) which reflects relatively high sulfur fugacities. Both gold- and silver-rich members are present and have moderate concentrations of base metals, notably copper. Ore deposition in this group closely followed emplacement of the host which in most cases is rhyodacite. The second group, typified by Creede, Colorado, has sericitic ± argillic alteration, a less-sulfidized vein mineral assemblage, and adularia. This group tends to have high concentrations of silver and moderate to high concentrations of base metals, especially lead and zinc. The third group, for example, Round Mountain, Nevada, has sericitic alteration, a vein mineral assemblage that reflects low sulfur fugacities, and adularia. Compared with the other groups, sulfides and sulfosalts are rare. The main ore minerals are native gold and silver, and electrum, with silver/gold ratios near unity. For the latter two groups, ore deposition usually occurred significantly later (>1 m.y.) than emplacement of the host rocks. These distinguishing features provide significant constraints for genetic models of epithermal mineralization. (Authors' abstract)

HAYNES, F.M., 1984, A geochemical model for sulfide paragenesis and zoning in the Cu-Fe-As-S system (Tsumeb, South West Africa/Namibia): Chem. Geol., v. 47, p. 183-190. Author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

The Cu-bearing hypogene mineralization at Tsumeb, south west Africa/Namibia, is interpreted to have resulted from the interaction of hot circulating Cu-rich saline solutions and host dolomites. Fluids attending formation of the main sulfide stage were warm (210-280°C) and moderately saline (6-12 wt.% NaCl equivalent).

Phase relations within the Cu-Fe-As-S system suggest that the observed paragenetic sequence (chalcopyrite → bornite → chalcocite → enargite → tennatite) is consistent with a model calling for successive introduction of a single Cu-rich solution into a host dolomite. The Cu and As content of the solution decreased as it passed through the permeable dolomite precipitating Cu-As-sulfides and sulfosalts. A concomitant increase in pH created by the dissolution and buffering effect of dolomite produced sufficient changes in the fluid chemistry to shift the stable sulfide mineral assemblage. (Author's abstract)

HAYNES, F.M. and KESLER, S.E., 1984a. Evolution of brine chemistry during sulfide deposition in the East Tennessee zinc district (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 535. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Energy dispersive SEM analyses of fluid inclusion decrepitates from the East Tennessee Zinc District (ET) reveal major differences among inclusion compositions in sphalerite, ore-stage gangue dolomite, and regional unmineralized dolomite. $CaCl_2$/NaCl ratios fluctuated from as low as 0.2 in unmineralized dolomite and early light-colored ZnS to as high as 1.5 in later darker ZnS and ore-associated dolomite.

These differences are thought to record changes in fluid chemistry as metal-transporting basinal brines deposited ZnS. Brines entering the Knox Group limestone units apparently encountered sufficient S to deposit early light green ZnS whose inclusions contain Ca/Na ratios only slightly higher than those detected in unmineralized dolomite from brines that presumably did not deposit ZnS. Concomitant with sulfide deposition these brines dissolved limestone creating the widely recognized "limestone edge" as the

ZnS depositing reaction is acid producing ($ZnCl_2(aq) + H_2S = ZnS + 2HCl(aq)$). This dissolution of limestone lead to a local increase in the Ca/Na ratio of the fluid as observed in the inclusion decrepitates from the later dark green ZnS and the solution cooled to 120-150°C as observed in fluid inclusions. The presence of several alternating bands of light and dark ZnS indicates that this cycle was repeated as each new pulse of warm (150-180°C) metalliferous brine entered the limestone. Formation of post-ore dolomite ("snow on the roof") followed the final influx of brine after the acid producing, sulfide generating process ceased.

No sulfur was detected in any of the decrepitates suggesting that ZnS deposition in ET may have been limited by S availability, unlike other MVT districts (Pine Point) where abundant S has been detected and where the amount of metal-rich brine may limit sulfide deposition. (Authors' abstract)

HAYNES, F.M. and KESLER, S.E., 1984, Direct measurement of the major element chemistry of individual fluid inclusions, Pine Point district, N.W.T. (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 72. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

We have refined a method of determining the major element chemistry of individual fluid inclusions by SEM energy dispersive analysis of evaporites produced on polished thick sections by thermal decrepitation of individual fluid inclusions. Application of this method to Mississippi Valley-type mineralization at Pine Point, N.W.T. reveals that fluids attending sulfide deposition were predominantly Na-Ca chloride brines. Subordinate but significant amounts of K, Mg, and Fe are also observed. A significant population of inclusion evaporites from sphalerite and dolomite also contain appreciable S, occasionally in amounts equalling or exceeding Cl. A 10 to 30% excess of cations in the analyses of many of the S-rich salts may signal the presence of carbonate species undetectable in energy dispersive analysis.

While the Na-Ca chloride chemistry of Pine Point fluids is in reasonable agreement with similar analyses in sphalerites from MVT ore in East Tennessee, the presence of S as a major anion in Pine Point inclusion evaporites represents a significant difference from the East Tennessee ores. If equilibrium is assumed, the presence of Ca and S together in the Pine Point inclusion evaporites without daughter anhydrite requires reduced sulfur speciation and supports mixing models involving metal-rich chloride brines and sulfur-rich waters in ore formation. However, in the low temperature environment of Pine Point, it is possible that the apparent oversaturation of anhydrite results from the presence of unstable sulfur complexes such as thiosulfate, thus negating the need for two fluids in transporting essential ions to the site of deposition. (Authors' abstract)

HAYNES, S.J., 1983, Typomorphism of turbidite-hosted auriferous quartz veins, southern Guysborough County: Nova Scotia Dept. of Mines & Energy, Mines and Minerals Branch Report of Activities Report 83-1, 1982, K.A. Mills, ed., Halifax, Nova Scotia, 1983, p. 183-224.

The mineralogy and form of the veins, and their attendant wall rock alteration effects, suggest that gold was deposited initially from hydrothermal solutions, that passed upward through the fault systems, as they were ejected into seawater as low density plumes from submarine hot springs. This resulted in aprons of siliceous sinter being deposited at the spring orifices and a flanking mat of siliceous chemical sediment being deposited from the plume. Phase relations and the composition of fluid inclusions suggest that CO_2 boiled off from low-salinity hydrothermal solutions to yield potassium silicate assemblages in the feeders and carbonate assemblages in the sediments (stratiform veins). The origin of these solutions is as yet unknown, but may be related to dewatering of the lower Meguma Group or the basement. Although hydrothermal mobilization of gold and silica during early Acadian dynamo-thermic events cannot be discounted, syn-deformational quartz veins emplaced during the main period of Acadian deformation and metamorphism (discordant, radial and vertical veins) are devoid of gold. This casts doubt on those previous theories that invoked deposition of the auriferous quartz veins during Acadian dynamo-thermal metamorphism and deformation. (From the author's abstract)

HE, Luqing, 1984, Situation of analysis on gaseous constituents in mineral inclusions: J. Central-South Inst. Mining & Metal., Sum 41, no. 3, p. 81-87 (in Chinese; English abstract). Author at Chem. Analysis Center.

The advantages and the limitations of nondestructive analytical methods for gaseous constituents in mineral inclusions, the present situation of destructive analytical methods, and a variety of sources of gaseous constituents are described in this paper.

In order to avoid major contamination and loss from a variety of sources, it is particularly important that extractive systems and their devices be applied to any destructive analytical method(sic). Therefore, typical extractive systems and extractive devices used for the analysis of gaseous constituents in mineral inclusions are discussed. (Author's abstract)

HEALD-WETLAUFER, P. and PLUMLEE, G.S., 1984, Significance of mineral variations in time and space along the Bulldog Mountain vein system with respect to the district-wide hydrology, Creede district, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 535. Authors at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

Conclusions based in part on fluid inclusion studies. (E.R.)

HEDENQUIST, J.W., 1984, Adiabatic boiling and ocean metal transport: Nature, v. 310, no. 5979, p. 636. Author at DSIR, Geotherm. Res. Cent., Wairakei, Taupo, New Zealand.

Discusses incorrect statements of R.N. Anderson (this volume) and of Delaney and Cosens (1982, Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 51-52) concerning supposed development of highly saline fluids in deep sea geothermal areas by boiling. (E.R.)

HELGESON, H.C., 1984, Mineral deposition and dissolution as a function of fluid pressure in hydrothermal systems (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 290 (in English). Author at Dept. Geol. & Geophy., Univ. California, Berkeley, CA, USA.

Thermodynamic calculations indicate that relatively minor changes in fluid pressure may affect significantly mineral equilibria in hydrothermal systems. The standard partial molal volume changes accompanying the hydrolysis of minerals in the upper 5 or 10 km of the Earth's crust are negative and maximize with increasing temperature at constant pressure. As a consequence, isothermal flow of fluid toward a region of lower hydraulic head and fluid pressure may be accompanied by a substantial decrease in mineral solubility. However, in the special case of downward flow, spatial differences in hydraulic conductivity and/or the cross-sectional area off low channels may result in intervals of increasing mineral solubility in response to increasing fluid pressure in the direction of fluid flow. Under these conditions, precipitation is favored in the narrow portions of flow channels and mineral dissolution in the wider intervals. It follows that steady state downward flow of a fluid may lead to a self-sealing system with "pinch and swell" vein characteristics. In contrast, upward flow should lead to precipitation and self-sealing, regardless of vein geometry. Correlation of interphase mass transfer and fluid flow calculations with field observations can be used to assess directions and relative rates of fluid flow in hydrothermal systems. (Author's abstract)

HELVACI, C., 1984, Apatite-rich iron deposits of the Avnik (Bingöl) region, southeastern Turkey: Econ. Geol., v. 79, p. 354-371. Author at Mineral.-Geol. Museum, Sarsgate 1, Oslo 5, Norway.

Evidence suggests that the apatite-rich iron deposits formed initially during volcanism, and it is concluded that they were immiscible liquids which had separated from strongly fractionated magmas. Similar rare earth element values in coexisting apatite and magnetite and in the associated metavolcanic rocks support this conclusion. The apatite-rich iron deposits were remobilized into stockworks containing large crystals of magnetite, apatite, and actinolite where these have been intruded by the Avnik granitoid. (From the author's abstract)

HELZ, R.T., 1984, In situ fractionation of olivine tholeiite: Kilauea Iki lava lake, Hawaii (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 536-537. Author at U.S. Geol. Survey, Reston, VA 22092.

The line of descent of the liquid produced by crystallization of an olivine tholeiite has been determined for Kilauea Iki lava lake, formed in 1959. Eruption pumices cover the range of liquid compositions from 10.0 to 6.0% MgO. Interstitial glasses in partially molten core obtained by lava lake drilling extend the compositional range to 0.2% MgO. (From the author's abstract)

HEMLEY, J.J., CYGAN, G.L. and WHITNEY, J.A., 1984, The concentration of iron in chloride solutions equilibrated with a synthetic granitic composition: the sulfur bearing system (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 537.

HENDERSON, C.M.B. and MANNING, D.A.C., 1984, The effect of Cs on phase relations in the granite system: Stability of Pollucite: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 41-42.

HENLEY, R.W., 1984, Structure of active geothermal systems and implications for the origins of some hydrothermal gold deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 40-43.

HENLEY, R.W., TRUESDELL, A.H. and BARTON, P.B., Jr., 1984, Fluid-mineral equilibria in hydrothermal systems: Reviews in Econ. Geol., v. 1, 267 pp.

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High temperature calculations in geothermal development
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HERSKOWITZ, Mordechai and KISCH, H.J., 1984, An algorithm for finding composition, molar volume and isochors of CO_2-CH_4 fluid inclusions from T_h and T_{fm} (for $T_h < T_{fm}$): Geochimica Cosmo. Acta, v. 48, p. 1581-1587. First author at Dept. Chem. Engrg., Ben-Gurion Univ. of the Negev, P.O.B. 653, Beer-Sheva 84105, Israel.

A modified Redlich-Kwong equation of state is used to calculate the solubility of CO_2 in methane at various temperatures and pressures. From the solubility of CO_2 in CH_4 at the triple point and at final melting ($T_h < T_{fm}$), and the molar volume of solid CO_2, the volume of solid at the triple point, and the molar volume of the inclusion can be calculated using a mass balance. The pressure at the melting point is calculated from the equation of state.

The algorithm predicts composition, molar volume, pressure at final melting and the isochor pressure (for a given temperature of trapping) for CO_2-CH_4 fluid inclusions for the case $T_h < T_{fm}$, given T_h, T_{fm} and experimental data on P_h and $d(CO_2)$ (solid) at T_h. (Authors' abstract)

HICKS, Brian, APPLIN, K.R. and HOUSEKNECHT, D.W., 1984, Crystallographic controls on the hydrothermal etching of quartz (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 539. Authors at Geol. Dept., Univ. Missouri-Columbia, Columbia, MO 65211.

Euhedral quartz crystals, crushed quartz, quartz sand, and quartzose sandstone were etched in distilled water at 280°C and 1.3 kb pressure. Crystallographically oriented etch pits were observed using a scanning electron microscope. Rhombohedral crystal faces exhibit a relatively uniform distribution of shallow, triangular etch pits. Deep, diamond-shaped pits presumably formed by the combination of two triangular pits were observed on prism faces. With further etching the diamond-shaped etch pits appear to coalesce into rectangular etch tubes. Deep etch pits and tubes appear to be nonuniformly distributed over individual crystals as well as corresponding faces of a suite of crystals. Etched, polished basal sections of quartz crystals exhibit a mammiform morphology which reflects the growth development of quartz crystals. Thus, the morphology of etch features in sedimentary quartz may be a useful indicator of the crystallographic orientation of quartz grains. The extent of etch pit development may also serve as a qualitative indicator of the state of dissolved silica saturation in pore fluids.

In an attempt to determine possible crystallographic controls on the intergranular pressure solution of quartzose sandstones, a limited petrographic study was performed on the Bromide Sandstone, Simpson Group, Oklahoma. Using a universal stage the orientation of the optic axes and poles to the contact planes were measured on 160 pairs of quartz grains exhibiting long, sutured, or concavo-convex contacts. The results indicate that grain orientation plays a minor role in the type and extent of intergranular pressure solution in quartzose sandstones. (Authors' abstract)

Of pertinence to the formation of fluid inclusions. (E.R.)

HIGGINS, M.D. and SHAW, D.M., 1984, Boron cosmochemistry interpreted from abundances in mantle xenoliths: Nature, v. 308, p. 172-173. Authors at Dept. Geol., McMaster Univ., Hamilton, Ontario, Canada L8S 4M1.

Recent technical advances have made it possible to measure the abundance of boron in ultramafic xenoliths from alkali basalts thought to be representative of the upper mantle. Such data can provide information on the cosmochemistry of boron, particulary the temperature and mode of condensation of this element from the solar nebula. Analysis of xenoliths, selected by Jagoutz et al. to represent fertile unaltered mantle, shows that the mean boron abundance is more than three times that expected for the condensation temperature of 700 K calculated by Cameron et al. Our measurements, reported here, suggest that boron condensed at approximately 1,200 K as a solid solution in alkali feldspar or anorthite and not as an independent phase. (Authors' abstract)

HILDRETH, Wes, CHRISTIANSEN, R.L. and O'NEIL, J.R., 1984, Catastrophic isotopic modification of rhyolitic magma at time of caldera subsidence, Yellowstone Plateau volcanic field: J. Geophys. Res., v. 89, no. B10, p. 8339-8369.

HILTON, D., O'NIONS, R.K., OXBURGH, E.R., GRONVOLD, K. and KRISTMANSDOTTIER, H., 1984, Regional distribution of ^{3}He anomalies in the Icelandic crust (abst.): EOS, v. 65, p. 295.

HOBBS, B.E., 1984, Point defect chemistry of minerals under a hydrothermal environment: J. Geophys. Research, v. 89, no. B6, p. 4026-4038. Author at Dept. Earth Sci., Monash Univ.

The kinetics of rock/water interactions are sufficiently rapid that most hydrothermal systems in nature will be in equilibrium with the adjacent rock mass. The bulk rock chemistry buffers the fugacity of oxygen, which in turn fixes the fugacities of water and of hydrogen for a given pressure and temperature. Systems in which only water, oxygen, and hydrogen are present as fluid phases are considered here. Variations in the fugacity of oxygen by several orders of magnitude are possible locally, controlled by variations in local rock chemistry; these lead to relative small variations in the fugacity of water. Incorporation of a hydrogen defect that is capable of acting as an acceptor into silicates leads to a strong dependence of point defect chemisty upon the fugacities of both water and oxygen. The strong dependence on the fugacity of water is capable of explaining the hydrolytic weakening effect, but in view of the strong dependence on oxygen fugacity, the question should also be raised whether it is an oxygen effect that is observed in the classical hydrolytic weakening process or solely a dependence on changes in the fugacity of water. Examples are given for impure natural quartz, olivine, and albite with trace amuonts of calcium. (Author's abstract)

HOERNES, S. and HOFFER, E., 1984, The oxygen isotopic composition of the fluid phase from regionally metamorphosed pelitic rocks of the Damara orogenetic belt, Namibia (abst.): Terra Cognita, v. 4, p. 94. First author at Inst. Mineral. und Petro., Poppelsdorfer SchloB, D-5300 Bonn-1.

The sedimentary starting material of the medium to high grade metamorphic pelitic rocks from the Damara orogenetic belt can be reconstructed from very low grade material from the Nama Group and from pre-Damara basement samples. The isotopic composition of the fluid phase during the Damara metamorphic event can be deduced from the recent isotopic composition of the metapelites since the metamorphic temperatures are known from previous petrologic and isotopic work. Quartz segregations which primarily formed parallel to a first schistosity and transform to concretions during continuing deformation are of special importance for the reconstruction of the fluid phase. Quartz forming mineral reactions may also contribute to these quartz segregations. The initial quartz segregations show higher $\delta^{18}O$-values (+18‰) than most quartz concretions in the medium to high grade area which average around +15‰. Significantly lower values (+13‰) are found in rocks which suffered anatexis. It can be shown that decrease in the isotopic composition is not a function of decreasing mineral-water fractionation in a closed system. The isotopic composition of the fluid phase therefore follows that of the analyzed quartzes. This decrease is not continuous. Two positive anomalies can be observed, the first in the temperature region of 550°C, the second at about 620°C. We explain this deviation from the general trend by dehydration reactions of chlorite and muscovite, which introduce isotopically heavy oxygen into the partially dehydrated system. (Authors' abstract)

HOFFMANN, C.F., MACKENZIE, A.S., LEWIS, C.A., MAXWELL, J.R., OUDIN, J.L., DURAND, B. and VANDENBROUCKE, M., 1984, A biological marker study of coals, shales and oils from the Mahakam Delta, Kalimantan, Indonesia: Chem. Geol., v. 42, p. 1-23.

HOFMANN, A.W., 1984, Mantle evolution by crustal recycling or by mantle metasomatism? (abst.): Terra Cognita, v. 4, p. 82.

HOFMANN, R. and BAUMANN, A., 1984, Preliminary report on the Sr isotopic composition of hydrothermal vein barites in the Federal Republic of Germany: Mineral. Deposita, v. 19, p. 166-169. First author at Inst. Kristal. & Petrogr., Univ. Hannover, FRG.

Sr varies from 0.5 to 3.8% and $^{87}Sr/^{86}Sr$ from 0.71018 ± 6 to 0.7205 ± 11 in 59 samples of barite from 21 localities. (E.R.)

HOFMEISTER, A.M., 1984, Spectroscopic and chemical study of the coloration of feldspars by irradiation and impurities, including water: PhD dissertation, California Inst. Tech., Pasadena, CA, USA, 425 pp.

Indexed under Fluid Inclusions. (E.R.)

HOGAN, L.G. and HART, Roger, 1984, Fractionation of noble gases in ocean ridge silicate melts by volatile exsolution (abst.): EOS, v. 65, p. 295.

HOLLOWAY, J.R., 1984, Graphite-CH_4-H_2O-CO_2 equilibria at low-grade metamorphic conditions: Geology, v. 12, p. 455-458. Author at Depts. Chem. & Geol., Arizona State Univ., Tempe, AZ 85287.

Equilibrium calculations and published phase equilibria are used to show that at temperatures below 400°C and pressures above 300 bar, the fluids coexisting with graphite in the C-O-H system consist either of CO_2-H_2O mixtures or CH_4-H_2O mixtures. Bulk fluid compositions consisting of CH_4-H_2O will unmix to methane-rich fluid and H_2O-rich liquid at temperatures below about 325°C. Compositions on the CO_2-H_2O join will unmix only at temperatures below about 275°C. Oxygen fugacity in the CH_4-H_2O-graphite three-phase region is fixed (at constant P and T) and approximately equal to that of the quartz-magnetite-fayalite assemblage. In the CO_2-H_2O-graphite three-phase region, oxygen fugacity is about three orders of magnitude greater. From the end stages of diagenesis to temperatures of 300°C (and possibly 400°C in salt-rich systems), many metamorphic rocks may contain CH_4-H_2O fluids rather than CO_2-H_2O mixtures. Thus, metamorphic reactions involving carbonate minerals would involve CH_4, graphite, and H_2O rather than CO_2. The immiscibility between CH_4 and H_2O could result in the common occurrence of methane (natural gas) in low-grade metamorphic terrains. (Author's abstract)

HORN, Elfrun, 1984, Studies of elements in individual closed fluid inclusions using the Heidelberg proton microprobe (PIXE) (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 55-57 (in English). Author at Geol.-Paläon. Inst. Univ. Göttingen, Goldschmidtstr., 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 [unopened] inclusions from a depth of 10-50 μm beneath the sample surface.

For investigations with PIXE the same 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 successive order within the same sample.

Initial qualitative investigations were carried out on quartz samples. (Author's abstract)

HOSTETTLER, J.D., 1984, Electrode electrons, aqueous electrons, and redox potentials in natural waters: Am. J. Sci., v. 284, p. 734-759.

HOVORKA, S.D., 1984, Textures formed during shallow water halite deposition--an example from Permian of Palo Duro basin, Texas (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Author at Bur. Econ. Geology, Austin, TX.

The Palo Duro basin, part of the broad northern shelf of the Midland basin during the Late Permian, accumulated cyclic, regressive, carbonate-anhydrite-halite sequences. Detailed interpretation of more than 2,000 m (6,500 ft) of halite core from 9 wells drilled by the United States Department of Energy in the northern Palo Duro basin permitted recognition of textures formed during halite deposition.

Textures formed on the bottom of a halite-saturated water body include color banding due to variation in composition and amount of impurities in halite beds, and vertically elongated anhedral halite mosaic, formed due to competition for space on the pool floor. Abundant fluid inclusions trapped along halite growth faces reflect rapid precipitation of halite in shallow water. Darker halite with sparse inclusions may have formed less rapidly in slightly deeper water.

Anhydrite partings, truncating the bottom-deposited fabrics, represent influx of marine-derived brine concentrated during transport across the broad, shallow shelf. The brine corroded existing halite and deposited gypsum before evaporation increased salinity and reinitiated halite deposition.

Halite precipitation ceased when brine supply decreased and then became emergent. Mudstone was transported onto the flat by wind sheetwash. Exposure of the halite to meteoric water during this phase caused development of halite karst and destruction of other fabric recrystallization. (Author's abstract)

HOWE, S.S., 1984, Formation of Mississippi Valley-type lead-zinc deposits by periodic expulsion of basin brines--an example from central Pennsylvania (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 544-545. Author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

Mineralogic, textural, and fluid-inclusion features of lead-zinc occurrences within a 5000 km^2 region in central Pennsylvania are consistent with periodic influxes of saline basin brines as the sites of deposition opened tectonically during sulfide mineralization and with the mixing of these brines with less saline meteoric waters as the systems progressively sealed during nonsulfide mineralization. (From the author's abstract)

HOWSE, A.F. and MALONEY, J., 1984, 18. Barite deposits of the Avalon peninsula, in Mineral Deposits of Newfoundland - A 1984 Perspective: Newfoundland Min. Dev. Div. Report 84-3, p. 173-177.

Fluid inclusion and stable isotope studies are in progress. Quartz associated with the barite has Th of 100-200°C, but one sample from the Silver Cliff vein showed 300-360°C. (E.R.)

HUANG, Fusheng, MU, Zhiguo, CHEN, Chengyie and WANG, Zhifen, 1984, Isotopic composition of oxygen, hydrogen, and carbon in granites of tin deposits, Gejin (China): Yanshi Kuangwu Ji Ceshi, v. 3, no. 1, p. 241-247 (in Chinese) (also in CA: 101(14)114155p).

Indexed under Fluid Inclusions.

HUBBARD, N., LIVINGSTON, D. and FUKUI, L., 1984, The composition and stratigraphic distribution of materials in the Lower San Andres salt unit 4: Materials Research Soc. Symp. Proc., v. 26, p. 405-415. First author at Battelle Memorial Inst., Columbus, OH 43201.

The salt bed in depositional cycle 4 of the Permian Lower San Andres Formation, Palo Duro Basin, Deaf Smith County, Texas consists of massive salt interlayered with discrete bands and beds of anhydrite and claystone. The massive salt consists of about 90% halite, with 7% anhydrite and 3% clays disseminated in and among the halite crystals.

The halite in this salt bed contains fluid inclusions filled with a (Na, K, Mg) Cl brine, with an average Mg concentration of about 50,000 mg/liter. The anhydrite in the salt will saturate the brines in $CaSO_4$, which in turn may coat the waste package with anhydrite because of the retrograde solubility of $CaSO_4$. This may increase waste package lifetime to failure by corrosion. (Authors' abstract)

HUNT, J.M., 1984, Generation and migration of light hydrocarbons: Science, v. 226, p. 1265-1270. Author at Dept. Chem., Woods Hole Oceanographic Inst., Woods Hole, MA 02543.

Light hydrocarbons (containing from 1 to 14 carbon atoms) are formed from disseminated organic matter in sediments at the parts-per-billion level by biological and low-temperature (<50°C) chemical reactions and at the parts-per-million level by high-temperature (>50°C) cracking reactions. The cooler reactions produce mainly branched hydrocarbons, whereas the hotter reactions yield more straight chains. Hydrocarbon generation zones in the subsurface can be recognized on the basis of hydrocarbon distribution patterns. Hydrocarbons with tertiary carbon atoms form at lower temperatures than those with quaternary carbons. Methane and ethane migrate vertically through fine-grained shales by diffusion and solution, whereas many of the C_{3+} hydrocarbons show little or no vertical migration. Concentrations of light hydrocarbons, including methane, in fine-grained source rocks decrease to low values in deep, high-temperature (>200°C) sediments. This decrease may be one reason why no economic accumulation of gas has been found to date deeper than 8.2 kilometers (27,000 feet). (Author's abstract)

HUT, G., WEERKAMP, H.R. and POELHEKKEN, T., 1984, Stable isotope ratios in the natural gas components CH_4 and N_2 separated by gas chromatography: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 129-138: Leipzig, Akad. Wissen. der DDR (in English). Authors at Isotope Physics Lab., Univ. Groningen, Westersingel 34, 9718 CM Groningen, The Netherlands.

Stable isotope data of natural gas components can provide important information on origin, maturity of source material and migration of these gases. To determine the stable isotope ratios in CH_4 and N_2 a system is constructed to separate these components from milliliter quantities of natural gas by gas chromatography. Having passed the separation column and a catharometer detector the gas flow is distributed consecutively to two lines, one in which N_2 is trapped in a He-cryostat and one in which CH_4 is immediately combusted by CuO to CO_2 and H_2O which are trapped separately.

The δ^2H, $\delta^{13}C$ and $\delta^{15}N$ values are determined by conventional mass spectrometry. (Authors' abstract)

HUTCHINSON, R.W., 1984, Significance of evolutionary changes in base metal deposits through time (abst.): Terra cognita, v. 4, p. 84.

HYNDMAN, D.W. and ALT, David, 1984, Large-scale evidence for liquid immiscibility differentiation in Square Butte laccolith, central Montana alkaline province (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 547.

IANNACCHIONE, A.T., GRAU, R.H., SAINATO, A., KOHLER, T.M. and SCHATZEL, S.J., 1984, Assessment of methane hazards in an anomalous zone of a Gulf Coast salt dome: Bureau of Mines Report of Investigations, RI-8861, 26 pp.

IGNATOV, V.A. and STAKHANOV, I.P., 1984, Formation and absorption of atmosphere in a cavity due to gas diffusion, adsorbed in its walls: Akad. Nauk SSSR Doklady, v. 275, no. 2, p. 361-364 (in Russian). Authors at Moscow Inst. of Fine Chemical Technology, Moscow, USSR.

The paper describes the conditions of achieving equilibrium between gas present in the walls of a cavity and the cavity atmosphere; pertinent to formation of G bubbles and to the problem of volatile diffusion through crystal lattice from inclusion filling. (A.K.)

ILLICH, H.A., HANEY, F.R. and GRIZZLE, P.L., 1984, Geochemical significance of seep oil from the Subandino Norte, northwest Bolivia: Geochimica Cosmo. Acta, v. 48, p. 391-394. Authors at Sun Exploration, Div. Sun Exploration & Prod. Co., Irving, TX 75234.

This report presents an interpretation of the geochemical significance of a surface seep oil sample from the Subandino Norte of Bolivia. The oil from this seep is unusual because it contains a limited range of low molecular weight normal paraffins. Normal paraffins containing more than 12 carbons are absent from the oil, while normal paraffins having fewer than 12 carbons are conspicuous components of the oil. The compositional peculiarities of the oil are attributed to transport of hydrocarbons in water, with water playing an active role in the final composition of the seep. The composition of the seep oil is qualitatively consistent with that anticipated if the hydrocarbons were moved in molecular solution in water. (Authors' abstract)

IMEOKPARIA, E.G., 1984, Geochemistry of intrusive rocks associated with molybdenite mineralization (Kigom complex, northern Nigeria): Chem. Geol., v. 47, p. 261-283. Author at Dept. Geol., Univ. Benin, Benin City, Nigeria.

The Kigom igneous complex of northern Nigeria is a small intrusive complex made up of peralkaline arfvedsonite granite, riebeckite-biotite granite and riebeckite-aegirine granite. The granites show coherent major-element chemistry typical of that of the Nigerian Younger Granites, and are enriched in Rb, Li, Zr, Nb, Th, Y, F and REE, and depleted in Ba and Sr compared to the world average for rocks of similar composition.

The riebeckite-aegirine granite exhibits a two- to three-fold increase in the concentration of Zr, Nb, Li, F, Th, Zn and REE over comagmatic granites. Concentrations of the highly charged cations in these granites are believed to be the result of halogen-alkali-rich fluid activity during the fractionation of the magma. Corresponding trace-element increases in the granites in areas of alkali metasomatism (albitization) support this argument, and reflect the partial confinement of this alkali volatile phase within the high-level magma chambers.

It is important to recognize that the chemical signatures of this liquid state fractionation process may be explanatory mechanisms in the formation of some kinds of lithophile ore deposits. The degree of peralkalinity maintained miscibility in the residual fluid between silicate and aqueous phase to low temperatures so that mineralizing components continuously accumulated together. The interaction between this phase and early-formed minerals led to Mo mineralization.

The well-known classification of granites into sedimentary protolith (S-type); igneous protolith (I-type) and A-type indicates that the granites studied here have typical A-type features. An origin by partial melting of lower-crustal material (probably granulite facies) under a high flux of mantle-derived volatiles is suggested for these rocks. As a result of mixing of crustal and mantle-derived fluids a syenitic magma was produced which then experienced selective contamination as a result of further reaction melting during fractionation and ultimately produced a peralkaline differentiate. (Author's abstract)

INSHIN, P.V., ABAULINA, L.I. and TSAREV, V.V., 1983, Behavior of carbon during the formation of gold deposits in clastic "black shale" sequences: Dokl. Akad. Nauk SSSR, v. 269, no. 5, p. 1156-1158 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 79-80, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 117, 1983. (E.R.)

IRVING, A.J. and FREY, F.A., 1984, Trace element abundances in megacrysts and their host basalts: Constraints on partition coefficients and megacryst genesis: Geochimica Cosmo. Acta, v. 48, p. 1201-1221.

ISUK, E.E. and CARMAN, J.D., 1984a Comment on "Transport and concentration of molybdenum in granite molybdenite systems: Effects of fluorine and sulfur:" Geology, v. 12, p. 568-569.

ISUK, E.E. and CARMAN, J.H., 1984b Comment and reply on "Transport and concentration of molybdenum in granite molybdenite systems: Effects of fluorine and sulfur:" Geology, v. 12, p. 568-569. First author at Dept. Comprehensive Sci., Morgan State Univ., Baltimore, MD 21239.

Refers to paper by Tingle and Fenn, 1984 (this issue). (E.R.)

IVANOV, I.P. and POKROVSKIY, V.A., 1982, Redox interactions in water-mineral systems: Dokl. Akad. Nauk SSSR, v. 264, no. 1, p. 212-216 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 264, p. 173-176, 1984).

IVANOV, V.V. and TASKAEV, V.I., 1984, New zinc- and iron-bearing variety of pyrargyrite: Akad. Nauk SSSR Doklady, v. 275, no. 3, p. 725-728 (in Russian). Authors at Far-East Geol.-Inst. of Far-East Sci. Center, Vladivostok, USSR.

Zn- and Fe-bearing pyrargyrite from Belaya Gora (Lower Priamur'ye) occurs in paragenesis with quartz of Td (vacuum method) 120-260°C and Th 240-280°C. (A.K.)

JACKSON, K.J. and HELGESON, H.C., 1984, Solubility of cassiterite and tin deposition in the southeast Asian tin belt (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 58-59 (in English). Authors at Dept. Geol. & Geophys., Univ. California, USA.

Thermodynamic calculations indicate that in the absence of appreciable chloride and fluoride concentrations, $Sn(OH)^\circ_2$ and $Sn(OH)^\circ_4$ are the predominant tin species in H_2O up to 350°C at $1 \leqslant pH \leqslant 6.5$. Except in the presence of geologically unrealistic concentrations of fluoride or a pH greater than ~3 at 250°C or ~4.5 at 350°C, chloride complexes of Sn^{2+} predominate by several orders of magnitude over their fluoride and hydroxide counterparts in 1-3 molal (m) NaCl solutions. At higher pH, most of the tin in solution is present as hydroxide complexes, even at concentrations of NaCl as high as 3m. Depending on the fugacity of oxygen and solution composition, the solubility of cassiterite in hydrothermal solutions may exceed 100 ppm under geologically realistic conditions. Taking account of phase relations and fluid inclusions in the Southeast Asian tin deposits, it appears that tin was present in the ore-forming solutions primarily as stannous chloride and hydroxide complexes. The presence of topaz precludes significant transport of tin as tin fluoride complexes. The intimate association of cassiterite and the greisenized wall rock adjoining the veins suggest that tin mineralization occurred in response to increasing solution pH accompanying hydrothermal alteration of the host rock. (Authors' abstract)

JACOBSEN, F.L. and four others, 1984, Zechstein Salt Denmark, Salt Research Project EFP-81, Volume I, Project Summary, DGU series C. no. 1·1984, 87 pp. (in Danish; English summary).

An investigation of fluid inclusions in halite and quartz crystals from dome salt has resulted in the determination of salinity and chemical composition of the brines present in the salt. Temperatures and corresponding pressures during the evolution of the salt pillow and salt dome have been established.

The dehydration conditions of natural carnallite in situ are clarified. (From the authors' summary)

JADHAV, G.N., PANCHAPAKESAN, V. and SAHU, K.C., 1984, Fluid inclusion characters of mica pegmatites of Nawada district, Bihar and Kalichedu district, Andhra Pradesh--a comparison: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 25. Authors at Dept. Earth Sci., Indian Inst. Tech., Powai, Bombay 400076, India.

Bihar Mica Belt in the north and Nellore Mica Belt in the south are compared in the present paper in regard to their fluid inclusion characters. Samples from Sethawa mine and Jainarayana mines represented Bihar and Nallore belts correspondingly during the study.

Inclusions in quartz of Sethawa Pegmatite are generally polyphase. They homogenize either in liquid state or in solid state(sic). Sylvite completely dissolves between 100°C and 180°C, and halite, between 180°C and 340°C. The inclusions which homogenize in gas do so between 140°C and 320°C, while homogenization in liquid in other inclusions is between 140°C and 390°C. The total salinity varies widely from ≅30% to as high as 50%. Mica producing zones have a lower Th as compared to the quartz core. Wide variation of the Th and salinity indicate repeated pulsations of formation.

Jainarayana inclusions have a gradual special variation of contents of glass, gas, gas-liquid, liquid-gas and polyphase. The liquid inclusions homogenize between 160°C and 275°C. There seems to be a gradual fall of temperature from the core to the periphery and a steady fall of temperature from lower to upper levels. (Authors' abstract)

JAIRETH, S. and SHARMA, Mithilesh, 1984, Physico chemical conditions of ore formation in Malanjkhand copper sulphide deposit (M.P.) India: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 4-5. Authors at Dept. Earth Sci., Univ. Roorkee, Roorkee.

Copper sulphide bearing quartz reef (length 2.6 km, average width 60 m) in the Malanjkhand copper deposit is localized within granodiorites that have undergone intensive potash-feldspathic, biotite, chlorite, epidote and sericitic alteration.

Optical microscopy of fluid inclusions in quartz from the reef reveals presence of liquid-gaseous (gas 5-30%) inclusions which clearly predominate over rarer gas-liquid (gas 90-95%) inclusions. Polyphase inclusions with solid phases are rare. At room temperature no inclusions with liquid CO_2 have been detected.

Over 400 P, PS, and S inclusions have been heated. The P and PS inclusions homogenize into a liquid phase at 214°C-431°C (mean of 236 = 279°C), whereas S inclusions homogenize at 104°C-209°C (mean value of 191 = 173°C).

Based on these Th values, it is concluded that mineralized quartzofeldspathic reef formed from hydrothermal solutions between 431°C and 214°C (no P corrections) with quartz beginning to form at minimum T of 431°C. P during the initial stages was far <1380 bars, but >350 bars.

Later, as the solutions cooled down, P also decreased.

In order to determine aO_2, aS_2 and pH of ore deposition a log aS_2-log aO_2 diagram at 300°C has been constructed using data from Barnes and Kullerud (1961) showing stability fields of ore and gangue minerals.

The parameters of ore deposition as determined are based on the coexistence of quartz, feldspar, chalcopyrite, pyrite, magnetite, and molybdenite are: log aO_2 -36.7 to -29.7 atm, log aS_2 -15.4 to -8.5 atm, pH 4.7 to 7.0. (Authors' abstract)

JAIRETH, S. and SINGH, A.K., 1984, Fluid inclusion geothermometry of quartz-wolframite veins at Degana wolframite deposit, Rajasthan, India (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 59 (in English). Authors at Univ. Roorkee, Roorkee, India.

Wolframite mineralization is represented by quartz-wolframite-sulfide veins trending NNW-SSE and NNE-SSW. Quartz, topaz, mica (muscovite-zinnwaldite), fluorite are the main gangue minerals. Pyrite, chalcopyrite, sphalerite, pyrrhotite, arsenopyrite, tungstenite, and molybdenite are present in small amount. Ore paragenesis studies show that wolframite is later than the quartz-mica-topaz association but is earlier than fluorite and sulfides. Fluid inclusions have been studied in quartz, topaz and fluorite. All these minerals show presence of dry gaseous, predominantly gaseous, gas-liquid, liquid-gaseous inclusions with variable gas filling. Many inclusions contain more than two solids. Some fluorite grains have inclusions containing eight to ten solids. Many of the inclusions show presence of liquid CO_2. Homogenization studies show that quartz, topaz and fluorite were formed at temperatures between 413°C and ~100°C, 283°C-135°C and 203°C-133°C, respectively, from hydrothermal solutions that underwent recurrent boiling. (Authors' abstract)

JAIRETH, S, MOHAN, P.C. and GUPTA, S.K., 1984, Fluid inclusion studies of quartz-sulphide veins of the central Himalayan region of Uttarkashi, U.P.: Indian J. Earth Sci., v. 11, no. 2, p. 126-133. Authors at Dept. Earth Sci., Univ. Roorkee, Roorkee-247667, India.

Sulphide mineralization associated with quartz calcite veins has been located at Janki Chatti and Banas areas within the central crystallines of Uttarkashi. Pyrite is the main sulphide accompanied by pyrrhotite at Janki Chatti and pyrrhotite, chalcopyrite and sphalerite at Banas.

Fluid inclusion studies of quartz-sulphide veins show presence of secondary, predominantly liquid inclusions (gas ≤5% at room temperature), and primary and/or pseudosecondary gas-liquid (gas = 20-25%) and liquid-gaseous (gas ≥70-75%) inclusions, representing entrapment from a hydrothermal mineral forming media.

Homogenization studies on fluid inclusions show that quartz and associated sulphide mineralization was formed at temperature of 170°C-110°C (Janki Chatti), 205°C-105°C (Banas) from low salinity hydrothermal solutions that underwent recurrent boiling. (Authors' abstract)

Includes the design of the heating stage used. (E.R.)

JAIRETH, S., SEN, A.K. and VARMA, O.P., 1984, Co-existence of two immiscible phases in carbonatites of Sung Valley complex, Meghalaya (India) as revealed by fluid inclusion studies: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 11-12. First author at Dept. Earth Sci., Univ. Roorkee, Roorkee.

The Sung Valley alkaline ultramafic complex, which shows its maximum development around the Sung village (25°33'N:92°07'E) in the State of Meghalaya, occurs within the framework of the Shillong Group of rocks. The complex rocks include a core of serpentinized peridotite rimmed by pyroxenite and intruded by small to medium-sized bodies of uncompahgrite, ijolite, syenite and carbonatite, the latter forming stocks, lenses, dikes and veins of varying sizes. The largest exposure of carbonatite rock in the mapped area is found near Masket village (25°33'N:92°08'E); here it is distinctly coarse-grained apatite-magnetite sövite representing early phase in the emplacement of carbonatite magma. The apatite in this rock occurs as scattered needles and also as rounded clusters of radiating needles within the mosaic of anhedral calcite.

The apatite of the carbonatite contains two types of primary inclusions: (1) solidified inclusions composed of solids ± gas, and (2) polyphase fluid inclusions consisting of gas (5-30%) + liquid ± solid at room temperature. Solids in the former are usually anisotropic with high interference colors accompanied occasionally by opaques, whereas solids of the latter are more varied, represented principally by halides (halite, sylvite), carbonate, bicarbonate (nahcolite) and opaques.

Solidified inclusions homogenize into a liquid phase in a temperature range of 750° to 805°C, while fluid inclusions homogenize into a liquid phase at temperatures ranging from 180°C to 400°C. Co-existence of primary solidified and fluid inclusions in apatite indicates that during the formation of apatite-magnetite sövite, the carbonatite melt co-existed with a high density saline fluid. Similar examples of co-existence of different types of primary inclusions are reported in apatites of sövites from Solki carbonatite complex, Finland. (Authors' abstract)

JANECKY, D.R. and SEYFRIED, W.E., Jr., 1984, Formation of massive sulfide deposits on oceanic ridge crests: Incremental reaction models for mixing between hydrothermal solutions and seawater: Geochimica Cosmo. Acta, v. 48, p. 2723-2738.

JANELIDZE, T.V. and TVALCHRELIDZE, A.G., eds., 1984, Proceedings of the Sixth Quadrennial IAGOD Symposium, Tbilisi, USSR, September 6-12, 1982, Vol. 1, 544. pp.: Stuttgart, E. Schweizerbart'sche.

Abstracts of the pertinent items in this volume will be found in Fluid Inclusion Research--Proceedings of COFFI, volume 15, 1982. The abstracts in this book differ somewhat from those given earlier. (E.R.)

JAOUL, Olivier, 1984, Sodium weakening of Heavitree quartzite: preliminary results: J. Geophys. Research, v. 89, no. B6, p. 4271-4280.

JAOUL, Olivier, TULLIS, Jan and KRONENBERG, Andreas, 1984, The effect of varying water contents on the creep behavior of Heavitree quartzite: J. Geophys. Research, v. 89, no. B6, p. 4298-4312.

JAVOY, M., PINEAU, F. and DEMAIFFE, D., 1984, Nitrogen and carbon isotopic composition in the diamonds of Mbuji Mayi (Zaïre): Earth & Planet. Sci. Ltrs., v. 68, p. 399-412. First author at Lab. Géochimie des Isotopes Stables, LA 196 C.N.R.S., Univ. Paris VII, 2, Place Jussieu, 75251 Paris Cedex 05, France.

The concentration and isotopic composition of nitrogen, measured in large diamonds (gram size) from the Mbuji Mayi kimberlite district (Zaïre) show a large range of variation ($100<N<2100$ ppm, $-11.2<\delta^{15}N<+6.0$). The ^{15}N-depleted nitrogen is associated with the higher nitrogen concentrations.

The large diamonds are individually rather homogeneous in ^{13}C (range of $\delta^{13}C<0.9‰$) while variations occur within small octahedral diamonds from the same district (range up to 5.8‰). The total range of $\delta^{13}C$ variations is about the same for the large diamonds ($-10.5<\delta^{13}C<-5.5$), the small octahedral diamonds ($-10<\delta^{13}C<-4.6$), and the carbonates from local kimberlites ($-11.8<\delta^{13}C<-5.5$). The diamond carbon isotopic data could indicate a complex story of crystallization within a deep-seated system fractionating its carbon isotopes.

The nitrogen results indicate that nitrogen in diamonds is, on the average, markedly depleted in ^{15}N (weighted average -5.15‰) relative to atmosphere, sediments and upper mantle. (Authors' abstract)

JEBRAK, Michel, DEBBAH, Bourhalem and TOURAY, J.-C., 1984, Brines associated with the fluorite veins of central Morocco (El Hammam orefield): Bull. Minéral, v. 107, p. 233-240. First author at Bureau de Recherches Géol. Minières - SGN/Gites Minéraux, B.P. 6009, 45060 Orléans Cédex, France (in French; English abstract).

Fluorite from the veins of El Hammam orefield (central Morocco) shows hypersaline fluid inclusions, rich in NaCl and $CaCl_2$. In this orefield, a strong zonality is focussed on a peraluminous granite apex. The study of fluid inclusions and REE suggests a centrifugal deposition. In the core, fluorite and carbonates are deposited by decreasing temperature brines (200°-100°) and reflect the circulation of hydrothermal solutions followed by more superficial fluids. On the edge, the fluorite veins and stockworks present lower deposition temperatures and more obviously feldspathic REE patterns. This orefield is thus very similar to that of the Tarn area (France). (Authors' abstract)

See also same authors, Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 124, 1983. (E.R.)

JOCKWER, Norbert, 1984, Laboratory investigations on radiolysis effects on rock salt with regard to the disposal of high-level radioactive wastes: Mat. Res. Soc. Symp. Proc., v. 26, p. 17-22. Author at Gesellschaft für Strahlen- und Umweltforschung mbH Munchen, Inst. Tieflagerung, Theodor-Heuss-Str. 4, D-3300 Braunschweig, FRG.

As a result of the heat producing high-level radioactive waste, volatile components which are in the host rock will be liberated and further gases will be generated by thermal cracking and radiolysis. (Author's abstract)

Also includes gas analyses from boreholes (for CO_2, O_2, H_2S, CH_4, C_2H_6, HHC), and from irradiated salt. (E.R.)

JOHAN, Z., 1984, Genesis of chromite deposits in the "Massif du Sud" ophiolitic complex, New Caledonia: Example of a high-temperature, fluid-rich, ore-forming system (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 146-147. Author at GIS BRGM-CNRS, Centre Recherches Synthèse et la Chimie des Minéraux, Orléans, France.

The Massif du Sud consists essentially of harzburgite and extends over 6000 km^2. In this ophiolitic complex occur more than 50 chromitite showings and deposits, all situated within the harzburgite. Most of them are concordant to the harzburgite foliation. Discordant, vein-like, chromitite bodies are also known. Examination of several deposits has revealed that: (1) wall-dunites were formed by a metasomatic process involving the interaction of harzburgite with a water vapor-rich fluid; (2) chromite crystallized from a complex fluid-rich phase, as indicated by solid and fluid inclusions in the chromitite. The presence of pargasite, sodium-phlogopite and clinopyroxene inclusions in the ore demonstrate high activities of Na_2O and CaO in the ore-forming fluid. Ca-rich olivine (up to 0.3 wt.% CaO) at the contact chromite-dunitic wall results from the reequilibration of wall-dunite with the ore-forming system.

A detailed textural study of chromitite showed that chromite crystallized later than olivine Fo_{95}. Chromite is strongly enriched in Os, Ir and Ru as compared to mantle rocks. Rutheniridosmine and laurite inclusions, sometimes associated with Ni-Cu alloys poor in iron (0.9 wt.% Fe), were found in massive chromite. Clinopyroxene inclusions in chromitite are often associated with PGM and minute native nickel droplets. Observed metallic phases indicate a drop in the oxygen fugacity causing the crystallization of chromite and imply the presence of a reducing fluid phase. Raman microprobe revealed methane concentration in fluid inclusions frequently observed in massive chromite. Nepheline associated with pargasite gives evidence of the incongruent melting of pargasite due probably to a pressure release and determines the maximum temperature of chromite precipitation at 1050°C. The composition of Ni-Fe alloys indicates oxygen fugacity ranging from 10^{-10} to 10^{-14} atm. The pressure estimated from fluid inclusions study is P = 5 to 7 kbars. An oversaturation of magma in water due to pressure release, an individualization of the fluid phase enriched in volatiles, the presence of carbon in the fluid and the development of hydrogen played important roles in chromite precipitation and consequently in the genesis of chromite deposits within the harzburgitic residual upper mantle. (Author's abstract)

JOHANNES, Wilhelm, 1984, Beginning of melting in the granite system Qz-Or-Ab-An-H_2O: Contrib. Mineral. Petrol., v. 86, p. 264-273. Author at Inst. für Kristal. und Petrogr. der Univ. Welfengarten 1, D-3000 Hannover 1, FRG.

The beginning of melting in the system Qz-Or-Ab-An-H_2O was experimentally reversed in the pressure range PH_2O = 2-15 kbar using starting materials made up of mixtures of quartz and synthetic feldspars. With increasing pressure the melting temperature decreases from 690°C at 2 kbar to 630°C at 17 kbar in the An-free alkalifeldspar granite system Qz-Or-Ab-H_2O. In the granite system Qz-Or-Ab-An-H_2O the increase of the solidus temperature with increasing An-content is only very small. In comparison to the alkalifeldspar granite system the solidus temperature increases by 3°C (7°C) if albite is replaced by plagioclase An 20 (An 40). The difference between the solidus temperatures of the alkalifeldspar granite system and of quartz-anorthite-sanidine assemblages (system Qz-Or-An-H_2O) is approximately 50°C.

With increasing water pressures plagioclase and plagioclase-alkalifeldspar assemblages become unstable and are replaced by zoisite + kyanite + quartz and zoisite + muscovite-paragonite$_{ss}$ + quartz, respectively. The pressure stability limits of these assemblages are found to lie between 6 and 16 kbar at 600°C. At high water pressures (10-18 kbar) zoisite-muscovite-quartz assemblages are stable up to 700 and 720°C. The solidus curve of this assemblage is 10-20°C above the beginning of melting of sanidine-zoisite-muscovite-quartz mixtures.

The amount of water necesary to produce sufficient amounts of melt to change a metamorphic rock into a magmatic looking one is only small. In case of layered migmatites it is shown that 1% of water (or even less) is sufficient to transform portions of gneiss into (magmatic looking) leucosomes. High grade metamorphic rocks were probably relatively dry, and anatectic magmas of granitic or granodioritic composition are usually not saturated with water. (Author's abstract)

JOHANSSON, Åke, 1984a, Fluid inclusion and stable isotope studies on some Caledonian sulfide-bearing veins in Sweden: Econ. Geol., v. 79, p. 1736-1748. Author at Ore Res. Group, Geol. Inst., Stockholm Univ., S-106 91 Stockholm, Sweden.

Sulfur isotope measurements have been made on sulfides from Caledonian sulfide-bearing calcite veins in the Precambrian basement of the Swedish Caledonides and from sulfide-bearing quartz veins within the Caledonides in Sweden. The calcite veins show a narrow range in $\delta^{34}S$ of the sulfides, between -7 and +1 per mil vs. CDT, whereas the quartz veins show a much wider range, from -12 to +14 per mil. A more detailed study of sulfide sulfur in one quartz vein deposit, Nasafjäll, however, shows little variation within that deposit, with most $\delta^{34}S$ values in a narrow range between 7 and 10 per mil. No vein deposits with sulfur as heavy as that of the sandstone-hosted impregnation ores of Vassbo and Laisvall ($\delta^{34}S = 17\text{-}28$) have been found in this study.

Fluid inclusion data from the Åkerlandet calcite vein suggest that it formed at temperatures between 75° and 165°C (not corrected for pressure) during mixing between two hot saline brines. Carbon isotope values, with $\delta^{13}C$ of the calcite close to -15 per mil vs. PDB, point to a significant contribution of reduced carbon to the ore-forming fluid. These data are used to reconstruct the chemical environment in terms of pH and oxygen fugacity for the formation of the Åkerlandet deposit. A similar tentative reconstruction is also made for the Nasafjäll quartz vein deposit.

The sulfur in the calcite veins is probably derived from leaching of sulfides in the granitic basement, in contrast to the organic reduction of seawater sulfate which has been proposed for the sandstone-hosted impregnation ores. Sulfide sulfur in the quartz veins may be a mixture of sulfide and sulfate sulfur leached both from the granitic basement and the overlying metasediments and metavolcanics of the Caledonian nappes, the sulfate being inorganically reduced through reactions with wall rocks prior to sulfide precipitation. The sulfur isotope data thus suggest different processes to have been involved in the formation of the different types of deposits. Together with lead isotope data, the sulfur data show that the Caledonian quartz and calcite veins in Sweden are not directly related to the Caledonian strata-bound ores but form distinct ore types of their own. (Author's abstract)

JOHANSSON, Åke, 1984b, The geology and genesis of lead-zinc veins in Sweden: Ph.D. dissertation, Stockholm Univ., Stockholm, Sweden.

The geology and genesis of Pb-Zn-bearing vein deposits in Sweden have been studied through investigations of their geological setting, vein and alteration mineralogy, wall rock geochemistry, lead and sulfur isotope composition and sphalerite composition, and through thermometric measurements on fluid inclusions from selected veins. The investigated deposits include Subjotnian veins from Alvdalen, Dalslandian veins from Dalsland and Värmskog, Caledonian quartz and calcite veins, Devonian deposits in the Siljan Ring structure, and Variscan veins in SE Scania. Based on their dominating gangue mineral, they may be divided into calcite veins and quartz veins.

The calcite veins have a simple Mississippi Valley-type mineralogy, and probably formed at rather low temperatures (around 100-150°C) from saline brines. The ore-forming solutions may have been brought up rapidly from depth by hydraulic fracturing in connection with deep faulting. The faulting was related to distant orogenic movements (the Caledonian and Variscan orogenies), to basin subsidence, magmatism and incipient rifting (in the Scanian/Variscan case), or, in the case of the Siljan astrobleme, to a Devonian meteorite impact.

The quartz veins have a more complex mineralogy and probably formed at higher temperatures (around 200-300°C). The Dalslandian Vegerbol quartz vein in Värmskog was deposited from a weakly saline, CO_2-bearing water solution. The Dalslandian quartz veins formed in connection with late-tectonic block faulting and hydrothermal activity related either to late-stage metamorphism or the intrusion of Bohus-type granite. The Caledonian quartz veins formed in connection with late thrusting and faulting, the hydrothermal activity possibly being related to the loading and movements of the nappes. The Subjotnian Alvdalen veins formed in relation to faulting and anorogenic magmatism.

The lead isotope composition of galena in the Subjotnian deposits, as well as in the Svecokarelian stratabound sulfide ores of the Bergslagen district, is uniform and non-radiogenic or weakly radiogenic. The late Proterozoic Dalslandian veins contain non-radiogenic to weakly radiogenic ore lead defining an isochron which suggests a Mid-Proterozoic crustal source for the lead (presumably the surrounding rock units). The Phanerozoic deposits contain lead ranging in composition from non-radiogenic to highly radiogenic values, forming a composite isochron which suggests the early Proterozoic Svecokarelian basement as the source of the radiogenic lead. The lead isotope composition of individual Phanerozoic deposits or groups of deposits may have been modified both through mixing with Phanerozoic, non-radiogenic lead, and through selective leaching of the more radiogenic lead fraction from the Svecokarelian rocks.

The veins do not appear to be feeder veins to, or remobilizations of, stratabound sulfide ores. Rather, they are distinct mineralization types of their own with their own geochemical characteristics, although in some cases part of a broader metallogenic epoch and province. (Author's abstract)

JONES, J.H., 1984, Temperature- and pressure-independent correlations of olivine/liquid partition coefficients and their application to trace element partitioning: Contrib. Mineral. Petrol., v. 88, p. 126-132.

JUSTER, T.C. and BROWN, P.E., 1984, Fluids in pelitic rocks during very low-grade metamorphism (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 553. Authors at Dept. Geol. & Geophy., Univ. Wisconsin, Madison, WI 53706.

Very low-grade metamorphism of pelitic rocks associated with coals of high-volatile bituminous rank (Tioga cty.) to anthracite rank (Schuykill cty.) in NE Pennsylvania has been characterized. Maximum metamorphic temperatures derived from models of coalification (Hood et al., 1975) range from approx. 150°C in the NW to approximately 275°C in the SE. Changes in the <2 μ fraction associated with metamorphism include (1) the total disappearance of expandable layers; (2) the partial formation of pyrophyllite (py) at the expense of kaolinite (ka) + quartz (qt); (3) an increase in the amount of chlorite; and (4) the formation of NH_4-bearing mica. Additional phases include muscovite, siderite (sid), paragonite, and mixed-layer paragonite/muscovite similar to that described by Frey (1969). The observed mineral assemblages are consistent with the metamorphic conditions as stated, and consistent with similar observations in very low-grade areas of the Swiss Alps where temperatures are unusually well-constrained (e.g. Frey, 1978).

The occurrence of the assemblage ka + py + qt over a broad range of temperatures requires associated changes in the mole-fraction of water from approx. 0.14-0.60. Additionally, the common assemblage sid + carbon serves to restrict $f(O_2)$ (French, 1967), which in turn allows calculation of $x(H_2O)$. These independent and consistent calculations then require a progressive change in the fluid in equilibrium with these rocks from low-H_2O (CH_4-dominant) to H_2O-dominant composition. This result is analogous to that reported by Mullis (1979) for the very low-grade pelitic Alpine rocks on the basis of fluid inclusions. It may thus be possible to generalize about the evolution of fluids in pelitic rocks during the transition from diagenesis to metamorphism. (Authors' abstract)

KADIK, A.A. and LUKANIN, O.A., 1984a Problems of redox regime of the upper mantle and ways of its degassing during melting (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 306-307 (in English). See next item.

KAKIK, A.A. and LUKANIN, O.A., 1984b Ways of degassing of mantle in the process of its melting: Role of carbon in formation of fluids in the places of formation of basaltic magmas: Geokhimiya, 1984, no. 7, p. 985-996 (in Russian; English abstract).

Based on thermodynamic calculations of equilibria in the system C-O-H, the conditions of stability of graphite and its role in formation of fluids in the places of formation of basaltic magmas are considered. Decrease of pressure in the process of uplift of the mantle material evokes significant change of composition of fluids to increase the percentage of CO_2 as well as CO, H_2, CH_4 with simultaneous decrease of H_2O percentage especially under pressures less than 10 to 15 kbar. Thus in the presence of graphite the fluid phase of the diapirs of the mantle rocks suffers from significant change that leads to vertical inhomogeneity in the composition of volatiles. This should be reflected both in composition of the generating magmas and in contents of volatile components in them. Significant dependence of concentrations of the main volatiles in the fluid (H_2O, CO_2, CH_4) on small variations of oxygen fugacity permits to wait among the upper mantle rocks a presence of remarkable inhomogeneities in composition of volatiles due to lateral and temporal variations of redox regime within the mantle[sic]. (Authors' abstract)

KADIK, A.A. and LUKANIN, O.A., 1984c Ways of degassing of the mantle in the process of its melting: Role of partial melting of the upper mantle rocks in formation of fluids and redox regime: Geokhimiya, 1984, no. 12, p. 1821-1831 (in Russian; English abstract).

Conditions of partial melting of graphite-bearing rocks of the mantle in the presence of a fluid phase are considered. Appearance of magmatic liquid leads to redistribution of volatile components between the melt and fluid phase in consequence of which a change of composition of the residual fluid phase and redox regime takes place. Progressive melting at T-P-$f(O_2)$ in the presence of an H_2O-CO_2 fluid leads to enrichment of the residual fluid in CO_2 and CO as well as to increase of $f(O_2)$. Melting in the presence of an H_2O-CH_4 fluid leads to enrichment of the residual fluid in CH_4 and H_2 and $f(O_2)$ in the system decreases. Processes of melting accompanied by the removal of some portions of the melt from the zones of partial melting enhance this effect and can be therefore one of the possible reasons of changing of fluid composition and redox conditions of the upper mantle rocks. (Authors' abstract)

KALE, P.G. and PATIL, R.R., 1984, Scanning electron microscopic studies of fluid inclusion daughter crystals: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October

1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 26. First author at KDM Inst. Petro. Explor., O.N.G.C., Dehradun.

A review of the method. (E.R.)

KALOGEROPOULOS, S. and MITROPOULOS, P., 1983, Fluid inclusion characteristics of fluorite from Laurion (Greece): Annales Geol. des Pays Helléniques, 1st Series, v. 31, p. 130-135, 1982-83 (published 1984?) (in Greek with English abstract).

The morphological and geochemical characteristics of the fluid inclusions of fluorite crystals from Laurion were studied. Microthermometric data suggest that the fluorite crystals were formed at temperatures ranging from 132 to 208°C and salinities from about 16 to 20 wt% eq-NaCl.

The Th and the salinity values measured suggest that the geochemical characteristics of the solutions from which the fluorite crystals were precipitated are similar with those which gave rise to the deposition of fluorite in Mississippi Valley type ore deposits as well as in vein Pb-Zn deposits in calcareous rocks. (Authors' abstract)

KALUZHNY*, V.A., NAUMKO, I.M. and VOZNIAK, D.K., 1984, Acid-alkaline periods of mineral formation and parageneses of minerals of pegmatites of zanorysh type of the Ukraine (according to data of fluid inclusions) (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 64-65 (in English). First author at Inst. Geol. & Geochem. of Fuel Minerals of the Ukrainian Acad. Sci., Kiev, USSR.

Inclusions of fluids are an important source [of data] about conditions of genesis of individual minerals and their paragenetic associations. An example of zanorysh (chambered) pegmatites illustrates completely the possibilities of fluid inclusions in reconstruction of the thermodynamic and geochemical parameters of mineral formation. A detailed crystal-genetic analysis of inclusions, a study of their composition and thermobaric properties precedes restoration of evolution of relative values of pH of the fluid. Conjugated alterations of P-T parameters and pH of fluids determines the sequence of formation, recrystallization and destruction of mineral individuals and their assemblages. Pegmatites are formed in two stages, divided by the polymorphic transition of quartz: preinversion and postinversion. Dynamics of mineral genesis in the postinversion stage is subordinated mainly in the acid-alkaline regime. According to measurements of pH solutions in quartz, topaz, fluorite and other minerals, the postinversion stage is divided into three acid and two alkaline periods. The depth of alteration of initial zones of pegmatites and observed constant of mineral new formation in nearby pegmatite bodies indicates an open system and superimposed influence of introduced fluids. Paragenesis of albitized, microclinized, topazized and quartzized rocks and also zanorysh regions of pegmatites are singled out. Division into periods of alteration of relative value of pH fluids, established for zanorysh pegmatites of the Ukraine and corroborated on other fields of analogous genesis, is a general regularity of postmagmatic processes of pegmatites and, apparently, granites of intermediate depths of formation. Obtained factual data and ideas of dynamics of process are corroborated by calculations of paragenetic and phase diagrams. They in general correspond to known theoretical models of evolution of pH postmagmatic fluids (Korzhinsky, 1965; Govorov, 1967; Naumov, 1975), [but reveal] however, new particular details of process. (Authors' abstract) * Sic

KALYUZHNYI, V.A. - See also KALUZHNY

KALYUZHNYI, V.A. and MATVIYENKO, A.D., 1983, Geochemistry of gas components of mineral-forming fluids and practice of prospecting for hidden chamber pegmatites, in Geochemistry of pegmatites and methods of their prospecting, p. 182-191, Siberian Br. "Nauka" Publ. House, Novosibirsk (in Russian). Authors at Inst. Geol. & Geochem. of Mineral Fuels, L'vov, Ukraine.

Inclusions were studied in minerals of topaz-morion pegmatites and wall-rock biotite-amphibole granites. Essential gas components of inclusions are CO_2, N_2 and CH_4. Fresh granite minerals bear inclusions essentially with N_2 (80-100% N_2 by vol.); blocky (late) quartz - essentially with CO_2 (80-95%). Altered granites, reticulate quartz and graphic intergrowths contain gases of intermediate composition. Absolute gas content increases rapidly in pegmatite-granite system in the quartz inner core of pegmatite: granite contains 5 to 40 cm^3 per kg, quartz core - >100 cm^3 per kg. Amount of CO_2 begins to increase at a distance of 15-20 m from the graphic zone of pegmatite; background content - 0.5-2 cm^3 per kg. The values of $\delta^{13}C$ in CO_2 from granites immediately adjacent to pegmatite ranges from -2.7 to -1.3%, and in pegmatite it reaches -1.0%. The above data may help in finding of hidden pegmatite bodies by studies of gas composition in fluid inclusions. (Abstract by A.K.)

KALYUZHNYI, V.A., TELEPKO, L.F. and SHCHIRITSYA, A.S., 1984, The composition and PT-parameters of the endogenic fluids in terms of the investigation of inclusions in calcites from mud volcano outbreaks: Min. Sbornik, v. 38, no. 2, p. 32-37 (in Russian; English abstract).

Gas-liquid inclusions of water solutions in calcites from breccia [of the] Kerch and Taman peninsula volcanoes and from Mountain Crimea surface veins are analogous. Their Th are 100...150°C, solution concentration 1.07...2.7% by wt., pH = 7.0-7.2. They delineate the conditions of primary mineral crystallization in the hydrothermal vein. Inclusions of liquid hydrocarbons and high density methane are typical only of the calcite from volcano outbreaks. Their properties reflect the parameters of the superimposed process of mineral transformation in water-pelitic environment of the volcanic source. On a basis of the calculations the temperature reached there 130 to 150°C, and pressure exceeded 40 mPa. (Author's abstract)

KAPEZINSKAS, K. and TOMILENKO, A.A., 1984, Variation of fluid pressure and its composition in the region of the Kholedninsk deposit (according to metamorphic inclusions): Reg. Metamorf. Metamorfog. Rudoobraz., [Tr. Vses. Soveshch.], 4th 1982, p. 116-124 (in Russian).

The Kholodnisk pyrite-polymetallic ore deposit (USSR) is localized in the Precambrian metamorphic rocks of the Riphean geosynclinal downwarp. Polygenetic and polychronous ores mineralized in three stages: hydrothermal-sedimentary, progressive metamorphism, and retrograde metamorphism. Metamorphic inclusions in minerals are of CO_2, CH_4, N_2, and aqueous saline composition. These inclusions represent the ore-forming fluids (OF). The homogenization temperature (-190 to -25°) and the fluid pressure at 600° (4.0-7.5 kbars) were determined in ore-free and ore-bearing rocks. The fluid pressure decreased steadily near ore deposits; the CO_2 and CH_4 contents of OF increased in orebodies. (C.A. 101: 195439j)

KAPLUNOV, L.D. and LEVSKII, L.K., 1984, Mass-spectral thermal analysis of minerals and rocks: Vestn. Leningr. Univ., Geol., Geogr., no. 3, p. 69-71 (in Russian).

The specially constructed app. for the mass spectral analysis of rocks and minerals is described. Some preliminary results are reported of its use for study of (1) the separation of volatiles (H_2O, CO, CO_2) from minerals, (2) the decrepitation of fluid inclusions, (3) decomposition processes of S-containing minerals, and (4) the separation of alkali metals from minerals. (C.A. 102: 28619g)

KAUFMANN, Ronald, LONG, Austin, BENTLEY, Harold and DAVIS, Stanley, 1984, Natural chlorine isotope variations: Nature, v. 309, p. 338-340. First author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721, USA.

Previously known natural variations in the stable isotope ratio of chlorine, $^{37}Cl/^{35}Cl$, have been within the experimental error of ±1.0‰. (All our measurements are reported in terms of δ^{37} in units of ‰; $\delta^{37}Cl = [(Rx/Rs) - 1] \times 1{,}000$, where $R = {}^{37}Cl/^{35}Cl$.) Using methyl chloride gas in a ratio mass spectrometer, we have increased the precision of measurement to ±0.24%, and report here significant isotope variation in natural chlorides. In general, salt deposits and saline hydrothermal springs tend to be enriched in ^{37}Cl with respect to seawater. Groundwater shows both enrichment and depletion with respect to seawater. Saline groundwater becomes more enriched in ^{37}Cl with increasing depth. (Authors' abstract)

KAWABE, Iwao, 1984, Anomalous changes of CH_4/Ar ratio in subsurface gas bubbles as seismogeochemical precursors at Matsuyama, Japan: Pure & Applied Geophysics, v. 122, no. 2-4 (1984), p. 194-214 (pub. 1985). Author at Dept. Earth Sci., Fac. Sci., Ehime Univ, Bunkyo-cho, 2-5, Matsuyama, Japan.

The results of seismogeochemical monitoring of subsurface gases associated with ground-waters from deep artesian wells in Matsuyama, Japan, are presented. The weekly collections of bubble-gas samples from the two borehole wells and gas chromatographic determinations of their He/Ar, H_2/Ar, N_2/Ar, and CH_4/Ar ratios for the recent nineteen months have revealed that the bubble-gas CH_4/Ar ratios at the two stations are correlated with the seismic activity in this area. Positive anomalies of the CH_4/Ar ratio were accompanied by five earthquakes with relatively large magnitudes and/or relatively small epicentral distances among thirty earthquakes that occurred during the monitoring period. The anomalous increases in the CH_4/Ar ratio had evidently begun prior to the respective earthquakes.

The occurrence of the geochemical anomaly appears to depend strongly upon the earthquake magnitude and distance, because the earthquakes that accompanied the anomalies and those that did not can be reasonably distinguished in the plot of magnitude vs. distance. Similar anomalies can be also seen in the variations of He/Ar and N_2/Ar ratios, but their magnitudes are much smaller than those of the CH_4/Ar ratio. These features have been discussed in relation to the possible mechanism of the seismogeochemical phenomena. (Author's abstract)

KEITH, T.E.C., BARGAR, K.E., HOWE, S.S., CAROTHERS, W.W. and BARNES, Ivan, 1984, Mineralogical studies of the hydrothermal system in Newberry Volcano drill hole 2, Oregon: Geothermal Resources Council, Transactions, v. 8, p. 125-128. Authors at U.S. Geol. Survey, Menlo Park, CA.

Studies of secondary mineral distribution, whole-rock chemical compositions, isotopes, and fluid inclusions are being conducted on the core from Newberry Volcano drill hole 2. Rocks from the drill core are divided into 3 major intervals on the basis of their alteration pattern, which is controlled by rock permeabilities, primary lithologies, and temperatures. Incomplete alteration of pumice-rich lithic tuff layers in the upper part of the altered section and lack of self-sealing in fractures of most lava flows suggest that the hydrothermal system is young. Most of the secondary minerals could have been formed at temperatures near those present today; maximum measured temperature was 265°C at the bottom of the hole. Fluid inclusions indicate that past temperatures in the deeper part of the drill hole may have been as much as 100°C hotter than presently measured temperatures. (Authors' abstract)

KEKELIYA, S.A., TVALCHRELIDZE, A.G. and YAROSHEVICH, V.Z., 1984, The geological and physicochemical conditions of formation of massive-sulfide-barite-base-metal deposits: Sovetskaya geologiya, 1984, no. 10, p. 30-36 (in Russian, English abstract; translated in Int'l. Geol. Rev., v. 26, no. 12, p. 1437-1444).

Th values found are given in a table as follows:

Temperature zonation in the massive-sulfide-barite-base-metal deposits of the Lesser Caucasus

Ore zone	Mineral	Homogenization temperature, °C		
		Madneuli	Alaverdi	Kedabek
Barite	Barite	60-100	About 120	-
Barite-base-metal	Quartz, barite, sphalerite	180-280	180-220	160-220
Copper-massive-sulfide	Quartz	250-300	240-280	About 250
Pyrite-massive-sulfide	"	280-370	-	280-370

KELLEY, Shari and BLACKWELL, David, 1984, Fission-track geochronology of the Meager Creek geothermal system, British Columbia: Geothermal Resources Council, Transactions, v. 8, p. 129-132. Authors at Dept. Geol. Sci., Southern Methodist Univ., Dallas, TX 75275.

Apatite and zircon from eight cores from two drill holes in the Meager Creek geothermal system were dated using the fission-track dating method. The preliminary apatite dating results indicate that the temperatures were above 120°C ± 25°C at shallow depths in both drill holes, and that the present temperatures measured in the area are cooler than they have been in the past. The zircon fission-track ages imply that for the most part, temperatures were never above 200°C ± 25°C at shallow depths in either hole. (Authors' abstract)

KELLY, W.C. and NISHIOKA, G.K., 1984, 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 main-stage White Pine copper mineralization. (Authors' abstract)

KELLY, W.C., PETERSEN, E.U., BLAKE, D.F. and ALLARD, L.F., 1984, Imaging and chemical analysis of microinclusions in opaque and transparent hydrothermal minerals by cryogenic scanning electron microscopy and energy dispersive methods (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 71 (in English). Authors at Univ. Michigan, Ann Arbor, MI, USA.

Cryogenic methods of X-ray microanalysis developed in the medical sciences for studies of frozen-hydrated biological tissues have been adapted to the imaging and semi-quantitative chemical analysis of fluid inclusions in minerals. After preliminary optical study, inclusions are "shock-frozen" in situ in their host crystals, are next exposed by cleaving or microdrilling under liquid nitrogen, and are then transferred to the cold stage of a scanning electron microscope (SEM) utilizing a specially designed sample holder. The inclusions are thus kept at liquid nitrogen temperatures throughout all stages of preparation, transfer, and analysis. Semi-quantitative chemical analysis is performed using the energy dispersive system (EDS) of the SEM to compare X-ray spectra of the frozen inclusions with those of saline standards prepared in the same manner and placed in the sample holder alongside the unknowns. These cryogenic SEM-EDS procedures are tedious, but they offer a unique means of determining major dissolved components in individual fluid inclusions. Moreover, the new technique is applicable to fluid inclusions in both optically opaque and transparent host crystals. (Authors' abstract)

KEMP, W.M., III and BOWMAN, J.R., 1984, A stable isotope and fluid inclusion study of contact Al(Fe)-Ca-Mg-Si skarns in the Alta stock aureole, Alta, Utah (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 558. Authors at Dept. Geol. & Geophy., Univ. Utah, Salt Lake City, UT 84112.

Petrologic, fluid inclusion, and stable isotope studies have been conducted on the contact skarns formed by replacement of lower Paleozoic dolomitic marble ($\delta^{18}O$ = +21.9 to +25.4‰; $\delta^{13}C$ = +0.5 to +2.7‰) adjacent to the 33 m.y. old Alta stock ($\delta^{18}O$ = +6.5 to +7.5‰). Two major stages of skarn development are recognized: Stage I - garnet + pyroxene + magnetite (earlier); Stage II - epidote + actinolite + quartz + calcite ± pyrite ± chalcopyrite (later). Temperatures of formation of Stage I assemblages have been estimated using oxygen isotope thermometry (T = 500 to 600°C) and fluid inclusion studies (T = 540 to 620°C). The fluid inclusion data are corrected for a 1.5 kb overburden estimated from biotite - cordierite - andalusite - K-feldspar assemblages in contact metamorphic shale. Fluid inclusion and oxygen isotope data indicate a highly saline (32 to 41 equivalent wt. % NaCl) fluid in oxygen isotopic equilibrium [$\delta^{18}O$(fluid) = +7.5 to +9.5‰] with the pluton. Replacement of host marble by Stage I skarn was accompanied by significant ^{18}O and ^{13}C depletion, and cannot be explained by simple decarbonation of the marble. Rather, the ^{18}O depletion suggests minimum skarn fluid to host marble ratios of three to twelve for the formation of Stage I skarns. Fluid inclusion studies indicate Stage II fluids formed at lower temperature (T = 395 ± 30°C) and lower salinity (1.0 to 7.0 equivalent wt. % NaCl) compared to Stage I fluids. Calculated oxygen and hydrogen isotopic ratios indicate that Stage II skarn fluids ($\delta^{18}O$ = +3.0 to +5.9‰; δD = -85 to-100‰) are depleted in ^{18}O relative to both Stage I skarn and the Alta stock and are significantly depleted in D relative to fluids in equilibrium with the Alta stock. The observed drop in temperature, salinity, $\delta^{18}O$ and δD values of the skarn fluids which accompanied skarn development from Stage I to Stage II suggests a significant influx of meteoric water into the evolving skarn system. (Authors' abstract)

KENNEDY, B.M., REYNOLDS, J.H. and SMITH, S.P., 1984, Helium isotopes: Lower Geyser Basin, Yellowstone National Park (abst.): EOS, v. 65, p. 304.

KERR, R.A., 1984, Doubling of atmospheric methane supported: Science, v. 226, p. 954-955.

Based on studies of gases dissolved in or as inclusions in glacial ice. (E.R.)

KERRICH, R., 1984, Chronology and ambient temperature/pressure conditions of fluid flow through the Eye-Dashwa Lakes pluton based on the $^{18}O/^{16}O$ ratio and fluid inclusions: Atomic Energy of Canada Ltd. TR-267, 32 pp. Author at Dept. Geol., Univ. Western Ontario.

Fracture-filling minerals in the Eye-Dashwa Lakes pluton near Atikokan were investigated for oxygen isotope ratios and fluid inclusions. The ambient temperature conditions of various fracture-filling minerals were estimated on the basis of these data: epidote-chlorite (220-290°C), prehnite-chlorite (250 to 290°C), fluorite-calcite (240 to 265°C), hematite (140 to 230°C), and gypsum (about 50°C).

Fluids involved in the epidote, prehnite, fluorite and hematite dominated fractures have a $\delta^{18}O$ of 0 to 2.5‰, and these low values suggest incursion of Archean marine water. A comparison of $\delta^{18}O$ ratios of fracture-filling minerals with minerals that would have crystallized from Pleistocene (2 million years old) surface waters suggests that all fracture fillings predate Pleistocene time. No influx of modern surface waters was involved in the formation of minerals submitted for analysis, although late fractures with clay coatings may be an exception; these will be analyzed in the future. (Author's abstract)

KERRICH, Robert and HYNDMAN, D.W., 1984, Thermal and fluid regimes in the Bitteroot Lobe-Sapphire block detachment zone: oxygen isotope data (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 558. First author at Dept. Geol., Univ. Western Ontario, Canada N6A 5B7.

In W. Montana, a 15 km thick sequence of allochthonous Belt Series metasediments is thought to have moved eastwards off the emergent Idaho batholith, and its extension, the Bitteroot Lobe. Near Missoula, the zone of detachment, defined by ~500 m thickness of mylonites, traverses the granite-metasediment boundary. Later chlorite breccias, characterized by intense transgranular fracturing, overlie and locally transect the mylonites.

In granite and pegmatite mylonites, quartz ($\delta^{18}O$ 10.4 to 11.1‰) and coarse muscovite (8.4‰) yield isotopic temperatures of ~650°C, interpreted as the temperature of ductile deformation; and fluids of 9.5 ± 0.5‰ --close to the magmatic range. K feldspar (7.4 to 1.3‰), fine muscovite (8.3 to 6.8‰) and biotite (2.0 ± 0.2‰) are shifted to low ^{18}O, reflecting post mylonite, meteoric water incursion resetting less retentive minerals, an effect also observed in undeformed precursors to mylonites.

In chlorite breccias, quartz and feldspar have undergone shifts of -10‰ relative to their values in mylonitic granites, and exhibit disequilibrium fractions (Δ = 5.3 to 9.6‰), due to exchange of feldspar down to lower temperatures. Albite and chlorite yield temperatures of 370°C (Δ = 4.5‰) to 250°C (Δ = 6.3‰), and calculated fluid $\delta^{18}O$ = -7‰ (370°C) to -11.8‰ (250°C). This temperature range is corroborated by fluid inclusion data. Near magmatic temperatures and fluid isotopic compositions are commensurate with a pluton roof zone environment, providing enhanced ductility in mylonites. Chlorite breccias are regarded as structural domains accommodating late vertical displacement of the batholith subsequent to removal of cover, and as conduits for incursion of low temperature meteoric H_2O. (Authors' abstract)

KERRICH, R., LA TOUR, T.E. and WILLMORE, L., 1984, Fluid participation in deep fault zones: evidence from geological, geochemical and $^{18}O/^{16}O$ relations: J. Geophys. Research, v. 89, no. B6, p. 4331-4343. First author at Dept. Geol., Univ. Western Ontario.

Fluid incursion into fault zones and their deeper level counterparts, brittle-ductile shear zones, is examined in a number of different crustal environments. At the Grenville front, translation was accommodated along two mylonite zones and an associated boundary fault. The high- (MZ II) and low-temperature (MZ I) mylonite zones formed at 580 to 640°C and 430 to 490°C, respectively, in the presence of fluids of metamorphic origin indigenous to the immediate rocks. A population of post-tectonic quartz veins occupying brittle fractures were precipitated from fluids with extremely negative $\delta^{18}O$ at 200 to 300°C. The water may have been derived from downwards penetration into fault zones of low-^{18}O precipitation on a mountain range induced by continental collision with uplift accommodated at deep levels by the mylonite zones coupled with rebound on the boundary faults. At Lagoa Real, Brazil, Archaean gneisses overlie Proterozoic sediments along thrust surfaces and contain brittle-ductile shear zones locally occupied by uranium deposits. Following deformation at 500 to 540°C, in the presence of metamorphic fluids and under conditions of low water to rock ratio, shear zones underwent local intense oxidation and desilicification. All minerals undergo a shift of -10‰, indicating discharge of meteoric water recharged formation brines in the underlying Proterozoic sediments up through the Archaean gneisses during overthrusting: about 1000 km^3 of solutions passed through these structures. At Yellowknife, a series of large-scale shear zones developed by brittle-ductile mechanisms, involving volume dilation with migration of ~5 wt % volatiles into the shear zones from surrounding metabasalts. This early deformation involved no departures in redox state of whole rock $\delta^{18}O$ from background states of $Fe^{2+}/\Sigma Fe = 0.72$ and 7 to 7.5‰, respectively, attesting to conditions of low water/rock. Shear zones subsequently acted as high-permeability conduits for pulsed discharge of >9 km^3 of reduced metamorphic hydrothermal fluids at 360-450°C. The West Bay fault, a late major transcurrent structure, contains massive bull quartz that grew at 200-300°C from fluids of 2 to 6‰ (possibly formation brines). In general, flow regimes in these fault and shear zones follow a sequence from conditions of high temperature and pressure with locally derived fluids at low water to rock ratios (during initiation of the structures) to high fluxes of reduced formation or metamorphic fluids along conduits as the structures propagate and intersect hydrothermal reservoirs. Later in the tectonic evolution and at shallower crustal levels there was incursion of oxidizing fluids from near-surface reservoirs into the faults. (Authors' abstract)

KERRICH, R. and WATSON, G.P., 1984, The Macassa mine Archean lode gold deposit, Kirkland Lake, Ontario: geology, patterns of alteration, and hydrothermal regimes: Econ. Geol., v. 79, p. 1104-1130. Authors at Dept. Geol., Univ. Western Ontario, London, Ontario N6A 5B7, Canada.

Calculations of chemical mass balance reveal that the principal chemical transfers accompanying hydrothermal alteration of wall rocks adjacent to ore involved additions of CO_2, but there are minor excursions of Fe_2O_3, MnO, MgO, and CaO of about zero gain or zero loss, corresponding to the variable carbonatization of the wall-rock silicates to Fe, Mg, Ca, Mn carbonates. Additions of K_2O along with depletions of Na_2O reflect the hydrolysis of albite to muscovite, and minor gains of SiO_2 plus S are evident in the coprecipitation of quartz and pyrite.

The $\delta^{18}O$ and δD of rocks and mineral separates in these three ore types suggest that the ore was precipitated from hydrothermal fluids of $\delta^{18}O = 7$ to 9.6 per mil and $\delta D = -35$ to -85 per mil, at 350° to 460°C. These data are consistent with a fluid which evolved by dehydration of volcanic and sedimentary rocks during accumulation and burial, and which ascended by hydrofracture along preexisting faults and fractures in which ore and gangue minerals were precipitated. A contribution from magmatic fluids is possible.

Isotopic data from rocks contained within the major faults suggest that this initial hydrothermal regime was followed by downward penetration of oxidizing, sulfate-bearing fluids, $\delta^{18}O = 0$ to 2 per mil, $\delta D = -20$ to -70 per mil, and of probable marine and/or meteoric water origin, initially at temperatures of <200°C, waning to 50°C or less. A third fluid regime is indicated for quartz-magnetite-chlorite veins which have mineral pair fractionations corresponding to fluids of $\delta^{18}O = -4.0$ to -0.5 per mil and 210° to 260°C, consistent with hydrothermal fluids of meteoric orign. These three hydrothermal fluid regimes are interpreted to reflect a sequence of crustal compression, relaxation, and finally uplift above sea level, probably all during the Archean. (From the authors' abstract)

KESTIN, J., SENGERS, J.V., KAMGAR-PARSI, B. and LEVELT SENGERS, J.M.H., 1984, Thermophysical properties of fluid H_2O: J. Phys. Chem. Ref. Data, v. 13, no. 1, p. 175-183.

KHEANG, Lao, 1984, Magmatic water/sea water mixing in an Archean hydrothermal system related to the formation of Millenbach Cu-Zn deposit, Rouyn-Noranda, Quebec (abst.): Geol. Assoc. of Canada and Min. Assoc. of Canada, Program with Abstracts, v. 9, p. 78. Author at Dept. Gen. Miner., Ecole Polytech., Montreal, Quebec, H3C 3A7, Canada.

Primary fluid inclusions in hydrothermal quartz from the Millenbach alteration pipe are divided into (1) moderately saline inclusions which contain 13 to 30 wt% eq. NaCl/$CaCl_2$, and (2) highly saline inclusions, with the salt concentration ranging from 27 to 46 wt% eq. NaCl. Some of the inclusions are liquid rich, with vapor/liquid ratio being generally lower than 35%. Thermometric data show that (1) 61% of the moderately saline inclusions are homogenized into the liquid phase at temperatures ranging from 250° to 399°C, averaging 310°C, (2) for highly saline inclusions, the maximum temperature of fluid phase homogenization is 383°C, and the corresponding salinity, deduced from the temperature of NaCl dissolution at 364°C, is 42 wt% eq. NaCl, and (3) the estimated temperature of the hydrothermal fluid, deduced from the average value of the Na/K atomic ratio, is approximately 350°C. The Na/(Na+K) ratios of 127 inclusions, analyzed with the electron microprobe, vary from 0.10 to 0.99, with 83% being higher than 0.70. Fluid inclusions allow us to draw the following conclusions: (1) the Millenbach hydrothermal system was composed of two fluids, (2) the highly saline fluid, with maximum salinity of about 40 wt% eq. NaCl, was probably of magmatic origin, (3) the moderately saline fluid, with salinities ranging from 15 to 26 wt% eq. NaCl/$CaCl_2$, probably originated from the mixing of sea water with the magmatic water, (4) the maximum temperature that the Millenbach hydrothermal system attained was 350° to 380°C, and (5) the weakly carbonic hydrothermal fluids were very sodic, with an average Na/(Na+K) ratio of 0.75. (Author's abstract)

KHETCHIKOV, L.N. and DOROGOVIN, B.A., 1982, Experimental data on the genesis of two types of inclusions in quartz: Dokl. Akad. Nauk SSSR, v. 267, no. 6, p. 1456-1457 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 267, p. 180-181, 1984). Authors at Inst. Lithosphere, USSR Acad. Sci., Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 110. (E.R.)

KHETCHIKOV, L.N. and POLENKOV, A.I., 1984, Certain regularities of distribution of inclusions of mineral-forming media in Precambrian minerals of various age: Dokl. Akad. Nauk SSSR, v. 279, no. 2, p. 431-433 (in Russian). Authors at Inst. of Lithosphere of Acad. Sci., Moscow, USSR.

Fluid inclusions in quartz from Precambrian quartzites of the Kursk Magnetic Anomaly prove that evolution of the mineral-forming solutions was as follows: from essentially CO_2 type in Archean rocks through CO_2-H_2O to essentially H_2O-salt in Proterozoic rocks. Differences in fluid inclusion filling are so significant and characteristic that they may be used for age identification of stratigraphically unknown Precambrian complexes. (A.K.)

KHITAROV, N.I. and LEBEDEV, E.B., 1984, Quantative base for the correlations between the properties of melts with their water contents (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 311 (in English). Text: Proc. 27th Int'l. Geol. Congr., v. 11, p. 467-483 (1984).

KHITAROV, N.I. and PUGIN, V.A., 1983, Probability of liquid immiscibility in andesite magma: Dokl. Akad. Nauk SSSR, v. 271, no. 4, p. 952-955 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 161-163, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 132, 1983. (E.R.)

KHLESTOV, V.V., 1984, Dynamics of mantle magma generation within the continental and oceanic segments of lithosphere: Int'l. Geol. Cong. 27, IX, part 1, p. 103-104. Author at Inst. Geol. & Geophys. of Siberian Br. USSR Acad. Sci., Novosibirsk, USSR.

The thermodynamics and kinetics of melt origination and dynamics of melt accumulation in extensive solid medium are considered for 2 models: initial continuous solid medium and solid medium with scattering fluid inclusions.

It has been found, firstly, that the stable nuclei generation is possible only when overheating takes place of solidus temperatures, in particular, at high volume effects of the isobar temperatures of the solidus. The required overheating in eclogites is 350-450°C, in a monomineral forsterite it is 100°C, while in gabbroic rocks is amounts to 40-60°C (with pressure in the upper mantle). Secondly, melting takes place at insignificant overheating.

The first model corresponds to a non-differentiated mantle which has not yet reached the stages of partial melting (in "protooceanic segments of the lithosphere) or to a "restite" mantle," from which the readily fused components were practically removed with the fluid. The second model characterizes the mantle at its intermediate stage of differentiation, when regressive crystallization of the residual melts results in the occurrence of fluid inclusions. It is shown that specific nature of magma generation in the solid medium in the course of progressive heat evolution of the Earth leads to a progressive melting of the mantle from the upper levels to the lower ones (resulting in the mantle differentiation from the upper levels to the lower ones), to the quasiperiodic change of the upwelling heat flows with a possibility of appearing of large lateral heterogeneities within the initially uniform layers. The differences in the course of magma injections from horizons with various preliminary differentiation are shown. In particular, the local centers do originate, in which melting of the overheated substance proceed "as a whole" (in the form of komatite lavas). On cooling due to the loss of heat at melting they are evacuated to the basalt melts. The obtained results supplemented by geologic observations are consistent with the early history of the Earth and oceanic continental joints. (Author's abstract, quoted verbatim)

KHOLMOGOROV, A.I., POPOV, A.A., STEPANOV, Ye.R. and KUZ'MINOV, M.A., 1983, Temperature fields of a deposit of tin-bearing greisens: Typomorphic features of ore minerals of endogenic formation of Yakutia, p. 19-31, ed. B.L. Flerov, Publ. House of Yakutian Div. Siberian Br. Acad. Sci. USSR, Yakutsk (in Russian).

Temperature zoning was studied in the tin ore greisen deposit in Tsentral'no-Poluosnyi ore region of NE Yakutia. The deposit is located in subvolcanic stock of Upper Cretaceous Li-F granite porphyries. Cassiterite-quartz (with molybdenite and wolframite) paragenesis is the main commercial assemblage of the ore stage. Mineral parageneses of pre-ore greisenization formed at 550-205°C, ore associations at 445-115°C and post-ore at 270-110°C, with T increment in the beginning of each following stage (and even in degree of mineralization) in comparison with the end of the preceeding stage or degree. By Th data, commercial cassiterite-quartz paragenesis crystallized at 445-230°C. Vacuum decrepitation of inclusions in cassiterite gives a more narrow T range: 304-240°C with distinct maximum at 260-270°C. The authors present also analysis of Td values for ore and post-ore metasomatites. Vertical T gradient was evaluated for deposit formation as 20-30°C per 100 m, horizontal T gradient - about 100°C per 100 m. (Abstract by A.K.)

KIEFFER, S.W. and STURTEVANT, Bradford, 1984, Laboratory studies of volcanic jets: J. Geophys. Res., v. 89, no. B , p. 8253-8268.

KILIAS, S., 1984, Genesis of gold deposits, Renabie area, Sudbury district, Ontario: MS thesis, Ottawa Univ., Ottawa, Canada.

The Renabie area, located 80 km northeast of Wawa, Ontario, is underlain by Archean mafic and felsic metavolcanic rocks of the northeastern end of the Wawa greenstone belt. The metavolcanic rocks are intruded on the east by the Missinaibi Lake Batholith, and Archean trondhjemite and tonalite body. The greenstone sequence experienced metamorphism to the lower amphibolite facies, perhaps coeval with the emplacement of the batholith. This was followed by partial retrogression of the batholith and the adjacent amphibolites to the greenschist facies during subsequent regional metamorphism, involving a carbon-dioxide hydrothermal fluid.

The Renabie Mine and the adjacent Braminco properties have gold-, sulphide-, telluride-bearing quartz-muscovite-carbonate veins in the marginal phase of the batholith and the adjacent greenstones, within 500 m of the intrusive contact. Wallrocks to these veins are modified (retrograded) by reactions with the gold-bearing hydrothermal fluids involving addition of K, H_2O, CO_2, Rb, Ba, and leaching of Na, resulting in pervasive development of muscovite and carbonate at the expense of sodic plagioclase. Wallrock alteration assemblages are indistinguishable from those produced by regional greenschist (retrogressive) metamorphism. Wallrock alteration and vein filling were concomitant with gold concentration under conditions of greenschist metamorphism at temperatures of T = 300°C to 470°C and maximum pressures of P = 2-3 kb, at depths of 8-10 Km.

Hydrothermal solutions forming the Renabie deposit and the adjacent gold-bearing veins were high temperature ascending aqueous fluids of metamorphic origin, possessing overall low salinities, probably low pH, high initial K/Na ratios, and containing significant quantities of CO_2, along with molecular hydrogen (H_2). An almost pure carbon dioxide fluid with little water was trapped in type II inclusions in the vein quartz, representing an early fluid phase which was probably later depleted in CO_2 through its fixation in altered wallrock and vein filling carbonates, giving rise to CO_2-H_2O solutions with approximately 20 vol. percent CO_2 and corresponding to those trapped in type I inclusions. A drop in the temperature of the mineralizing fluid and wallrock reactions involving fixation of hydrothermal CO_2 in alteration carbonates was important in the concentration of gold in the quartz-muscovite-carbonate veins of the Renabie Mine area. (Author's abstract)

KINGHORN, R.R.F., 1983, An introduction to the physics and chemistry of petroleum: New York, John Wiley & Sons, 420 pp.

Includes a 40-page chapter on oilfield brines, as well as discussions of the nature, origin, alteration, and movements of petroleum. (E.R.)

KINNAIRD, J.A., 1984, Contrasting styles of Sn-Nb-Ta-Zn mineralization in Nigeria: J. African Earth Sci., v. 2, no. 2, p. 81-90. Author at Univ. St. Andrews, Dept. Geol., Purdic Bldg., North Haugh, St. Andrews, Fife KY169ST, UK.

Two distinct and economically important types of primary Sn-Nb-Ta-Zn mineralization occur in Nigeria.

The early stage is related to Palaeozoic pegmatite which occur sporadically in a 400 km long north-east trending belt. Mineralogically the pegmatites consist of quartz, potash feldspar, albitized mica and are characterized by extensive development of tourmaline. Economically they are important for minerals of the columbo-tantalite series.

The later stage of mineralization is found in granites of the Mesozoic ring complexes. Tantalum-bearing columbite, accompanied by cassiterite, and rare earth minerals have been disseminated in the cupola zones of biotite granites during an albitization process. A similar albitization process in the arfvedsonite granites has led to the dissemination of pyrochlore, thorite, monazite and xenotime. Mineralized veins, which are limited in occurrence to the biotite granites, form four major types which contain either an oxide series of minerals dominated by cassiterite and wolframite or a series of sulphides dominated by sphalerite.

Fluid inclusion studies related to the Younger Granite minealization show a gradual evolution of fluids from highly saline, at around 500°C, to dilute fluids at 320°C or below. It is from these later dilute fluids that the sulphide ore assembage is deposited.

The contrasting styles of Palaeozoic pegmatite and Younger Granite mineralization are related to granites of differing chemistry whose tectonic setting may also be different. (Author's abstract)

KIRBY, S.H., 1984, Introduction and digest to the special issue on chemical effects of water on the deformation and strength of rocks: J. Geophy. Research, v. 89, no. B6, p. 399-3995.

KIRBY, S.H. and KRONENBERG, A.K., 1984a Hydrolytic weakening of quartz: uptake of molecular water and the role of microfracturing (abst.): EOS, v. 65, p. 277.

KIRBY, S.H. and KRONENBERG, A.K., 1984b Diffusion-induced grain-boundary motion (DIGM) and diffusion-induced recrystallization (DIR): applications to the rheology of rocks (abst.): EOS, v. 65, no. 45, p. 1098. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

Many polycrystalline metals display extraordinary increases in the rates of grain boundary motion and recrystallization when they are annealed in a solute environment. Most observers agree that the driving potential for these processes is the free energy reduction associated with mixing, but the nature of the coupling with grain boundary motion is controversial. Imposed changes in solute activity thus promote grain boundary motion and in some substitutional alloys, these changes are communicated primarily along grain boundaries at temperatures where grain-boundary diffusion is much faster than intracrystalline diffusion. Solute dissolution is then accomplished by the sweeping of the solute-laden grain boundary. It is very likely that similar processes occur in rocks undergoing metamorphism or metasomatism where changes in solute activity are communicated by hydrothermal solutions. Rocks may equilibrate to the aqueous-fluid environment far faster by this mechanism than by intracrystalline diffusion, especially at low to intermediate temperatures. These changes in intragranular rock chemistry may alter the rheological properties of rocks by influencing the mineral defect chemistry (Hobbs, 1983, 1984) or by varying the concentration of intracrystalline water and thus the degree of hydrolytic weakening. At this year's Spring meeting, we reported that single crystals of quartz recrystallize along fluid-filled fractures at far lower temperatures than are necessary for dry quartz to recrystallize and we suggested that DIR was responsible for this enhanced recrystallization. We expand upon this observation in the present work and suggest that the presence of water may promote recrystallization in silicates as a part of the driving force as well as influencing grain boundary mobility. (Authors' abstract)

KIRBY, S.H. and SCHOLZ, C.H., eds., 1984, Workshop on chemical effects of water on the strength and deformation of crustal rocks: J. Geophys. Research, v. 89, no. B6.

A series of 31 papers covering various aspects; those most appropriate to fluid inclusion studies are abstracted or cited in these volumes. (E.R.)

KITAMURA, K., TSUTSUMI, M., KIMURA, S. and KOMATSU, H., 1984, Microscopic voids in FZ-grown NdGG garnet; occurrence and morphology: J. Crys. Growth, v. 67, p. 656-659. First author at Nat'l. Inst. for Research in Inorganic Materials, 1-1 Namiki, Sakura-mura, Niiharigun, Ibaraki 305, Japan.

Microscopic voids with a diameter of a few μm were found in NdGG single crystals grown by the FZ method. The occurrence of the voids strongly depended on the growth rate. They were concentrated in the {211} facet regions under certain growth conditions. Each void exhibited a lot of small flat faces, which were less than 1 μm in diameter, on the concave surface. The {211} and {100} faces were superior to the {100} faces in size and distinctness. (Authors' abstract)

KITYK, V.I., BOKUN, A.N., PANOV, G.M., SLIVKO, Ye.P. and SHAYDETSKAYA, V.S., 1983, Halogene formations of Ukraine-Transcarpathian belt: "Naukova Dumka," Kiev, 168 pp., 500 copies printed, price 1 rbl. 90 kopecks (in Russian). Authors at Inst. Geol. and Geochem. of Mineral Fuels of Acad. Sci. of Ukr. SSR, L'vov, Ukraine.

In the Transcarpathian belt the Middle Miocene saline formation consists essentially of halite. It is exploited presently at the Solotvino deposit. Halite bears P inclusions in growth zones and S inclusions in cleavage planes. P inclusions are essentially liquid, liquid plus a solid phase or phases. L is saline solution; solids are xenogenic minerals (gypsum, anhydrite and clay minerals). S inclusions are filled by G, G+L or L. Relics of primary-sedimentary halite bear P inclusions of L type only; recrystallized halite - essentially L, L + solid and solid inclusions (L is sometimes under high P and "boils" after inclusion opening, i.e., dissolved G separates from L); redeposited halite - L, L + solid and solid inclusions. Halite contains average 0.23 cm^3 of G per kg. G consists of (in vol. %) H_2 0.71-0.96, CH_4 12.6-20.2, C_2H_6 6.3-8.1, C_3H_8 22.9-26.8, C_4H_{10} 30.5-37.6, C_5H_{12} 15.2-18.6, CO_2 not determined, He not found. Analysis of L in individual inclusions in halite yielded the following elements (in g per L): K 4-25, Mg 9.5-36.5, Ca traces to 43, SO_4 nil to 46, Cl and Na - saturated solution, number of determinations from 30 to 74. (Abstract by A.K.)

KIYOSU, Yashuhiro and KURAHASHI, Makoto, 1984, Isotopic geochemistry of acid thermal waters and volcanic gases from Zaō volcano in Japan: J. Volcanol. Geotherm. Res., v. 21, p. 313-331.

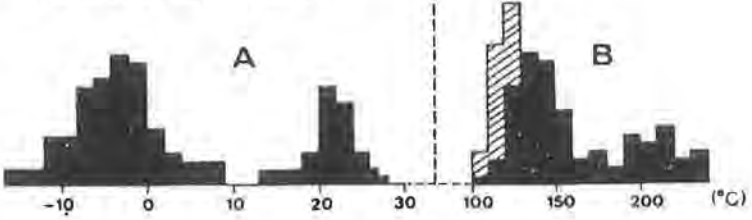
KLATT, E. and SCHOCH, A.E., 1984, Comparison of fluid inclusion characteristics for high grade metamorphic rocks from Finnish Lapland with medium grade rocks from north-western Cape Province, South Africa (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 73 (in English). Authors at Univ. of the Orange Free State, Bloemfontein, RSA.

It is intended to illustrate the essential differences between volatile fluids associated with Proterozoic metamorphic events of different grades. For this purpose fluid inclusions in quartz are studied using granite, augen gneiss, granulite, mica schist and quartzite from both areas. The fluid properties are deduced from determined peak melting and homogenization temperatures (Tm and Th), and effects attributable to later hydrothermal events are excluded as far as possible.

The sillimanite-garnet-cordierite-gneiss of the granulite belt of Finnish Lapland, formed during the Karelian orogeny (2.1-1.9 b.y. ago), has high carbon dioxide mole fractions. In the granulite complex to the east of the river Tana, carbon dioxide forms between 100% and 25% of all inclusions, with a peak density of 0.88-0.99 g/cc (A left). These inclusions contain as much as 20% equivalent methane. The coexisting water inclusions (B, hatched) exhibit a high salinity, ranging from 5% to 35% equivalent chlorides in the system H_2O-NaCl-KCl-$CaCl_2$.

The gneiss, quartzite and granite from the north-western Cape Province, South Africa (1.5-1.1 b.y. old), are mainly of amphibolite grade metamorphites. The peak density of water inclusions ranges from 0.89 to 0.94 g/cc (B), with peak salinity of 6% to 12% equiv. NaCl. Carbon dioxide inclusions are relatively few and exhibit a peak density of 0.70 - 0.78 g/cc, probably representing a late or retrograde metamorphic event. Metamorphites from the more highly deformed regions (such as the Augrabies area) have water inclusions with a similar density to those of the less deformed rocks, namely 0.90-0.97 g/cc, but the salinity varies very widely from 0 to 25% equiv. NaCl. The peak density of the carbon dioxide inclusions in the deformed rocks is somewhat more variable than for the less deformed material, namely 0.68-0.84 g/cc (A, right). All the carbon dioxide inclusions are practically free of hydrocarbons.

It is concluded that the granulite terrane studied (Finland) has fluid inclusions of higher density than the amphibolite terrane (Cape Province). The CO_2 inclusions of the former area contain far more hydrocarbons than those of the latter region, possibly reflecting differences in regional subcrustal composition at the two areas. It is to be noted that variation in the intensity of regional deformation is reflected by a concomittant spreading of some fluid inclusion properties, but that the peak characteristics can still be determined by careful microthermometric observations. (Authors' abstract)



KLEMM, W., 1984, Remarks to the situation of the isotopegeochemical investigations on gas-fluid-inclusions in hydrothermal minerals: Freiberger Forschungshefte, Reihe C, V. 389, p. 292-295 (in German). Author at Freiberg Mining Acad., G.D.R. - 9200 Freiberg/Sa.

Some selected isotopic results (D/H- and $^{18}O/^{16}O$-data) from the literature are presented and discussed. (R. Thomas)

KNAPP, Steve, SHERVAIS, J.W. and TAYLOR, L.A., 1984, Granite on the Moon: an unlikely rock for mafic rock associations (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 561. Authors at Geol. Sci., Univ. Tennessee, Knoxville, TN 37996.

Silicate liquid immiscibility better explains the high K/REE and K/P ratios. (From the authors' abstract)

KNAUTH, L.P. and HUBBARD, Norman, 1984, Isotope geochemistry of formation waters in the Palo Duro Basin, Texas (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 561. First author at Dept. Geol., Arizona State Univ., Tempe, AZ 86287.

δD and $\delta^{18}O$ values for formation waters in the Palo Duro Basin fall into two linear arrays on a δD-$\delta^{18}O$ diagram. One array, Group I, is characterized by constant δD values of -12 ± 3‰ and $\delta^{18}O$ values which range from -1 to 2.5‰. The second array, Group II, varies in δD by 40‰ and ranges from the meteoric water line at $\delta D = -55‰$, $\delta^{18}O = -8$ to and end-member value of $\delta^{18}O = 0$, $\delta D = -12$, a point common to both arrays.

$\delta^{18}O$ of the carbonate aquifer rocks ranges from +26.2 to 29.9‰. Group I waters have $\delta^{18}O$ values indicative of isotopic equilibrium with these carbonates at the measured subsurface temperatures. The calculated water/rock ratio ranges from .3 to 3.9. A possible recharge water for these aquifers could have been an ancient meteoric water with $\delta^{18}O = -2.5$, $\delta D = -12$.

Group II waters are substantially depleted in ^{18}O relative to values expected for carbonate-water equilibrium. These waters have experienced minimal exchange with carbonates and can be readily interpreted as a mixture of meteoric waters with Group I waters. Group II waters are encountered as deep as 8200 feet.

We suggest that meteoric waters are able to penetrate deeply into the basin, primarily through permeable clastics near the margins of the basin. These waters migrate into the carbonate aquifers where they mix with older waters and also undergo isotopic exchange with the carbonate. This mixing process may also apply to other sedimentary basins where isotope data have been previously interpreted in terms of a single recharge water which undergoes isotopic evolution exclusively via rock/water interactions. (Authors' abstract)

KOGARKO, L.N., KRIGMAN, L.D. and BELYAKOVA, F.N., 1984, System nepheline-diopside-apatite and evolution of melt in the process of crystallization of apatite-bearing ijolite-urtite magma: Geokhimiya, 1984, no. 4, p. 472-493 (in Russian; English abstract).

Phase diagram of the system nepheline-diopside-apatite was studied in experiments. The compositions of mineral phases and coexisting melts (by microprobe) were used to calculate partition ratios of trace elements between the crystals and melt. Based on the data obtained the trajectories of evolution of ijolite-urtite melts were considered that led to conclusion that the Khibiny apatite-nepheline deposits are the result of crystallization differentiation of a single ijolite-urtite magma and cannot be the products of immiscibility differentiation of phosphate and alumosilicate melts. (Authors' abstract)

KOIVULA, J.I., 1984, Inclusions in a better light: Z. Dt. Gemmol. Ges., v. 33, no. 1/2, p. 43-47.

In gemmology the separating of natural gemstones from their synthetic counterparts was and is of utmost importance and top priority. With the recent onslaught of a variety of sophisticated synthetic gemstones onto the market, such as rubies, alexandrites and amethysts, these separations are, quite often, no longer possible unless recognizable internal characteristics are present. This article stresses the tremendous role played by inclusions in the field of gemmology today and the importance of the modern gemmological microscope in fulfilling that role. (Author's abstract)

KOLASINSKI, Wojciech, 1984a, On the formation of liquid inclusions in some solution-grown crystals: (I) Sodium-cadmium formate: Mat. Res. Bull., v. 19, p. 867-872. Author at Inst. Physics, Tech. Univ. of Lodz, 93-005 Lodz, ul. Wolczanska 219, Poland.

The formation of liquid inclusions in sodium-cadmium formate (SCF) single crystals has been studied. Crystals were grown on seeds by slow cooling of unstirred aqueous solution. It was found that liquid inclusions in SCF are a result of convective flow around a crystal. The results are briefly analyzed from theoretical considerations. (Author's abstract)

KOLASINSKI, Wojciech, 1984b, On the formation of liquid inclusions in some solution-grown crystals: (II) Potassium dihydrogen phosphate: Mat. Res. Bull., v. 19, p. 873-876. Author at Inst. Physics, Tech. Univ. of Lodz, 93-005 Lodz, ul. Wolczanska 219, Poland.

The observations of the formation of liquid inclusions in KDP single crystals grown from aqueous solution in static conditions are presented. It was found that the mechanism of creation of inclusions as proposed by Chernov may be applied to understand their morphology. (Author's abstract)

KOLESAR, P.T., 1984, Development of banding in calcite veins precipitated from groundwater (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 564.

KOL'KOVSKI, B.G., BOGDANOV, K.B. and PETROV, S.L., 1984, Mineralogy, geochemistry and genetic features of the deposits along the Goljam Palas - Ribnica fault, Madan ore field: God. SU "Kl. Ohridski." Geol.-Geogr. Fak., v. 74, 1980, no. 1, Geologija, 1984, p. 97-139 (in Russian; English abstract).

The area of the deposits consists mostly of banded and migmatized biotite gneisses of Proterozoic(?) age. There are three types of ore bodies - metasomatic bodies, veins and stockworks. Thirty one hypogene minerals and mineral varieties are found. Among them galena, sphalerite, quartz and carbonates are of primary importance while pyrite and chalcopyrite are subordinate minerals. The hypogene ores are grouped in five mineralogical types: (1) quartz-sphalerite-galena ores with pyrite and chalcopyrite, (2) quartz-galena ores, (3) quartz with some sulphides, (4) quartz-carbonate-sulphide ores, (5) carbonate-sulphide ores. They are formed in seven mineralization stages. The temperature of mineral formation, as determined by Th of fluid inclusions in quartz, barite and calcite is in the interval 355-120°C. (From the authors' abstract)

KOLODIY, V.V. and KOYNOV, I.M., 1984, Oxygen and hydrogen isotopic composition of the Carpathian underground waters and the problem of their genesis: Geokhimiya, 1984, no. 5, p. 721-733 (in Russian; English abstract).

KOLPANOV, L.P., MALYUSOV, V.A. and ZHAVORONKOV, N.M., 1984, Joint heat and mass exchange in systems consisting of agglomeration of drops of bubbles: Akad. Nauk SSSR Doklady, v. 274, no. 4, p. 890-893 (in Russian). Authors at Inst. of New Chem. Problems, Chernogolovka near Moscow, USSR.

The paper presents mathematical analysis of heat- and mass-exchange in systems consisting of liquid drops or G bubbles in a continuous medium that may be useful for interpretation of heterogeneous mineral-forming environments. (A.K.)

KONNERUP-MADSEN, Jens, 1984a Compositions of fluid inclusions in granites and quartz syenites from the Gardar continental rift province (south Greenland): Bull. Minéral., v. 107, p. 327-340. Author at Inst. Petrol., Univ. Copenhagen Øster Voldgade 10, DK-1350 Copenhagen, Denmark.

Fluid inclusions in quartz from granites and quartz syenites from the Precambrian Gardar province (south Greenland) vary in composition from CO_2-CH_4, through CO_2-CH_4-H_2O mixtures, to aqueous saline fluids. The inclusions primarily represent fluids present during most-magmatic stages. Aqueous inclusions are the dominant type in all examined complexes. Salinities vary from 1 to 64 weight per cent, but late inclusions contain less than 40 equivalent weight per cent NaCl and have densities from 0.9 to 1.15 g/cm^3. Boiling of the aqueous fluids does not appear to have played a prominent role in the generation of the higher salinity fluids. Early CO_2-CH_4 fluids contain less than 5 mole per cent CH_4 and have densities from 0.75 to 1.0 g/cm^3, but later fluids may contain up to about 80 mole per cent CH_4 and have lower densities. Conditions for entrapment of most of the examined inclusion fluids at 250° to 400°C and about 1-2 kbar are indicated. (Author's abstract)

KONNERUP-MADSEN, Jens, 1984b Hydrocarbon gases in fluid inclusions associated with alkalic igneous activity in the Precambrian continental Gardar rift province, south Greenland (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 83 (in English). Author at Inst. Petrology, Geol. Inst., Univ. Copenhagen, Copenhagen, Denmark.

Studies of fluid inclusions in minerals from alkalic igneous complexes belonging to the Precambrian Gardar continental rift province in south Greenland have revealed a distinct difference in the composition of carbonic fluids between Si-oversaturated and Si-undersaturated rock types. Whereas granites and quartz syenites are essentially characterized by CO_2 and contain only minor amounts of CH_4, agpaitic nepheline syenites are dominated by hydrocarbons (mainly CH_4) and contain only insignificant amounts of CO_2 and/or CO. Stable isotope analyses favor a juvenile origin for both types of carbonic fluids.

The formation and subsequent entrapment of hydrocarbon gases in agpaitic nepheline syenites is considered to reflect: (1) low oxygen fugacities; (2) retention of volatiles during crystallization; (3) a low-temperature solidus; and (4) redissolution of previously exsolved water in an increasingly peralkaline melt on cooling and crystallization.

Comparisons of the hydrocarbon gases in the Gardar agpaitic nepheline syenites with those in similar rock types from other continental rift environments reveal a high degree of similarity and suggest the existence of a characteristic hydrocarbon-rich vapor phase associated with Si-undersaturated, peralkaline magmatic activity. The significance of these data for the existence of hydrocarbons (CH_4) in the Earth's crust and upper mantle is discussed. (Author's abstract)

KONNERUP-MADSEN, Jens and ROSE-HANSEN, John, 1984, Composition and significance of fluid inclusions in the Ilímaussaq peralkaline granite, south Greenland: Bull. Minéral., v. 107, p. 317-326. Authors at Inst. Petrol., Univ. Copenhagen Øster Voldgade 10, DK-1350 Copenhagen, Denmark.

Fluid inclusions were studied in quartz from peralkaline granite, hydrothermal granitic veins, and quartz veins from the essentially silica-undersaturated Ilímaussaq intrusion, south Greenland. In contrast to the hydrocarbon-dominated fluids of the agpaitic nepheline syenite in the intrusion, the fluids in the alkali granite are entirely aqueous solutions with salinities from about 2 to 64 weight per cent and densities from 0.2 to 1.2 g/cm^3. Conditions at the time of intrusion of the alkali granite of about 1 kbar for temperatures of 650° to 700°C are indicated by the fluid inclusion data.

Fluid inclusions in veins of alkali granite formed from reaction of Ilímaussaq augite syenite with sandstone country rock, and in quartz veins, contain CO_2 and/or CH_4 in addition to aqueous fluid. The difference in fluid composition between the main Ilímaussaq alkali granite and the granitic veins suggests that the alkali granite is not related to the augite syenite and nepheline syenites in the intrusion through assimilation of sandstone but represents an independent alkali acidic magma alien to the main silica-undersaturated Ilímaussaq magma(s). (Authors' abstract)

KONTAK, D.J., CLARK, A.H. and FARRAR, Edward, 1984, The influences of fluid and rock compositions, and tectono-thermal processes on Al-Si distribution in alkali feldspars in granitoid rocks, S.E. Peru: Bull. Minéral., v. 107, p. 387-400. Authors at Dept. Geol. Sci., Queen's Univ., Kingston, Ontario K7L 3N6, Canada.

The Al-Si distribution in alkali feldspars in two suites of granitoid rocks, of Permo-Triassic and mid-Tertiary age, in SE Peru has been studied using X-ray techniques in conjunction with geochemical, petrographic, geochronological and fluid inclusion work. The data indicate that multistage processes contributed to the final structural states of the feldspars in both suites. (From the authors' abstract)

KONTOROVICH, A.E. and DANILOVA, V.P., 1984, Geochemistry of hydrocarbons in salt-bearing rocks: Geologiya i Geofizika, v. 25, no. 11, p. 55-64 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 11, p. 54-63, 1984).

This article presents the first information on the bitumoids, including hydrocarbons, within the Cambrian salt deposits in the southern part of the Siberian platform. Their composition is compared with that of the bitumoids in carbonate rocks and also with the oils in petroleum deposits of the same age. The considerable biological productivity of fossil salt-generating basins is substantiated. (Authors' abstract)

KORMUSHIN, V.A., IVKINA, I.N., DARBADAYEV, A.B., SAVOSTIN, B.A. and BOGOMAZ, V.P., 1984, Reconstruction of mineral-forming solutions in accordance with microinclusions in minerals (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 83-84 (in English). First author at Inst. Geol. Sci. Kazakh SSR Acad. Sci., Alma-Ata, USSR.

Various methods have been used to reveal ion composition and the liquid phase concentration in microinclusions. Gas was analyzed independently. The composition of mineral-forming solution (MS) was reconstructed according to the data of analyses and the results of determination of the microinclusion volume and the fluidity degree of solutions. The microinclusions volume was measured by the diameter of a gas bubble and calculated by a formula combining the value of the gas bubble diameter and the thermal expansion of mineral and liquid. MS fluidity degree was determined by the method of vacuum thermometry. Microinclusions were broken up in vacuum and the partial pressure of volatiles (water and gas) was selectively measured while temperature decreased. The mineral volume expansion was calculated according to the X-ray data of the lattice cell parameters of minerals. The experimental data processing was carried out by the method of approximation and in accordance with the programs which were processed in Fortran machine language for electonic computers. Microinclusions in quartz and fluorite from pegmatites and the rare metal Kazakhstan deposits were investigated. The resultant data of analyses of MS composition are given in kg of substance per m^3 of solution. The experiment was carried out at Th. The solution density and the pressure of the mineral-forming medium were also calculated. (Authors' abstract)

KORYTOV, F.Ya., KUDRIN, V.S., PROKOFEV, V.Yu. and RYABENKO, S.V., 1984, Genesis of cryolite: Dokl. Akad. Nauk SSSR, v. 279, no. 6, p. 1464-1467 (in Russian). Authors at Inst. Mineral. Geokhim. Kristallokhim. Redk. Elem., Moscow, USSR.

The thermobarogeochemical method was used on gas-liquid inclusions to determine the origin of cryolite from various deposits in the USSR and from Ivigtut, Greenland. Cryolite from deposits in the USSR occurs generally as two varieties, which differ in crystal morphol. and mineral association. Most of the fluid inclusions in the cryolites homogenized at 90-330°. All the crystals homogenized in a liquid phase, which indicates crystallization from hydrothermal solutions. The eutectic temperatures obtained show that the solutions were of two compositional types: chloride (-28 to -24) and fluoride (-5.5 to 3.5). The cryolite-forming solutions were also characterized by an absence of Ca, which if present would have resulted in the crystallization of fluorite. (C.A. 102: 152330v)

KORZHINSKII, D.S., PERTSEV, N.N. and ZOTOV, I.A., 1984, Transmagmatic fluids and magmatogenic ore formation. A problem of mantle ore sources: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 131-138.

KOSALS, Ya.A., 1983, Geochemical peculiarities of pegmatite-bearing granite formations, in Geochemisry of pegmatites and methods of their prospecting, p. 14-29, Siberian Br. "Nauka" Publ. House, Novosibirsk (in Russian). Author at Inst. Geol. & Geophys. of Siberian Br. Acad. Sci. USSR, Novosibirsk, USSR. Continued next page.

The paper bears numerous Th values of inclusions in granite and pegmatite minerals, quoted from various papers of other authors. (A.K.)

KOSHEMCHUK, S.K. and TIKHOMIROVA, V.I., 1984, The CHN analyzer to measure contents of absorbed crystallization water-CO_2 in microsamples of minerals and rocks: Geokhimiya, 1984, no. 7, p. 1083-1987 (in Russian; English abstract).

A gas-chromatographic method has been developed to determine the content of absorbed crystallization water and CO_2 in mineral or rock specimens using a modified combustion unit of the CHN-1 analyzer in which the zone heated to 105°C was fixed. The contents of absorbed crystallization water and CO_2 in some natural and synthetic specimens are given together with the analyses of standard PIM-1, SGS-1A, and Biotite-123 samples. The standard deviation is calculated as large as 1-3%. (Authors' abstract)

KOSUKHIN, O.N., BAKUMENKO, I.T. and CHUPIN, V.P., 1984, Magmatic stage of granite pegmatite formation: Inst. Geol. Geophy. SB AS USSR, v. 476, 137 pp. (in Russian).

The work is the first monographic description of the investigation of the primary solidified inclusions and syngenetic fluid inclusions in quartz of granite pegmatites of some regions of the USSR and Mongolia. P-T crystallization conditions of magmatic zones of chambered and related pegmatites, formed from relic granite melts, and some more abyssal pegmatites of anatectic origin, are defined. It is shown that temperature and fluid pressure variations are conditioned by crystallization of relic and anatectic pegmatites of different formation types from melts with different content of water, carbon dioxide and other volatile and fluxing components. Cases of saturation of melts by fluids and separation of the latter during pegmatite crystallization are established. The data require consideration of a number of traditional ideas of pegmatite processes. (Authors abstract)

KOUTZ, F.R., 1984, The Hardshell silver base-metal manganese oxide deposit, Patagonia Mountains, Santa Cruz County, Arizona: A field trip guide: Arizona Geol. Soc. Digest, v. 15, p. 199-217. Author at Southwestern Explor. Div., ASARCO Inc., P.O. Box 5747, Tucson, AZ 85703.

Includes data on fluid inclusions (pp. 204 and 216). Th 50-400°C; salinity 0-16%. (E.R.)

KOVALENKO, V.I., NAUMOV, V.B. and BOGATIKOV, O.A., 1984, Potential ore-bearing capacity of acid magmatic rocks (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 357-358. First author at Inst. Geol. of Ore Deposits, Petrogr., Mineral. & Geochem. of USSR Acad. Sci., Moscow, USSR.

The criteria of potential ore-deposit production, physico-chemical parameters (temperature, pressure, water contents in melts, composition of fluids, etc.) and the ways of formation of ore-deposits from acid rocks of the lithium-fluoride, standard and alkaline geochemical types are considered. The evolution of acid magmas, directed towards fluorine, alkalies, boron and water accumulation, is favorable for the formation of rare-metal and tin-tungsten ore deposits at the late-magmatic and post-magmatic stages. A wide range of temperatures for crystallization of acid magmas (exceeding 1000° to 550°C) is favorable for a deep differentiation of these magmas and the development of ore-deposit ongonite melts.

The investigation of melt and fluid inclusions in minerals showed that the most important volatile component of natural acid magams, as compared to the basic magmas, is water. Its concentration in the melt varies over a considerable range - from less than 0.1 to 13.9 wt. %, and the majority of 115 determinations are characterized by high values, of the order of 2-8 wt. %. A wide variation was also determined for water pressure (from less than 0.1 to 6.1 kbar), and the fluid pressure in many cases considerably exceeds the lithostatic load. The elevated gradients of fluid pressure developing at the late stage of crystallization of magmas result from the ascending movement of hydrothermal solutions, forming ore deposits. The formation of some post-magmatic tin and tungsten ore deposits, related to leucogranites, may develop due to the extraction of tin and tungsten from magmas or rocks by chloride fluids. (Authors' abstract)

KOZLOV, Vl.K., 1984, The role of carbonate complexes in hydrothermal silver transport as defined by experimental data: Geokhimiya, 1984, no. 10, p. 1432-1442 (in Russian; English abstract).

The solubility method was used to study effects of Ag^+ ion complex-formation in alkaline (0.01-0.40 m) carbonate-bearing (0.05-1.00 m) solutions with $\mu = 3.00$ (KNO_3, $NaClO_4$) in case of $Ag_2O_{(s)}$ at 25, 60 and 90°C. Under these conditions, $Ag(CO_3^-)$, $Ag(CO_3)_2^{3-}$, and $AgOHCO_3^{2-}$ complex-formation was established and their stability constants were determined. An $Ag(OH)_2CO_3^{3-}$ species was found in solutions at 90°C. $Ag_2CO_{3(s)}$ thermodynamic characteristics at 25°C from various literature sources were revised. It is shown that the carbonate complex-forming process is not a factor determining the forms of hydrothermal silver transport in natural systems. (Author's abstract)

KOZLOV, Vl.K. and KHODAKOVSKIY, I.L., 1983, The thermodynamic parameters of atomic silver in aqueous solution at 25-280°C: Geokhimiya, no. 6, p. 836-848 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 3, p. 117-131, 1984).

KOZLOVA, O.G., STEPANOVA, T.V. and EGOROV-TISMENKO, Yu.K., 1984, The mica law of twinning and the formation of primary inclusions: Vestnik Moskovskogo Univ., Geologiya, v. 39, no. 3, p. 52-57 (in Russian, translated in Moscow Univ. Geol. Bull., v. 39, no. 3, p. 54-57, 1984).

KOZŁOWSKI, Andrzej, 1984a, Epigenetic alterations of fluid inclusions: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 2. Author at Univ. Warsaw, Poland.

Fluid inclusion studies, widely discussed for many years, presently are accepted for reconstruction of conditions of diagenetic, metamorphic, magmatic and post-magmatic mineral and rock-forming processes. However, an enthusiastic approach to such studies based on a simplified and even trivalized understanding, may lead to misinterpretation of the observed objects and features. One of the more difficult problems is the question of change in the inclusion by any of several known or as yet unknown but possible processes during its existence. This question is basic for the correct interpretation of the fluid inclusion studies and any genetic conclusion derived from them.

Several alterations of inclusion habit and filling are recognized by the author and by others. The most important are: (i) epigenetic separation of parts of inclusions with formation of two or more daughter ones (necking down); (ii) precipitation of host mineral substance inside vacuole from inclusion filling; (iii) irreversible chemical reactions of inclusion filling; (iv) recrystallization of inclusion vacuole to achieve an equilibrium habit; (v) inclusion migration in host crystal; (vi) various cases of inclusion leakage, e.g., hydrogen diffusion through crystal lattice, "stretching" of inclusions, natural decrepitation; (vii) refilling phenomena, e.g., liquid by liquid, gas by liquid and vice versa, melt by gas or liquid and crystallization of minerals like pyrite, chalcedony or quartz in inclusion vacuoles formerly filled by melt etc. All kinds of altered inclusions should be thoroughly studied but not excluded from studies as "anomalous" or "non-representative" ones. (Author's abstract)

KOZŁOWSKI, Andrez*, 1984b, Calcium-rich parent solutions of fluorite: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 10. Author at Univ. Warsaw, Poland.

Inclusions in fluorite crystals from pegmatitic druses in the Strzegom granitoid massif in Poland, bear aqueous solution with calcium chloride as the main solute component (Th of these inclusions is 165-180°C). Freezing studies need special overcooling runs for breaking the liquid metastability even in large inclusions (0.4x0.15x0.2 mm). The following treatment of the frozen inclusion was applied: (i) determination of eutectic temperature (Te) here in range -54 to -58°C (eutectic composition 1.8 wt. % NaCl + 29.4 wt. % $CaCl_2$ + 68.8 wt. % H_2O); (ii) recrystallization of inclusion filling: hydrohalite and ice crystals floating in $CaCl_2$ + NaCl water solution, to separate volumes of ice and hydrohalite; (iii) determination of the point of last hydrohalite crystal melting (-32.3°C) on the cotectic curve separating the hydrohalite + solution and ice + solution fields on the plot $CaCl_2$-NaCl-H_2O: this gives $CaCl_2$:NaCl ratio = 75:25 by weight; (iv) determination of the last ice crystal melting (Tm = -21.8°C) that gives the total salt content in solution (24 wt. %). From the above data the main components in inclusion solution are: H_2O 76 wt. %, $CaCl_2$ 18 wt. %, NaCl 6 wt. %. Magnesium, sulfate or carbonate ions cannot be present in significant amounts. The amount of F in pegmatite was limited by inflow of fluoride ions to the solution bearing excess of calcium. (Author's abstract) *Sic

KOZŁOWSKI, A., 1984c, Tourmaline in aplite from Lisiec Hill near Strzegom - an example of boron metasomatism (abst.), p. 58-59, in Acta Univ. Wratislaviensis No. 834 - Mineralogy and tectonics of the granitoid massif Strzegom-Sobo'tka (Materials of Sci. Conf. Strzegom, September 28-29, 1984) (in Polish). Author at Inst. Geochem., Mineralogy and Petr., Warsaw Univ., 02-089 Warzawa, al. Zwirki i Wigury 93, Poland.

The studied aplite at least partly occurs in amphibolites of the metamorphic crust of the Strzegom-Sobo'tka massif. Presence of other rocks in this part of the metamorphic crust cannot be excluded. The aplite consists of K-spar, sodic plagioclase, quartz, tourmaline, relic biotite and accessory garnet and andalusite. Rock texture varies from fine- to coarse-crystalline (grain size from 1 to 20 mm). Tourmaline crystals are arranged in bands and schlieren making the ribbon-type texture.

Petrographic characteristics of the rock were given by J. Puziewicz (1981), who connects the origin of the entire listed mineral assemblage (including tourmaline) with magmatic crystallization, and the ribbon-type texture with the arrangement of tourmaline during magma injection in the fracture (fluidal texture). Microscope studies of the rock performed by the present author revealed features of minerals proving the significant role of metasomatism during formation of the observed mineral association, especially tourmaline, in the tourmaline aplite. Primary fluid inclusions in tourmaline are filled by liquid (hydrothermal) solution and yield Th 340-400°C. Similar inclusions in part of the quartz grains had Th 300-390°C. Rare G inclusions indicate local boiling of hydrothermal solution.

Ribbon-like arrangement of tourmaline crystals may be also explained by action of other factors than that proposed by J. Puziewicz. It may be, e.g., the result of metasomatic zoning caused by solution filtration, solution migration along fractures in aplite parallel to vein walls (such dense fractures may be observed in the aplite vein outcropping in the Strzegom massif, "Andzej" quarry, 1978-81), crystallization under stress conditions or zoning inherited after metamorphic rocks were replaced by metasomatites. The last possibility presently cannot be excluded.

Thus, there are important premises suggesting that the aplite is a vein of essentially magmatic origin with strongly developed boron-alkaline metasomatism. Th range and certain other features are similar to processes revealed in other parts of the Sudetic crystalline area (W. Heflik 1960, L. Karwowski 1977, A. Kozlowski 1978, M. Madaliviska 1983). Probably also coarse-crystalline (pegmatoid) zones formed due to metasomatic processes, as has been proved in the other locations (A. Kozlowski 1978). (Author's abstract)

KOZŁOWSKI, A. and SACHANBINSKI, M., 1984, Remarks on genesis of Polish chrysoprase as indicated by inclusion studies: Spraw. Pos. Kom. Nauk PAN, v. 28, no. 1., p.   (in Polish). First author at Inst. Geochem., Mineralogy and Petrogr., Warsaw Univ., 02-089 Warzawa, al. Zwirki i Wigury 93, Poland. See Translations.

KOZLOVSKY, Ye.A., 1984, The world's deepest well: Sci. Amer., v. 251, no. 6, p. 98-104.

The world's deepest well, now at 12,000 meters, in the Kola Peninsula, USSR, encountered flows of gases (He, H_2, N_2, CO_2, CH_4 and other hydrocarbons) at all levels, and flows of "mineralized water" in a "zone of disaggregation" at 4000-9000 m and in thin, sharply defined formations below. Mineralization of various types was also encountered. Thus in the disaggregated zone the rock fragments are cemented by sulfides of Cu, N, Fe, Zn and CO; the isotopic composition of the S resembles that of meteoritic sulfur. (E.R.)

KRAINOV, S.R., MATVEYEVA, L.I., RYZHENKO, B.N., SOLOMIN, G.A. and KOLOTOV, B.A., 1984, Geochemical peculiarities of evolution of pore waters of sedimentation basins (in connection with their participation in stratiform ore-formation): Geokhimiya, 1984, no. 8, p. 1155-1170 (in Russian; English abstract).

Based on empirical generalization and chemico-thermodynamical computer calculations it was shown that formation of high (n. 10 to n. 100 ppm) contents of zinc, copper, lead and iron in the pore solutions of sedimentation basins is the regular geochemical consequence of their diagenetic and katagenetic metamorphism (evolution) in sedimentary rocks. Such metamorphism is accompanied by transfer of significant masses of calcium and many ore elements from the rocks into the pore water. A phenomenon of accumulation of ore elements in pore waters is of regional distribution especially in structures having saline formations. Enrichment of pore waters of sedimentation basins in ore elements leads to their acquiring the properties of the ore-forming solutions geochemically identical to the fluid inclusions in minerals of the stratiform ore deposits. The pore waters were shown to be among the probable sources of ore material for the formation of these deposits. (Authors' abstract)

KRAMER, A.M., 1984, Paragenetic and fluid inclusion study of the Smith Vein, Smith Mine, Blackhawk, Colorado: MS thesis, Colorado Sch. Mines, Golden, CO, USA. See next item.

KRAMER, A.M., 1984b Genesis of the gold-bearing Smith vein, Smith mine, Blackhawk, Colorado (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 226. Author at Geol. Dept., Colorado Sch. Mines, Golden, CO 80401.

The Smith vein, located in the Central City mining district of the Colorado Front Range Mineral Belt, is characterized by the following six stages of mineralization: I - hematite, II - early pyrite, III - base-metal, IV - galena, V - chalcopyrite, and VI - late pyrite. Gold was deposited principally during stage III mineralization and occurs as inclusions within base-metal sulfides.

Measurements on primary fluid inclusions in stage II quartz show trapping temperatures of 353-375°C, 2.3-3.7 wt. % NaCl equiv., and a dissolved CO_2 content of <3 mole %. Primary fluid inclusions in stage III sphalerite formed at temperatures between 342 and 365°C with salinities of 6.3 to 8.4 wt. % NaCl equivalent. Planes of secondary fluid inclusions, which were sealed prior to liquid-vapor separation, occur in stage II quartz and show filling temperatures of 308-397°C with a salinity of 6 wt. % NaCl equiv. Secondary fluid inclusions in quartz from QSP alteration enveloping the vein have salinities of 3.7-5.8 wt. % NaCl equiv. and trapping temperatures of 308-341°C or 350-387°C, suggesting two events of fracturing and fluid movement.

The absence of lateral and vertical temperature gradients within the vein precludes a model requiring simple cooling as the prime mechanism for ore deposition; in addition, the fluids did not boil. Therefore, ore deposition is attributed to solutions reacting with wall rocks and/or fluid mixing. (Author's abstract)

KRAMER, C.J.M. and DUINKER, J.C., 1984, Complexation of trace metals in natural waters: The Hague, Martinus Nijhoff/Dr. W. Junk Publishers, 448 pp.

Includes much on both analytical technique and theory that is pertinent to analyses of metals in inclusions. (E.R.)

KRASNOZHINA, Z.V., 1984, Physico-chemical conditions of forming of tin ore deposits, associated with lithium-fluorine-bearing granites (southeast Pamirs): Dokl. Akad. Nauk SSSR, v. 278, no. 1, p. 174-180 (in Russian). Author at Inst. Geol. Sci. of Acad. Sci. of Ukrainian SSR, Kiev, Ukraine.

Cassiterite in greisens formed at 360-290°, from alkali-F-Cl solutions of relatively low pH (acid); ion concentrations in mineral-forming solutions are (in moles per kg of H_2O): Na 0.3, K 0.25, Cl 0.35, HCO_3 0.11, F 0.25, ionic strength of solution 0.65-0.75, total salt concentration 4.3-5.6%. CO_2 concentration is the highest in inclusions in cassiterite from muscovite-topaz greisens (2.62 mole per kg H_2O) and dereases for albite-fluorite-K-spar and hastingsite-stilpnomelane-fluorite mineral associations. Methane concentration increases sharply for associations formed from heterogeneous fluids. Low-T minerals from cataclastic zones in granites bear high concentrations of CH_4 and N_2. (Abstract by A.K.)

KRĂSTEVA, Margarita, 1983, Gas-fluid inclusions in sphalerite, quartz and carbonate from the deposits in the Zvezdel-Galenit ore field: Geohim., mineral. i petrol. (Bulgaria), v. 17, p. 41-50 (in Russian; English abstract). Continued next page.

The ore mineralizations in the Zvezdel-Galenit ore field (Eastern Rhodopes) consist mostly of carbonate-sulphide veins and ore breccias confined to fault structures, as well as of metasomatic ore bodies in Paleogene limestones and Proterozoic marbles. The measured intervals of homogenization temperatures (T_x) of the gas-fluid inclusions are 300-220°C for sphalerite from the ore veins and ore breccias, 220-150°C for cleiophane from the ore breccias, 350°C for the early grey quartz, 300-180°C for the quartz accompanying the ores, 330-180°C for the metasomatic quartz, and 300-180°C for the carbonate from ore vein, ore breccias and non-metalliferous veinlets. The results obtained define the temperature range of 350 to 50°C for mineral formation in the Zvezdel-Galenit ore field. (Abstract by A. Arnaudova)

KRAVCHUK, K.G., 1984, Model conceptions of phase equilibria in hydrothermal systems: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 375-378. Author at N.S. Kurnakov Inst. Gen. and Non-organic Chem. of the Acad. Sci. USSR, Moscow, USSR.

The modern physico-chemical views on properties of p-Q type systems and their use as a model for showing different ways of forming hydrothermal solutions are discussed. (Author's abstract)

KREBS, Wolfgang and MACQUEEN, Roger, 1984, Sequence of diagenetic and mineralization events, Pine Point lead-zinc property, Northwest Territories, Canada: Bull. Canadian Petroleum Geol., v. 32, no. 4, p. 434-464.

KRESZ, D.U., 1984, Archean variolites of the Wabigoon subprovince, northwestern Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 79. Author at Dept. Geol., Brock Univ., St. Catharines, Ontario L2S 3A1, Canada.

A pillowed basalt flow near Kawashegamuk Lake, northwestern Ontario, is characterized by the presence of numerous white, felsic varioles with a smooth margin ranging from 1 to 10 mm in diameter set in a devitrified mafic matrix. The size of the varioles progressively increases towards the center of pillows where many of them coalesce. Textures clearly indicate that the intervariole matrix throughout the entire pillow remained as a glass after cooling and solidification. Similar rocks have been documented from other Archean greenstone belts as well as younger basalts found in ophiolite belts. Variolites of this type are considered by many to have originated through liquid immiscibility implying either the unmixing of a magma into two separate liquids, or the hybridization of two magmas of differing composition. The following evidence, however, suggests that the formation of felsic varioles formed by a process that involved crystallization differentiation upon rapid cooling: 1) concentric compositional changes across varioles are comparable with zoning in spherulitic bodies occurring in recent rhyolites; 2) radial crystallization has originated from skeletal feldspar nucleii of the center of variole; 3) TiO_2 content in both varioles and matrices is similar; 4) the bulk chemistry of the variolite falls outside the experimentally determined liquid immiscibility field. Recognition of the mechanisms by which spherical bodies develop in a molten rock is critical because liquid immiscibility may be of great importance to the understanding of petrogenetic processes, whereas spherulitic crystallization has only limited implications. (Author's abstract)

KRIVENKO, A.P., PONOMARCHUK, V.A. and SKRIPNICHENKO, V.A., 1984, Distribution of rare-earth elements during the liquation of basite melt with high content of phosphorus: Dokl. Akad. Nauk SSSR, v. 275, no. 2, p. 468-471 (in Russian).

KRONENBERG, A.K. and TULLIS, Jan, 1984, Flow strengths of quartz aggregates: grain size and pressure effects due to hydrolytic weakening: J. Geophys. Research, v. 89, no. B6, p. 4281-4297.

KRONENBERG, A.K., YUND, R.A. and GILETTI, B.J., 1984, Carbon and oxygen diffusion in calcite: Effects of Mn content on PH_2O: Phys. Chem. Minerals, v. 11, p. 101-112.

KRUPKA, K.M., 1984, Thermodynamic analysis of some equilibria in the system magnesium oxide-silicon dioxide-water (calorimetry, metamorphic, heat capacity): Ph.D. dissertation, Pennsylvania State Univ.

KUDRIN, A.V., VARYASH, L.N., PASHKOV, Yu.N. and REKHARSKY, V.I., 1984, Copper and molybdenum behavior during the formation of copper-molybdenum deposits (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 176-177. Authors at Inst. Ore Deposit Geol., Petrogl, Mineral. and Geochem. of USSR Acad. Sci., Moscow, USSR.

Geological and geochemical studies show that the extent in which copper and molybdenum mineralization occurs in copper-molybdenum deposits is directly dependent on the intensity of hydrothermal-metasomatic alterations. Molybdenum mineralization is mainly associated with feldspar-quartz facies, copper mineralization - with quartz-sericite and partly with propylite, beresite, and other facies.

According to the studies on fluid inclusions, the bulk of molybdenum ores was formed at temperatures from 470 to 300°C, copper ores - from 320 to 200°C. The principal constituents of ore-bearing solutions were chlorides of alkali metals and carbon dioxide. Their total salinities varied from 50,000 to 500,000 ppm, with carbon dioxide contents reaching 8 to 10 mol.% and decreasing with a temperature decline. Examination of paragenetic mineral assemblages showed that hydrogen sulfide contents during ore deposition could comprise 10^{-2} to 10^{-3} mole per 1 kg H_2O. Estimates for oxygen volatility give the range of values constrained by the Fe_3O_4-Fe_2O_3 and Ni-NiO buffer systems. Taking into account the data on physico-chemical parameters of ore-bearing fluids, experimental studies suggest that the main forms of molybdenum occurrence in slighly acid and slightly alkaline solutions were: hydroxoalkalichloride complexes of Mo (VI) and possibly of Mo (IV), such as $HMoO_4(Na,K)Cl^-$, $HMoO_23(Na,K)Cl^-$, and to a lesser extent $HMoO_4^-$, $H_2MoO_4^0$. Molybdenite precipitation was mainly supported by the two factors: temperature decrease and acidity increase of a solution.

In acid and/or near-neutral solutions, copper was transported in the form of chloride complexes of Cu (I) - $CuCl^0$ and $CuCl_2^-$, in slightly alkaline ones - in the form of hydroxochloride $Cu(OH)Cl^-$ and hydrosulfide $Cu(HS)_2^-$ complexes. Chalcopyrite precipitation resulted from a temperature decrease, and from changes in acidity and in sulfide sulfur, chlorine, iron contents of solutions. (Authors' abstract)

KUEHN, C.A. and BODNAR, R.J., 1984, P-T-X characteristics of fluids associated with the Carlin sediment-hosted gold deposit (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 566. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Fluid inclusion studies of the Carlin sediment-hosted, disseminated Au deposit reveal a complex fluid history. At room T fluid inclusions appear to contain either 1, 2 or 3 fluid phases in various proportions. These 3 inclusion groups may be subdivided into 7 general types based on low-T petrographic, heating/freezing and crushing studies. Single-phase inclusions contain either (1) H_2O liquid (L), (2) CO_2 (L) or (3) CH_4 (L). Two-phase inclusions contain either (4) H_2O (L+vapor), (5) CO_2 (L+V), or (6) H_2O (L) and CO_2 (L or V). Three-phase inclusions (7) contain H_2O (L), CO_2 (L) and CO_2 (V). Types 2, 3 and 5 may also contain an optically unresolvable amount of liquid H_2O. Type 4 inclusions are the most common; they have low salinities and homogenize between 130-300°C. H_2O-CO_2 inclusions (types 6 and 7) have low salinities and homogenize to either the H_2O phase or CO_2 phase between 165-275°C. CH_4-bearing inclusions (type 3) homogenize between -85 and -105°C; CO_2-bearing inclusions (types 2 and 5) homogenize between 8-31°C. Single-phase H_2O inclusions (type 1) remain metastable upon cooling. Relative ages of the various inclusion types and their relationship to gold deposition are presently unknown. Th of H_2O-CO_2 inclusions (types 6 and 7) suggest minimum formation pressures of 500-1500 bars. Projection of the isochores for CH_4 (type 3) and CO_2 (types 2 and 5) inclusions to these same temperatures provide similar pressure estimates, and isochores for two-phase water inclusions (type 4) also project into this same P-T regime. These data suggest that the rocks hosting the Carlin deposit have been exposed to at least 3 chemically distinct fluids, and temperatures and pressures may have been as high as 300°C and 1500 bars respectively. (Authors' abstract)

KULAKOVA, I.I., OGLOBLINA, A.I., RUDENKO, A.P., FLOROVSKAYA, V.N., BOTKUNOV, A.I. and SKVORTSOVA, V.L., 1982, Polycyclic aromatics in accessory minerals of diamond and their possible genesis: Dokl. Akad. Nauk SSSR, v. 267, no. 6, p. 1458-1461 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 267, p. 206-209, 1984). Authors at Univ. Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 125. (E.R.)

KUL'CHETSKAYA, A.A. and SHCHIRITSA, A.S., 1984, Genetic importance of inclusions in gypsum from mud volcanos of the Kerch Peninsula: Mineral. Zh., v. 6, no. 1, p. 83-88 (in Russian; English abstract). First author at Inst. Geochem. Phys. Miner., Kiev, USSR.

Fluid inclusions in new-formed gypsum crystals from the Bald-Mountain breccia were studied to establish a genetic relation between gypsum formation and mud effusion. The sulphate-ion was derived from surface-oxidized Bald-Mountain water and gases containing hydrogen sulphide and sulphur-bearing bitumens of high resin content.

Information on inclusions assisted in restoration of conditions for Tortonian gypsum-bearing strata formation in the Kerch peninsula, the strata being spatially associated with sulphur deposits. An assumption is advanced on the unity of gypsum and sulphur formation due to activation of mud volcanism. (Authors' abstract)

KULIKOV, I.V., 1982, Polyphase brine inclusions in fluorite and calcite and their genetic significance: Dokl. Akad. Nauk SSSR, v. 264, no. 4, p. 958-961 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 264, no. 4, p. 198-201, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 126, 1982. (E.R.)

KULIKOV, I.V., 1984, Mechanism of explosive-crystallization concentrating as possible reason for the origin of formation of hydrous saline melts: Akad. Nauk SSSR Doklady, v. 277, no. 3, p. 693-696 (in Russian). Author at the Moscow Geol.-Prospecting Inst., Moscow, USSR.

Parent solutions of deposits of the following types [are considered]: fluorite-rare metal-polymetal, fluorite-rare metal, copper-molybdenum-porphyry, carbonatite and certain others. Such deposits occur in zones of tectonic-magmatic activization, strictly associated with magmatism and volcanism of various composition; high F content is typical; gases play an active role during their formation; early minerals bear inclusions of hydrous salt melts, brines and special crystal-gas inclusions, Th >500°C to 800°C; evidence of boiling is always found in ore precipitation period. Not all of the above types of deposits typically have explosive processes and high T of mineral formation, only shallow and hypabyssal ones. The author discusses the mode of formation of explosive conditions, and he suggests that heterogeneous fluids might form the homogeneous hydrous-salt melts due to additional heat of rock crystallization, quoting data in fluid inclusions in the Tyrnyauz deposit minerals (see also Kulikov 1980, v. 13, p. 138; 1981a, v. 14, p. 257; 1981b, v. 14, p. 257-258; 1981c, v. 14, p. 117; 1982a,b, v. 15, p. 126; Kulikov, Devyatov and Gromov 1982, v. 15, p. 126; Kulkiov, Devyatov, Mel'nikov and Gromov 1982, v. 15, p. 126, all in Fluid Inclusion Research--Proceedings of COFFI, and Kulikov and Boyarskaya 1984, this volume). (Abstract by A.K.)

KULIKOV, I.V. and BOYARSKAYA, R.V., 1984, Inclusions of graphite in fluorite and their possible genetic significance: Akad. Nauk SSSR Doklady, v. 276, no. 5, p. 1213-1216 (in Russian). First author at Moscow Geol.-Prospecting Inst., Moscow, USSR.

Colorless octahedral fluorite from Tyrnyauz Mo-W skarn deposit (N. Caucasus), low in Mn and TR admixtues and bearing inclusions of brines with high Th and unusual G in inclusions, contains also solid black inclusions or phases in fluid inclusions. This fluorite (crystals 0.5-3 cm) occurs in 1-3 m^3 vugs in skarn-marble rock in a layer of zoned anisotropic andradite. Fluorite contains numerous P brine inclusions (to 1-3 mm in size) with several dms (chlorides, carbonates, sulfides, etc.); Th reaches 700-800°C. The black substance may occupy 3-90 vol.% of a fluid inclusion and it does not dissolve even at 1000°C. By electron diffraction the black trapped mineral was identified as graphite. The wall-rock (marble) might be the source of graphite which was sealed in inclusions in fluorite. (Abstract by A.K.)

KULIKOV, I.V., DEVYATOV, V.Ye., MEL'NIKOV, F.P. and GROMOV, A.V., 1982, Solid phases of gas-liquid inclusions in fluorite: Dokl. Akad. Nauk SSSR, v. 265, no. 4, p. 963-966 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 265, no. 4, p. 180-183, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 126, 1982. (E.R.)

KUO, L.-C., LEE, J.H., ESSENE, E.J. and PEACOR, D.R., 1984, A TEM/AEM study on silicate liquid immiscibility in a Columbia River basalt (abst.): EOS, v. 65, p. 295.

KURAT, Gero, NTAFLOS, Theodoros, BRANDSTATTER, Franz, PALME, Herbert, SPETTEL, Bernhard, PRINZ, Martin and TOURET, Jaques, 1984, Metasomatism of upper mantle rocks from Zabargad island, Red Sea (abst.): Int'l. Geol.

Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 324-325 (in English). First author at Naturhistorisches Museum, Vienna, Austria.

The main peridotite hill ultramafic complex on the island of Zabargad, Red Sea, apparently represents the upper portion of the upper mantle beneath the Red Sea. This complex intruded the Precambrian basement and overlying sediments. Extensive thermal contact metamorphism of these sediments evidences a high uplift rate. Consequently, the ultramafic rocks are fresh and show only minor retrograde reactions. Thus, the ultramafic complex of the northern peridotite hill of Zabargad represents an almost undisturbed sample of the upper mantle.

The main rocks are harzburgites and lherzolites which show a wide range of tectonic alterations from undisturbed to multiply sheared. The tectonically undisturbed rocks have normal bulk chemical compositions corresponding to mostly depleted upper mantle matter. The mineralogy mostly represents spinel peridotite conditions with minor transitions towards plagioclase periodite conditions. Mineral compositions are typically of depleted rocks: high Mg/Fe, low Na and Al.

The highly sheared rocks are enriched in incompatible elements to different degrees. Their mineralogy is altered by the growth of neoblasts, most common of clinopyroxene. Common are also hornblende, hercynite and plagioclase. Minor amounts of phlogopite and apatite are sometimes associated with hornblende neoblasts. The newly grown minerals differ in chemical composition from the indigeneous ones by being richer in Na, T, and K.

Apparently, shearing is a prerequisite for bulk metasomatism of rocks in the upper mantle. Only in mobile zones there is apparently room provided for fluids to migrate and to react with the minerals present.

Associated with the bulk metasomatized rocks are also sheets and sheetlets (mm to m wide) which consist mainly of monomineralic rocks: clinopyroxenites, orthopyroxenites, olivinites, hornblendites, and plagioclasites. They are mostly very coarse grained (0.5-20 cm) and have fluid inclusions which indicate formation from highly saline H_2O-CO_2 "fluids" under high to intermediate pressures and high temperatures.

Apparently, elemental mobilizations via fluids were wide-spread within the upper mantle beneath the Red Sea and continued to operate during uplift. Since both monomineralic rocks and bulk metasomatized rocks can be found in most ophiolitic complexes, elemental mobilization of fluids appears to be a normal process which is operative probably throughout the Earth's upper mantle. (Authors' abstract)

KURDZIEL, M., 1983, Origin of pegmatites of High Tatra Mountains: Prace Nauk Univ. Sl. no. 614; Geologia, v. 7, p. 46-56 (in Polish; English and Russian abstracts). Author at Faculty of Earth Sci. of Silesian Univ., Sosnowiec, Poland.

The studied pegmatites in the Tatra leucocratic granitoids are bodies from several tens cm to few meters long and they consist of microcline, oligoclase, quartz, muscovite, biotite and rare apatite, magnetite, ilmenite, sphene, garnet and tourmaline. Inclusions were studied in quartz; they are filled by LH_2O + G, rarely by LH_2O + LCO_2 + G. After opening and evaporation of solution, NaCl cubes were found by scanning electron microscope. The determined Th are in ranges 80-230°C, Td - 100-550°C. Inclusions make up from 0.21 to 0.71 wt % of quartz sample. From water leachates the following ion concentrations in inclusion fillings were calculated (in milliequivalents): Li 0.02-0.05, Na 2.88-11.18, K 0.88-3.93, Ca to 0.52, Mg and Fe not detected, F 0.1-0.16, Cl 1.30-11.99, Br 0.02-0.16, carbonates and SO_4 not determined. Pegmatites formed most probably during metasomatic processes. (Abstract by A.K.)

KURODA, Yoshimasu, YAMADA, Tetsuo and MORIKIYO, Toshiro, 1984, Behavior of water involved in metamorphism and granite plutonism in view of hydrogen isotope study (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 326 (in English).

KURSHAKOVA, L.D., 1983, Properties of boron-bearing hydrothermal solutions: Essays on physico-chemical petrology, v. 11, p. 51-56 (in Russian).

The paper presents the experimental equilibrium for the reaction wollastonite + H_3BO_3 = datolite + H_2O at T 150-500°C and H_3BO_3 concentrations up to 15 moles per 1000 g of H_2O, vapor pressure above H_2O + H_3VO_3 solution, relation between ΔG_T of datolite formation and temperature, H_3BO_3 activity in water solution and solubility of H_3BO_3 at 0 to 181°C. (A.K.)

KURSHAKOVA, L.D. and TIKHOMIROVA, V.I., 1983, Experimental studies of problem of connection of boron-silicate mineralization with magmatism: Essays on physico-chemical petrology, v. 11, p. 57-76 (in Russian).

Experimental studies of the system B_2O_3-quartz-potassium feldspar at 1100, 1200 and 1300°C are presented. Immiscibility phenomena were encountered. (A.K.)

KURZ, M.D., 1984, Helium isotopic systematics of oceanic volcanic rocks: correlations with the other noble gases and implications for mantle degassing (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 326-327 (in English).

KURZ, M.D., MEYER, P. and SIGURDSSON, H., 1984, Helium isotopic systematics within the neovolcanic zones of Iceland (abst.): EOS, v. 65, no. 45, p. 1152. First author at Woods Hole Oceanographic Inst., Woods Hole, MA 02543.

Helium isotopic compositions have been measured in a suite of 21 subglacial basalt glasses from the neovolcanic zones of Iceland. The $^3He/^4He$ ratios vary between 9 and 26.2 x atmospheric; the high ratios suggest a relatively undegassed mantle source for the helium, which is consistent with the mantle plume hypothesis for Icelandic volcanism. There is a striking correlation between the helium isotope variations and the tectonics of Iceland. Each of the three main volcanic zones of Iceland has a distinctive $^3He/^4He$ isotopic signature: 18-26.2 x atmospheric in the Eastern Volcanic Zone (which includes central Iceland); 12-16 x atmospheric in the Western Volcanic Zone; and 8-11 x atmospheric in the Northern Volcanic Zone. These systematics, the high observed helium concentrations in the glasses (up to 1.6×10^{-6}cc STP/g), and the young age of the Icelandic crust argue strongly against any crustal contamination effect on the helium. The volcanics with the highest $^3He/^4He$ are erupted in Eastern and Central Iceland, which suggests that the plume is presently centered beneath this region. The preferred model to explain the systematics involves a mantle plume model in which the plume itself consists of a series of "blobs." The regional variations are attributed to temporal variations in the position of the blobs, particularly since the Eastern Volcanic Zone is the youngest rift zone. (Authors' abstract)

KUSHNIROV, V.V., 1983, Initial state of gaseous hydrocarbons in retrograde gas-liquid systems: Sovetskaya Geologiya, no. 9, p. 14-23 (in Russian; translated in Int'l. Geol. Review, v. 26, no. 6, p. 702-712, 1984). Author at Inst. Geol. & Prospecting for Oil and Gas (IGiRNiGM).

The article outlines the geochemistry of petroleum gases in complex natural systems, and compares them with experimental studies. (E.R.)

KUZNETSOVA, S.V., GOSTYAEVA, N.M. and LAZARENKO, E.E., 1984, Behavior of titanium during regional post-ultrametamorphism (according to data of fluid inclusions): Reg. Metamorf. Metamorfog. Rudoobraz., (Tr. Vses. Soveshch.), 4th, Beltsev, Y.A., ed., p. 206-211 (in Russian) (also in CA: 101(20)175021p).

Indexed under Fluid Inclusions.

KVENVOLDEN, K.A., CLAYPOOL, G.E., THRELKELD, C.N. and SLOAN, E.D., 1984, Geochemistry of a naturally occurring massive marine gas hydrate: Org. Geochem., v. 6, p. 703-713. First author at U.S. Geol. Survey, Menlo Park, CA 94025, USA.

During Deep Sea Drilling Project (DSDP) Leg 84 a core 1 m long and 6 cm in diameter of massive gas hydrate was unexpectedly recovered at Site 570 in upper slope sediment of the Middle America Trench offshore of Guatemala. This core contained only 5-7% sediment, the remainder being the solid hydrate composed of gas and water. Samples of the gas hydrate were decomposed under controlled conditions in a closed container maintained at 4°C. Gas pressure increased and asymptotically aproached the equilibrium decomposition pressure for an ideal methane hydrate, $CH_4.5\text{-}3/4H_2O$, of 3930 kPa and approached to this pressure after each time gas was released, until the gas hydrate was completely decomposed.

The gas evolved during hydrate decomposition was 99.4% methane, ~0.2% ethane, and ~0.4% CO_2. Hydrocarbons from propane to heptane were also present, but in concentrations of less than 100 p.p.m. The carbon-isotopic composition of methane was -41 to -44 permil (‰), relative to PDB standard. The observed volumetric methane/water ratio was 64 or 67, which indicates that before it was stored and analyzed, the gas hydrate probably had lost methane. The sample material used in the experiments was likely a mixture of methane hydrate and water ice.

Formation of this massive gas hydrate probably involved the following processes: (i) upward migration of gas and its accumulation in a zone where conditions favored the growth of gas hydrates, (ii) continued, unusually rapid biological generation of methane, and (iii) release of gas from water solution as pressure decreased due to sea level lowering and tectonic uplift. (Authors' abstract)

KYSER, T.K. and O'NEIL, J.R., 1984, Hydrogen isotope systematics of submarine basalts: Geochimica Cosmo. Acta, v. 48, p. 2123-2133. First author at Dept. Geol. Sci., Univ. Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 0W0.

The D/H ratios and water contents in fresh submarine basalts from the Mid-Atlantic Ridge, the East Pacific Rise, and Hawaii indicate that the primary D/H ratios of many submarine lavas have been altered by processes including (1) outgassing, (2) addition of seawater at magmatic temperature, and (3) low-temperature hydration of glass. Decreases in δD and H_2O^+ from exteriors to interiors of pillows are explained by outgassing of water whereas inverse relations between δD and H_2O^+ in basalts from the Galapagos rise and the FAMOUS Area are attributed to outgassing of CH_4 and H_2. A good correlation between δD values and H_2O is observed in a suite of submarine tholeiites dredged from the Kilauea East Rift Zone where seawater (added directly to the magma), affected only the isotopic compositions of hydrogen and argon. Analyses of some glassy rims indicate that the outer millimeter of the glass can undergo low-temperature hydration of hydroxyl groups having δD values as low as -100.

δD values vary with H_2O contents of subaerial transitional basalts from Molokai, Hawaii, and subaerial alkali basalts from the Society Islands, indicating that the primary δD values were similar to those of submarine lavas.

Extrapolations to possible unaltered δD values and H_2O contents indicate that the primary δD values of most tholeiite and alkali basalts are near -8- ± 5; the weight percentages of water are variable, 0.15-0.35 for MOR tholeiites, about 0.25 for Hawaiian tholeiites, and up to 1.1 for alkali basalts. The primary δD values of -80 for most basalts are comparable to those measured for deep-seated phlogopites. These results indicate that hydrogen, in marked contrast to other elements such as Sr, Nd, Pb, and O, has a uniform isotopic composition in the mantle. This uniformity is best explained by the presence of a homogeneous reservoir of hydrogen that has existed in the mantle since the very early history of the Earth. (Authors' abstract)

LaKIND, J.S. and BROWN, P.E., 1984, Characterization of the gold-bearing fluid at Red Lake, Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 80. Authors at Dept. Geol. & Geophys., Univ. Wisconsin, Madison, WI 53706.

The Red Lake Gold Camp lies within the Uchi subprovince of western Ontario, a characteristic Archean gold-producer composed of a greenstone-metasedimentary belt that has been subjected to episodes of granitic to granodioritic intrusions. Both hydrothermal and metamorphic fluids have been hypothesized as the gold-bearing fluid. This geochemical study, supplemental to a project headed by the Mineral Deposits Section of the OGS, will provide fluid inclusion and stable isotope data on the gold-bearing fluid at Red Lake.

Two types of vein systems have been examined: 1) Quartz-carbonate veins hosted by mafic volcanics were sampled from the Wilmar Mine, located in the Highly Altered Zone. This intensely deformed area has undergone silicification, sericitization and carbonitization, and contains most of the major producing mines in the district. 2) Quartz veins hosted by felsic intrusives were collected from stocks within a 13 kilometer radius of the Wilmar Mine. Visible alteration bands with varying mineralogy, including chlorite, actinolite, k-feldspar, albite, sericite, pyrite, pyrrhotite, epidote, tourmaline, calcite and ilmenite frequently border the veins. All veins contain free gold.

Fluid inclusions contain 1, 2 or 3 phases. 1-phase inclusions are interpreted as secondary meteoric. 3-phase inclusions are composed of H_2O, CO_2 liquid and CO_2 vapor, with the CO_2 density equal to 0.65-0.75 g/cc. Relatively constant V/Z ratios imply lack of boiling during vein formation. Absence of daughter salts and freezing temperatures of approximately 0°C indicate extremely low salinity fluids. A minimum trapping temperature of 275°C was determined by heating.

Stable isotope and gas chromatographic work are in progress. The data obtained from this study will aid in determining the origin for the gold mineralization. (Authors' abstract)

LAMB, William and VALLEY, J.W., 1984, Granulite formation, C-O-H fluids + graphite (abst.): EOS, v. 65, p. 288.

LAMBERT, I.B., DONNELLY, T.H., ETMINAN, H. and ROWLANDS, N.J., 1984, Genesis of late Proterozoic copper mineralization, Copper Claim, south Australia: Econ. Geol., v. 79, p. 461-475. First author at Baas Becking Geobiological Lab., P.O. Box 378, Canberra City, A.C.T. 2605, Australia.

The late Proterozoic sequence at Copper Claim comprises dolomitic, magnesitic, and cherty strata, with intercalated quartzofeldspathic clastics. It is considered to have accumulated in an intracratonic, tectonically controlled depression. Pyrite is present in generally low concentrations throughout the sequence, while chalcopyrite is concentrated in two units. Both sulfides occur as bedded disseminations, in carbonate-rich veinlets, and less commonly, in intraclasts. On petrographic evidence, some of the veinlets formed before cleavage development in their host strata, and others formed during or after regional metamorphism. There is no evidence for hydrothermal alteration.

The disseminated sulfides have a $\delta^{34}S$ range of -17.3 to 15.8 per mil, consistent with bacterial reduction of sulfate. Veinlet sulfides have a similar but smaller $\delta^{34}S$ range (-12.2 - +9.3‰), in accord with formation by remobilization of the disseminated sulfides.

There are no significant $\delta^{13}C$ differences between bedded and veinlet carbonates, nor between dolomite and magnesite. However, there are marked variations in $\delta^{18}O$ values, with magnesite values being generally higher than dolomite, and the median value for bedded carbonates being around 23 per mil, some 3 per mil higher than the median value for veinlet carbonates. These data imply a general tendency toward low-temperature oxygen isotope equilibration during early diagenetic carbonate reactions, followed by generation of some veinlets from components in the sediments at temperatures only a few tens of degrees higher. Low-grade regional metamorphism caused minor recrystallization and formation of additional veinlets but did not extensively overprint the diagenetic isotopic trends. Isotopic similarities between the cupriferous and the unmineralized lithologies support introduction of the copper during sedimentation and/or early diagenesis.

Veinlet carbonates contain small NaCl-rich fluid inclusions. These are mainly secondary, occurring along healed microfractures. Microthermometric measurements imply that they formed at around 300°C and 4 km depth, during the metamorphism.

The Copper Claim sulfides fit a general trend of increasing mean $\delta^{34}S$ values with decreasing age of the late Proterozoic strata in the Adelaide geosyncline and Stuart shelf. This trend may be the product of local environmental conditions which resulted in sulfate reduction outweighing sulfate replenishment. Alternatively, it could be reflecting global processes which caused major ^{34}S enrichment of seawater sulfate. (Authors' abstract)

LAMBERT, I.B., ETMINAN, H., EADINGTON, P. and 8 others, 1984, Ore genesis investigations: Baas Becking Geobiological Lab. Annual Rept., 1983 (pub. 1984), p. 4, 5, 6, 9.

Fluid inclusions were studied in calcite from the Pillara sphalerite-galena-marcasite mineralization that occurs in calcite veins and breccia cements in unaltered Frasnian platform limestone. They show a range of freezing temperatures, mainly between 4 and 19°C [presumably -4 and -19°C], which indicate that the precipitating fluids were variably more saline than seawater. The freezing temperatures measured in some calcite crystals are lower than the eutectic of the NaCl-H_2O system, implying the presence of major concentrations of Ca and/or Mg. In most other cases, the presence of moderate concentrations of Ca and/or Mg is indicated by initial melting temperatures lower than the NaCl-H_2O eutectic. Most of Th are between 50 and 85°C, which, because of the negligible compressibility of brines at low temperatures, should be close to temperatures of formation.

Inclusions in sphalerite are rarely large enough for detailed study, but appear to have similar features to those in adjacent calcite spar.

Further work is needed before it will be possible to distinguish any systematic salinity and temperature trends. However, initial indications are that the highest salinities and temperatures are from the deepest samples. The Pillara results are consistent with various degrees of mixing of ascending basinal brines with waters of marine derivation. Further evidence for the role of basinal brines comes from the presence of hydrocarbons in some fluid inclusions. [Isotopic studies of $\delta^{13}C$, $\delta^{18}O$ and $\delta^{34}S$ are reported.]

Fluid inclusion studies of dolomite from the Wagon Pass mineralization have not shown any marked difference in salinities and Th between early and late dolomite, or between dolomite within and distant from the mineralization. Freezing point depressions indicate generally highly saline brines commonly from 19 to 21.5% NaCl equivalent. Initial melting temperatures imply the presence of divalent cations such as Ca^{2+} and Mg^{2+}. The Th are concentrated between 75 and 95°C; a few values above 100°C may be the result of leakage.

Post-dolomite calcite is widespread and the fluids included in this spar have widely varying salinities, from 2 to 21.5% NaCl equivalent, with evidence for divalent cations. The mean Th is around 70°C, slightly lower than for dolomite. [Isotopic studies of C, O, and S are reported for both areas.]

Further fluid inclusion work has confirmed the presence of CO_2-rich, high salt-content fluids in the Mount Gunston area. The two most likely sources for such fluids are (1) a deep-seated origin, ultimately from degassing of the mantle, and/or (2) decarbonation reactions of impure carbonate rocks. A Ca-rich magma of intermediate or basic alkalic composition, such as formed the volcanic sequence, may generate CO_2-rich fluids. Alternatively, decarbonation reactions in the calc-silicate sequence beneath the volcanics could generate such fluids. The circulation of these CO_2-rich fluids could effectively scavenge base metals from the strata infiltrated. (From the authors' text)

LAMBERT, I.B., PHILLIPS, G.N. and GROVES, D.I., 1984, Sulphur isotope compositions and genesis of Archaean gold mineralization, Australia and Zimbabwe, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 373-387.

LAND, L.S., 1984, Evidence for vertical movement of diagenetic fluids, Texas Gulf Coast (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Author at Univ. Texas, Austin, TX.

Both the study of burial diagenesis and the study of present-day formation waters of Jurassic through Pleistocene formations from the Texas Gulf Coast document local vertical fluid transport of at least several kilometers. Evidence includes the following. (1) Discharge at the land surface of Mesozoic-derived brines as "bad water." (2) Emplacement of Mississippi Valley-type lead-zinc mineralization by fluids derived from Mesozoic formations in salt dome cap rocks at or near the land surface. (3) Emplacement of uranium in Tertiary aquifers as a result of reduction by ascending reduced sulfur, presumably of Mesozoic origin. (4) Emplacement of calcite cement derived from Mesozoic strata in Tertiary sandstones. (5) Presence of fluids in Plio-Pleistocene rocks with chemical signatures that could only have been derived from Mesozoic strata.

Material-transport calculations indicate that the volumes of fluid involved far exceed the volume of connate water deposited in the basin, strongly suggesting some mechanism of thermally driven convective flow. (Author's abstract)

LAND, L.S. and PREZBINDOWSKI, D.R., 1984, Why Edwards brines are not connate (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 105. First author at Dept. Geol., Univ. Texas, Austin, TX 78712.

Stoessell and Moore (AAPG, v. 67, p. 886-906) claim that saline formation waters in the Edwards Formation, South Central Texas "...are the result of mixing of seawater evaporated to halite saturation with waters of present-day seawater composition" (p. 897). This is incorrect for at least six reasons:

1) Edwards brines are enriched in bromide relative to seawater evaporated to halite saturation because of subsurface halite recrystallization.

2) The Na/Cl and Ca/Cl ratios of Edwards brines differ significantly from seawater evaporated to halite saturation because of extensive albitization in the subsurface.

3) The magnesium content of Edwards brines cannot be achieved by dolomitization at temperatures below about 300°C.

4) Stabilization of metastable dolomite consumes magnesium and cannot account for the up-dip increase in magnesium which is observed.

5) The volume of connate brine sedimented along with the Louann salt is much smaller than the present brine volume in the rocks. Considerable brine loss during the Tertiary is evidenced by Mississippi-valley-type ore occurrences, uranium depositions and large amounts of chloride added to rivers.

6) Oxygen, hydrogen and strontium isotope ratios bear no resemblance to Jurassic seawater evaporated to halite saturation. The dominant reaction controlling Edwards brine composition is: Halite + plagioclase → albite + brine. (Authors' abstract)

LANDIS, G.P., LEACH, D.L. and HOFSTRA, A.H., 1984, Silver-base metal mineralization as a product of metamorphism; Coeur d'Alene district, Shoshone County, Idaho; concepts of genesis, <u>in</u> The Belt, S.W. Hobbs, ed., Belt Symp. II, 1983, Missoula, MT, USA, Oct. 3-9: Special Publ. - State of Montana Bureau of Mines and Geol. 90, 68 pp.

Indexed under Fluid Inclusions. (E.R.)

LANGE, I.M. and KROUSE, H.R., 1984, Sulfur isotopic variations in the A2844 vein and wall rock, Butte, Montana: Geochem. J., v. 18, p. 269-280. First author at Dept. Geol., Univ. Montana, Missoula, MT 59812, USA.

Sulfur isotopic analyses on vein pyrite and associated sulfides in a short section of a vein in the Intermediate Zone, Butte, Montana, show remarkable isotopic uniformity. The standard deviation (0.5%) and range of pyrite values (1.4 to 3.9‰) are attributed to ore formation in a fO_2-pH regime where the isotopic composition was insensitive to large changes in the physico-chemical conditions. The $\delta^{34}S$ of the hydrothermal solution responsible for pyrite deposition is estimated to be +3.1‰. Large per mil differences and textural relationships between pyrites and associated copper and zinc sulfides show that the different sulfides were not deposited simultaneously and/or in isotopic equilibrium.

Disseminated wall rock pyrites are depleted in ^{34}S by as much as 2.4‰ relative to the adjacent vein and veinlets. The isotopic relationship between vein and disseminated pyrites may be due to a number of phenomena including diffusional fractionation, the effects of wall rock on the physico-chemical properties of the solution but are probably largely due to the interaction of pre-Main Stage and Main Stage hydrothermal processes. Delineation of these mechanisms is confounded by the presence of many veinlets in the wall rock. (Authors' abstract)

LAO, Kheang,* 1984, Magmatic water/sea water mixing in an Archean hydrothermal system related to the formation of Millenbach Cu-Zn deposit, Rouyn-Noranda, Quebec (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 78. Author at Dépt. de Génie Minéral, Ecole Polytech., Montréal, Québec, H3C 3A7, Canada.

Primary fluid inclusions in hydrothermal quartz from the Millenbach alteration pipe are divided into (1) moderately saline inclusions which contain 13 to 30 wt% eq $NaCl/CaCl_2$, and (2) highly saline inclusions, with the salt concentration ranging from 27 to 46 wt% eq NaCl. Some of the inclusions are liquid rich, with vapor/liquid ratio being generally lower than 35%. Thermometric data show that (1) 61% of the moderately saline inclusions are homogenized into the liquid phase at temperatures ranging from 250° to 399°C, averaging 310°C, (2) for highly saline inclusions, the maximum temperature of fluid phase homogenization is 383°C, and the corresponding salinity, deduced from the temperature of NaCl dissolution at 364°C, is 42 wt% eq NaCl, and (3) the estimated temperature of the hydrothermal fluid, deduced from the average value of the Na/K atomic ratio, is approximately 350°C. The Na/(Na+K) ratios of 127 inclusions, analyzed with the electron microprobe, vary from 0.10 to 0.99, with 83% being higher than 0.70. Fluid inclusions allow us to draw the following conclusions: (1) the Millenbach hydrothermal system was composed of two fluids, (2) the highly saline fluid, with maximum salinity of about 40 wt% eq NaCl, was probably of magmatic origin, (3) the moderately saline fluid, with salinities ranging from 15 to 26 wt% eq $NaCl/CaCl_2$, probably originated from the mixing of sea water with the magmatic water, (4) the maximum temperature that the Millenbach hydrothermal system attained was 350° to 380°C, and (5) the weakly carbonic hydrothermal fluids were very sodic, with an average Na/(Na+K) ratio of 0.75. (Author's abstract) *Apparently family name is Kheang; see p. 162, this volume.

LAPHAM, K.E., HOLLOWAY, J.R. and DELANEY, J.R., 1984, Diffusion of H_2O and D_2O in obsidian at elevated temperatures and pressures: J. Non-Crystalline Solids, v. 67, p. 179-191. First author at Dept. Chem. & Geol., Arizona State Univ., Tempe, AZ 85287, USA.

Diffusion couples of Los Posos rhyolite obsidian were run at 850°C over a range of pressures from 700 bar to 5 kbars to determine the effects of pressure on water diffusion in a silicate melt. Each couple consisted of a naturally "dry" half and an artificially hydrated half containing about 3.7 wt% H_2O. Using an ion microprobe, analyses of $^1H/^{16}O$ concentration ratios were made at 50 micron intervals on longitudinal sections of the couples. Normalized water concentration-distance profiles showed that, within experimental error, pressures up to 5 kbar have no effect on water diffusivity in a rhyolitic melt at 850°C. An error analysis allows a maximum activation volume of 4 cm^3 $mol.^{-1}$ at 850°C.

Electron microprobe analyses made along the diffusion path indicated that the major cation composition remains constant. Hence, a diffusion mechanism dependent on interdiffusion of alkali ions and water is not supported by the data.

The diffusion of D_2O was also investigated using a semi-infinite medium with the "dry" obsidian and D_2O fluid at 850°C and 700 bar to test the effect of mass on diffusion. Normalized deuterated water concentration-distance profiles were compared to profiles for water from similar experiments. Assuming that the solubility of D_2O is the same as that of H_2O in obsidian, there is a small isotopic effect on water diffusivity, with the diffusion coefficient for D_2O about one-half that for H_2O at the same concentration. (Authors' abstract)

LAPIN, A.P., 1983, Significance of limited miscibility in silicate-carbonate melts in the petrology and genesis of carbonatites: Geol. Rudnykh Mestorozh., no. 2, p. 3-20 (in Russian; translated in Int'l. Geol. Review, v. 26, no. 7, p. 779-794, 1984). Author at Inst. Rare Element Mineral. and Geochem.

The article describes some remarkable textures indicative of immiscibility of carbonatite and silicate magmas. (Author's abstract)

LARSON, P.B., 1984, I, An oxygen 18/oxygen 16 investigation of the Lake City caldera, San Juan Mountains, Colorado; II, Oxygen 18/oxygen 16 relationships in Tertiary ash flow tuffs from compelx caldera structures in central Nevada and the San Juan Mountains, Colorado: Ph.D. dissertation, California Inst. Tech.

LARSON, S.Å. and TULLBORG, E.-L., 1984, Stable isotopes of fissure-filling calcite from Finnsjön, Uppland, Sweden: Lithos, v. 17, p. 117-125. First author at Sveriges Geol. Undersökning, Kungsgatan 4, S-411 19 Göteborg, Sweden.

Includes some unpublished Th data of Sten Lindblom for calcite (175°C to <50°C) and salinity (high to low), and prehnite (115°C). Some calcite could have formed recently, from modern waters. (E.R.)

LASAGA, A.C., 1984, Chemical kinetics of water-rock interaction: J. Geophys. Research, v. 89, no. B6, p. 4009-4025. Author at Dept. Geosci., Pennsylvania State Univ.

The recent literature on the kinetics of water-rock interactions is reviewed. The data are then extended to provide a quantitative framework for the description of weathering and alteration. The available experimental data on dissolution of silicates verifies quantitatively the usual mineral stability series in sedimentary petrology. The rate of hydration of carbonic acid is shown to be a possible limiting factor in water-rock interactions. The framework is developed to enable use of laboratory dissolution experimental results and thermodynamics to arrive at a rate law applicable up to equilibrium and therefore applicable to natural systems. The kinetic justification for the significance of a water-rock ratio is discussed. With a proper treatment of fluid flow, the equations are applied to the weathering profile leading to the development of bauxites from nepheline syenites. (Author's abstract)

LAZAR, Boaz and HOLLAND, H.D., 1984, Fluid inclusions in halite: clues to the chemical evolution of seawater (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 571-572. Authors at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

We have developed procedures to extract and to analyze fluid from inclusions of diameter > 300 μm in halite. A hole ca. 90 μm in diameter is drilled, a micropipette of constant bore with a tip pulled to ca. 5-10 μm is inserted into the inclusion, fluid is extracted, and its volume measured. The extracted solution is then diluted to 100 μl with dionized water. Cation and anion analyses are carried out on a Dionex 2010 ion chromatograph. Alkalinity titrations on undiluted droplets ca. 35-40 nl in volume are carried out by following the pH during the generation of H^+ ions by passing current through Sb-Sb_2O_3 microelectrodes.

We have started to apply these techniques to the analysis of inclusion fluids on upper Miocene halite from core No. 34, DSDP site 237, in the Red Sea. The bromine profiles in the evaporite horizons in this core are simple (Stoffers and Kühn, 1974). Later migration of this element has therefore almost certainly been minor. Our concentration data in mg/liter for two inclusions from this material are as follows:

Na^+	K^+	Mg^{+2}	Cl^-	SO_4^{-2}	Br^-	T.D.S.
45,800	9,740	39,400	178,700	24,100	3,590	301,330
52,500	9,770	37,600	182,900	26,300	3,180	312,250

The concentration of calcium in the dilute inclusion fluids was below the detection limit of our instrument. The Na^+, K^+, Mg^{+2}, and Cl^- concentrations are close to those in present-day seawater concentrated by a factor of 27-32. The SO_4^{-2} concentration is lower than expected for this degree of concentration. The Br concentration is approximately a factor of two higher than expected. It seems likely that the high Br content of the inclusion fluids is due to the redistribution of this element between halite and fluid during essentially closed-system recrystallization of the halite. (Authors' abstract)

LEA, D.W., 1984, An oxygen isotope and fluid inclusion study of the Eureka graben paleo-hydrothermal system, western San Juan Mountains, Colorado: Senior paper, Bryn Mawr College, Bryn Mawr, PA 19010, 67 pp.

Oxygen isotope and fluid inclusion data have been obtained on altered volcanics and quartz vein samples from the mid-Tertiary hydrothermally mineralized Eureka graben in the western San Juan Mountains, Colorado. $\delta^{18}O$ (in per mil notation) for whole-rock samples of volcanic rocks range from -4.6 to +2.9 and thus are depleted in O^{18} from normal igneous values by 3.5 to 11 per mil. Samples of wall-rock collected directly adjacent to hydrothermal veins yield the greatest depletions, with progressively smaller depletions in samples collected farther from the veins. $\delta^{18}O$ for the quartz vein material ranges from -2.9 to +6.0. $\delta^{18}O$ for all sample types (altered volcanics, sulfide-bearing and sulfide-free quartz) is lower for samples from lower altitudes, and sulfide-free quartz samples are depleted in O^{18} relative to sulfide-bearing quartz samples. Fluid inclusion Th for 8 samples range from 199°C to 273°C. These temperatures increase with depth and are slightly higher for sulfide-free samples. Using temperatures from the fluid inclusion data, the calculated $\delta^{18}O$ values of the hydrothermal fluids fall predominantly in the range -7.0 to -11.0; thus these fluids have undergone O^{18} enrichments of 4 to 8 per mil relative to unaltered meteoric water. Salinities for the trapped fluids range from 0 to 1.5 weight % NaCl equivalent for sulfide-free samples and 0.8 to 2.7 weight % for sulfide-bearing samples. The hydrothermal fluids, as characterized by $\delta^{18}O$ and salinity, are not distinctly different in vein quartz samples bearing sulfides vs. those lacking sulfides. It appears that temperature differences were the primary factor in controlling sulfide formation in the hydrothermal veins of the Eureka graben, and in addition, these temperature differences are the most important single factor in accounting for the observed oxygen isotope anomalies. (Author's abstract)

LEA, D.W., LARSON, P.B. and TAYLOR H.P., Jr., 1984, Oxygen isotope and fluid inclusion study of veins and wallrocks in the Eureka graben, San Juan Mts., Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 572. First author at Dept. Geol. & Geophy., Woods Hole Oceanographic Inst., Woods Hole, MA 02543.

Oxygen-isotope and fluid-inclusion data have been obtained on altered volcanic rocks and quartz veins from the mid-Tertiary, hydrothermally mineralized Eureka graben, which extends SW from the Lake City caldera and NE from the Silverton caldera. The $\delta^{18}O$ values of volcanic rocks range from -4.6 to +2.9 and of quartz veins from -2.9 to +6.0; these are depleted in ^{18}O relative to normal igneous values by 3 to 12 per mil. Wall-rocks collected directly adjacent to hydrothermal veins exhibit the greatest ^{18}O depletions. $\delta^{18}O$ for all samples (altered volcanic rocks, sulfide-bearing quartz, and sulfide-free quartz) is lower for samples from lower altitudes (range in 3048m to 3980m). Sulfide-free quartz is more depleted in ^{18}O than sulfide-bearing quartz. Mean fluid inclusion Th for 8 quartz samples range from 199° to 273°C. These temperatures increase with depth and are slightly higher for sulfide-free samples. Calculated $\delta^{18}O$ values of the hydrothermal fluids based on these temperatures fall in the range -7.0 to -11.0, indicating deposition from meteoric-hydrothermal fluids that underwent ^{18}O enrichments of 4 to 8 per mil relative to local Miocene meteoric water. These fluids are isotopically very similar to the fluids responsible for hydrothermal alteration in the adjoining Lake City caldera (Larson and Taylor, 1982). The $\delta^{18}O$ values and salinities of the hydrothermal fluids were similar in both the sulfide-bearing quartz veins and in those lacking sulfides; hence, temperature differences may have been an important factor controlling sulfide formation. (Authors' abstract)

LEACH, D.L., VIETS, J.G. and ROWAN, Lanier, 1984, Appalachian-Ouachita orogeny and Mississippi Valley-type lead-zinc deposits (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 572. Authors at U.S. Geol. Survey, P.O. Box 25046, Denver Fed. Center, MS 912, Denver, CO 80225.

Many of the Mississippi Valley-type lead-zinc deposits in the central and eastern U.S. are interpreted to be related to rapid expulsion of fluids from pericratonic-foreland basins during Appalachian-Ouachita orogeny in late Paleozoic time. This model is consistent with fluid inclusion, geochemical, and geological studies that implicate the Ouachita-Arkoma basin as the source of the ore-forming fluids responsible for the abundant lead-zinc-barite deposits in the Ozark region. (From the authors' abstract)

LEBEDEV, L.M. and NIKITINA, I.B., 1983, The Cheleken ore-forming system: "Nauka," Moscow, 240 pp., 600 copies printed, price 3 rbls. 70 kopeck (in Russian).

The book characterizes in detail the present-day working hydrothermal ore-forming system, especially its geochemical features, and mineral-forming processes connected with natural and industrial circulation of the Cheleken hydrotherms. Minerals of the previous periods of hydrothermal activity are also described. (A.K.)

LE BEL, L., LI, Yi-dou and SHENG, Ji-fou, 1984, Granitic evolution of the Xihuashan-Dangping (Jiangxi, China) tungsten-bearing system: TMPM Tschermaks Min. Petr. Mitt., v. 33, p. 149-167. First author at GIS CNRS-BRGM, CRSCM, 1A, rue de la Férollerie, F-45045 Orléans Cedex, France.

Geochemical investigations have been carried out on the granites associated with the intragranitic wolframite vein type deposits of Xihuashan and Dangping (Jiangxi, China). The behavior of major elements during evolution is identical to that of many evolved granites in orogenic provinces but trace elements and in particular REE indicate a complex magmatic and deuteric evolution. Partial melting or fractional crystallization fail to explain LREE and Eu depletions and HREE enrichments which are more likely due to volatile transfer. Sr isotopes give an age of 155 ± 2 Ma and an initial rato of 0.7169 excluding the involvement of wall-rock material in the generation of the granites. In addition they indicate that waters involved in the metasomatic and hydrothermal processes are not meteoric but rather magmatic. Suggestions for employment of the distinctive granite REE patterns for prospecting are given. (Authors' Summary)

LE CLOAREC, M.-F., LAMBERT, Gerard, LE GUERN, Francois and ARDOUIN, Benedicte, 1984, Volcanology - Exchange of volatiles between solid, liquid and gaseous phases during the 1983 eruption of Mount Etna: C.R. Acad. Sc. Paris, v. 298, Ser. II no. 18, p. 805-808 (in French).

The radioactivity of ^{210}Pb, ^{210}Bi, and ^{210}Po was measured in various samples of gases, aerosols, and lavas collected during the 1983 Mt. Etna eruption. It was shown that the lava outgassing of ^{210}Pb is very weak when that of ^{210}Po is almost complete. Moreover the liquid lava is very enriched in volatiles probably emitted from the still hot edges of the active lava flow. (Authors' abstract)

LEE, R.W. and KIRBY, S.H., 1984, Experimental deformation of topaz crystals: possible embrittlement by intracrystalline water: J. Geophys. Research, v. 89, no. B6, p. 4161-4166. Authors at U.S. Geological Survey.

Crystallographically oriented single-crystal prisms of gem quality topaz (composition $Al_2SiO_4\ (OH_x\text{-}F_{1-x})_2$ where $x = 0.04 \pm 0.01$) were deformed at a confining pressure of 1.50 GPa, a temperature of 800°C, and a strain rate of $2 \times 10^{-5}\ s^{-1}$. Under nearly identical conditions, all crystals of anhydrous rock-forming minerals that have been tested to date, such as olivine, quartz, feldspars, pyroxenes, and refractory oxides, deform plastically; in contrast, our topaz crystals failed by brittle fracture regardless of the orientation of the compression direction. No optical evidence for plastic deformation was detected. Another suite of experiments with compression perpendicular to the (001) cleavage at T = 100°-950°C and a strain rate of $2 \times 10^{-5}\ s^{-1}$ displayed two regimes of behavior: (1) at $T > 400°C$, fracture strength was independent of temperature, and fracture occurred on one or two surfaces parallel to $\{103\}$; (2) at $T < 400°C$, the fracture strength increased rapidly with decreasing temperature, no macroscopic stress drop was observed, and many closely spaced conjugate fractures formed on $(\bar{1}03)$ and (103). The anomalous brittleness of topaz compared to anhydrous silicate and oxide crystals indicates that intracrystalline "water" plays a role in the embrittlement. We suggest that water within the topaz crystals promotes fracture in ways similar to the mechanisms of slow crack growth aided by environmental moisture. (Authors' abstract)

LEPEZIN, G.G. and MELENEVSKIY, V.N., 1983, The problem of H_2O and CO_2 in cordierites: Dokl. Akad. Nauk SSSR, v. 269, no. 4, p. 920-924 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 127-131, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 151-152, 1983. (E.R.)

LEPEZIN, G.G., OSORGIN, N.Yu. and SHVEDENKOV, G.Yu., 1984, Determination of diffusion coefficients for CO_2 in cordierites: Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 970-974 (in Russian). Authors at Inst. Geol. & Geophysics of Siberian Br. Acad. Sci. USSR, Novosibirsk-90, USSR.

Experimentally determined diffusion coefficients for CO_2 in cordierite ranged from 1.7×10^{-12} to 7.5×10^{-9} (in cm^2/sec, average values) in temperature interval 600-1000°C, number of determinations from 2 to 17. The 95% saturation of cordierite with CO_2 would be achieved in the following time ranges (in seconds? - A.K.): 500°C, grain diameter 1 mm - 1.26×10^{10}; 800°C grain diameter 0.01 mm - less than 1. Pertinent to eventual CO_2 presence in inclusions in cordierite. *Note*: the paper has incomplete explanations - in addition to the lacking time units in the Table 2, two abbreviations t_1 and t_2 are not explained and no values are given for the vertical axis dCO_2/dt in Fig. 3. (A.K.)

LESPINASSE, Marc, 1984, Strings of fluid inclusions as microstructural markers of metallogenic interest: 10e Reunion Ann. des Sci. de la Terre, Bordeaux, 1984, Abstracts, p. 361 (in French). Author at C.R.E.G.U., BP 23, 54501 Vandoeuvre-lés-Nancy, France.

As part of a structural study of uranium mineralization related to episyenites in Marche (northwest Limousin, France), the author studied the alignment of fluid inclusions as they might relate to circulation of ore forming fluids. The study demonstrated that: 1) The fluid inclusions show clear and regular preferential orientation from one sample to another; 2) The networking of the fluid inclusion trains is analogous to the micro- and meso-fracturing of the granite; the principal preferred orientation is parallel to the regional σ_1; 3) This preferred orientation is also parallel to the principal axis of the episyentites; and 4) The density of fluid inclusions decreases away from the episyenites. (From the author's abstract, translation courtesy M.J. Logsdon)

LETNIKOV, F.A. and ZHATNUYEV, N.S., 1983, The fluoride-water-silicate system in the presence of a temperature gradient: Dokl. Akad. Nauk SSSR, v. 268, no. 1, p. 199-201 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 176-178, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 152, 1983. (E.R.)

LEUNG, I.S., 1984a New mineral and melt inclusions found in a natural diamond (abst.): EOS, v. 65, no. 45, p. 1154. Author at Dept. Geol. & Geography, Herbert H. Lehman College, City Univ. of New York, Bronx, NY 10468.

A diamond about 2 mm in size contains at least 20 inclusions, 5 to 150 microns in size, some of which have been identified as biotite, calcite, pyrrhotite, clinopyroxene, rutile, apatite and coesite. Two crystals of calcite found in this diamond have been reported elsewhere as the first occurrence of calcite in diamond. Another new mineral inclusion discovered in this diamond is an apatite crystal 6 x 8 microns in dimension coexisting in juxtaposition with a grain of similarly-sized rutile while this assemblage is partially encased in a much larger clinopyroxene. Apatite associated with diamond had been found previously only as an exterior coat on diamond.

Three grains of coesite were found, two are globular in shape, while the largest grain, 80 x 60 microns in size, contains over 15 brown melt globules ranging from 3 to 10 microns in diameter. These melt inclusions, forming immiscible blebs of diverse chemical compositions enriched either in Si, Fe-Ca, Ca-Fe-Mn or Ca-Cu-Zn, appear to be residues of a silica-rich melt in which the coesite host crystallized.

Diamond inclusions are considered to belong to one of two distinct suites of minerals, either *peridotitic* or *eclogitic*. The assemblage of minerals described in this investigation has composition akin to that of a late-stage kimberlitic magma which had undergone extensive olivine fractionation. Because of their kimberlite affinity, these mineral inclusions form a unique group of *kimberlitic* inclusions which is recognized here for the first time in diamond. This also suggests that at least some diamonds are phenocrysts and not xenocrysts of kimberlite. (Author's abstract)

LEUNG, I.S., 1984b Polymineralic inclusions in natural diamond (abst.): EOS, v. 65, p. 306.

LEUNG, I.S., 1984a The discovery of calcite inclusion in natural diamond and its implications on the genesis of diamond, kimberlite and carbonatite (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 574.

LEVITSKIY, V.V., RAZVOZZHAYEVA, E.A., DEMIN, B.G., KHRENOV, P.M., BABURIN, L.M. and ODINTSOVA, I.V., 1983, Asphaltenes of petroleum and gold ores as concentrators of organometallic compounds: Dokl. Akad. Nauk SSSR, v. 270, no. 1, p. 196-199 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 53-57, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 152, 1983. (E.R.)

LI, Binglun and XIE, Yihan, 1984, Genesis, classification and genetic model of iron ore deposits of Nanjing-Wuhu type in Nanjing-Wuhu district: Scientia Sinica, Ser. B, v. 27, no. 6, p. 625-634 (in English). Authors at Inst. Geol., Acad. Sinica, Beijing, China.

The generation and evolution of ore-forming magma and its relation to the formation of two genetic series of iron ore deposits are discussed in this paper. Characteristics of ore-fabric and mineral paragenesis of the various iron ore deposits are theoretically explained. Information on the physicochemical condition during the ore-forming process and of its spatial variation is obtained by the fluid inclusion method. Therefore, the authors present a new genetic classification and ore-forming model of the iron ore deposits of Nanjing-Wluhu type. (Authors' abstract)

LI, Binglun, XIE, Yihan and WANG, Yinglan, 1983, New understanding of porphyrite type iron ore deposits acquired through inclusion studies: Mineral Deposits, no. 2, p. 25-31 (in Chinese; English abstract). Authors at Inst. Geol., Acad. Sinica.

A reinvestigation on inclusions in minerals of volcanic iron ore deposits from Nanjing-Wuhu region indicates convincingly the presence of ore-magma and deuteric mineralization during the formation of some of these deposits.

The main minerals in the hypogene ore-magma deposits are determined to have crystallized in the sequence of pyroxene, garnet, apatite, magnetite, quartz and calcite. Of these minerals, different ones contain diverse inclusions: in pyroxene, there occur mainly melt inclusions; in garnet, apatite and magnetite, gas-liquid-solid polyphase and gas-liquid biphase inclusions are found together with melt ones; quartz in miarolitic cavities contains primarily gas inclusions; and calcite has in it chiefly liquid inclusions. All this demonstrates that ore-forming processes of ore-magma deposits started from "dry" ore magma and then gradually converted into ore fluids.

Of numerous iron deposits spatially related to diorite or porphyrite, the deuteric pneumato-hydatogenic metasomatic iron deposits occurring within the intrusion have in their early pyroxene and apatite melt, polyphase and biphase inclusions, while the contact-metasomatic and hydrothermal deposits contain predominantly biphase inclusions, which suggests that the ore-forming processes of these diverse deposits associated with diorite or porphyrite must have also started with the residual magma, then evolved into the hydrothermal stage. These facts bear out the claim that porphyrite iron deposits include two genetic series, the magmatic iron ore deposits and residual magmatic deposits.

The ore-forming temperatures of volcanic iron deposits have been measured and summarized thus:

Ore-forming temperatures of the hypogene ore-magma iron deposits (Meishan) were in the range of 120°C to 1075°C with magnetite formed between 450°C and 840°C, while hematite from the supergene ore-magma iron deposits (Gushan) has formation temperatures from 350°C to 1040°C, higher than those of hypogene deposits. Such a phenomenon can well compare with the high formation temperatures of extrusive rocks relative to intrusive rocks. The widespread hematitization took place from 350°C to 400°C while siderite and pyrite occurred at 260°C to 280°C.

Melt inclusions have been recognized in early apatite and diopside of deuteric pneumato-hydatogenic metasomatic deposits (Taochun). Impregnated magnetite has Td of about 800°C, indicating a deuteric genesis, whereas significant quantities of magnetite were deposited from 360°C to 460°C, assigned to the pneumato-hydrothermal stage.

Magnetite in contact metasomatic deposits (Baixiangshan and Xiangyang) was formed approximately from 500°C to 630°C during the hydrothermal stage, the main stage of its deposition.

Inclusions in minerals from several iron deposits contain such gaseous components as H_2O, CO_2, CO, CH_4 and H_2. N_2 and O_2 have not yet been observed and sulphur-bearing gases not analyzed. It is suggested that $CO_2 + CH_4 + H_2$ (Mol)/CO_2 (Mol) be defined as a reduction parameter, and a discussion is made concerning the relationship of this parameter to ore occurrence and mineral association. (Authors' abstract)

LI, Yinqing, 1984a, Melt and fluid inclusions in some intermediate-acidic intrusions and volcanic complex in the Yulong Copper (molybdenum) Belt: Bull. Chinese Acad. of Geol. Sci., no. 8, p. 85-106 (in Chinese; English abstract). Author at Inst. Mineral Deposits, CAGS.

Rhyolites and monzonitic granite porphyries in the Yulong Copper (molybdenum) Belt contain melt inclusions of various types. Most of them are simple glass inclusions which consist of bubbles and glass, but some of them are polyphase glass inclusions which contain in addition such daughter minerals as Ti-biotite, titaniferous magnetite, zircon and apatite, or are crystalline melt inclusions which consist of crystalline materials and bubbles, or are devitrified glass inclusions which are derived from recrystallized glass. These melt inclusions are commonly developed in rhyolites, but relatively less in monzonitic granite porphyries, and even less in ore-bearing monzonitic granite porphyries that only contain a few crystalline melt and devitrified glass inclusions. However, the discovery of glass inclusions containing liquid (water) in quartz phenocrysts of barren monzonitic granite porphyries is very important to the study of the physico-chemical condition of magmatic solidus. Th of melt inclusions are estimated by means of heating-stage and quenching methods as 1000-1300°C in rhyolites and 900-1150°C in monzonitic granite porphyries. Because the sluggish [melting] of solid materials would cause inaccuracy, constant temperature for Th measurement must be kept for 4-24 hours. In order to reduce inaccuracy, it is better to measure smaller glass inclusions.

The composition of glass and daughter minerals of melt inclusions was determined by electron microprobe. The results show that the mean composition of the primary magmas of rocks in this region is as follows: SiO_2 63.10%, Al_2O_3 14.09%, TiO_2 3.22%, FeO + Fe_2O_3 6.77%, MnO 0.09%, MgO 3.29%, CaO 0.40%, Na_2O 1.16%, K_2O 5.69%, and that they contain more TiO_2 and MgO than do the partial melt magmas from the sial.

These igneous rocks are rich in fluid inclusions, and especially in the ore-bearing monzonitic granite porphyries (and in the barren porphyries near ore bodies); gaseous and liquid inclusions often coexist with high-saline inclusions which contain various daughter minerals. All of these indicate that copper (molybdenum) mineralization in this region resulted from repeated boiling of ore-bearing hydrothermal fluid. (Author's abstract)

LI, Yinqing, 1984b, Some problems concerning the study of fluid inclusions in porphyry copper (molybdenum) deposits of China: Geochem., v. 3, no. 3, p. 206-219 (in English). Author at Inst. Min. Deposits, Chinese Acad. Geol. Sci.

This paper reviews the types, Th, salinities, compositions, boiling and formation mechanisms of inclusions in porphyry copper (molybdenum) deposits of China. In addition, it discusses, in particular, pH conditions during quartz sericitization and potash-silicate alteration. If Th, KCl and NaCl concentrations and chemical compositions of K-feldspar and sericite are obtained, pH and $a(K^+)$ can be worked out with the equilibrium equations and expressions.

Research on the Yulong, Malasongduo and Dexing porphyry copper (molybdenum) deposits reveals that at the stage of quartz sericitization, potash silicate alteration and ore deposition, the activity values of K' in ore solutions are 0.1-25 mole, averaging 0.67 mole, and pH values range from 4.0-4.7. (Author's abstract)

LI, Zhitong, 1984, A brief introduction to geological characteristics of the gold ore deposit of metamorphosed hydrothermal type in Taipinggou of Luobei County, Heilongjiang Province: Bull. Shenyang Inst. Geol. Min. Res., 1984, no. 9, p. 51-60 (in Chinese; English abstract).

The Taipinggou gold ore deposit is in the Hegan gold ore province, in the Jiamusi uplift, and occurs in metamorphic rocks of Proterozoic Heilongjiang group. The ore bodies are composed of gold quartz veins and gold-bearing kata-altered rocks; the ore minerals consist of mainly pyrite pyrrhotite, galena, titanomagnetite, chalcopyrite, sphalerite, and native gold. The native gold is mainly present in the pyrite. The wall rock alteration is represented by silification and pyritization. The mineralizing temperature determined by the inclusion decrepitation method ranges from 310°C to 390°C. The sulphur isotopic composition of pyrite shows a dispersed tendency. These data indicate that the gold concentration in the green schist of Lower Heilongjiang group is obviously rather high (up to 142 ppm), which seems to be a possible gold source in this district[sic]. This gold ore deposit belongs to the hydrothermal type with metamorphic genesis. (Author's abstract)

LIGHTFOOT, P.C., NALDRETT, A.J. and HAWKESWORTH, C.J., 1984, The geology and geochemistry of the Waterfall Gorge section of the Insizwa complex with particular reference to the origin of the nickel sulfide deposits: Econ. Geol., v. 79, p. 1857-1879.

LIN, Chuanxin, BURT, D.M. and ZHANG, Zheru, 1984, Phase equilibria of several tungsten deposits in southern China: Geochimica, no. 1, p. 22-30.

LIND, Th., SCHMETZER, K. and BANK, H., 1984, Gem quality blue and green beryl (aquamarine and emerald) from Nigeria: Z. Dt. Gemmol. Ges. Jg. 33, no. 3/4, p. 128-138 (in German; English abstract).

Beryls of gem quality from a recently discovered mining area near Jos in Nigeria are described. The samples with refractive indices of n_o 1.570-1.574, n_e 1.564-1.568 and densities between 2.66 and 2.68 g/cm^3 show blue or green coloration of variable intensity. Crystals with color zoning are frequently observed. The variable colors and color intensities of the beryl crystals are caused by strongly varying concentrations of V, Cr and Fe. By spectroscopic investigations, absorption spectra which are typical of the blue beryl variety aquamarine (colored by iron) and spectra which are typical for the green beryl variety emerald (colored by chromium and vanadium) were measured. By microscopic investigations, a distinct growth zoning parallel to the basal pinacoid, the hexagonal dipyramid and parallel to the prism of first-order was observed in aquamarines and emeralds, as well as two different types of two-phase inclusions. (Authors' abstract)

LINDBLOM, Sten, 1984a Calcite carbon and oxygen isotope evidence for ore formation at Laisvall, Sweden: Bull. Minéral., v. 107, p. 241-253. Author at Ore Res. Group, Geol. Inst., Stockholms Univ., S-106 91, Stockholm, Sweden.

The Laisvall sandstone lead-zinc deposit located at the Caledonian border, Sweden, originally contained 80 million tons of ore in two thin Eocambrian sandstone horizons. The ore mineral assemblage consists of galena, sphalerite, calcite, barite, fluorite and quartz. Fluid inclusions and mineralogical textures particularly in sphalerite and calcite imply ore formation from mixing two solutions. This results in simple mineralogy but a complex paragenesis in several stages of deposition. Temperatures between 170°C and 130°C and a total salt content of 24 wt % eq. NaCl characterized the ore-forming environment. Initial calcite deposition occurred around 180°C from a solution with 18 wt % eq. NaCl.

The present study reports carbon and oxygen isotope measurements correlated to inclusion measured calcite samples in the ore. A narrow range (2‰) of carbon isotope ratios of -14.5‰ indicates a stable environment of deposition for both ore-bearing strata. Calculation of water in equilibrium with calcite in the ore likewise shows a homogeneous environment.

One sample gives higher isotope ratios ($\delta^{13}C$ = -8‰ and $\delta^{18}O$ = +17‰) implying an early calcite formed at a higher temperature.

Oxygen isotope ratios were generally heavier for the upper sandstone (+13.5‰) than for the lower sandstone (+11‰). This may indicate formation at a higher temperature or in more stages in the upper sandstone, compared to the lower sandstone.

$\delta^{18}O$ varies over a greater range than $\delta^{13}C$, illustrating the greater reactivity for oxygen than carbon, implying that several stages have taken place both in the upper and lower sandstone but within a fairly stable fluid environment.

Hydrocarbons have been present a Laisvall during ore formation but appear to have played a minor role as indicated by the isotopic data presented in this study. (Author's abstract)

LINDBLOM, Sten, 1984b Hydrogeological and hydrogeochemical investigations in boreholes - fluid inclusion studies in the Stripa granite: Internal Report, Stripa Project 84-07, Swedish Nuclear Fuel & Waste Management Co., 42 pp. Author at Stockholm Univ., Stockholm, Sweden.

Abundant inclusions have been found in quartz in the Stripa granite. Inclusion occurrence reaches 1.74×10^8 inclusions per cm^3 with a mean size of 6 µm in diameter.

These inclusions mainly contain an aqueous solution. Fractured rock sections contain inclusions with lower salinity than unfractured rock sections, 1.7 and 4 eq. wt% NaCl respectively. Comparison with measured salinities in the Stripa groundwater shows that only about 5-10% of the available fluid inclusions have to be leached in order to explain groundwater salinities.

Homogenization temperatures from the same inclusions indicate formation at over 130°C for the inclusions in unfractured rock sections. A later rehealing event at over 190°C is represented by inclusions in fractured rock sections. This later fluid has a lower salinity and indicates that the granite may have been flushed by deep circulating meteoric waters at a possible late date.

The aqueous inclusions are secondary but rare primary CO_2 inclusions occur which may indicate conditions of granite emplacement. (Author's abstract)

LINKER, M.F., KIRBY, S.H., ORD, Alison and CHRISTIE, J.M., 1984, Effects of compression direction on the plasticity and rheology of hydrolytically weakened synthetic quartz crystals at atmospheric pressure: J. Geophys. Research, v. 89, no. B6, p. 4241-4255.

LINNEN, R.L. and WILLIAMS-JONES, A.E., 1984, The Trout Lake molybdenum deposit, S.E. British Columbia: a study of contact metamorphism, wallrock alteration, and ore deposition (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 84. Authors at Dept. Geol. Sci., McGill Univ., Montreal, P.Q., H3A 2A7, Canada.

This quartz-molybdenum stockwork is hosted by pelitic quartzites in the contact metamorphic aureole of a small granodioritic stock. Assemblages from calcareous schists and marbles in the aureole (e.g. tremolite (tr)-chlorite(ch)-clinozoisite(cz)-calcite(cc)-plagioclase(An50)-quartz(q)) indicate that contact metamorphism occurred at 300-400°C and $XCO_2 < 0.03$. Low XCO_2 and outwardly telescoping isograds suggest that heat transfer was advective. Pyroxene-garnet-cz skarn containing scheelite is the earliest alteration (possibly coeval with contact metamorphism) and occurs along faults in limestone adjacent to the stockwork. Four additional alteration types are recognized. The earliest is pervasive and is exemplified by progressive biotitization and margarite-corundum-biotite(bi)-cc-q-An30 in the pelitic quartzites and tr-bi-ch-An30-cc-q-sphene in the calcareous schists. A temperature of 375-450°C and XCO_2 of 0.15-0.3 is inferred. Subsequent alteration was associated with the development of stockwork; biotitic haloes formed about quartz-albite veins; and silicification accompanied the main stockwork emplacement. Fracture-controlled phyllic alteration overprints the above and is characterized by sericite-pyrite-alkali feldspars-ankerite which indicate lower temperature and possibly higher XCO_2 conditions. Molybdenite in the main stockwork is commonly intergrown with muscovite and calcite but rarely with K-feldspar, all of which replace albite. Preliminary fluid inclusion data indicate that stockwork development occurred at temperatures similar to early alteration and at possibly higher XCO_2 (inclusions with up to 50 vol.% CO_2 are common). A model is proposed where contact metamorphism, alteration, and stockwork formed at similar temperatures, and XCO_2 increased with time. Changing pH, K/Na ratios, and CO_2 effervescence are factors which may have controlled molybdenite deposition. (Authors' abstract)

LISTER, B., 1978, The preparation of polished sections: NERC, Inst. Geol. Sciences [London] Report 78/27, 20 pp.

Describes the procedures used in the Applied Mineralogy Unit, Institute of Geological Sciences, London. (E.R.)

LIU, Yingjun, LI, Zhaolin and WU, Qizhi, 1984, Studies on the physicochemical formation conditions of some basalts in the eastern part of China (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 381-382. Authors at Dept. Geol., Nanjing Univ., Nanjing, China.

The Cenozoic basalts which are widely distributed in the east of China are an important part of the Pacific Basalt-Ring. The present studies apply mainly the results of studying inclusions in minerals to the approach of the physical chemistry conditions of basalt generation in the area. It has been shown that the basalts evolve in the order alkali-calcic and calcic--calc-alkalic and alkali-calcic--alkalic in petrochemistry, of shallow to deep in the magmatic source depth and of high to low rock-forming temperature, from the south to the north in this area. The solidified inclusions in the alkali basalts coming from relative deep, such as those in Wudalianci, have a high proportion of gas phase and the gas phase is often round in shape. Those inclusions are relative large either in volume or in amount but relatively low in formation temperature, 890-1150°C. Conversely, those in the relatively shallow alkali basalts, such as those in LÜshan, have obviously lower gas proportions, smaller size and amount of inclusions, and higher viscosity and Th (1200-1450°C). This evolution is identical with the direction of the Kula plate moving. The discoveries of the solidified inclusions in the pyroxene nodules and other minerals from the mantle by the studies have opened up a new way to study the conditions of physical chemistry of pyrolite generation. (Authors' abstract)

LIU, Yingjun, ZHANG, Jingrong, QIAO, Enguang, MAO, Huixin and ZHAO, Meiang, 1984, Geochemistry of gold deposits in west Hunan and east Guangxi, China: Geochem., v. 3, no. 4, p. 307-321 (in English). Authors at Dept. Geol., Nanjing Univ.

Includes some data showing a systematic relationship between Td and the amount of gold in gold quartz vein samples. (E.R.)

LOEWENTHAL, R.E. and MARAIS, G.vR., 1984, Carbonate chemistry of aquatic systems, Vol. 2: High Salinity Waters: Butterworths, Boston.

LONDON, David, 1984a The role of lithium and boron in fluid evolution and ore deposition in rare-metal pegmatites (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 578. Author at Sch. Geol. & Geophy., Univ. Oklahoma, Norman, OK 73019.

The poorly defined "pneumatolytic" transition between magmatic and hydrothermal crystallization in granitic systems appears to be especially important to the genesis of rare-metal pegmatites. At the TANCO pegmatite, Manitoba, fluid inclusions trapped by spodumene, and model experiments based on this natural fluid, indicate that Li and B (as $Li_2B_4O_7$ in fluid inclusions) played a major role at this transition. Dense aqueous borosilicate liquid was present down to ~480°C and 2.75 kbar at TANCO. Fluid inclusion evidence, however, indicates that the borosilicate components of this fluid were precipitated between ~350°-480°C and 2.25-2.75 kbar. The crystallization products of such fluids probably are represented by albite-Li mica-tourmaline units at TANCO and elsewhere. These zones contain most deposits of rare metals and gem minerals in pegmatites throughout the world (e.g., the albite-Li mica-tourmaline aplite that hosts most Be, Ta, and Sn mineralization at TANCO). The contents of the TANCO inclusions, plus the relatively late appearance of tourmaline-rich albite-mica zones, bear evidence of high Li and B contents of late-stage liquids, and of the instability of tourmaline throughout much of pegmatite crystallization. Nucleation and growth of tourmaline during pegmatite consolidation apparently is not dependent solely on activity of boron. Other parameters, such as the coordination number of boron, or the availability of ferromagnesian components to stablize crystal nuclei, may be controlling factors. When tourmaline nucleates stably, the hyperfusible components Li, B, and F are extracted from residual liquids, with the result that aluminosilicate and ore components are dumped from solution. (Author's abstract)

LONDON, David, 1984, Experimental phase equilibria in the system $LiAlSiO_4$-SiO_2-H_2O: a petrogenetic grid for lithium-rich pegmatites: Am. Mineral., v. 69, p. 995-1004. Author at Sch. Geol. & Geophys., Univ. Oklahoma, Norman, OK 73019.

Phase relations for the bulk composition $LiAlSi_5O_{12}$ (system $LiAlSiO_4$-SiO_2-H_2O) have been investigated experimentally over the range 340-950°C and 0.5-6.0 kbar $P(H_2O)$. Stability relations among eucryptite, spodumene, petalite, β-spodumene (tetragonal), and virgilite (hexagonal) have been determined for quartz-saturated subsolidus conditions. The result is a quantitative P-T phase diagram that is applicable to quartz-saturated lithium aluminosilicate assemblages in pegmatites and some volcanic rocks. Thermochemical data derived from these experimental results are internally consistent and in close agreement with values obtained from calorimetry.

Under the quartz-saturated conditions that prevail in pegmatites, stability relations among the lithium aluminosilicates are a function of P and T and are largely independent of the nature and proportions of other phases in the chemically complex pegmatite system. Thus, the lithium aluminosilicate phase diagram constitutes a petrogenetic grid from which P-T conditions of emplacement and crystallization can be ascertained for many lithium aluminosilicate-bearing pegmatites. (Author's abstract)

LOREDO, J., GUILHAUMOU, N., TOURAY, J.-C. and GARCIA IGLESIAS, J., 1984, Study of fluid inclusions in the Oseja fluorite deposit (Leon), especially inclusions in the system H_2O-SH_2-CO_2-elemental sulphur: Microthermometric and Raman microscopic data: Bol. Geol. Min. (Madrid), v. 95, no. 11, p. 142-150 (in Spanish).

LOREDO, J. and IGLESIAS, J.G., 1983, Fluid inclusions and genetic model for fluorspar mineralization in the Villabona-Arlos district (Asturias, Spain) (abst.): Symp., European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 40 (in French).

See next item. (E.R.)

LOREDO, Jorge and IGLESIAS, J.G., 1984, Fluid inclusions and genetic model of fluorspar mineralizations in the "Villabona-Arlós" district (Asturias, Spain): Bull. Minéral., v. 107, p. 217-226 (in French; English abstract). Authors at Dept. Metalog., Escuela de Ingenieros de Minas, Independencia 13, Oviedo-4, Spain.

As a result of fluid inclusion studies of stratiform fluorite deposits in the "Villabona-Arlós" district (Villabona, Cucona, Santofirme, Arlós, Gloria, Moscona), it is shown that there is a significant decrease in mineralization solution temperature from Villabona towards Arlós, with intermediate values for Moscona and Gloria deposits. The cooling is accompanied by a notable dilution of the fluids due to probable mixing with shallow, low salinity waters. The early, relatively low temperature, high salinity fluids (80-90°C; 18-22 wt % NaCl equiv.) become progressively diluted to give cooler, low salinity fluids (60-70°C; 0-8 wt % NaCl equiv.) during the later stages of mineralization.

From the information obtained by the fluid inclusion studies, and the geological data, a genetic model for the fluorite mineralizations in the "Villabona-Arlós" district (Asturias) is proposed in which the mixing of different fluids is an important factor in determining the genesis of the deposits. (Authors' abstract)

LOTKHOV, V.A., LANDA, I.V., MALYUSOV, V.A. and ZHAVORONKOV, N.M., 1984, Influence of kinetics on selectivity of evaporation process: Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 934-937 (in Russian). Authors at Inst. General & Inorganic Chem., Moscow, USSR.

Pertinent to heterogenization process of mineral-forming fluids. (A.K.)

LOUCKS, R.R., 1984, Fluid dynamics associated with the boiling zone in epithermal fissure veins, Topia, Durango, Mexico (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 21. Author at Dept. Geosci., Purdue Univ., West Lafayette, IN.

Extensive fluid inclusion studies indicate that very coarse-grained sphalerite, galena, pyrite, and intergrown freibergite, which dominate vein filling in the high-grade ore band, were precipitated from non-boiling solutions, but intercalated quartz/chert crustification bands associated with sphalerite leaching episodes record fluid inclusion and textural evidence of repeated descent of the base of the boiling zone to depths within the main ore horizon in response to salinity decrease and possibly CO_2 increase or release of confining pressure.

The mineralized vertical interval in each fissure vein is dimensionally analogous to a 2-5 km Hele-Shaw cell some 200-500 m high, bounded above by gradation to reduced permeability in response to accelerated silica precipitation in a steep (boiling) temperature gradient, and bounded below by gradation to reduced permeability due to decreasing structural stability of open space with increasing lithostatic load. For the pertinent model case of a 12.5 wt% NaCl solution that begins to boil isenthalpically at 230°C, with 7 wt% vaporization, the temperature falls to 195°C, salinity of the residual liquid increases to 13.4 wt% NaCl, and the liquid density increases by about 5% from .933 to .976 g/cm^3 over a vertical interval of 400 m. Taking into account the flow-impeding effect of the large volumetric fraction of vapor (nearly 90%) in the upper part of this interval, the marked gravitational instability of the inverted liquid density gradient is indicated by values of the Rayleigh number (R) in the range 10^5-10^8 for fissures of 5-40 cm open-space aperture at intermediate filling stages. For the case of 137 m interval in an all-liquid column at its boiling temperature in the 230-195°C interval (non-adiabatic wall rocks), $R \approx 10^6$-10^9 in fissures 5-40 cm wide. These two boiling models, which should bracket the behavior range of the natural system, both indicate that the liquid should be involved in vigorous partial recirculation in the form of convection cells superposed on the general fluid flux in the bottom and out the top of the zone of interest. Due to the greater permeability requirements of the more voluminous upwelling flow, upwelling limbs of the cells are expected to coincide with intervals of greater fissure aperture. Because the downwelling liquid is denser than hot, non-boiling liquid entering the zone of interest from below, the downwelling currents should penetrate below the boiling zone. Vertically-telescoped ore deposition may occur below the base of the boiling zone as downwelling, cooler, higher pH (by acid volatile loss) liquid and hotter brines ascending from greater depth undergo mixing along the base and upwelling limbs of the convection rolls. Mineral saturation fronts are expected to reflect the configuration of isotherms, which are inflected upward in zones of upwelling flow, thus possibly accounting for the sinusoidal configuration of the ore zones in Topia veins. Conductive cooling models can yield fluid isotherm configurations that reflect the distribution of permeability variations along the fissures, but cannot account for telescoped ore deposition from non-boiling solutions. (From the author's abstract)

LOUCKS, R.R. and SOMMER, M.A., II, 1984, Solution of structural problems in the Topia Ag-Au-Pb-Zn district, Durango, Mexico, using laser decrepitation and capacitance manometer gas analysis for fluid inclusion geobarometry (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 40. Author at Dept. Geosci., Purdue Univ., West Lafayette, IN.

In the Topia district, epithermal fissure vein mineralization is exposed in early Tertiary andesites over an area ~3 x 5 km. Whether regional tilting of host rocks was pre- or post-ore was determined from fluid inclusion geobarometry, as was the significance of post-ore fault block rotation.

PCO_2 and PH_2O were determined from studies of fluid inclusions trapped during boiling in samples from four veins, spanning a strike length of two km in one vein and an elevation range of 545 m among the veins. PH_2O was determined from heating and freezing tests on approximately 200 liquid-rich inclusions of 0.6-4 wt % NaCl equiv. salinity associated with vapor-rich inclusions, yielding sample mean values of PH_2O in the range of 19-62 atm. for Th = 210-280°C, varying systematically over the 545 m depth range of the samples. PCO_2 was determined by a method developed by Sommer, involving selective decrepitation of individual liquid-rich fluid inclusions in vacuo by a Nd laser (blast area ~50 μm diameter) and collection of the liberated volatiles in a liquid N_2 cold trap. Analysis of CO_2/H_2O was by fractional distillation into a capacitance manometer (detection limit ≈7 x 10^{11} moles of gas, ≈1 fluid inclusion, 15 μm diameter). Analytical precision of CO_2/H_2O determinations is better than ±15% of the mean. Among the samples, mean mCO_2 varies from 0.32 to 0.57, yielding calculated PCO_2 at Th of 35-56 atm. A plot of relative sample elevations versus Th shows that the data are nearly coincident with the boiling-point-with-depth curve with a 2% NaCl, 0.4 m CO_2 solution, establishing that tilting of host rocks is pre-mineralization, and that post-ore fault-block rotation resulted in relative post-ore displacements of veins that are on the order of tens, not hundreds, of meters. Therefore, the southwestward vein-to-vein trend of decreasing elevation of the ore horizon reflects a trend of increasing depth of ore formation and is a primary feature whose recognition may be of exploration significance in the district. (From the authors' abstract)

LOVELACE, R.W., 1984, Origins of fluid and glass inclusions in mafic and ultramafic xenoliths from the Volcano Teneguia, La Palma, Canary Islands:

AB thesis, Princeton Univ., Princeton, NJ, 76 pp.

LU, Huanzhang, 1984, On the genesis of Fankou Pb-Zn ore deposit in Guangdong province: Geochimica, 1984, no. 4, p. 357-365 (in Chinese; English abstract). Author at Inst. Geochem., Acad. Sinica.

Same abstract as given by Lu, 1983a, Fluid Inclusion Research--Proceedings of COFFI, v. 16, 1983, p. 159. (E.R.)

LU, Liangzhao, JIN, Shiqin, YE, Huiwen and ZHENG, Songyan, 1984, Geothermometric and barometric studies of metamorphism of the Miyun Group near Beijing: Geochimica, 1984, p. 50-60.

Involves various mineral and isotope geothermometers and geobarometers, showing granulite facies metamorphism at 820 ± 50°C and 10 kb (35 km). (E.R.)

LUCIDO, Giuseppe and TRIOLO, Roberto, 1984, Critical phenomena originating magmatic rocks in western Sicily: Geochem. J., v. 18, p. 125-133. First author at Istituto di Mineralogia, Petrografia e Geochimica, Univ. Palermo, 90123 Palermo, Italy.

The behavior of a model magma in the vicinity of a critical region is in agreement with results of studies of structures in the melt in basaltic rocks from Sicily. The behavior of ionic-non ionic fluid mixtures simulating a magma has been analyzed in the light of results obtained recently with simple statistical mechanical approximations. It is suggested that the Sicilian magma is to be considered as an extremely rare natural example of two immiscible liquids having almost consolute composition. (Authors' abstract)

LUHR, Jim and CARMICHAEL, I.S.E., 1984, Volatiles and trace element partitioning in the El Chichón trachyandesite (abst.): EOS, v. 65, p. 299.

LUHR, J.F., CARMICHAEL, I.S.E. and VAREKAMP, J.C., 1984, The 1982 eruptions of El Chichon Volcano, Chiapas, Mexico: Mineralogy and petrology of the anhydrite-bearing pumices: J. Volcanol. Geotherm. Res., v. 23, p. 69-108. First author at Dept. Geol., Franklin & Marshall College, Lancaster, PA 17604, USA.

The 1982 eruptions of El Chichon Volcano produced three major pumice- and ash-fall layers. Fresh pumices from the three layers are indistinguishable porphyritic trachyandesites with 55.9 wt. % SiO_2, 2.2% MgO, 2.8% K_2O, 0.4% P_2O_5, and over 1.2% SO_3. The pumices contain 58 wt. % crystals dominated by plagioclase (mode An43) and hornblende, with lesser amounts of augite, titanomagnetite, anhydrite, apatite, sphene, pyrrhotite, and biotite enclosed in a vesiculated matrix glass with 68 wt. % SiO_2. Anhydrite forms subhedral to euhedral microphenocrysts without reaction coronas, as well as inclusions within the outer zones of major phenocrystic minerals. Inclusions of apatite and glass occur within anhydrite microphenocrysts. Anhydrite was crystallizing from the melt prior to eruption. Pumices resampled some ten months after the eruptions contain only 0.2 wt. % SO_3, and have only scattered remnants of anhydrite and traces of gypsum lining vesicles.

Prior to eruption, the El Chichon trachyandesite was at a relatively low temperature in the range 750° to 850°C, with fO_2 above the Ni-NiO buffer. The melt was very water rich with some 4 to 10 wt. % H_2O; the magmatic water content was 2-4 wt. %. The magma also contained an estimated 2.6 wt. % sulfur (as SO_3). Of this amount, 1.2 wt. % resided in anhydrite crystals and <0.1 wt. % in pyrrhotite. The melt appears to have contained <0.1 wt. % sulfur, consistent with experimentally determined sulfur solubility limits. The remaining 1.2 wt. % sulfur was probably present as a discrete vapor phase with $H_2S>SO_2$. (From the authors' abstract)

LUKANIN, O.A. and KADIK, A.A., 1984, Possible role of partial melting in the formation of redox and fluid regimes of the upper mantle: Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 996-998 (in Russian). Authors at Inst. Geochem. & Anal. Chem., Moscow, USSR.

Under conditions of formation of basalt magmas (10-50 kbar, 1200-1350°C) fluids of the system C-O-H coexisting with magma have various solubilities in silicate melt. CH_4 has higher solubility than CO_2 and CO, but significantly lower than H_2O. Oxygen fugacity in the basalt magma generation is also discussed. (A.K.)

LUTH, Robert and BOETTCHER, Art, 1984, Hydrogen and the melting of silicates (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 580. Authors at Dept. Earth and Space Sci., Univ. California, Los Angeles, CA 90024.

To determine the effect of hydrogen on the melting of hydrous silicate systems, we determined solidi in the systems $CaMgSi_2O_6$(Di)-H_2O-H_2 and $NaAlSi_3O_8$(Ab)-H_2O-H_2 as functions of P, T, and hydrogen fugacity (fH_2). (From the authors' abstract)

LYNDON, J.W. and JAMIESON, H.E., 1984, The generation of ore-forming hydrothermal solutions in the Troodos ophiolite complex: some hydrodynamic and mineralogical considerations, in Current Research, Part A: Canadian Geol. Survey Paper 84-1A, p. 617-625.

LYON, G.L. and HULSTON, J.R., 1984, Carbon and hydrogen isotopic compositions of New Zealand geothermal gases: Geochimica Cosmo. Acta, v. 48, p. 1161-1171. Authors at Inst. Nuclear Sci., DSIR, Lower Hutt, New Zealand.

Carbon and hydrogen isotopic compositions are reported for methane, hydrogen and carbon dioxide from four New Zealand geothermal areas: Ngawha, Wairakei, Broadlands and Tikitere. Carbon-13 contents are between -24.4 and -29.5% (PDB) for methane, and between -3.2 and -9.1‰ for carbon dioxide. Deuterium contents are between -142 and -197‰ (SMOW) for methane and between -310 and -600‰ for hydrogen. The different areas have different isotopic compositions with some general relationships to reservoir temperature.

The isotopic exchange of hydrogen with water indicates acceptable reservoir temperatures of 180-260°C from most spring samples but often higher than measured temperatures in well samples. Indicated temperatures assuming ^{13}C equilibria between CH_4 and CO_2 are 100-200°C higher than measured maxima. This difference may be due to partial isotopic equilibration or may reflect the origin of the methane. Present evidence cannot identify whether the methane is primordial, or from decomposing sediments or from reduction of magmatic CO_2. The isotopic equilibria between CH_4, CO_2, H_2 and H_2O are reviewed and a new semi-empirical temperature scale proposed for deuterium exchange between methane and water. (Authors' abstract)

MA, Deyou, 1984, Isotope geology of the Duobaoshan copper ore field: Mineral Deposits, v. 3, no. 1, p. 47-57 (in Chinese; English abstract). Author at Geol. Bureau of Heilongjiang Province, PRC.

The Duobaoshan copper ore field shows a regular time and spatial distribution in sulfur isotope compositions of sulfide, related especially intimately to mineralization and alteration. The precipitation temperatures calculated from sulfur isotope fractionation are in the range of 220-370°C, quite in agreement with those from the fluid inclusion determination. The sulfur isotope distribution and the estimated sulfur isotope composition of the ore-forming fluids lead to the presumption that sulfur in the ore field was probably derived from the deep portion of the crust.

The δC^{13} values of the carbonatization stage calcite from the Duobaoshan copper ore deposit are quite consistent with those of marble from the Duobaoshan formation, denoting that the carbon material of the carbonatization stage might have come from the adjacent carbonate rocks. The δO^{18} values of hydrothermal solution in carbonatization stage are much lower than those of magmatic water, indicating the probable dilution of the hydrothermal solutions by underground water.

The intrusives possess identical initial Sr^{87}/Sr^{86} ratios and are hence the products of the same sources formed during different stages of tectonic and magmatic activities. (From the author's abstract)

MA, Xiujuan and CHEN, Weishi, 1984, Experimental studies of mineral inclusions from the Dajishan quartz-vein type tungsten deposit with an approach to ore genesis: Bull. of the Inst. Mineral Deposits,Chinese Acad. Geol. Sci., Ser. 3, v. 11, p. 57-69 (in Chinese; English abstract). Authors at Inst. Mineral Deposits, Chinese Acad. Geol. Sci.

The Dajishan tungsten-bearing quartz veins are of postmagmatic high-temperature hydrothermal type, formed by both contact metasomatism and fissure filling. Microscopic examination of their gaseous and fluid inclusions as well as homogenization and decrepitation measurements give ore-forming temperatures from 238°C to 328°C, showing a tendency of gradual increase in temperature with depth - a rise of about 30-50°C for every 100 m.

Freezing measurements show primary inclusions, 4.4-9.5 (NaCl wt%); secondary inclusions, <2.1 (NaCl wt%); metasomatism-related inclusions, 0.5-6.8 (NaCl wt%). These data indicate evidently that salinities of mineral inclusions also increase with depth.

When the ratio between gaseous and fluid inclusions in the veins is less than 50%, it shows positive correlation with the ore-forming temperature and the salinity(sic).

Ore-forming fluids possess lesser amounts of volatiles, and have a density of 0.8-0.9 g/cm^3, while ore-forming pressures vary considerably, ranging from 110 to 160 bar. (Authors' abstract)

McCARTHY, T.S., LEE, C.A., FESQ, H.W., KABLE, E.J.D. and ERASMUS, C.S., 1984, Sulphur saturation in the lower and critical zones of the eastern Bushveld Complex: Geochimica Cosmo. Acta., v. 48, p. 1005-1019.

McCURDY, Karr, RUSSELL, Norman, DOMINICANA, Rosario and KESLER, S.E., 1984, Primary dispersion of trace elements, fluid inclusion zoning, and alteration zoning at the Pueblo Viejo Au-Ag deposit, Dominican Republic (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 42. First author at S.A., Apartado 944, Santo Domingo, Dominican Republic.

Zoning of hydrothermal alteration minerals is the most useful indicator of Ag-Ag mineralization at the Pueblo Viejo Au-Ag hot spring deposit. Mineral sequence is characterized by an alteration funnel with high level massive jasperiod underlain successively by quartz-pyrophyllite and alunite and surrounded by regionally extensive calcite.

Fluid inclusions from 33 jasperiod samples taken from within and surrounding the Pueblo Viejo ore body have been analyzed for their H_2O, Ar, CH_4, CO, CO_2, H_2, N_2, and O_2 gas contents. Fluid inclusion gases from within the ore zone are H_2O rich and CO-CO_2 poor, while inclusions surrounding the ore body are CO-CO_2 rich. (From the authors' abstract)

MACDONALD, A.J., 1984a The Au-CO_2 association, evolving hydrothermal fluids and precipitation mechanics (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 581. Author at Ontario Geol. Survey, 77 Grenville St., Toronto, Ontario, M5S 1B3, Canada.

Archean gold deposits are commonly associated with extensive zones of carbonatization, with hydrothermally altered rocks containing up to 20 wt. % secondary CO_2. Fluid inclusion studies in the Geraldton Camp, Ontario, suggest that early hydrothermal activity was dominated by a dense CO_2-rich, dilute aqueous fluid, while later fluids were CO_2-poor and saline. Field based studies in Ontario suggest that gold mineralization occurs either during or after felsic intrusion, regional metamorphism and major deformation. Fluid inclusion populations with variable salinity and highly variable CO_2 contents have been reported from both metamorphic and magmatic-hydrothermal environments. While formation of conduits necessary for large volumes of fluid flow can be ascribed to the deformation event(s), data associating gold mineralization with either a CO_2-bearing magmatic or metamorphic fluid remain equivocal. Gold precipitation may be instigated by one of several mechanisms, including carbonatization of wall rock: loss of CO_2 from the hydrothermal fluid necessitates breakdown of carbonic acid, with attendant pH rise that may destabilize the gold species in solution.

In the Geraldton camp, gold mineralization is spatially and temporally associated with a felsic intrusion, the Croll Lake Stock and specifically with a porphyry complex developed on the margin of the stock. Quartz-tourmaline ± carbonate veins are found in the porphyry complex and can be traced westward into the auriferous zone, displaying a metal zonation from east to west of Mo $\rightarrow$ Cu $\rightarrow$ Au. Quartz-tourmaline veins in the porphyry complex contain anomalous gold (up to 900 ppb) whereas veins in the main body of the stock contain less than 15 ppb. These field observations suggest that auriferous fluids were generated during felsic intrusive activity. (Author's abstract)

MacDONALD, A.J., 1984b Boss Mountain molybdenite deposit; fluid geochemistry and hydrodynamic considerations: PhD dissertation, Univ. Toronto, Toronto, Ontario, Canada.

Indexed under Fluid Inclusions.

MACDONALD, A.J., KRECZMER, M.J. and KESLER, S.E., 1984, Silver-base metal mantos associated with silver veins, Fresnillo, Mexico (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 85. First author at Ontario Geol. Survey, 77 Grenville St., Toronto, M5S 1B3, Canada.

At a depth of 1 km in the Fresnillo silver mine a quartz monzonite stock intrudes Mesozoic sediments which are overlain by Tertiary conglomerate and rhyolite. The ore consists of steeply dipping argentiferous quartz carbonate veins and stratabound, apparently stratiform, disseminated sulphide mantos in calcareous carbonaceous siltstone and wacke wall rock. The economically significant mantos were encountered during development and mining of veins. Bedding control of manto ore lent credence to a proposed syn-sedimentary origin for the Ag-Pb-Zn mineralization.

Mapping and petrography reveal, however, that the mantos formed by selective replacement of the host sediments where they had been folded. A conjugate fracture set developed near fold hinges, providing conduits for hydrothermal fluids. Replacement proceeded by early formation of secondary silicates (garnet, epidote, pyroxene and axinite). Argentiferous sulphides and sulph-arsenides fill interstices between the gangue silicates.

A computer analysis of grade data suggests that the conjugate fracture set controlled metal distribution and that large veins adjacent to the manto were the fluid source. The bulk of fluid inclusion filling temperatures from both veins and mantos fall between 250° and 300°C. Salinities range from 4 to 12 wt.% (NaCl equiv.). $\delta^{34}S$ values in galena and sphalerite range from -3.5%. to -6%. in both veins and mantos. (Authors' abstract)

MACDONALD, A.J. and RAY, E.G., 1984, Fluids responsible for lode gold deposition in the Cordillera and the Superior Province; implications for cost-effective exploration technique: Symp., Cordilleran geology and mineral exploration; status and future trends, Geol. Assoc. Can., Cordilleran Sec., Vancouver, BC, Canada, p. 20. First author at Ontario Geol. Survey, Toronto, Ontario, Canada.

Similarities in the geological setting of lode gold deposits in both the Cordillera of British Columbia and the Archean in the Superior Province of central Canada are well documented (e.g., Hodgson et al., 1982). Additional features common, but not ubiquitous, to both areas include the presence of pre-ore sodic felsic intrusions, secondary hydrothermal carbonate alteration, and large quantities of hydrothermal silica, commonly as quartz veining.

This preliminary study tests the hypothesis that the fluid(s) responsible for transportation and deposition of the gold and associated gangue minerals possess a readily identifiable physical and chemical signature. Data from this and other studies suggest that the gold-hosting gangue minerals have crystallized from a highly specialized fluid. The primary fluid inclusions in the gangue are of low salinity and contain variable amounts of carbon dioxide, ranging from 0 to almost 100% CO_2. The fluids could be interpreted as resulting from metamorphic devolatilization of a fluid intrinsically rich in CO_2. However an alternative hypothesis is that the fluids, derived from an unspecified source, originally contained less than 10 mole percent CO_2 and subsequently underwent CO_2 effervescence (i.e., both a phase and component separation). This unmixing resulted in both an H_2O-rich liquid fraction, a CO_2-rich gas fraction as well as mixtures of the two end members.

Preliminary fluid inclusion observations on auriferous vein deposits in both the Superior Province and the Cordillera of British Columbia support this latter hypothesis, although additional research is needed. If it can be proved that CO_2 effervescence from hydrothermal fluids is an integral stage in the ore-forming process, then thin section microscope observation of the gas contents of fluid inclusions in gangue minerals would provide an easy and cheap additional tool for ranking lode gold prospects. (Authors' abstract)

MACDONALD, A.J. and SPOONER, E.T.C., 1984, Hydrodynamics of a magmatically derived hydrothermal fluid, Boss Mountain, British Columbia (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 86. First author at Mineral Deposits Sec., Ontario Geol. Survey, 77 Grenville St., Toronto, Ontario, Canada M5S 1B3.

Light stable isotopic data (C, S, O, H) from the Boss Mountain quartz-molybdenite veins and breccias indicate that a magmatic fluid was responsible for mineralization. The solidus temperature for the monzogranite intrusion from which the hydrothermal fluid was derived was between 750° and 800°C. The majority of measured filling temperatures of fluid inclusions within vein and breccia quartz are between 300° and 350°C with no temperature zonation throughout the deposit. As inclusions were trapped while the fluid underwent CO_2 effervescence, a pressure correction is not required; filling temperatures are crystallizaton temperatures.

We suggest that the vapor pressure of a fluid phase within the magma body exceeded the tensile strength of the enclosing rock and lithostatic load, causing the fluid to be expelled violently from the magma chamber and undergo rapid irreversible adiabatic expansion, i.e., isenthalpic decompression with concomitant temperature drop. A fluid at magmatic temperatures (e.g. 800°C) cools to 350°C if undergoing adiabatic expansion during rapid decompression through a vertical distance of approximately 1 km. The fluid subsequently entered breccia zones and a sheeted vein complex with higher permeability in which fluid flow rates decreased. However, flow rates remained high enough to preclude both heat loss, through wall rock conduction, and significant fluid temperature drop. (Authors' abstract)

McDOWELL, S.D., 1984, Composition and structural state of coexisting feldspar, Salton Sea geothermal field (abst.): EOS, v. 65, no. 45, p. 1126. Author at Dept. Geol. & Geol. Engrg., Michigan Tech. Univ., Houghton, MI 49931.

Active metamorphism of fine grained sandstone in the ~16,000 year old Salton Sea Geothermal System has produced a suite of chemically and structurally(?) equilibrated, coexisting authigenic alkali feldspars, and reequilibrated detrital feldspars, in the 250-360°C temperature range. At ~335°C, the average compositions, 2V's, and $(t_1o + t_1m)$ and Z ordering parameters of coexisting authigenic feldspars are [$Or_{0.52}Ab_{97.40}An_{2.80}$, $2V_x = 91.3 \pm 4.8$, $(t_1o = t_1m) = 0.89 \pm 0.05$, $Z = 0.79 \pm 0.09$] and ($Or_{94.42}Ab_{5.10}An_{0.48}$, $2V_x = 70$ $(t_1o + t_1m) = 0.90$, $Z = 0.81$]. At 360°C albite becomes more An-rich and less ordered [$Or_{1.21}Ab_{92.83}An_{5.97}$, $2V_x = 87.5 \pm 3.4$, $(t_1o = t_1m) = 0.85 \pm 0.3$, $Z =0.70 \pm 0.07$] and K-feldspar is no longer stable. This suggests that fully ordered albite is stable at less than 300°C. Detrital plagioclase (An up to 40%) is preserved metastably to temperatures up to ~190°C in strongly carbonate-cemented sandstone which forms part of a geothermally-produced permeability cap. It undergoes rapid alkali exchange at temperatures near 200°C, and by 250°C no plagioclase with An-content over 12% is observed. At T >250°C, authigenic and most detrital alkali feldspar compositions produce a solvus that is close to but slightly inside the Bachinski-Müller (1971) microcline-low albite solvus, and is consistent with the Smith-Parsons (1974) sanidine-high albite solvus. (Author's abstract)

McLIMANS, R.K., 1984, Subsurface diagenesis as evidenced by fluid inclusions (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 109. Author at Conoco Inc., Exploration Res. Div., P.O. Box 1267, Ponca City, OK 74603.

Fluid inclusion data collected from calcite cements in both carbonate and clastic rocks show that the processes of cementation and/or recrystallization occur in the deep subsurface. This, as well as the relative timing of events, are evidenced by fluid inclusion geothermometry and chemical analyses of inclusion fluids. In petroleum reservoirs the processes of cementation, recrystallization, and petroleum migration and alteration are interrelated. Calcite precipitation is dependent upon the concentration of petroleum in subsurface fluids and may be localized by the geometry of permeable channels. Oil-bearing and water-filled inclusions are common in cements from petroleum reservoirs. Fluid inclusion data collected by geothermometry and thermal decrepitation-gas chromatography are used to investigate the timing of cementation relative to oil migration and alteration processes.

Fluid inclusions are also present in dolomites collected from the deep subsurface. Geothermometric studies of these inclusions provide evidence for the deep formation of recrystallization of dolomite.

Case examples of these processes are presented for the Smackover, Ellenburger, Mishrif, and other formations. (Author's abstract)

McNUTT, R.H., FRAPE, S.K. and FRITZ, P., 1984, Strontium isotopic composition of some brines from the Precambrian Shield of Canada: Isot. Geosci., v. 2, p. 205-215.

MacPHERSON, G.J., 1984, A model for predicting the volumes of vesicles in submarine basalts: J. Geol., v. 92, p. 73-82. Author at Dept. Geophys. Sci., Univ. Chicago, 5734 S. Ellis Ave., Chicago, IL 60637.

The total volume percentage of vesicles in submarine pillow basalt rinds can be modelled by the exsolution of H_2O and CO_2 vapor, using available solubility determinations for these components in basalt. In accordance with observations on natural samples, CO_2 is predicted to be the major vapor component in vesicles at eruption depths >1-2 km. Only small initial contents of CO_2 (0.1-0.2 wt %) are consistent with the vesicle volumes observed in most deep sea pillow lavas. H_2O is important only at shallow depths. Crystallization of pillow interiors can lead to more extensive vesiculation inside of pillow lavas than in the vesicle-poor outer rinds. (Author's abstract)

MACQUEEN, R.W., 1984, Alteration of organic matter around carbonate-hosted lead-zinc deposits (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 40.

MACQUEEN, R.W. and POWELL, T.G., 1984, Genesis of Pine Point lead-zinc ores by organic matter - sulphate reactions (abst.): Geol. Assoc. Canada/ Min. Assoc. Canada Program with Abstracts, v. 9, p. 86. First author at Dept. Earth Sci., Univ. Waterloo, Waterloo, Ontario, Canada, N2L 3G1.

Bitumen is a common associate of carbonate-hosted Pb-Zn deposits. On the Pine Point Pb-Zn property, N.W.T., Canada, two main forms of bitumen occur. Unaltered bitumens (n = 28) have atomic H/C ratios of $\approx$1.4, sulphur contents of $\approx$7.8%, and sulphur isotope ratios of $\approx$+4.6‰ $\delta^{34}S$. Altered bitumens (n = 15), occurring in proximity to sulphide orebodies and white sparry dolomite, have atomic H/C ratios of $\approx$1.02, sulphur contents of $\approx$22%, and sulphur isotope ratios of $\approx$12.4‰ $\delta^{34}S$. A few samples are partly altered, having intermediate values. These data indicate that some bitumen has participated in thermochemical reduction of sulphate to provide H_2S required to precipitate the ores, at temperatures of $\approx$100°C (from fluid inclusions). Thermochemical organic matter-sulphate reactions have been demonstrated experimentally at 175°C (W.G. Orr, 1977): extrapolation of kinetic data indicates their feasibility in geological systems at temperatures of $\approx$100°C. The amount of organic matter required to generate the $\approx 8.1 \times 10^6$ tonnes of reduced sulphur present in Pine Point orebodies is 16.8×10^6 barrels of bitumen/heavy oil. This figure compares well with in-place oil reserves of 3929×10^6 barrels in Middle Devonian fields downdip from Pine Point in the Elk Point basin. Mass balance considerations show that the amount and degree of alteration is more than adequate to account for the reduced sulphur species present in metallic sulphides at Pine Point. Such reactions elsewhere may have provided an important means of generating the large volumes of sulphide necessary to precipitate sulphide orebodies in carbonate rocks. (Authors' abstract)

MAHTAB, M.A., 1984, Occurrence and control of gas outbursts in domal salt: First Conf. on the Mechanical Behavior of Salt, The Pennsylvania State Univ., November 9-11, 1981, 775-789. Author at Henry Krumb Sch. Mines, Columbia Univ., New York, USA.

Five of the six dome salt mines in Louisiana have experienced gas outbursts which are sudden eruptions of salt and gas from the face or roof of a mine heading. Potential risks from gas outbursts include an unplanned connection to a reservoir of water or hydrocarbons and, possibly, a loss of the mine. It is proposed that in Louisiana dome-salt mines a gas outburst occurs at a certain depth when a heading face approaches a pressure pocket (altered salt with entrapped, high-pressure gas). The gas outburst is initiated by disking and propogates by spalling of the cavity walls and further disking. The outburst is terminated by a combination of dilatancy hardening, increase in stress along the cavity axis, and enlargement of the cavity to boundaries of the pressure pocket. Methods for control of gas outbursts include advanced location of pressure pockets and shock blasting in advance of mining to destress and degassify the pressure pockets. (Author's abstract)

The "altered salt" in a "pressure pocket" is presumably salt containing high pressure gas inclusions. (E.R.)

MAHTAB, M.A., BOSHKOV, S. and SHIRSHAC, A., 1984, Controlled mining of salt under gas outburst conditions, in Optimal Exploitation of Solid Mineral Resources - Challenges and Constraints: 12th World Mining Congress, Nov. 19-23, 1984, New Delhi, India, p. 1-15. Authors at Henry Krumb Sch. Mines, Columbia Univ., New York, NY, USA.

Gas outbursts in salt mines are sudden eruptions of salt and gas from the face of a heading and generally occur in proximity to anomalous zones containing inclusions (sediments, entrapped fluids). Potential risks from gas outbursts include loss of production, life, and the mine. This paper presents a review of three aspects of the gas outburst phenomenon: the geomechanical conditions, detection of anomalous zones, and controlled mining for prevention. A possible explanation of the outbursts involves cracking of the outburst-prone rock under mining-induced stresses, mobilization of the pore pressure due to the entrapped fluids, and failure by a combination of disking and Coulomb-type mechanisms. Advanced detection of burst-prone zones is possible by using geophysical, microseismic, geomechanical, and gas flow measurement techniques. Methods for controlled mining through outburst-prone salt include shock blasting, stress transfer, and sequential mining. (Authors' abstract)

MAINPRICE, D.H. and CHEEL, V., 1984, Water and hydroxyl incorporation in doped synthetic quartz-implications for hydrolytic weakening (abst.): Terra Cognita, v. 4, no. 3, p. 313. First author at Lab. Tectonophys., 2, rue de la Houssinière, 44072 Nantes Cedex, France.

Synthetic quartz crystals have been hydrothermally grown under slow growth rate conditions (less 0.4 mm per day) on high quality seed plates. The crystals have been doped by seeding the growth solution with the oxide of the dopant. Seeded solutions produced crystals with between 1,000 to

13,000 ppm (H/Si), whereas unseeded solutions produced "dry" crystals (less 50 ppm). The nature of the hydrogen incorporation has been studied by Infrared (IR) (4000 to 2000 cm^{-1}) and Near Infrared (NIR) spectroscopy (4000 to 7000 cm^{-1}). Specimens doped with Fe, Ge, Co, Ca have broad absorption spectra in the IR and strong molecular water absorption (5200 cm^{-1}) in the NIR, whereas Ti and Al doped samples have a sharp peak at 3440 cm^{-1} (IR) and a strong OH absorption (4500 cm^{-1}) in the NIR region. The broad band IR absorption (sometimes called the "gel" band) present in mechanically weak synthetic crystals is identified as molecular water. It is concluded that molecular water not hydroxyl is responsible for the "water" weakening effect. It is suggested that the molecular water must be very finely dispersed. (Authors' abstract)

MAINPRICE, D.H. and PATERSON, M.S., 1984, Experimental studies of the role of water in the plasticity of quartzites: J. Geophys. Research, v. 89, no. B6, p. 4257-4269.

MAKAROV, T.I., SIDOROV, Yu.I. and NAUMOV, V.B., 1984, Formation conditions for iron minerals in ultrabasic-alkali metasomatites: Geokhimiya, no. 1, p. 70-82 (in Russian; translated in Geochem. Int'l., v. 21, no. 1, p. 148-160). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Zoning in soda alkali metasomatites has been defined and the temperatures and pressures of mineral formation have been estimated from fluid inclusions. The stability fields of iron minerals have been related to hydrogen fugacity, solution pH, and sodium and silicon activities in solution over the range 200-300°C at pressures equal to the saturation vapor pressure of water. It is found that the solubility of uraninite in a solution containing halides is very low ($mUO_2(OH)_2{}^0$ = 10-11 mol/kg H_2O). The calculations have been based on new thermodynamic data for grunerite, acmite, and riebeckite. (Authors' abstract)

MAKAROVA, T.I., SIDOROV, Yu.I. and NAUMOV, V.B., 1984, Formation conditions of ferruginous minerals in the uranium-bearing alkaline metasomatites: Geokhimiya, 1984, no. 1, p. 70-83 (in Russian; English abstract).

Character of zoning of sodium alkaline metasomatites has been revised and using the fluid inclusions the temperatures and pressures of mineral-formation have been estimated. Fields of stability of ferruginous minerals in relation to hydrogen fugacity, pH of solution and activities of sodium and silicon in the solution of the temperature range 200 to 300°C and pressure corresponding to the pressure of saturated water vapor were calculated. It was determined that in saline solution a solubility of uraninite is very insignificant ($mUO_2(OH)_2{}^0 = 10^{-11}$ mol per kg of H_2O). The calculations were made using new thermodynamical data for grunerite, acmite and riebeckite. (Authors' abstract)

MAKO, D.A. and SHANKS, W.C., III, 1984, Stratiform sulfide and barite-fluorite mineralization of the Vulcan prospect, Northwest Territories: Exhalation of basinal brines along a faulted continental margin: Canadian J. Earth Sci., v. 21, no. 1, p. 78-91. First author at Getty Mining Co., P.O. Box 7900, Salt Lake City, UT 84107, USA.

Laminated and massive sulfide (pyrite, sphalerite, galena) mineralization and massive barite-fluorite-galena lenses occur in Upper Silurian-Lower Devonian Road River Formation shales of the Vulcan property along the eastern flank of the Selwyn Basin, Northwest Territories, Canada. The 5 km thick stratigraphic section, ranging in age from Hadrynian through Mississippian, offers insight into the nature of the Mackenzie Platform-

Selwyn Basin transition. Abrupt facies changes, synsedimentary faults, debris flows, local unconformities, and the presence of high-potassium mafic flows indicate extensional tectonics during deposition of the Road River Formation. Mineralization resulted from heated, metal-rich basinal brines that vented on the sea floor up normal faults.

Sulfur-isotope studies indicate that both sulfate and sulfide were derived from the exhaling metalliferous brine. Sulfur-isotope data also suggest that reduction of sulfate in the brine occurred as a result of organic decomposition, possibly during thermal maturation of hydrocarbons at temperatures greater than 80°C. Fluid inclusion observations indicate that the brine salinity reached 26 wt. % NaCl for at least a portion of the evolution of the hydrothermal system.

Cooling of the brine during venting into bottom waters caused initial rapid precipitation of fine-grained barite, resulting in a baritic buildup above vent areas. Continued percolation of the brine through the baritic mound caused recrystallization of the barite and then the deposition of interstitial fluorite and galena. In other areas the dense ore fluid collected in topographic depressions, or brine pools, in which sulfide minerals accumulated under anoxic conditions. Location of hydrothermal vents, paleotopography, and intensity of hydrothermal activity were the main controls on the thickness, distribution, and grade of Vulcan mineralization. (Authors' abstract)

MALININ, S.D. and KHITAROV, N.I., 1983, Correlations in the fluid-melt system pertaining to the distribution of elements between phases: Dokl. Akad. Nauk SSSR, v. 270, no. 2, p. 427-428 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 161-162, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 166, 1983. (E.R.)

MALININ, S.D. and KHITAROV, N.I., 1984, Base-metal and petrogenetic elements in a magma-fluid system: Geokhimiya, 1984, no. 2, p. 183-196 (in Russian; translated in Geochem. Int'l., v. 21, no. 2, 1984, p. 93-104). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

A critical survey is presented of papers on element distributions between aluminosilicate melts and supercritical water-chloride solutions (fluids), together with research methods, trends in the behavior of elements in these systems, and the chemical interactions of metals with the phases. For nearly all metals, their entry into a solution is determined by the presence of Cl^-, with the Me taking the form of chlorides or hydroxychlorides in the fluid; Mo, on the other hand, is best extracted by fluids of alkaline composition. The separation coefficients K^S form a regular series: they decrease monotonically if the elements are arranged in order of increasing free energies of formation for the oxides (CuO, PbO, FeO, ZnO, Cs_2O, Pb_2O, MnO, Na_2O, K_2O, BaO, SrO, MgO, CaO, MoO_3, rare earth oxides). Estimates show that the elements' Clarke levels in the melt are sufficient for the mobilization of amounts of ore material comparable with ore deposits ($\sim 10^5$ t) if the source volume is from 4 to 1000 km^3, but according to the criterion for minimum ore-bearing concentration (10 ppm), the Clarke contents are sufficient only for Fe, Zn, Cu (Pb). Factors that increase the transfer of Me to the fluid are high Cl^- contents in the fluid and high acidity. (Authors' abstract)

MALISA, Elias, KINNUNEN, Kari and KOLJONEN, Tapio, 1984, Thermometric evidence for the hydrothermal origin of the vanadiferous zoisite (tanzanite) of the Merelani area, Tanzania (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 102 (in English). First author at Univ. Dar es Salaam, Dar es Salaam, Tanzania.

In the Merelani area, Tanzania, transparent vanadiferous zoisite with natural tan/blue zoning (tanzanite when a gemstone) occurs as residual crystals in indistinct pockets and veins in weathered and hydrothermally altered Upper Prcambrian graphite-kyanite gneiss of the Mozambique Belt. The deeply weathered nature of the host rocks in the tanzanite mines and in their surroundings has hindered the use of conventional petrological working methods in deciphering the genesis of the mineralization. Thermometric observations on the vanadiferous zoisite crystals reveal that 1) the few primary gas-liquid inclusions are filled with gas from 220°C to 250°C, 2) the solid phases in the inclusion cavities begin to dissolve above about 390°C and 3) the conversion of tan to blue zoisite begins under oxidizing atmospheric conditions above about 440°C. These thermometric observations and the deduced original pocket paragenesis with doubly-terminated quartz crystals and small empty voids strongly suggest that the vanadiferous zoisite is hydrothermal in origin and not a metamorphic segregation. (Authors' abstract)

MALYSHEV, A.G., 1983, Effect of geological structure on the formation of crystal-bearing quartz veins: Dokl. Akad. Nauk SSSR, v. 268, no. 5, p. 1448-1450 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 103-105, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 166, 1983. (E.R.)

MAMYRIN, B.A. and TOLSTIKHIN, I.N., 1984a Helium isotopes in nature: Geochimica Cosmo. Acta, v. 48, p. 2397-2401.

MAMYRIN, B.A. and TOLSTIKHIN, L.N., 1984b Helium isotopes in nature, in Developments in Geochemistry 3: Amsterdam, Elsevier, 273 pp. Authors at Geol. Inst., Kola Dept. USSR Acad. Sci., Apatite 184200, USSR.

Includes 2 pages (6-7) on helium in fluid inclusions and the methods of extraction. (E.R.)

MANABE, Takashi and EJIMA, Yasuhiko, 1984, Tectonic characteristics and hydrothermal system of fractured reservoir at the Hatchobaru geothermal field: J. Japan Geothermal Energy Assoc., v. 21, no. 2 (Ser. 82), p. 37-54 (in Japanese; English abstract).

The geothermal system of the Hatchobaru field is characterized by geological and electrical[sic] uplift structure, development of faults and fractures and horizontal acid altered zone. Recent data have emphasized vertical circulation rather than horizontal flow.

The pre-Tertiary basement in the Kujyu region becomes deep by step-faulting from south to north, and depressed exceeding 1,500 m. The Hatchobaru geothermal field forms a small horst.

Geothermal fluids seem to be flowing up from the basement on the lower part of fault planes and form main reservoir in the Usa group and the Hohi volcanic rocks. The acid altered zone which extends near the surface play the role of cap rock. The main reservoirs are water-dominated type (chloride type) and are found along the Komatsuike sub-fault and Hatchobaru fault. The reservoir temperature is estimated to be 240-270°C on the basis of the fluid inclusion geothermometry and measured temperature.

The reservoirs along these faults are considered to be isolated and SO_4^{2-}, Cl^--SO_4^{2-}, HCO_3-SO_4^{2-} and Cl^- type fluids distribution from shallow levels to deep levels from discharge fluid chemistry. Chemical evidence revealed that the north-eastern part of Mt. Goto is highest reservoir temperature and is considered the principle upflow zone from deep level in the Hatchobaru field.

There is a large possibility of finding high temperature reservoir in the basement. (Authors' abstract)

MANGAS, J., 1981, Microthermometric study in Golpejas tin deposit: Tesina de Licenciatura, Univ. de Salamanca, July 1981 (in Spanish). Author at Fac. de Cien., Univ. de Salamanca, Spain.

The tin mineralization of the Golpejas mine is either disseminated in several sheets of altered apogranites or in quartz veins, generally subhorizontal and more or less parallel to the foliation of microgranites.

The study of 600 fluid inclusions have been carried out in 4 mineralized veins. On the basis of the chemical composition and number of phases at room T, 6 inclusion subtypes have been grouped into 2 well-differentiated types:

- Type 1, low salinity aqueous inclusions: 1a) monophase: liquid H_2O; 1b) two-phase: liquid and vapor H_2O (the most abundant type); 1c) triphase: liquid and vapor H_2O, and crystals; and

- Type 2, CO_2 and volatile-rich aqueous inclusions: 2a) monophase: vapor CO_2; 2b) two-phase: liquid and vapor CO_2; and 2c) triphase: liquid and vapor CO_2, and liquid H_2O.

Th ranges between 400° and 70°C although the principal hydrothermal stage took place between 330° and 230°C. The salinities of mineralizing fluid have values below 9 wt% NaCl equiv. (Tm ice $\geqslant$-6°C), with a maximum between 3.5 and 4 wt% NaCl equiv., and the total densities range between 0.5 and 1 g/cc. The salinity-Th graphs indicate that the salinity is more or less constant up to 220°C, although it decreases progressively below this temperature[sic].

The carbonic-aqueous inclusions (type 2) are characteristic of the early stages in the orebody hydrothermal evolution and these have Tm CO_2 ranging between -56° and -59.5°C, Tm hid. [CO_2 hydrate?] around 10°C and Th CO_2, generally in gas, between 22° and 31°C.

- The first stage, associated with the deposition of scheelite, is represented by trapping of type 1 inclusions, of low density and salinity, at temperatures between 500° and 300°C and pressures below 1500 bars.

- The second, related to the precipitation of sulphides, is represented by type 2 inclusions of low salinity (below 7 wt% NaCl equiv.), trapped at temperatures between 300° and 150°C and pressures below 1000 bars.

- The third stage, connected with the oxidation phase, is characterized by type 3 inclusions, trapped at temperatures between 150° and 50°C and low pressures. (Modified from author's abstract, translated courtesy the author.)

MANGAS, J. and ARRIBAS, A., 1984a, Evolution and characteristics of fluid phases associated with quartz veins of Golpejas tin deposit (Salamanca, Spain): I Congreso Español de Geologia, v. 2, p. 551-564 (in Spanish). Authors at Dept. de Min., Univ. de Salamanca, Spain.

Golpejas orebody is a albitite-greisen transitional type where principal minerals (cassiterite, columbotantalite and tapiolite) appear disseminated in sheets of albitic granites (apogranites), or in quartz veins with amblygonite, stannine and small amounts of Cu, Fe, Zn and Bi sulphides.

The results of microthermometric, decrepitometric and Raman spectroscopic studies of 700 fluid inclusions trapped in quartz from 4 veins of Golpejas deposit are summarized. Three compositional types of inclusions have been distinguished: I) aqueous, II) carbonic, and III) carbonic-aqueous. The hydrothermal evolution was developed in three stages:

1) The first is characterized by the circulation of aqueous and carbonic-aqueous solutions, of low density and salinity, and by carbonic fluids, to temperatures ranging betwen 300° and 420°C and pressures <900 bars.

2) The second is represented by the trapping of low salinity aqueous fluids (Tm ice >-5°C), at T <300°C and P ~200 bars.

3) The third is characterized by low salinity aqueous solutions (Tm ice -2°C) to T below 2°C[sic] and low P.

The fluid inclusion study and mineralogical, petrological and tectonic data about these mineralizations, confirm that the Golpejas deposit is similar to Dajishan (Kiangshi, China) and these orebodies are a model of Sn and W mineralizations associated with small albitic laccoliths. (Authors' abstract, translated courtesy Dr. Mangas)

MANGAS, J. and ARRIBAS, A., 1984b, Physical-chemical characteristics of fluids associated with uranium mineralizations of Mina Fe (Salamanca, Spain): VII Cong. Intern. de Mineria y Metalurgia, v. 1, p. 435-451 (in Spanish). Authors at Dept. de Min., Univ. de Salamanca, Spain.

Microthermometry, Raman spectrometry and crushing have been used to discover the composition and trapping conditions of fluid inclusions present in carbonates that accompany the uranium minerals in Mina Fe. In general, fluid inclusions are primary, aqueous and two-phase, with degrees of filling (Vg/Vt) that range between 1 and 5%. Tm ice ranges between 0° and -25.5°C. Some have Te below -21°C and nucleation of ice and hydrates, which indicate the presence of Ca^{++}, Mg^{++}, K^+ and Na^+ in solution[sic]. Th ranges between 230° and 60°C. Raman results confirm the absence of CO_2, CH_4, N_2 and SO_2 in the vapor phase and ($SO_4^=$) in the liquid phase.

The notable variations of salinity that these inclusions have correspond to the different aqueous fluid flows that accompany successive stages of hydraulic fracturing, fluid circulation and mineral deposition in the breaches [breccias?]. The important changes, in time and space, in the physical and chemical parameters of mineralizing solutions confirm near surface environments involving mixing of meteoric and/or ground waters. Trapping conditions of fluids correspond to temperatures below 230°C and low pressures but high enough to prevent boiling.

If we accept that the uranium of these mineralizations has been extracted from the host rock (Precambrian and Cambrian schists), the following mechanisms can cause the deposition of this element: P-T changes, interaction between the mineralizing fluids and the host rock and/or waters or different nature. (Authors' abstract, translated courtesy Dr. Mangas)

MANNING, D.A.C., 1984, Volatile control of tungsten partitioning in granitic melt-vapor systems: Trans. Instn. Min. Metall. (Sect. B: Appl. Earth Sci.), v. 93, p. B185-B189.

A recent experimental study (performed at 800°C and a pressure of 1 kbar) has determined the behavior of tungsten in granitic melt-vapor systems in the presence of several volatile species (F, Cl, CO_2, P and B) as well as water alone. In the presence of chloride and phosphate solutions tungsten partitions strongly into the aqueous fluid phase, whereas with fluoride and borate solutions tungsten partitions slightly in favor of the melt. With carbonate solutions of increasing concentration tungsten partitions increasingly into the melt and with water alone tungsten partitions strongly into the melt. This behavior is believed to reflect the presence in solution of W-Cl complexes and phosphorus heteropolytungstates as well as orthopolytungstates. Fluoride and carbonate complexes of tungsten are considered to have been unimportant under the experimental conditions. It has also been noted that the behaviors of gold and tungsten are inverse, which suggests that the two may compete for complexing agents. Natural mineralizing fluids are considered to carry a mixture of W-Cl complexes, orthopolytungstates and heteropolytungstates of phosphorus, arsenic and silicon; the stability and relative proportions of these are largely controlled by changes in ion solution chemistry through wallrock reaction. Solutions rich in phosphate, as well as chloride solutions, appear to be very effective for tungsten transport. It is suggested that in some circumstances primary phosphorus anomalies as well as arsenic anomalies might be associated with hydrothermal tungsten deposits. (Author's abstract)

MANNING, D.A.C. and HENDERSON, Paul, 1984a The behavior of tungsten in granitic melt-vapor systems: Contrib. Mineral. Petrol., v. 86, p. 286-293. First author at Centre de Rech. Pétrogr. & Géochim., B.P. 20, 54501 Vandoeuvre-lès-Nancy, France.

An experimental study has been carried out to determine the effect of solution composition on the partitioning behavior of tungsten in granitic melt-vapor systems at 800°C and 1 kbar. With chloride and phosphate solutions, tungsten partitions strongly into the aqueous phase, whereas with fluoride, carbonate and borate solutions, and water alone, tungsten partitions in favor of the melt. With chloride solutions, the fluid/melt partition coefficients (K_D) for W show a marked positive correlation with chloride concentration, and suggest that at low chloride concentrations W-Cl complexes with low Cl:W ratios (such as associated equivalents of $(WO_3)_2Cl^-$) may be present. In contrast, at higher chloride concentrations complexes with high Cl:W ratios (such as $WOCl_4$, WCl_6 and associated ionic equivalents) may predominate. With phosphate solutions, K_D shows little variation with phosphate concentration, and phosphorus heteropolytungstates (such as $H_3[PW_{12}O_{40}]$) may be present. There is no evidence to suggest that fluoride, carbonate or borate complexes of tungsten are important under the experimental conditions; the data for these compositions can be interpreted assuming that isopolytungstates (such as $H_6[H_2W_{12}O_{40}]$) are present. Within high temperature hydrothermal solutions tungsten may be transported principally as isopolytungstates and heteropolytungstates in addition to chloride complexes, and this may, in part, account for the common association of apatite and arsenopyrite with scheelite and wolframite in tungsten deposits. (Authors' abstract)

MANNING, D.A.C. and HENDERSON, P., 1984b The behavior of tungsten in granitic melt-vapor systems: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 43-44. See previous item.

MANNING, D.A.C., MARTIN, J.S., PICHAVANT, M. and HENDERSON, C.M.B., 1984, The effect of F, B and Li on melt structures in the granite system: Different mechanisms?: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 36-41.

MANNING, D.A.C. and PICHAVANT, M., 1984, Experimental studies of the role of fluorine and boron in the formation of late-stage granitic rocks and associated mineralization: Proc. 27th Int'l. Geol. Congr., v. 9, p. 353-372. First author at Dept. Geol., The Univ., Newcastle upon Tyne, NE1 7RU, UK.

Fluorine and boron are believed to play a particularly important role in the petrogenesis of volatile-enriched late-stage granitic rocks and their associated ore deposits, especially tin and tungsten. Recent experimental studies have extended earlier work using natural materials to determine the effect of fluorine and boron separately on phase relationships in the hydrous 'synthetic granite' system, and can be used to model the behavior of F and B-enriched residual magmas. Liquidus and solidus temperatures are greatly reduced (at 1 kbar water pressure) to 630°C with 4 wt% F and to below 660°C with 4.5 wt% B_2O_3. The minimum composition is displaced in both cases towards the albite apex, but this effect is less marked for the boron-bearing system than for the fluorine-bearing system. Magmatic differentiation producing F or B-enriched granitic magmas may consequently lead to normative albite-enriched residual melts, particularly in the case of F-rich systems. Melt-fluid and crystal-fluid interaction processes are strongly dependent on the volatile species involved (F, B, Cl), as illustrated by alkali exchange equilibria between feldspars and aqueous solutions with fluorine or borate anions. Similarly, the partitioning of tungsten between melt and vapor shows that fluorine-rich melts are able to transport and concentrate metals, whereas chlorine-bearing fluids may effectively extract metals from magmas. (Authors' abstract)

MARAKUSHEV, A.A., 1984a Contributions to petrography of deep-formed nodules in kimberlites and basalts: Izvestiya Vysshikh Uchebnykh Zavedeny-Geologiya i Razvedka, no. 1, p. 37-53 (in Russian). Author at State Univ., Moscow, USSR.

Deep faults reach Earth's mantle, stimulating degassing of subcrustal zones and they are the paths of migration of strongly reduced fluids (H_2, CO, CH_4, H_2S, HF, HCl, etc.); such fluids on oxidation in the lithosphere cause complete melting of mantle or crustal material and the formation of magmatic chambers. The author quotes also data of Melton and Giardini (Amer. Mineral. 1974, v. 59, no. 7) on composition of fluid inclusions in diamonds. (A.K.)

MARAKUSHEV, A.A., 1984b Liquation origin of andesites and rocks connected with them: Dokl. Akad. Nauk SSSR, v. 273, no. 6, p. 1456-1459 (in Russian).

MARAKUSHEV, A.A., 1984c Peridotite nodules in kimberlites and basalts as indicators for lithosphere deep-seated structure: Proc. 27th Int'l. Geol. Congr., v. 9, p. 327-342.

MARAKUSHEV, A.A., 1984d The liquation nature of andesitic volcanic series: Izvest. Akad. Nauk SSSR, Ser. Geol., 1984, no. 8, p. 25-37 (in Russian).

Includes numerous analyses of coexistng immiscible liquids, and plots of their position on MgO vs (FeO + Fe_2O_3 + TiO_2). (E.R.)

MARAKUSHEV, A.A., GRAMENITSKIY, Ye.N. and KORATAYEV, M.Yu., 1983, A petrologic model for the formation of endogenous ores (in Russian; translated in Int. Geol. Rev., v. 26, p. 1295-1310, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 169, 1983. (E.R.)

MARTIN, J.S. and HENDERSON, C.M.B., 1984, An experimental study of the effects of small amounts of lithium on the granite system: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 30-35.

MARTINI, Marino and CELLINI LEGITTIMO, Paola, 1984, Relations between chemical species distribution and the fluctuating activity of Vulcano (Italy), in N. Oskarsson and G. Larsen, eds, Volcano Monitoring: J. Volcanol. Geotherm. Res., v. 22, p. 123-132. First author at Dept. Earth Sci., Univ. Florence, Via La Pira 4, 50121 Florence, Italy.

Five years of systematic observation of the fumaroles of Vulcano have allowed us to detect some compositional trends coincident with a fluctuation in temperature.

A gradual decrease of CO_2, $H_2S + SO_2$, HF is observed with the lowering of temperature, while HCl slightly increases. These physical-chemical characters of the system are not readily explained as simply produced by different stages in magma degassing, and the previous hypothesis of the significant influence of a brackish aquifer on the fumaroles still appears a reliable working model.

R-mode factor analysis allowed to distinguish the differentiated role of chemical species for which different genetic processes can be derived.

The ratios HF/HCl and SO_2/H_2S are taken as indicators of the changing activity of the system, and also the available data for Usu (Japan) and Mount St. Helens (USA) are considered. (Authors' abstract)

MARTYNOV, Yu.A., 1984, Peculiarities of fluid regime of formation of magmatic rocks bearing normative corundum: Dokl. Akad. Nauk SSSR, v. 278, no. 4, p. 971-974 (in Russian). Author at Far-East Geol. Inst. of the Far-East Sci. Center, Vladivostok, USSR.

Magmatic rocks bearing normative corundum formed by contamination of magma melts by the Earth's high-aluminum crustal substrate - this caused also rather reducing regime of fluids in magmatic chambers and low concentration of Cl in volatile phase, as determined by thermodynamic calculations. (A.K.)

MASALOVICH, A.M. and OVCHINNIKOV, L.N., 1983, Model of polymorphism of water at 0-370°C - calculation of density and enthalpy, in Experimental studies of endogeneous ore formation: "Nauka" Publ. House, Moscow, p. 142-155 (in Russian).

With use of model of water polymorphism the various elements of theoretical constructions were verified: the position of special T points, discrete existence of structural grouping, mechanism of ice melting and formation of water, concentration of structural groups and character of its change during T increment. With satisfactory precision the density of water at T 0-40°C was calculated, including the density maximum near 4°C, as well as the water enthalpy at 0-370°C. (A.K.)

MASSARE, D., 1983, Experimental crystal growth in glass inclusions: Possibilities and limitations of the method (abst.): Symp., European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 41 (in French). Author at ER 45 du CNRS Inst. Sci. de la Terre, 91405 Orsay, France.

Glass inclusions trapped in bytownite phenocrysts (eruption of Ardoukoba, 7-11-78, Republic of Djibouti) were used as the experimental medium to follow the evolution of fractional crystallization and residual liquids in a tholeiitic magma. The results obtained were compared with those of Walker et al., 1979, related to abyssal tholeiites. A certain number of geothermometers used by igneous petrologists were compared with our results. For conditions close to equilibrium, we obtained eutectic separation of olivine and pyroxene in silicate liquid inclusions and epitaxial plagioclase growth on the cavity walls.

Olivine is homogeneous, in low abundance (<5 volume %), and separates from 1186° ± 3 (Fo 85) until 1125° (Fo 66). The correlation between the amount of Mg in the solid and the amount in the liquid as a function of temperature is very satisfactory ($r^2 = 0.98$). Augite is more abundant (≈20 volume %) and is characterized by varying composition from the core to the edge of the crystals (Wo 43.5 → 36.2, En 43.8 → 41.7, Fs 12.7 → 22.1), and is poorly correlatable with temperature; at most it can be shown that there is an enrichment in Fs with decreasing temperature. The composition of plagioclase deposited on the inclusion walls varies linearly from An 73.3 at 1186°C to An 56.5 at 1135°C in the case of eutectic crystallization. If these results are explained by supercooling by analogy with the ferromagnesians, supercooling may reach 150°C, and the composition of plagioclase veins from An 78.8 at 1160°C to An 52.8 at 1025°C. In the case of eutectic crystallization, inclusion liquids evolve from tholeiitic basalt to ferrobasalts, in agreement with lavas studied in the Asal rift by Stieltjes et al. (1980). The advantages and limitations of this method are described. (Author's abstract; translation courtesy of R.J. Bodnar)

MASTERSON, W.D. and KYLE, J.R., 1984, Geological, geochemical, stable isotope, and fluid inclusion characteristics of epithermal gold mineralization, Velvet district, Nevada: J. Geochem. Explor., v. 20, p. 55-74. First author at ARCO Alaska, Inc., P.O. Box 100360, Anchorage, AK 99510, USA.

Gold mineralization in the Velvet district occurs in an eastward dipping sequence of late Tertiary rhyolitic ash-flow tuffs, flows, and tuffaceous sediments in northwestern Nevada. Minor gold and silver concentrations are associated with irregular zones of brecciation, argillic alteration, and quartz veining along north-northeast trending normal faults. Reaction of mineralizing fluids with wallrock produced an argillic alteration assemblage of illite, mixed-layer clays, smectite, and kaolinite. Illite alteration and highest gold concentrations appear to be associated with zones of high water/rock ratios. Kaolinite, smectite, alunite, and opal are postulated to have formed during a steam-dominated episode of alteration.

Fluid inclusion studies indicate that the quartz veins were deposited in the temperature range 230 to 280°C from fluids which had salinities equivalent to 0.2-0.8 weight percent NaCl. $\delta^{18}O$ of quartz veins varies from -2.5 to +6.7‰ and indicates that the ore fluid must have been Tertiary meteoric water. Stable isotope data appear to define a zone of concentrated fluid flow and potential subsurface mineralization in the southeastern part of the district. Fluid inclusion and isotope studies can be used in combination with more standard geochemical, geophysical, and geological information to provide site-specific targets for epithermal metal concentrations. (Authors' abstract)

MATHEZ, E.A., BLACIC, J.D., BEERY, J., MAGGIORE, C. and HOLLANDER, M., 1984, Carbon abundances in mantle minerals determined by nuclear reaction analysis: Geophys. Res. Ltrs., v. 11, no. 10, p. 947-950. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA.

Profiles of C concentration versus depth were determined in a spinel megacryst and two olivine crystals of a mantle xenolith from Kilbourne Hole, New Mexico, using the $^{12}C(d,p)^{13}C$ nuclear reaction technique. The 0-1400 A layers of all crystals are characterized by C concentrations of ~1000 wt. ppm. This C is interpreted to be a contaminant acquired during sample preparation or ion bombardment. Below the surface, measurable C concentrations were not found in the spinel and one of the olivine crystals, but a bulk C content of 425 ppm was measured for a second crystal. The latter is interpreted to be due to the presence of discrete C-rich phase(s) in submicroscopic inclusions or microcracks rather than C dissolved in the crystal lattice. The detection limit potentially obtainable by the (d,p) reaction technique for bulk C in minerals is several 10's of ppm. (Authors' abstract)

MATHEZ, E.A., BLACIC, J. and MAGGIORE, C.J., 1984, Carbon abundances in spinel and olivine determined by the $^{12}C(d,p)^{13}C$ nuclear reaction method (abst.): EOS, v. 65, p. 306.

MATHEZ, E.A., DIETRICH, V.J. and IRVING, A.J., 1984, The geochemistry of carbon in mantle peridotites: Geochimica Cosmo. Acta., v. 48, p. 1849-1859. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195, USA.

Carbon abundances have been determined in mantle xenoliths from alkalic basalts and kimberlites and interpreted in terms of the nature and distribution of the C-rich phases. Anhydrous Cr-diopside Group I spinel lherzolites from basalts typically contain 15-50 ppm C, and amphibole-bearing ones have only marginally higher concentrations (40-100 ppm). Carbon abundances in Al-augite Group II pyroxenites are not significantly different from those of the Group I rocks. Although most LREE-depleted lherzolite xenoliths contain less C than enriched samples, there is no clear relationship between abundances of C and the incompatible trace elements.

In the suite of deformed cumulate peridotite and dunite xenoliths of the 1801 Kaupulehu flow of the Hualalai volcano, Hawaii, C abundances are clearly related to texture, modal composition, and style of deformation. The most C-rich rocks are wehrlites in which the clinopyroxenes deformed more brittly and thus possess higher fluid inclusion and crack densities than the surrounding olivines.

Regardless of their lithology, all xenoliths from kimberlites (including both peridotites and eclogites) are C-rich compared to those from basalts. Most of the C in these xenoliths exists as calcite or carbonaceous matter associated with serpentine veins and was thus probably contributed by the kimberlite host. Primary carbonates are extremely rare in all xenoliths, although occasionally they have been observed as daughter products in fluid inclusions.

Although most C exists as inclusions of CO_2-rich vapor, condensed carbonaceous matter also appears to occur in all rocks as discrete platy grains and as a film on natural surfaces such a grain boundaries and cracks. (Authors' abstract)

MATHIESON, G.A. and CLARK, A.H., 1984, The Cantung E zone scheelite skarn orebody, Tungsten, Northwest Territories: a revised genetic model: Econ. Geol., v. 79, p. 883-901. First author at Misty Meadows, Station Road, Milltimber, Aberdeen, Scotland.

The unusually large (4.2 million metric tons) and high-grade (1.6% WO_3) Cantung E zone exoskarn scheelite orebody developed in a dolomite-poor, Lower Cambrian marble horizon as a result of infiltration metasomatism shortly following the epizonal intrusion of an Upper Cretaceous, peraluminous, biotite monzogranite pluton. Thermal metamorphism attained the pyroxene-hornfels facies and was accompanied by the formation of minor folds and a foliation parallel to contact in the inner aureole. Subsequently, following a temperature drop of 50° to 100°C, initial hydrothermal activity at 450° to 500°C generated, essentially simultaneously, a zoned array of anhydrous and hydrous reduced skarn facies (garnet-pyroxene, pyroxene ± pyrrhotite, amphibole ± pyrrhotite, and biotite ± pyrrhotite), probably reflecting steep gradients in the ratio activity Ca/activity sum of introduced components in the fluid. Skarn development thereafter persisted to temperatures as low as 270°C, with the continued development of the richly mineralized hydrous facies, in part through replacement of anhydrous skarns, but also through reaction with hitherto unmetasomatized marble as fluid channelways changed. Skarn formation occurred under a confining pressure of ca. 1 ± 0.3 kb (from sphalerite geobarometry) and was associated with extensive brittle and ductile deformation of the exoskarn contact zone.

Scheelite, abundant in all skarn facies except the garnet-pyroxene, is everywhere strongly correlated with pyrrhotite and shows little textural evidence of dissolution in the course of skarn development. It is implied that it was a stable phase throughout the evolution of the zoned skarns, at least in pyrrhotite-forming environments, perhaps reflecting unusually high tungsten contents in the fluid. Deposition of scheelite was probably widely caused by aggregate increases in fluid a(Ca^{+2}) and pH, resulting from the associated and interrelated reactions: $FeCl_{2aq} + H_2S_{aq} \rightarrow FeS$ (pyrrhotite) + $2H^+ + 2Cl^-$; and $CaCO_3$ (calcite) + $2H^+ \rightarrow Ca^{+2} + H_2CO_3$.

The hydrothermal fluid was a predominantly, or entirely, nonboiling moderately saline (4-14 equiv. wt % NaCl) brine which is inferred to have contained $CaCl_2$, $FeCl_2$, $MgCl_2$, and KCl, in addition to NaCl. The skarn-generating fluids apparently remained essentially constant in composition during the protracted mineralizing event, although some progressive enrichment in $CaCl_2$ is tentatively inferred from fluid inclusion first-melting temperatures, and limited variations in CO_2 and CH_4 contents (together not exceeding 2-3 mole %) are revealed by final melting temperatures. The salient characteristics of the ore fluids are compatible with a juvenile origin, perhaps related to emplacement of an alkali feldspar granitic intrusion, represented in the mine area by aplitic dikes.

The proposed genetic model for the E zone scheelite orebody retains key aspects of those earlier proposed by Zaw and Clark (1978) and Dick and Hodgson (1982) and Newberry and Einaudi (1981). (Authors' abstract)

MATSON, D.W., MUENOW, D.W. and GARCIA, M.O., 1984, Volatiles in amphiboles from xenoliths, Vulcan's Throne, Grand Canyon, Arizona, USA: Geochimica Cosmo. Acta, v. 48, p. 1629-1636. First author at Chem. Dept. & Hawaii Inst. Geophys., Univ. Hawaii, Honolulu, HI 96822.

Analyses of major element and volatile components of amphiboles from Vulcan's Throne, a Recent volcano on the north rim of the Grand Canyon, Arizona, USA, have been performed by using the electron microprobe and high temperature mass spectrometry. The amphiboles occur as megacrysts, as oikocrysts in peridotite and pyroxenite xenoliths, in amphibole-rich selvages on lherzolite xenoliths, and as grains in hornblendite xenoliths. Total volatiles range from 1.27 to 1.75 wt.%. In all samples, H_2O is the principal volatile species. Lesser amounts of structurally bound fluorine, chlorine, and oxygen were also released. The amphiboles studied are hydrdoxyl-deficient. The O(3) site is probably partially occupied by O^{2-}, which was detected as O_2 during degassing of the amphibole. Ti shows a strong positive correlation with the amount of hydroxyl deficiency in the amphiboles except for one oxidized sample. Thus, Ti probably is significant in charge balancing the substitution of O^{2-} for OH^- and the substitution probably occurred during crystallization rather than by dehydrogenation. Small amounts of both oxidized and reduced carbon and sulfur-bearing volatile species (e.g., CO_2, CO, CH_4, SO_2, H_2S) were detected in all samples. The observation of reduced carbon species supports the hypothesis that the oxygen fugacity of at least portions of the upper mantle is probably less than the quartz-fayalite-magnetite buffer. (Authors' abstract)

MATSUO, S., 1984a Occurrence and chemical form of volatiles in the mantle (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 342 (in English). See next item.

MATSUO, Sadao, 1984b Occurrence and chemical form of volatiles in the mantle: Proc. 27th Int'l. Geol. Congress, Vol. II, Geochem. & Cosmochem., p. 253-277. Author at Dept. Chem., Tokyo Inst. Tech., O-okayama, Meguro-ku, Tokyo 152, Japan.

Abundance, chemical form and isotopic composition of H, He, C and N are discussed. The present mantle is concluded to be heterogeneous with respect to volatile components. (Author's abstract)

MATTEY, D.P., CARR, R.H., WRIGHT, I.P. and PILLINGER, C.T., 1984, Carbon isotopes in submarine basalts: Earth & Planet. Sci. Letters, v. 70, p. 196-206. Authors at Dept. Earth Sci., The Open Univ., Walton Hall, Milton Keynes MK7 6AA, UK.

High-sensitivity stepped extraction reveals two isotopically distinct forms of carbon in submarine basalt glasses: an isotopically light carbon component released by combustion from 200 to 600°C and an isotopically heavy CO_2 liberated from vesicles (magmatic carbon) from 600 to 1200°C. The $\delta^{13}C$(PDB) of the low release temperature carbon varies from -24 to -30‰ and is believed to be surficial organic contamination. A survey of various types of oceanic glasses demonstrates that the $\delta^{13}C$ of magmatic CO_2 varies from -4.2 to -7.5‰ in mid-ocean ridge basalt (MORB), from -2.8 to -6.7‰ in glasses from Hawaii and Explorer Seamount and from -7.7 to -16.3‰ in glasses from the Scotia Sea and Mariana Trough. Magmatic CO_2 in back-arc basin basalts (BABB) is on average 5‰ lighter than equivalent CO_2 in MORB and can be explained by the mixing in the source regions for BABB magmas of juvenile (MORB-like) CO_2 with an organic carbon component from subducted pelagic sediments. It is inferred that significant amounts of pelagic carbonate carbon ($\delta^{13}C \approx 0‰$) must be recycled into the mantle. (Authors' abstract)

MATTEY, D.P., PILLINGER, C.T., SEAL, M., MILLEDGE, H.S. and MENDELSSOHN, M.J., 1984, Carbon isotopic variation in diamonds (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 343-344 (in English).

MATTHEWS, Alan and GOLDSMITH, J.R., 1984, The influence of metastability on reaction kinetics involving zoisite formation from anorthite at elevated pressures and temperatures: Am. Mineral., v. 69, p. 848-857.

MEDARIS, L.G., Jr., 1984, A geothermobarometric investigation of garnet peridotites in the Western Gneiss Region of Norway: Contrib. Mineral. Petrol., v. 87, p. 72-86. Author at Dept. Geol. & Geophys., Univ. Wisconsin, Madison, WI, USA.

Various mineralogical geothermometers and geobarometers are compared. (E.R.)

MEINERT, L.D., 1984, Mineralogy and petrology of iron skarns in western British Columbia, Canada: Econ. Geol., v. 79, p. 869-882. Author at

Dept. Geol., Washington State Univ., Pullman, WA 99164.

Calcic iron skarns are present in a discontinuous belt extending from northern California through western British Columbia and into the Alaskan peninsula. Most of these deposits were formed in an oceanic island-arc environment and were later accreted to continental terrane. These iron skarn deposits are of particular interest because of their large size; minor element suite of Au, Co, Cu, and Zn; igneous protoliths; and common association with "primitive" intrusions and cogenetic volcanic rocks. A comparative study of six calcic iron skarn deposits in western British Columbia documents several important differences from other major skarn types. Compared to other skarn types, plutons associated with calcic iron skarns have a similar wide range of silica contents but are generally more mafic, and they have similar total alkali contents but much higher Na_2O/K_2O ratios (avg = 2.6). The iron content of intrusions is inversely proportional to the iron content of calc-silicate minerals in associated skarn, suggesting a magmatic component of iron in skarn.

Fluid inclusion analyses suggest that early, relatively iron-poor calc-silicate minerals formed from hot, relatively dilute fluids (T_h = 450°-690°C, 3.3 wt % NaCl), whereas later, iron-rich calc-silicate minerals associated with magnetite formed from cooler, more saline fluids (T_h = 370°-460°C, 10-50 wt % NaCl, with local KCl). The correlation between fluid inclusion salinity and skarn composition is consistent with experimental evidence suggesting that the molar ratio of Fe/Al in solution should increase with the cube of the chloride concentration.

The abundance of igneous protoliths for skarn results in an unusual concentration and unexpected mobility of elements such as Ti, V, and Al in calc-silicate minerals. Electron microprobe analyses show that early skarn minerals incorporate the less mobile elements until fluid dominance allows transport both into the pluton and into nearby carbonate rocks. Large fluid travel distances prior to reaction with carbonate rock cause unusually high contents of mobile elements such as manganese in pyroxene (up to 52 mole % johannsenite) and ilvaite. This suggests that the manganese-rich zinc skarns which form distal to many other hydrothermal systems can also evolve from initially iron-rich and manganese-poor intrusions. Additionally, the presence of native gold in chalcopyrite suggests that gold may be an economically important by-product in some calcic iron skarns. (Author's abstract)

MEINSCHEIN, W.G., HEGEMAN, G.D. and BROMLEY, B.W., 1984, Intramolecular distribution of stable isotopes of carbon (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 345-346 (in English).

MELCHIOR, Daniel, ROGERS, P.S.Z. and LANGMUIR, Donald, 1984, The geochemistry of Ca, Sr, Ba and Ra sulfates in some deep brines from the Palo Duro Basin, Texas (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 593.

MERCOLLI, Ivan, SCHENKER, Franz and STALDER, H.A., 1984, Geochemistry of alteration of granite by hydrothermal solutions (Central Aar granite): Schweiz. Mineral. Petrogr. Mitt., v. 64, p. 67-82 (in German; English abstract). First author at Mineral.-Petrograph. Inst. Univ. Bern, Baltzerstr. 1, CH-3012 Bern, Switzerland.

Using whole rock analyses, the effect of hydrothermal alteration of granite adjacent to fissures was examined in the granite of the central Aar Massif (a greenschist metamorphosed Hercynian granite).

Cations can be classified into four groups (BOC, TOC, TEC, ALC) depending on their crystal-chemical properties. It was found that cations of the same group behave similarly during fluid/rock interaction, allowing an estimate of the behavior of elements which were not measured. On the other hand the four groups show considerable differences in magnitude and in direction of transport. The four groups are:

BOC: nearly totally depleted in the altered granite
TOC, TEC: fairly depleted in the altered granite
ALC: varies between slight depletion and enrichment.

The hydrothermal processes can be summarized as follows: unaltered granite + fluid → altered granite + fluid 2 → fissure minerals + fluid 3. (Authors' abstract)

MEREDITH, P.G. and ATKINSON, B.K., 1984, Influence of temperature and humidity on subcritical crack growth in quartz: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 222-225.

MERGENOV, B.M., PARILOV, Yu.S., KOZHAKHMETOV, Ye.M. and MIKHALEVA, V.A., 1984, Character of gas separation and fluid composition of inclusions in quartz of volcanic rocks: Akad. Nauk SSSR Doklady, v. 275, no. 6, p. 1488-1490 (in Russian). Authors at Inst. Geol. Sci. of Acad. Sci., Alma-Ata, Kazakh, SSR

The authors made preliminary determinations of gas phase of melt inclusions in quartz of the Devonian liparite porphyries of the Nikolaevskoe deposit (Rudnyi Altai), paragenetically connected with pyrite-polymetal ores. Melt inclusions in quartz are glassy, partly or completely crystallized, with one to several G bubbles, inclusion size 10-30 μm. Moreover, quartz phenocrysts bear S G/L two- and polyphase inclusions. Th of melt inclusions were measured by quenching method. For gas analysis quartz grains were selected under binocular, grain size 0.1-0.3 mm, sample weight for single Td determination (vacuum decrepitometer) was 0.5 g, and for determination of G composition - 5 g. Accuracy of P measurements was 0.1 mm of Hg. After each individual large peak of G released from sample, the grains were taken from decrepitometer chamber and thoroughly checked under microscope in immersion oil. G components were determined by selective sorption on solid sorbents; H_2, H_2S, N_2, CO_2, CO, NH_3, HCl and H_2O in test mixtures were sorbed in the 91.5-100% range. Three intervals of gas release were distinguished. At T 360-730°C fluid (G/L) inclusions decrepitate and G composition is in the following ranges (wt. %): H_2O 46.6-66.3, H_2S 1.2-11.1, SO_2 nil-1.8, CO_2 23.1-45.3, CO 0.02-2.3, NH_3 1.0-7.8, H_2 0.07-2.59, N_2 nil-1.1; at 780-1000°C opening of melt inclusions (Th 880-1020°C): H_2O 5.3-43.6, H_2S 9.6-19.5, SO_2 not found, CO_2 13.6-42.1, CO 0.39-28.9, NH_3 6.4-19.1, H_2 0.16-1.77, N_2 nil-8.5; at 1000-1200°C maybe gas release from crystal lattice: H_2O 1.8-38.6, H_2S 22.2-43.4, SO_2 nil-11.8, CO_2 1.3-36.9, CO 1.3-48.3, NH_3 3.6-12.6, H_2 0.05-3.3, N_2 nil-3.8. For all determinations total rare gases content ranges from nil to 12.1, CO/CO_2 ratio - from 0.01 to 10.2. Hence, post-magmatic fluids are of H_2O-CO_2 composition, but melt inclusions bear much lower H_2O content, but higher H_2S content and they have lower Eh values. (Abstract by A.K.)

MERZBACHER, Celia and EGGLER, D.H., 1984, A magmatic geohygrometer: Application to Mount St. Helens and other dacitic magmas: Geology, v. 12, p. 587-590. Authors at Geosci. Dept., Pennsylvania State Univ., University Park, PA 16802.

Compositions of andesitic to dacitic melts in equilibrium with plagioclase, orthopyroxene, and clinopyroxene have been experimentally calibrated as a geohygrometer. Application to Melson's data on melt inclusions and matrix glasses from the 1980-1982 cycle of eruptions of Mount St. Helens reveals systematic dewatering trends - ca. 4% (1980) to 1% (1982) H_2O in subliquidus (intratelluric) melt in pyroclastics and 2%-3% (1980) to 1% (1982) in subliquidus melt in dome-building dacites. Before each pyroclastic event, intratelluric crystallization achieved melt H_2O contents of ca. 6% (at a depth of at least 8 km), a necessary condition for crystallization of amphibole. Dewatering trends indicate that individual magma blobs or ribbons then ascended to successively higher levels over the 3-yr cycle, from a minimum depth of 4 km in 1980 to 0.35 km in 1982, and pyroclastically erupted.

Comparison of Mount St. Helens compositions to worldwide andesites and dacites suggests that near-liquidus arc magmas that crystallize plagioclase and pyroxenes contain 1%-2% H_2O, on average, whereas magmas in continental margins contain appreciably more H_2O. (Authors' abstract)

METRICH, N., 1983, Magmatic inclusions in plagioclases in pumice from the island of Ventotene (Italy) (abst.): Symp., European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 42 (in French). Author at ER 45 du CNRS Lab. de Petrogr. Volcanol., Bt 504 Univ. Paris Sud, 91405 Orsay France.

Several plinian eruptions, of trachytic to phonolytic nature, followed the emplacement of Pliocene flows occur on the island of Ventotene. The study of several explosive episodes was conducted by observation and analysis of the intercrystalline liquids present in the minerals, particularly in plagioclase. Evidence for the different stages of crystallization are found in the same formation with:

... idiomorphic crystals of anorthite (An_{90-92}), containing two-phase inclusions, which homogenize at 1000 ± 15°C;

... bytownite crystals (An_{79-77}), in which numerous glass inclusions homogenize at 1060 ± 15°C;

... tabular crystals, with composition varying from An_{56} to An_{48} and minimum temperatures of crystallization of 1020 to 950 ± 15°C. These contain a large quantity of glass.

The composition of the trapped liquid in the different crystals shows an evolution (enrichment of SiO_2, FeO, alkalies) parallel to that of the mineral hosts, and independent of later modifications after sealing of the cavities. Th obtained from glass inclusions in clinopyroxenes (1060 ± 15°C to 1020 ± 15°C) prove syncrystallization of the salite-plagioclase. The same type of behavior was observed in other episodes, separated from these by paleosols, which seems to demonstrate the repetitive nature of the magmatic reservoir. (Author's abstract; translation courtesy of R.J. Bodnar)

METRICH, Nicole and DHAMELINCOURT, Paul, 1984, Interaction between magmatic liquid and carbonatic host rocks: The case of the xenoliths from Ventotene Island pumices (Pontine Island): C.R. Acad. Sci. Paris, v. 298, Series II, p. 469-474 (in French; English abstract). First author at Lab. Pierre-Sue, Bat. 37 C.E.N. Saclay, 91191 Gif-sur-Yvette Cedex, France.

Some xenoliths from Ventotene pumices, are characterized by a progressive transformation between a metamorphic mineral association (diopside and phlogopite without titanium) and a magmatic one with clinopyroxene, phlogopite (with 4-5 wt% TiO_2 content) scarce forsterite, anorthite, pargasite and apatite. Clinopyroxene and plagioclase crystals show melt inclusions.

Studies of fluid inclusions, using Chaixmeca freezing stage and Raman spectrometry, pointed out the coexistence of dolomite and calcite microcrystals and pure CO_2 fluid phase in clinopyroxenes. These results suggest that the magmatic liquid was contaminated with the carbonatic host rocks.

Fluid inclusions in anorthite are characterized by chloride crystals and mixed CO_2-H_2O fluid phase, which suppose a late crystallization stage coeval with the pargasite formation. All the results suggest that these xenoliths represent a progressive reaction between melt and carbonatic rocks. CO_2 pressures calculated with clinopyroxenes fluid inclusions ranging from 0.95 to 2.5 kb are consistent with a shallow magma chamber. (Authors' abstract)

METZ, P.A., 1984, Fluid inclusion and stable isotopic evidence for the origin of the Au-As-Sb-W mineralization of the Fairbanks mining district, Alaska (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 594-595. Author at Mineral Industry Res. Lab., Sch. Mineral Engrg., Univ. Alaska, Fairbanks, AK 99701.

The Fairbanks mining district is located in central Alaska and includes an area of approximately 400 square miles. Gold was discovered in the district in 1902 and since then the area has produced 7,500,000 troy ounces of placer gold and 250,000 troy ounces of lode gold. In addition, the district has produced several thousand short tons of antimony and several thousand short ton units of tungsten.

Detailed mapping and ore petrologic investigations have resulted in the definition of the following five types of mineralization: 1) Volcanogenic stratabound mineralization-in which intergrowths of zinc, antimony, lead, and copper sulfides ± gold and scheelite occur in conformable laminae and lenses parallel to both foliation and compositional banding in the metavolcanic host rocks; 2) Lead sulphosalt-bearing quartz sulfide veins-with argentiferous galena, sphalerite chalcopyrite, stibnite, arsenopyrite and gold which occur in Cretaceous intrusives; 3) Tungsten skarn mineralization found adjacent to the Gilmore and Pedro Dome granitic stocks; 4) Gold bearing polymetallic quartz sulfide veins which cross-cut the metavolcanic host rocks; 5) Stibnite gash veins and fracture fillings-associated with axial plane shears in the metavolcanic host rocks.

Fluid inclusion compositional and thermometric data form significantly different populations for each of the above deposit types. Ore and metamorphic fluid Th range from 190 to 350°C while salinities vary from 1-6 wt. percent NaCl equivalent. Types 1 and 4 mineralization have CO_2 contents up to 18 mole percent. Quartz from granitic intrusive rocks in the district have fluid Th in excess fo 550°C and salinities in excess of 26 wt. percent NaCl.

Oxygen and hydrogen isotopic data also suggest a major metamorphic fluid component to the mineralization. (Author's abstract)

MEYERS, P.A., RULLKOTTER, Jürgen and DUNHAM, K.W., 1984, Paleozoic oils of the Michigan basin: organic geochemical evidence of migration (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 595.

MICHARD, G., 1984, Equilibre entre minéraux et solutions géothermales: Bull. Mineral., v. 107, no. 6, p. 29.

MICHARD, G., ALBAREDE, F., MICHARD, A., MINSTER, J.-F., CHARLOU, J.-L. and TAN, N., 1984, Chemistry of solutions from the 13°N East Pacific Rise hydrothermal site: Earth Planet. Sci. Lett., v. 67, p. 297-307. First author at Lab. Géochimie des Eaux, Univ. Paris 7, Paris, France.

Ten samples were recovered by the submersible "Cyana" submersible from two groups of hydrothermal vents located 2600 m deep along the East Pacific Rise at 13°N. The maximum measured temperature was 317°C and minimum pH 3.8. A systematic determination of major and trace elements has been carried out and mixing lines between a high-temperature component (HTC) and seawater are observed. The water chemistry of the HTC slightly differs for several elements at the two sites. This HTC is deprived of SO_4 and Mg and is greatly enriched in most other species. Maximum concentrations are (in units per kg): Cl = 0.72 mol; Br = 1.1 mmol; Na = 0.55 mol; K = 29 mmol; Rb = 14 µmol; Ca = 52 mmol; Sr = 170 µmol; Mn = 750 µmol; Fe = 1 mmol; Al = 15 µmol; Si = 21 mmol. For many elements, the magnitude of the anomaly relative to seawater does not compare with the results obtained from the Galapagos or East Pacific Rise 21°N. The enrichment of cations relative to seawater is likely related to the huge Cl excess through charge balance. The Br/Cl ratio is close to that for seawater. However, it is not clear whether the Cl excess is due to gas release or basalt hydration (formation of amphibole chlorite or epidote). P-T dependence of SiO_2 solubility suggests that water-rock interaction last occurred at a depth in excess of 1 km below the sea floor. A mixing line of $^{87}Sr/^{86}Sr$ vs. Mg/Sr demonstrates that the HTCs have a nearly identical $^{87}Sr/^{86}Sr$ ratio of 0.7041 for both sites. A water/rock ratio of about 5 is inferred, which differs from the 1.5 value obtained at 21°N. (Authors' abstract)

MICHOT, G., WEIL, B. and GEORGE, A., 1984, In situ observation by synchrotron X-ray topography of the evolution with temperature of fluid inclusions in synthetic quartz: J. Crys. Growth, v. 69, p. 627-630. First author at Lab. Phys. du Solide, associé au CNRS 155, Parc de Saurupt, F-54042 Nancy Cedex, France.

The evolution of fluid inclusions in synthetic quartz up to decrepitation was followed in situ by X-ray topography. Fluid inclusions could be distinguished from dislocations above the homogenization temperature because of a contrast enhancement on X-ray topographs. (Authors' abstract)

MILLER, M.F. and SHEPHERD, T.J., 1984, The determination of lead in fluid inclusions using voltammetric trace analysis: an exploratory investigation: Chem. Geol., v. 42, p. 249-259. Authors at Geochem. & Petrol. Div., Inst. Geol. Sci., London WC1X 8NG, Great Britain.

A method has been investigated for the quantitative determination of Pb in hydrothermal fluid inclusions present in mineralized vein quartz. To obtain the required sensitivity, thin-film anodic stripping voltammetry was used, following conventional rock dissolution procedures. Thus determined, the whole-rock Pb concentration data were then related to the quantity of inclusion fluid in the host-rock matrix, assessed independently, to yield values for the level of Pb carried in solution by the hydrothermal fluids. This technique has been successfully employed to compare the Pb content of inclusions associated with auriferous quartz deposits from the Dolgellau "gold belt" area in North Wales, with tungstaniferous quartz sampled from the Hemerdon Sn-W deposit in southwest England. In the case of the Hemerdon material, the high levels of Pb found in the inclusions lends support to other evidence that heavy-metal concentrations in mineralizing fluids may, in some instances, be several orders of magnitude greater than has been generally accepted hitherto. (Authors' abstract)

MILLERO, F.J., MILNE, P.J. and THURMOND, V.L., 1984, The solubility of calcite, strontianite and witherite in NaCl solutions at 25°C: Geochimica Cosmo. Acta., v. 48, p. 1141-1143.

MIRONOVA, G.D., ZOTOV, A.V. and GUL'KO, N.I., 1983, Determination of the solubility of orpiment in acid solutions at 25-150°C: Geokhimiya, no. 12, p. 1762-1768 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 6, p. 53-59, 1984).

MIRWALD, P.W., 1984, The sodium content of synthetic Mg-cordierite at 600 and 800°C up to 6 kbar and its effects on the incorporation of H_2O and CO_2 (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 111 (in English).

MISRA, Kula, 1984, Zinc-lead deposits in carbonate rocks: The evaporite connection (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 2, p. 139.

MITROFANOV, F.P., KOZAKOV, I.K., KOTOV, A.B., SAMORUKOVA, L.M. and VINOGRADOV, D.P., 1984, Geology and magma-generation conditions of early Precambrian plagiogranites (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 397. Authors at Inst. Precambrian Geol. & Geochron. of USSR Acad. Sci., Leningrad, USSR.

Early Precambrian orthomagmatic plagiogranitic associations are of definite geological position into every particular tectono-metamorphic cycle. Their intrusion occurred between the stages of deformation creating the subhorizontal and vertical structures and were correlated with the generation of the highest temperature metamorphic parageneses. Two types of plagiogranitic associations have been found. Plagiogranites-I take part in the construction of the differentiated plutons with early phases represented by gabbroids. Plagiogranites-II are associated with granodiorites and microcline-plagioclase granites. The maximum Th of the melt inclusions was found for plagiogranites-I to be 1100-1200°C and that of 780-820°C for plagiogranites-II. Both types of homogenization are mainly due to "retrograde boiling," suggesting a water-saturated parent melt. The corresponding fluids show predominance of H_2O and H_2 and subordinate role of CO and CO_2. Plagiogranites-I are characterized by higher H_2O and $CO+CO_2$ contents, high oxygen fugacity and respectively by a higher oxidation degree of the fluid. The above evidence alongside the oxygen isotopic study suggests that the Early Precambrian intrusive plagiogranites have been formed by two ways, i.e., as derivatives of differentiation of deep-seated mafic magmas (plagiogranites-I) and those of crustal diatexis. (Authors' abstract)

MIYOSHI, Tadashi, SAKAI, Hitoshi and CHIBA, Hitoshi, 1984, Experimental study of sulfur isotope fractionation factors between sulfate and sulfide in high temperature melts: Geochem. J., v. 18, p. 75-85.

MOATS, M.A., WEISS, D.S. and ULMER, G.C., 1984, Redox conditions in the mantle: an unfinished story? (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 349 (in English).

MOHAN, Anand, 1984, Geothermobarometry: thermodynamic basis and sources of errors: Geosci. J., v. 5, no. 2, p. 23-26. Author at Dept. Geol. Banaras Hindu Univ., Maranasi, 221 005 India.

A discussion is given of (1) criteria for selecting mineral equils. suitable for geothermometers and geobarometers, (2) the interrelation between pressure, temperature, and composition variables, and their application to the thermodynamic regime of metamorphism, and (3) different possible sources of errors. Geothermobarometers based on theory of cation distribution between coexisting minerals, considered from the standpoint of equil. thermodynamics have uncertainties of 50-100° and 1-3 kbar. (C.A. 102: 48989f)

MOON, A.R. and PHILLIPS, M.R., 1984, The physics of asterism in sapphire: Schweiz. Mineral. Petrogr. Mitt., v. 64, p. 329-334. Authors at Dept.

Physics, The New South Wales Inst. Tech., P.O. Box 123, Sydney 2007, Australia.

The star image observed in silky sapphire (the optical phenomenon of asterism) is shown to result from the incoherent superposition of reflected Fraunhofer diffraction patterns which arise when light is scattered from precipitates strictly oriented within the sapphire host. The theory explains why long, thin precipitates produce sharper stars than their shorter and wider counterparts and why a cabochon is normally required to observe the star image. (Authors' abstract)

MOON, K.J., 1984, Mineral geochemistry and fluid inclusion study on the Buam skarn deposit: Chijil Hakhoe Chi (J. Geol. Soc. of Korea), v. 20, no. 4, p. 266-281 (in English) (also in CA: 102(10)81929j).

Indexed under Fluid Inclusions.

MOON, K.J. and SOLOMON, M., 1984, The nature of the ore fluids at the Sangdong scheelite mine, S. Korea (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 349-350 (in English). Authors at Univ. Tasmania, Australia.

Scheelite occurs in stratabound skarns that replace Cambrian limestones, and also in associated quartz veins. The Main Orebody shows a zonal distribution of the major minerals from meter to centimeter scales: a central quartz-mica zone surrounded by an amphibole-rich zone, which is enveloped by a pyroxene-garnet zone. The scheelite contents of the central zones reach over 2% WO_3.

$\delta^{18}O$ values in skarn quartz (+10.8%[sic]), $\delta^{34}S$ in skarn sulphides (+3.9 to +6.1) and $\delta^{13}C$ and $\delta^{18}O$ in skarn carbonate (-8.1 to +11.8 respectively) indicate derivation from magmatic fluids, and the high temperatures indicated by the mineralogy and fluid inclusions (up to 600°C) suggest a magmatic heat soure. Though drilling has not encountered granite to a depth of 500 m below the mine, a granitoid pluton is inferred within a kilometer of the deposit.

Skarn assemblages appear to approach equilibrium with the hydrothermal fluid, justifying the use of phase equilibria and allowing calculation of some fluid parameters, e.g.: T°C: mostly 300 to ~600°C(?); P(atm): probably <400 bars ($NaCl-H_2O$ data) to 800 bars (sphalerite composition); Fluid composition: $H_2O-NaCl-KCl \pm MgCl_2 \pm CaCl_2$; pH: ~4.0 at 350°C in central skarn zone (mineralogy and the need to carry 1 ppm W in solution); ΣS: $\sim 2.5 \times 10^{-3}$ m (mineralogy); fO_2: 10^{-30} to 10^{-32} atm at 350°C in central zone (mineralogy); fS_2: $\sim 10^{-9}$ to 10^{-11} atm at 350°C in central zone (mineralogy); $\delta^{34}S-H_2S$: 4.5 - 5.3‰; $\delta^{18}O-H_2O$: 6.6 - 8.5‰; $\delta^{13}C-C$: ~8‰.

Scheelite precipitation was probably caused mainly by increase in the activity of calcium in the fluids. (Authors' abstract)

MØRK, M.E., 1984, Magma mixing in the post-glacial Veidivötn fissure eruption, southeast Iceland: A microprobe study of mineral and glass variations: Lithos, v.17, p. 55-75. Author at Nordic Volcanological Inst. Reykjavik, Iceland.

Local tephra-stratigraphy and chemical analyses of lavas and tephras and their minerals provide detailed information on the eruptive history of the mixed post-glacial Veidivötn eruption. Basalts and rhyolites originated and were chemically modified in separate volcanic systems, but were mobilized and mixed, and erupted simultaneously in the Veidivötn fissure both as tephras and lavas.

Different extent of chemical mixing of basalt and rhyolite magmas associated with some fractionation and resorption can explain: (1) significant K_2O-variations within the basaltic tephras (Stutshraun tephra); (2)

formation of homogeneous intermediate tephras of different compositions (Namshraun tephra); (3) incomplete mixing with heterogeneous contamination of alkali-rhyolite.

The mixing is proposed on the basis of the mixed appearance of different tephra-compositions in the field, the frequent distribution of basaltic xenocrysts in the rhyolitic and intermediate melts (while intermediate mineral compositions are scarce) and resorption and reversed zoning of phenocrysts in the rhyolitic lavas. Least-squares mixing tests support the models for (1) and (2), but the present data are not sufficient to explain all the chemical variations in the alkali-rhyolites. (Author's abstract)

MORRISON, S.J. and PARRY, W.T., 1984, Paleothermometry and fluid chemistry of diagenetic calcite deposition in the Chinle Formation - San Rafael Swell and Lisbon Valley areas, Utah (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 601. Authors at Geol. & Geophy. Dept., Univ. Utah, Salt Lake City, UT 84112.

Fluid inclusions in diagenetic carbonates afford an opportunity to study the thermal and chemical evolution of basinal fluids that have flowed through sandstone aquifers in the Moss Back (Trassic Chinle Formation). These fluids may be related to ore grade uranium and copper mineralization. Fluid inclusions in calcite formed during Moss Back diagenesis have been routinely located and their homogenization temperatures determined.

Calcite cements from Moss Back sandstones in the southeastern San Rafael Swell area were deposited at a temperature of ~52°C whereas replacement dolomite in the upper Chinle associated with the nearby Temple Mountain collapse structure formed at ~70°C. The fluid inclusion data coupled with thin section relationships and an assumed geothermal gradient similar to the present day gradient indicates that the cementing episode took place at a burial depth of ~2.3 km. Subsequently, fluids moving up along the collapse structure dissolved much of the calcite and deposited dolomite in the upper Chinle. These fluids were likely derived from the underlying Coconino Sandstone, which suggests a burial depth for the Moss Back of ~3.8 km during the dolomitizing event. Previous investigations suggest that the dolomitizing fluids are contemporaneous with U-V-Cu deposits at Temple Mountain.

Fluid inclusions in calcite vugs and veinlets in the Moss Back at Lisbon Valley were formed at ~102°C which corresponds to an estimated burial depth of ~4.3 km. Total salinities of ~20% were determined for these inclusions by freezing measurements. A $NaCl-CaCl_2-H_2O$ system is indicated having a $NaCl:CaCl_2$ ratio of 2:1 which is reasonably consistent with present day formation fluids in hydrologic continuity with the Paradox Salt beds. These fluids may be contemporaneous with copper mineralization along the Lisbon Valley fault system. (Authors' abstract)

MORTON, R.L. and NEBEL, M.L., 1984, Hydrothermal alteration of felsic volcanic rocks at the Helen siderite deposit, Wawa, Ontario: Econ. Geol., v. 79, p. 1319-1333.

MOSELEY, David, 1984, Symplectic exsolution in olivine: Am. Mineral., v. 69, p. 139-153.

MOSKOVSKY, G.A., SIROTIN, K.M. and KOVALSKY, F.I., 1984, Physico-chemical conditions of saline sedimentation in the western part of the Pricaspian syneclise, from examination of inclusions in saline minerals (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v.

2, p. 140-141. First author at Sci. Res. Inst. Geol., Saratov State Univ., Saratov, USSR.

Examination of inclusions in saline minerals provides much information on the conditions of salt sedimentation, diagenesis and catagenesis. The present composition analysis of the inclusions in sedimentary halite from Kungur saline deposit sections in the western part of the Pricaspian syneclise shows that in most cases this halite was deposited from partially metamorphosed sulphate brine which contained respectively 5.22 and 12 g/ℓ of potassium, magnesium and sulphate ions in the initial stage of deposition. During this period the composition of the brine was greatly influenced by the interstitial solutions of carbonate and argillaceous rocks that controlled the decrease of sulphate ion concentration.

The temperature of salt accumulation (from inclusion homogenization) during this stage did not exceed 30-35°C at basin depths (from gas saturation of the inclusions) over 70-90 m. During potassium salt deposition the temperature of the brine reached 50-70°C; the depths of the salt-producing basin did not exceed 20 m. Saline sedimentation in the areas close to the coast belt of the salt-producing basin was characterized by the importance of salt redissolution and by increasing influence of the interstitial solutions of sulphate-carbonate and argillaceous rocks upon brine composition. In some cases this led to brine conversion into a chlorine-calcium type, which is particularly characteristic of the upper parts of the saline section through the western and north-western syneclise margins. The freshening stage was characterized by the lower temperature of the relative condensation stage and by the increased importance of the solutions leaching potassium-magnesium salts in brine composition[sic]. (Authors' abstract)

MUGRIDGE, S.-J. and YOUNG, H.R., 1984, Rapid preparation of polished thin sections for cathodoluminescence study of carbonate rocks: Can. Mineral., v. 22, p. 513-515. First author at Chevron Canada Resources Ltd., 500 Fifth Ave. SW, Calgary, Alberta T2P 0L7, Canada.

Polished thin sections of carbonate rocks for use in cathodoluminescence studies should have a minimum of surface irregularities and should render a clear image of high optical resolution. Rock chips are prepared by grinding with 600-grit silicon carbide and then polishng with 5 μm alumina. After cementing the chips to glass slides with high-temperature epoxy, they are trimmed, ground to approximately 30 μm with 800-grit silicon carbide and polished with 6 μm diamond paste. Final polishing is accomplished in two stages using 0.3 and 0.05 μm alumina. The sequence of abrasives, though important, is not as critical to the rapid, economical production of the polished thin sections as are the techniques of fabrication. The method described here is particularly suited to use by small laboratories not equipped with automatic polishing equipment. (Authors' abstract)

MULLIS, J., 1983, Solid- liquid- and gaseous inclusions in quartz crystals from the Swiss Alps as witnesses of the genesis of alpine mineral fissures: Mittl. d. Österr. Mineral. Ges. Nr. 129, 1983, p. 46-53 (in German).

Essentially the same as Mullis, 1983c, Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 180-181. (E.R.)

MULLIS, Josef, 1984, Evolution of fluid composition in alpine fissures during prograde and retrograde metamorphism of the Swiss Alps (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 116-117 (in English). Author at Univ. Freiburg, Inst. Mineral. & Petro., Freiburg, Switzerland.

Fluid inclusion studies in quartz crystals from >200 alpine fissures of the Swiss Alps have been carried out by different methods: Microthermometry, Raman spectroscopy and mass spectrometry (stable isotopes). The aim was to study the evolution of the fluid composition during 1) the prograde and 2) the retrograde metamorphism.

Evolution of the earliest fluids from the non-metamorphic zone to the mesozone: The earliest fluids change their composition in correlation with the prograde alpine regional metamorphism:

Non-metamorphic zone: ~1 to >80 mole-% higher hydrocarbons, (H_2O, NaCl, CO_2, CH_4, ...); Low-grade anchizone: ~1 to >90 mole-% CH_4, <1 mole-% higher hydrocarbons, (H_2O, NaCl, H_2S, CO_2, ...); High grade anchizone and epizone: ~70 to >99 mole-% H_2O, <1 mole-% CH_4, (NaCl, H_2S, CO_2, N_2, ...); and Mesozone: ~10 to >60 mole-% CO_2, (H_2O, NaCl, H_2S, CH_4, N_2, ...).

The higher hydrocarbons in fluid inclusions from the non-metamorphic zone were derived from organic material through biochemical and geochemical processes during sedimentary burial. The predominance of CH_4 in the low-grade anchizone is mainly due to the cracking of the higher hydrocarbons with an increase in temperature and pressure. The observed transition from the methane-rich fluids to the water-rich fluids however cannot be explained.

Evolution of the fluids during the retrograde path of metamorphism: Characteristic changes of fluid compositions can be observed in the epi- and mesozone. The earliest fluids are poor in CH_4 and N_2. The contents of both often increased during retrograde metamorphism, whereas the amounts of CO_2 and NaCl decrease.

The origin of N_2 is uncertain. It is perhaps a product of NH_4-rich biotite and feldspar decomposition. The amount of CH_4 increases probably during decreasing temperature and pressure in the presence of graphite and the quartz-fayalite-magnetite (QFM) buffer. The decrease of CO_2 and NaCl is probably due to water supply whereas the precipitation of CO_3^{2-} in the presence of suitable cations plays a lesser role. (Author's abstract)

MULLIS, J., DUBESSY, J., KOSZTOLANYI, C. and POTY, B., 1983, Fluid evolution in alpine fissures during prograde and retrograde metamorphism along the Geotraverse: Lucerne-Bellinzona (Swiss Alps) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 46. First author at Inst. de Mineral. et Petrographie, Pérolles - 1700 Fribourg, Suisse.

Along the geotraverse Lucerne-Bellinzona, fluid inclusions in quartz crystals from 45 alpine fissures have been studied. The investigation was made by microthermometry and partly by microsonde Raman Mole. The aim was to find out the fluid evolution during 1) the prograde and 2) the retrograde metamorphism.

1) Evolution of the earliest fluids from the non-metamorphic zone to the mesozone: The earliest fluids reflect an evolution during the prograde alpine regional metamorphism. It can be assumed that the early fluid inclusions from the epi- and mesozone disclose a fluid influenced by small retrograde changes, whereas the early fluids from the non-metamorphic zone and the anchizone show a composition which was presumably almost identical to the composition during the temperature peak. a) Non-metamorphic zone: 1 to >80 mole % higer hydrocarbons, (H_2O, NaCl, CO_2, CH_4, ..); b) Low grade anchizone: ~1 to >90 mole % CH_4, <1 mole % higher hydrocarbons, (H_2O, NaCl, H_2S, CO_2, ..); c) High grade anchizone and epizone: ~70 to >90 mole % H_2O, <1 mole % CH_4, (NaCl, H_2S, CO_2, N_2, ..); and d) Mesozone: ~10 to >60 mole % CO_2, (H_2O, NaCl, H_2S, CH_4, N_2, ..).

The higher hydrocarbons in fluid inclusions from the non-metamorphic zone were derived from organic material through biochemical and geochemical processes during the sedimentary burial. The predominance of CH_4 in the low-grade anchizone is due to the cracking of the higher hydrocarbons with an increase in temperature and pressure. The transition from methane to water however is not clear.

2) Evolution of the fluids during the retrograde path of metamorphism: A strong evolution of fluids is observed in the epi- and mesozone. As the earliest fluids are poor in CH_4 and N_2, they become enriched in both of these during retrograde metamorphism, whereas the amount of CO_2 decreases. The origin of N_2 is uncertain. N_2 is perhaps yielded through the decomposition of biotite and feldspars rich in NH_4^+. The increasing amount of CH_4 during decreasing temperature and pressure is probably controlled by the presence of graphite under conditions near the quartz-fayalite-magnetite (QFM) buffer. (Authors' abstract)

MUNIZ, P.F. and BROWN, P.E., 1984, Au-Ag mineralization in the Buffalo Hump district, central Idaho (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 604. Authors at Univ. Wisconsin, Dept. Geol., 1215 W. Dayton St., Madison, WI 53706.

Au-Ag mineralization occurs as vein deposits in mining districts around Buffalo Hump in Idaho County, Idaho. Studies of the physical-chemical processes and conditions which attended mineralization are being undertaken. The deposits are Cretaceous in age, and are related to the emplacement of the Idaho Batholith which includes both S- and I-type phases in the area. There is no evidence of major hydrothermal convection cells analogous to those associated with ores in the eastern Idaho Batholith. Country rocks include Middle Proterozoic Concord calc-silicate gneisses and schists. The deposits exhibit dominantly open space filling with minor replacement textures.

Fluid inclusions in gangue quartz indicate that the ore fluid was composed of dominantly $CO_2 + H_2O$. Gas chromatography and CO_2 triple point depression indicate 1-3 mole % CH_4 in the fluid phase. Freezing point depression measurements indicate 1-4 wt. % equivalent NaCl. Two populations of inclusions with different gas/liquid ratios (.01-.02 and .04-.08) appear to coexist.

Alteration is limited to within two to three meters of the veins. Silicification is dominant closest to the veins, grading outward to a zone of muscovite sericitization pervasively affecting all rock components. This passes outward into a zone of typical propylitic alteration with evidence of amphibole breakdown. Biotite + chlorite analyses did not detect clay minerals in the alteration zones. Gouge is locally developed around the veins and there is good evidence for multiple episodes of quartz formation. Deposition of ore and gangue is likely to have taken place in a narrow P-T range, and mineralogy is characteristic of epi- to mesothermal ore deposits. (Authors' abstract)

MURAMATSU, Yoichi, 1984, Fluid inclusion study in the Takinoue geothermal field, Iwate Prefecture, Japan: an application to the estimate of the present underground temperature: Proc. 6th NZ Geothermal Workshop 1984, Univ. Auckland, p. 21-25. Author at Geother. Dev. Div., Japan Metals & Chem. Co., Ltd., 24 Ukai, Takizawa-mura, Iwate-gun, Iwate-ken, 020-01, Japan.

Study has been made to measure Th and salinities of fluid inclusions in the cuttings of wells in the Takinoue geothermal field, Iwate Prefecture, Japan, by means of the heating and freezing stage microscope. Fluid inclusions are composed mainly of two-phase high density liquid inclusions. In almost [all?] wells, the minimum Th has a tendency to increase abruptly from near the surface to about 400 m deep, and to be about constant from 212 to 236°C at the deeper parts. The minimum Th are in good agreement with the measured borehole temperatures. The salinities of fluid in primary and secondary inclusions range from 0.1 to 1.5 wt.% and 0.05 to 0.7 wt.% NaCl equivalent, respectively.

The major results obtained are as follows: (1) The cap rock exists at the northwestern part of the field, (2) At least about 900 m of overburden was possibly eroded after mineralization had taken place, (3) The last trapping fluid is probably the present deep geothermal fluid. (Author's abstract)

MURAMOTO, F.S. and ELDERS, W.A., 1984, Identification of zones of progressive hydrothermal metamorphism from wireline logs and their correlation to reservoir temperatures in the Salton Sea and Westmorland geothermal systems, Imperial Valley, California, in C.A. Rigsby, ed., The Imperial Basin-tectonics, sedimentation, and thermal aspects: Pacific Sec. S.E.P.M., p. 87-95.

NABELEK, P.I., LABOTKA, T.C., O'NEIL, J.R. and PAPIKE, J.J., 1984, Contrasting fluid/rock interaction between the Notch Peak granitic intrusion and argillites and limestones in western Utah: Evidence from stable isotopes and phase assemblages: Contrib. Mineral. Petrol., v. 86, p. 25-34.

NAESER, C.W. and CUNNINGHAM, C.G., 1984, Age and paleothermal anomaly of the Eagle mine ore body, Gilman district, Colorado: a fission-track study (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 607. First author at U.S. Geol. Survey, Denver, CO.

As suggested by preliminary stable-isotope and fluid-inclusion data, the ore body was formed at a temperature in excess of 300°C; this is well above the fission-track annealing temperature for both apatite and zircon. The results indicate that the age of the ore body is about 34 Ma and that a major paleothermal anomaly extends more than 1.5 km from the deposit. (From the authors' abstract)

NAGAR, A.K., RAWAT, R.S. and PATIL, R.R., 1984, Geological and fluid inclusion petrographic observations on barite mineralization in the Tons Valley, Lesser Himalaya: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 30. Authors at Wadia Inst. Himalayan Geol., Dehra Dun-248001, India.

In the present paper barite mineralization from the basal part of Nagthat Formation exposed in Himachal and Garhwal Himalaya, along the Tons Valley, is being reported. The mineralization occurs around Kumla and Kathwar villages in Himachal Pradesh, and around Atlau Ridge in Dehra Dun District of U.P. The field study has revealed that the mineralization is exploitable and is lithologically as well as structurally controlled. The structural and field evidence further indicates two types of barite mineralizations. The first type is white, synsedimentary, embedded within the Nagthat, occurs as massive beds lenses and pockets, while the second younger one, occurs as white remobilized veinlets, fracture fillings and stringers cross cutting the host. The petrographic study indicates presence of smaller (8-35 μ) inclusions most of which are restricted to cracks or grain boundaries. The two distinct phases of mineralization also showed variation in their inclusion contents. The massive barite was dominated by larger inclusions, (>15 μ) which homogenized in gaseous state and most of the inclusions showed Brownian movement, while the younger barite was characterized by liquid inclusions (<15 μ) with small anisotropic daughter crystals in them, which homogenized in liquid state, indicating their hydrothermal affinity. (Authors' abstract)

NAIK, M.S., 1984, Fluid inclusion studies and genesis of the copper deposit at Kalyadi, Karnataka: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 7. Author at Dept. Applied Geol., Indian Sch. Mines, Dhanbad.

The high ore bearing potential of the granite pluton and the hydrothermal alterations observed within the copper mineralization at Kalyadi suggest a hydrothermal origin for the deposit. Fluid inclusion studies in quartz from the granite and gangue quartz from the copper ore have supported the genetic link of ore forming fluids and hydrothermal solutions derived from the granite magmatism. From the nature of the fluid inclusion dms, it has been found that the most saline of these fluids contained both the alkali chlorides required for the transport of metal ions from the magmatic column. These metal bearing brines migrated along brittle fractures in the host rock and resulted in the minable ore deposit. (Author's abstract)

NANEY, M.T., 1984, A grinding/polishing tool to aid thin section preparation of small samples: Am. Mineral., v. 69, p. 404-405. Author at Chem. Div., Oak Ridge Nat'l. Lab., Oak Ridge, TN 37830.

A simple two piece grinding/polishing tool permits controlled thinning of samples mounted on round petrographic glass slides. The tool consists of a body with a finely-threaded axial hole and an adjusting screw to control sample thickness. (Author's abstract)

NARR, W. and BURRUSS, R.C., 1984, Origin of reservoir fractures in Little Knife Field, North Dakota: Am. Assoc. Petrol. Geol. Bull., v. 68, no. 9, p. 1087-1100. First author at Gulf Explor. Tech. Center, P.O. Box 36506, Houston, TX 77236.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 170-171, 1982. (E.R.)

NARSEYEV, V.A. and NARSEKLYEV, A.V., 1984, Fluid regime of rich ores deposition in gold and tungsten veined deposits (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 353 (in English). Authors at Central Research Inst. of Geological Exploration of Base & Precious Metals, Moscow, USSR.

Geochemistry of the formation of gold and tungsten vein deposits related to thermostatic structures, i.e., distribution of gold, tungsten, gases (nitrogen, hydrogen, methane, CO, CO_2, argon isotopes, etc.) in ore veins and wallrocks as well as spatial position have been studied on the basis of systematic mapping and sampling. Rich metal concentrations have been found to occur inside aureoles of high gas contents: hydrogen, methane, CO for gold; CO_2 for tungsten. Predominance of argon heavy isotope points to isolation of the system at that period. The aureole volume is one order higher than that of ore columns. The fluid regime has been studied in terms of polymerization. A group of autogenous geochemical barriers related to the inner evolution of ore-forming system has been identified. Oxygen and sulphur regime is governed by the same phenomena. Activation of sulphur and arsenic at different periods of time is attributed to the passing of isoelectrical points at various stages of the evolution of solutions. The appearance of thiosulphate forms and their destruction govern transportation of gold and its deposition. Wolframite composition of various stages is accounted by reducability of the fluid at the period of redeposition. (Authors' abstract)

NAUMKO, I.M., VYNAR O.N. and KICHURCHAK, V.M., 1984, Postmagmatic mineralization in some rare-metal pegmatite veins (middle Dnieper area): Dopov. Akad. Nauk Ukr. RSR, Ser. B: Geol., Khim. Biol. Nauki, no. 7, p. 13-15 (in Ukrainian). Authors at Inst. Geol. Geokhim. Goryuch. Kopalin, L'vov, USSR.

Post-magmatic rare-metal (RM) ore mineralization was studied in the pegmatites traversing plagiogranites and plagiomigmatites of the area. Mode of occurrence and composition were studied of fluid inclusions in quartz, spodumene, and albite from the pegmatites. Postmagmatic RM ore localization occurred at 400-150° and (1.3-1.4) x 10^2 MPa. The Na-rich ore-forming fluids resulted in albitization; those enriched in Li formed spodumene and Li-tourmaline. (CA 101: 114170q)

NAUMOV, G.B., 1984a, Geochemical barriers in hydrothermal ore formation: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 169-174. Author at Inst. Geochem. & Anal. Chem., Moscow, USSR.

Includes some discussions of inclusion data. (E.R.)

NAUMOV, G.B., 1984b, Regime of the endogenic fluids and their role in hydrothermal ore-formation (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 355 (in English). Text: Proc. 27th Int'l. Geol. Congr., v. 11, p. 537-557 (1984). Author at V.I. Vernadsky Inst. Geochem. & Anal. Chem. USSR Acad. Sci., Moscow, USSR.

The analysis of present measurements of T and P of mineral-forming hydrothermal deposits sheds light on intervals and maxima of these parameters and pertaining gradients of thermobaric conditions. The change of acidity and partial pressure of hydrogen connected with fall of T and P is observed in light of these values. It is shown that contrast of chemical changes of liquids at the same values of T and P gradients increases while approaching the surface. Such changes lead to the emergence of zones with different geochemical conditions and different mobility of ore elements. Such conditions can cause the emergence of geochemical barriers leading to accumulation of ore substance. It is caused by the presence of weakly penetrated screen ore zones with high fractionality in the path of liquids movement fixed in natural conditions by the results of studying fluid inclusions. (Author's abstract)

NAUMOV, G.B., MIRONOVA, O.F., SAVEL'YEVA, N.I. and DANILOVA, T.V., 1984, Concentration of uranium in hydrothermal solutions; data from fluid inclusion studies: Dokl. Akad. Nauk SSSR, v. 279, no. 6, p. 1486-1488 (in Russian). Authors at Inst. Geochem. & Anal. Chem., Moscow, USSR.

First results were obtained by water leachate method for uranium concentration in fluid inclusions. Investigations were performed for 1) pre-ore quartz (Th >250°C), 2) barren quartz (Th 120-170°C) and calcite veins of the ore stage and 3) quartz and calcite ore veins (Th 150-90°C) of the nasturan-carbonate formation. Leachates from quartz after opening of inclusions by decrepitation were made with 2 N HNO_3, and from calcite - with 0.5% solution of Na_2CO_3. The results obtained for the samples noted above are as follows: 1) 0.4-4.3, 2) 0.2-3.3, 3) 3.6-340 mg U per ℓ H_2O of inclusion fluid. The total of 14 samples were analyzed, U determination was performed by the laser-luminescence method. (Abstract by A.K.)

NAUMOV, G.B., VOZNYAKH, D.K., NAUMOV, V.B. and KHITAROV, D.N., 1984, Mineral genesis and fluid inclusions: Mineral. Zh., v. 6, no. 3, p. 87-97 (in Russian; English abstract). First author at Inst. Geochem. & Anal. Chem., Moscow, USSR.

It is shown possible to apply data of fluid inclusion studies for obtaining information on genesis of mineral individuals and aggregates. Certain essential problems of mineral genesis are generalized, as fluid inclusions in them are of primary importance for their solution. The conclusion necessitates a wider application of the methods for studying fluid inclusions in mineralogical research. (Authors' abstract)

NAUMOV, V.B. and CLOCCHIATTI, R., 1983, An example of fluorine of magmatic origin in glass inclusions in ongonites from Mongolia (abst.): Symp., European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 47 (in French). First author at Vernadsky Inst. Geochem., Kosigin shosse 19, Moscow, USSR.

The Durben-Dort-Ula region is located in central Mongolia ~500 km S of Ulan Bator. The ongorhyolites occur as flows, which reach thicknesses of one hundred meters, as well as subvolcanic intrusions of lower Cretaceous age (118-125 MY). The flows are weakly porphyritic with 2-3% acidic plagioclase, 4-5% potassic feldspar (Or 55.3, Ab 43, An 1.7), 4-5% quartz, and accessory apatite, biotite and ilmenite; the glassy groundmass constitutes 87-90% of the rock.

The ongonites are enriched in fluorine, rubidium and boron, and depleted in strontium and barium. The quartz crystals are characterized by the presence of dihexahedral glass inclusions, a few of which reach dimensions of about 100 microns, containing pleochroic biotite crystals, transparent adularia and quartz crystals, as well as small cubes of fluorite. All of these minerals, which crystallized from the silicate liquid after the liquid was trapped as an inclusion and are, therefore, daughter minerals, as well as the remaining liquid (glass), were analyzed by electron microprobe. The melting temperatures of the different phases is between 760°-830°C. The composition of the residual glass in the system Qz-Or-Ab requires the thermal minimum to be at $P(H_2O)$ between 0.7 to 1 kb. The partial pressure of water vapor (V.B. Naumov) is between 0.8 and 1.4 kb. The halogen (F and Cl) content of the residual liquid (after separation of biotite and fluorite) remains high: 1000 to 1500 pm Cl an 3000 ppm F. The halogen content of the biotites in inclusions (Cl 4000 ppm, F 1.3%) and in the groundmass (Cl 1800 ppm, F 4500 ppm) were also measured. (Authors' abstract; translation courtesy of R.J. Bodnar)

NAUMOV, V.B., CLOCCHIATTI, R., KOVALENKO, V.I., SOLOVOVA, I.P. and MALOV, V.S., 1983, Composition of biotite, potassic feldspar and melt in equilibrium with them, as shown by study of inclusions in ongorhyolite quartz: Dokl. Akad. Nauk SSSR, v. 270, no. 6, p. 1450-1452 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 129-131, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 182-183, 1983. (E.R.)

NAUMOV, V.B. and IVANOVA, G.F., 1984a Genetic relationship between rare-metal mineralization and acid magmatism as revealed by the study of micro-inclusions and indicator microcomponents: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 395-401.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 172-173. (E.R.)

NAUMOV, V.B. and IVANOVA, G.F., 1984b Geochemical criteria of genetic relation of the rare-metal ore-mineralization with acid magmatism: Geokhimiya, no. 6, p. 791-804 (in Russian).

For estimation of the genetic relation of processes of rare-metal ore formation with acid magmatism the following were considered: 1) distribution of a number of indicator elements (tantalum, niobium, lithium, fluorine) in minerals of granitic rocks, metasomatites, and ore zones; 2) relation of levels of concentration of some elements in minerals with the temperature of mineral formation (germanium in topaz, rare earths, yttrium, and manganese in fluorites); 3) physico-chemical parameters (temperature, pressure, concentration, density) and their evolution in the system magmatic melt - hydrothermal solution according to data on study of the melt and fluid inclusions. The data considered give evidence on principal genetic relation of the rare-metal ore-mineralization and acid magmatism. (Authors' abstract)

NAUMOV, V.B., KOVALENKO, V.I., CLOCCIATTI, R. and SOLOVOVA, I.P., 1984, Parameters of crystallization and composition of phases of the melt inclusions in quartz of ongorhyolites: Geokhimiya, 1984, no. 4, p. 451-464 (in Russian; English abstract).

Optical and microprobe study shows that in primary melt inclusions in quartz of ongorhyolites of Durben-Dort-Ula, Mongolia, were formed potassium feldspar, biotite (manganese-bearing siderophyllite) fluorite, quartz, and magnetite with variable titanium content. During crystallization of the quartz phenocrysts the ongorhyolite melts have temperature 830-760°C, water content 2.0-5.4% in weight, water pressure 0.5-1.8 kbar. Contents of fluorine, chlorine, and sulfur in biotite, residual glass of the inclusions and matrix of ongorhyolite were determined also. The main volatile components of ongorhyolite melts are considered to be water, fluorine and chlorine. (Authors' abstract)

NAUMOV, V.B., KOVALENKO, V.I. and KOSUKHIN, O.N., 1982, Crystallization parameters of ongonite magma, as shown by study of melt inclusions: Dokl. Akad. Nauk SSSR, v. 267, no. 2, p. 435-437 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 267, p. 113-115, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 173, 1982. (E.R.)

NAUMOV, V.B., RUB, M.G. and RODNOV, Yu.N., 1983, Genesis of ore-bearing volcanoplutonic complexes (with tin and silver), as inferred from the study of melt inclusions: Dokl. Akad. Nauk SSSR, v. 268, no. 2, p. 406-409 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 116-118, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 183-184, 1983. (E.R.)

NAYAK, B.K. and PANCHAPAKESAN, V., 1984, Geothermobarometric studies on lead-zinc deposits of Zawar, Rajasthan: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 6. Authors at Dept. Earth Sci., Indian Inst. Tech., Powai, Bombay 76.

Fluid inclusions of gangue quartz intimately associated with the sulphides were studied. The inclusions were essentially of biphase type with small gas bubbles. Most of the inclusions were geometrically equant and all homogenized in liquid. No dense phase of carbon dioxide could be detected at temperatures around 25°C. The inclusions had Th ~315°C.

Sphalerite associated with pyrrhotite indicated a pressure of 1.6 kilobars and a correspondingly corrected temperature of 440°C for the assemblage of its final stage of evaluation. (Authors' abstract)

NECHAEV, E.A., 1984, Influence of the solution composition on the adsorption of chloride complexes of gold (III) upon hematite: Geokhimiya, 1984, no. 4, p. 527-533 (in Russian; English abstract).

NEDACHI, Munetomo, KANISAWA, Satoshi and YAMAMOTO, Masahiko, 1984, Chlorine and fluorine contents of the Neogene granitic rocks in Kyushu, Japan: Mining Geol., v. 34, no. 6, p. 437-446. First author at Dept. Geol., College Liberal Arts, Kagoshima Univ., Kagoshima, Japan.

Chlorine and fluorine contents of the Neogene granitic-rocks in Kyushu were analyzed by an X-ray fluorescence analyzer and a specific ion electrode. Based on the petrography, Kyushu is divided into the Inner zone, the Outer zone I and the Outer zone II from NW to SE. With some exceptions, chlorine and fluorine decrease as SiO_2 increases in each granitic mass. From the halogen contents in large granitic masses in the three zones, it is suggested that the chlorine content decreases and the F/Cl ratio increases toward the Pacific Ocean in modes of generation and granitic magma emplacement. On the other hand, the hypabyssal rocks in this region show a different pattern of halogen content from the plutonic rocks, indicating that the mode of emplacement affects the behavior of halogen elements.

Granitic rocks of the Inner zone associated with base metal mineralization are rich in chlorine. Those of the Outer zone I are characterized by rather high fluorine content. Whereas, some hypabyssal rocks closely related to in mineralization in the Outer zone I contain high chlorine concentrations or minerals with high chlorine contents. Hence, it is thought that chlorine plays an important role in transportation of tin, but that fluorine is enriched during differentiation process or by later greisenization. There are some small tungsten-tin ore deposits in the Outer zone II. It is thought that there is no intense mineralization in the Outer zone II, because of the low chlorine content of the granitic rocks. (Authors' abstract)

NEKRASOV, I.Ya., 1984, The possible genesis of ore-bearing quartz bodies in differentiated granite massifs: Akad. Nauk SSSR Doklady, v. 276, no. 5, p. 1224-1227 (in Russian). Author at Inst. Exper. Mineralogy of Acad. Sci., Chernogolovka near Moscow, USSR.

Well-differentiated granitoid intrusives frequently bear hidden quartz bodies of vein, irregular equant, lenticular or spherical shape with rare-metal (Sn-W, W-Be, Mo or TR) mineralization, but without a feeder channel for mineral-forming solutions. These quartz bodies occur almost completely in the latest granitoid magma derivatives such as the F-Li granophyres, and only rarely in early granitoids. Th and Td range from 550-625°C, close to T of pegmatite formation. Some of the quartz bodies bear, in addition to G/L, and glassy apparent melt inclusions of quartz or albite-quartz composition. Experiments showed that in the "system" granite-SnO-aqueous chloride fluid, when Sn^{2+} concentration exceeds 15 wt.%, the melt splits into two immiscible phases, one of them is distinctly enriched in SiO_2 + 17 wt.% SnO and more, and the second (the matrix) of alumosilicate composition with 0.7 to 1 wt.% SnO. On this basis the author suggests that quartz-ore bodies might form by immiscibility in the process of differentiation of granitoid magma. (Abstract by A.K.)

NEKRASOV, I.Ya., CHEVYCHELOV, V.Yu. and KONYUSHOK, A.A., 1984, Physicochemical conditions of formation of the deposits of gold-silver and gold-antimony formations: Sovetskaya Geologiya, no. 10, p. 80-85 (in Russian). Authors at Inst. of Experimental Mineralogy, Moscow, USSR.

Analyses of water leachates from quartz of the gold-silver and gold-antimony deposits from the Asian Pacific ore belt showed similar compositions. Prevailing cations are K, Na, Ca, anions - Cl and HCO_3, only rarely inclusions richer in HSO_3 (in quartz-adularia-sulfoantimonite association) or in SO_4 (in acanthite-pyrargyrite-stephanite association) were found. The paper presents also experimental data on Au complexes under hydrothermal conditions. (Abstract by A.K.)

NEKRASOV, I.Ya. and KONYUSHOK, A.A., 1982, Behavior of system Au-Fe-Sb-S under hydrothermal conditions at 300° to 600°C: Dokl. Akad. Nauk SSSR, v. 265, no. 1, p. 180-185 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 265, no. 1, p. 159-163, 1984).

NESBITT, B.E., LONGSTAFFE, F.J., SHAW, D.R. and MUEHLENBACHS, Karlis, 1984, Oxygen isotope geochemistry of the Sullivan massive sulfide deposit, Kimberley, British Colubmia: Econ. Geol., v. 79, p. 933-946. First author at Dept. Geol., The Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

Oxygen isotope analyses of whole-rock and mineral samples from country rocks, major alteration zones, and ore zones of the Sullivan deposit were conducted to provide information on the hydrothermal evolution of the deposit. An additional objective of the project was to evaluate potential applications of isotopic analyses to exploration for strata-bound, stratiform, Pb-Zn-Ag deposits. The Sullivan deposit is hosted by thin- to medium-bedded argillite and arenite of the Proterozoic Aldridge Formation. The $\delta^{18}O$ results for samples from the Aldridge range from 10.0 to 13.1 per mil with an average of 11.4 ± 1.0 per mil. Oxygen isotope results from the tourmaline alteration zone, located in the footwall of the western, proximal ores, range from 10.7 to 13.1 per mil with an average of 11.9 ± 0.8 per mil. The similarity between values for the tourmalinite and the Aldridge Formation suggests that the fluids which produced the tourmalinite alteration did not significantly alter the primary $^{18}O/^{16}O$ of the host sedimentary units. Similarly, samples of argillite and arenite which immediately adjoin the eastern, distal ores possess $\delta^{18}O$ values indicating little oxygen isotope exchange between ore-forming fluids and the host sedimentary units. Isotopic values for samples from the albite-chlorite alteration zone, located in the hanging wall of the proximal ores, range from 6.1 to 7.7 per mil. Such values indicate that there is a distinct difference in the isotopic composition of the albite-chlorite zone relative to unaltered country rocks.

Based on various isotopic, geologic, and geochemical arguments, the following sequence for the formation of the Sullivan deposit is proposed. The first hydrothermal stage consisted of the migration of low-temperature (<100°C), boron-rich fluids up permeable zones, causing the development of the tourmalinite alteration zone. This event occurred in many locations within the Aldridge sedimentary basin and represents a diagenetic, sediment-dewatering stage. Subsequent to this event, hotter (approximately 150°C) Pb-Zn-Fe-bearing fluids rose through the same zone at Sullivan and deposited sulfides on the sea floor. The final hydrothermal event was the alteration of the tourmalinite, ore, and hanging-wall sedimentary units to produce the albite-chlorite alteration assemblage. The fluids which produced the albite-chlorite assemblage were most likely more saline than normal seawater and had a temperature of 250°C or more. (Authors' abstract)

NESBITT, H.W., 1984, Calculation of the solubility of CO_2 in NaCl-rich hydrothermal solutions using regular solution equations: Chem. Geol., v. 43, p. 319-330. Author at Dept. Geol., Univ. Western Ontario, London, Ontario N6A 5B7, Canada.

The simple equation: $\ln \gamma_1 = A_{12}(X_2^2 - 1.0)$ derived from regular solution theory, duplicates CO_2 activity coefficients in groundwaters and hydrothermal aqueous NaCl solutions. The equation can be used to accurately predict CO_2 activity coefficients in concentrated (≥6 m) NaCl solutions up to ~500°C and 1000 bar pressure. The equation is of particular use in the fields of low-temperature geochemistry in that carbonate mineral-brine-atmosphere interactions can be accurately assessed, in economic geology where boiling hydrothermal systems influence ore deposition and in metamorphic petrology where the mole fractions of H_2O and CO_2 strongly influence mineral assemblages. (Author's abstract)

NEVES, J.M.C., MONTEIRO, R.L.B.B. and DUTRA, C.V., 1984, Chemical composition of Brazilian pegmatitic beryls and its petrologic and metallogenetic significance: Revista Brasileira de Geoci., v. 14, p. 137-146 (in Portuguese; English abstract). First author at the Fed. Univ. Minas Gerais, Belo Horizonte, Minas Gerais, Brazil.

Fourteen pegmatitic beryls have been analyzed for main elements and Fe, Mg, Ti, Li, K, Na, Cs, Ca, P, Rb, Ba, Zr, Sr, Sc and Zn. Infrared diagrams revealed H_2O, CO_2 and CH_4 occluded in channels of the beryl structure and/or present in fluid inclusions of the same mineral. The petrologic and metallogenetic implications of the chemical composition, mainly the variation in the alkali contents, are discussed and interpreted. (Authors' abstract shortened by K. Fuzikawa)

NEWMAN, Sally, STOPLER, Edward and EPSTEIN, Samuel, 1984, Hydrogen isotopic - IR spectroscopic studies of dissolved water in silicate glasses (abst.): EOS, v. 65, p. 287.

NEWTON, R.C., 1984, Proterozoic and Late-Archaean granulite terrains as collisional orogens (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 1, p. 159-161. Author at Dept. Geophys. Sci., Univ. Chicago, Chicago, IL, USA.

CO_2-rich fluid inclusions in quartz and feldspar [are a feature of granulite terranes.] Many studies have revealed high-CO_2 (75 mol %) inclusions in transitional charnockites and high grade granulites. Evidence for high CO_2 activity exists indirectly in mineralogically-deduced decrease of H_2O activity with increasing grade. Another feature is the pressure increase across the transition zone. This has been well-documented for the Adirondacks, southern Karnataka and Broken Hill. Five to six kbar is characteristic of the transition zone and seven to ten kbar of the highest grade zone.

The foregoing features are all consistent with continent-continent or island-arc-continent collision as a fundamental cause of granulite metamorphism. The horizontal structures imply some form of plate tectonics. Shelf sediments overridden in continental collision are a plausible source of deeply-buried CO_2, although limestone subducted prior to collison, with carbonation of the mantle wedge, is also plausible. A number of recent studies have implicated a shelf or cover sequence, perhaps with evaporites, as a lubricating surface for continent-scale overthrusting. Stratigraphic sources of Be, F and B, characteristic of the chemistry of many granulites, are more plausible than mantle sources. Destabilization of biotite by rising CO_2 probably best explains Rb depletion. The ubiquitous 7-10 kbar pressures of the highest-grade terrains is equivalent to burial beneath an overriding continent of 25-35 km thickness. The old age of most granulites suggests that the temperatures prevailing at the base of continents were higher in the Precambrian than at present. Even so, an additional source of heat, such as magmatism, is probably needed to account for most Proterozoic granulites. (From the author's abstract)

NEWTON, R.C., HANSEN, E.C. and JANARDHAN, A.S., 1984, A continuous prograde amphibolite-facies to granulite-facies transition in the Archean of southern India (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 2, p. 359-360. First author at Geophy. Sci., Univ. Chicago, Chicago, IL, USA.

A steady increase of metamorphic grade southward in the Archean terrain of southern Karnataka and northern Tamil Nadu, India, has long been recognized. Gray gneisses and sedimentary-volcanic enclaves of the greenschist grade in central Karnataka give way to amphibolite grade and finally granulite grade rocks in southern Karnataka.

A north-south sampling traverse at about 77°15'E was made across a region from 12°45'N to 12°00'N. This region spans the amphibolite facies to granulite facies transition and appears to be uninterrupted by major structural breaks, based on N-S continuity of linear features in LANDSAT imagery. The major results are listed:

Fluid inclusions. The primary fluid inclusions in quartz of gray gneiss, migmatite and charnockite are all dominantly (>75 mol %) CO_2. Coarse charnockites and granitic leucosomes have many more fluid inclusions than gray gneisses. Predominant homogenization temperatures range continuously from 0°C at 12°45' to -35°C in the southern part of the area, indicating entrapment pressures at 750°C from 5.1 kbar to 7.7 kbar. This southward increase of pressure is quantitatively consistent with the mineralogic geobarometry and indicates that the CO_2-rich inclusions represent the peak metamorphic fluids.

These and other features all point to the influx during metamorphism of a copious CO_2-rich, H_2O-poor fluid. Amphibole was dehydrated to pyroxene. F-rich, Ti-rich biotite was the only stable hydrate in acid to intermediate rocks. The CO_2 activity increased with increasing pressure; therefore CO_2 came from a deep level. Possible sources include mantle out-gassing, exsolution from deep-seated magmas, and deeply buried carbonaceous sediments. The latter possibility, resulting from shelf sediments deeply buried in a continental collision process is increasingly cited as a source of fluids in Precambrian granulite metamorphism. Stratigraphic sources of metamorphic fluids seem better suited to explain high levels of F and B found in many granulites than do mantle sources. (From the authors' abstract)

NIEDERMAYR, V.G., MULLIS, J., NIEDERMAYR, E. and SCHRAMM, J.-M., 1984, On anchimetamorphism of Permian-Scythian sediments in western Drauzug, Kärnsten-Osttirol (Austria): Geol. Rundschau, v. 73, no. 1, p. 207-221 (in German; English abstract).

The illite-crystallinity index (IC) of some Permo-Scythian to Cretaceous sediments of the western Drauzug had been investigated. In addition, the fluid inclusions of quartz crystals from crosscutting clefts of 9 localities were analyzed.

The IC-values indicate an anchizonal metamorphism of the postvariscic sediments. The data also show that metamorphism is of lower intensity in the southern than in the northern part of the Drauzug. In that area the metamorphism is traceable upward into the Carnian Raibler Schichten.

The earlier fluid inclusions in cleft quartz consist of a saline water. Neither CO_2, methane nor higher hydrocarbons could be detected. This fluid composition is indicative of the water field of the high grade anchizone. This imples that a minimum temperature of >270°C and a minimum pressure of 1500 to 2000 bar were reached during the alpidic metamorphism in the western Drauzug. This corresponds to an estimated overburden of 5500 to 7500 meters. These estimates are in fairly good agreement with our IC-data. (Authors' summary)

NIKOLSKII, N.S., 1984, The P-T-fO_2 conditions of phlogopite stability in the presence of the H-O-C system fluids and the problems of petrogenesis: Dokl. Akad. Nauk SSSR, v. 275, no. 4, p. 962-966 (in Russian).

NISHIOKA, G.K., KELLY, W.C. and ELMORE, R.D., 1984, Copper occurrences in stromatolites of the Copper Harbor conglomerate, Keweenaw peninsula, northern Michigan: Econ. Geol., v. 79, p. 1393-1399. Authors at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

Calcites associated with copper in the stromatolites and in the crosscutting Lakeshore-type veins contain numerous fluid inclusions, but these are typically necked down, difficult to classify, and so small in size (most less than 3 μm) that very few were suitable for quantitative studies. All isolated inclusions homogenize (by vapor disappearance) in the range of 53° to 88°C, with most homogenizing between 65° and 70°C. In freezing runs, these same inclusions give final melting points in the range of -3° to -11°C, indicating salinities of about 6 to 15 equivalent weight percent NaCl. (From the authors' text)

NITZSCHE, H.-M. and STIEHL, G., 1984, Investigation of isotopic fractionation of nitrogen in the systems ammonium ion/ammonium and nitride/nitrogen: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 283-291: Leipzig, Akad. Wissen. der DDR (in German; English abstract). Authors at Zentralinstitut Isotopen- & Strahlenforschung der AdW der DDR, 7050 Leipzig, PermoserstraBe 15.

For the interpretation of connections between the amount of nitrogen and its isotopic composition in parametamorphic and igneous rocks the knowledge of the separation factors of some interesting isotopic exchange processes is essential. On the basis of quantum mechanics several authors calculated interesting isotope effects (Scalan 1957, Kung and Clayton 1978, Hanschmann 1981). The aim of our investigation was to determine experimentally some of these calculated equilibrium constants. In the system NH_4^+/NH_3 the nuclide ^{14}N is enriched in the gaseous phase. In the systems CrN/N_2 and Ca_3N_2/N_2 the nuclide ^{15}N is enriched in the gaseous phase. (Authors' abstract)

NITZSCHE, H.-M. and STRAUCH, G., 1984, Extraction of inclusion components from minerals for isotope and geochemical investigations: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 292-303: Leipzig, Akad. Wissen. der DDR (in German; English abstract). Authors at Zentralinstitut Isotopen- & Strahlenforschung der AdW der DDR, 7050 Leipzig, Permoserstr. 15.

The thermal decrepitation of minerals is an often used method for obtaining inclusion components. In this paper a decrepitation method under vacuum is described to extract water and CO_2 included in minerals.

The investigations were made on pegmatitic to hydrothermal quartz and hydrothermal fluorite from southern part of the GDR.

For obtaining the inclusion components and for measuring the isotope ratio of hydrogen and carbon in water and CO_2, respectively, the samples are treated by stepwise thermal decrepitation. All gases extracted are trapped and CO_2 and water are separated by cooling with liquid nitrogen and ethanol/dry ice. Isotope analysis is made on purified CO_2 and hydrogen obtained by reaction of water with hot chromium.

The results are shown and a detail explanation is given relative to methodical and geological aspects. (Authors' abstract)

NOACK, Werner and RUNGE, Klaus, 1984, Thermomigration of fluid inclusions in rock salt. Conclusions for the permanent storage of radioactive wastes: Rep.-SAAS (Staatliches Amt fuer Atomsicherheit und Strahlenschutz der DDR), No. SAAS-313, 70 pp (in German) (also in CA: 101(26)237074u).
Indexed under Fluid Inclusions.

NOLAN, J. and BUCHANAN, D.L., 1984, Sulphide saturation in synthetic tholeiitic melts at 1400°C: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 163-168.

NOLAN, J., HENDERSON, P., CUNNINGHAM, G. and LOWRY, R.K., 1984, Diffusion studies in silicate melts: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 154-162.

NORMAN, D.I., TING, W., PUTNAM, B.P., III and SMITH, R.W., 1984, Mineralization of the Hansonburg MVT deposit, New Mexico, in light of fluid inclusion and mineral equilibrium studies (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 93. Authors at Geosci. Dept., New Mexico Tech., Socorro, NM 87801.

Fluid inclusion gases were analyzed in samples which had previously been studied by microthermometry and analysis of inclusion liquids. Volatiles are 99.0-98.6% H_2O; 1.4-1.0% CO_2, N_2, and C_nH_n, approximately in equal amounts; .01 to <.0001% H_2S; plus minor amounts of Ar and He. The organic compounds are the same as the principal organic compounds reported in oil field brines. Calculated average fN_2 is 132 atm, calculated average fCO_2 = 43 atm, and calculated pH of fluids from CO_2-Ca^{++}-CO_2 equilibrium is 4.5. When fN_2 is plotted vs. fCO_2, the points fall on a calculated boiling curve suggesting a declining pressure on fluids during mineralization with minor N_2-CO_2 boiling. Measured concentration of H_2S agrees with the aH_2S calculated from mineral equilibria.

Early fluids deposited PbS, qtz, fluorite, and barite at 170-200°C from a 18-10% brine with 100-500 ppm Pb transported as Pb-Cl complexes and 200 to 20 ppm H_2S. Later fluids deposited fluorite and barite but only minor sulfides at 170-130°C from metaliferous fluids which were chemically similar to early fluids except nearly devoid of H_2S. Conodont geothermometry indicates that mineralization occurred during a period of high heat flow when temperatures of the host Pennsylvanian carbonate were 110-140°C. Mineral deposition was principally by cooling early in the paragenesis and by pH change resulting from CO_2 loss in later mineralization. Ore fluids are postulated to be sedimentary-connate waters mobilized during a regional heating event. (Authors' abstract)

NORONHA, F., 1983, Physico-chemical characteristics of fluids associated with genesis of the Borralha tungsten deposit (northern Portugal) (abst.): Symp., European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 48 (in French). Author at Center Geol. Univ. Porto, I.N.I.C., Fac. Sci., 4000 Porto, Portugal.

The Borralha tungsten deposit is a vein type deposit with quartz as the main gangue mineral. The deposit has the peculiarity of having two collapse breccias, cemented by quartz, spatially associated with the veins. Characteristics of the deposit suggest that the breccias and veins formed very near to the surface and were associated with fluids in the liquid phase. These fluids, although hot and relatively saline (10% NaCl) were only weakly acidic. Very schematically, the mineralogy of the mineralized structures is characterized by quartz, wolframite, scheelite and sulfides. The temperature did not vary much from tungstate to sulfide deposition, and the maximum values are between 290° and 330°C. The pressure during the initial stages of tungstate deposition ranged from 650 to 1000 bars. Tungsten was deposited from solutions with Na>K; the dominant components in solution were Na^+ and Cl^- and probably HCO_3^-. The amount of CO_2 did not exceed 8-10 mole %, except perhaps during the initial stages of hydrothermal activity. The pH changed from slightly acidic to slightly alkaline and caused tungstate deposition, first wolframite followed by later scheelite. (Author's abstract; translation courtesy of R.J. Bodnar)

NORONHA, Fernando, 1984, Physico-chemical characteristics of the fluids related to the genesis of the tungsten-ore deposit of Borralha (north Portugal): Bull. Minéral., v. 107, p. 273-284 (in French; English abstract). Author at Centro de Geol. da Univ. do Porto, Faculdade de Ciencias, 4000 Porto, Portugal.

The tungsten-ore deposit of Borralha is of the vein-type, with quartz being the gangue mineral. The ore deposit comprises, also, two collapse breccias cemented by quartz which are spatially related to the veins. Schematically, the mineralized structures are characterized by an association of quartz, wolframite, scheelite and sulphides. The temperature has not markedly changed from the tungstates up to the sulfide deposition: it lies between 330°C and 290°C. During the main W-mineralization and breccia formation, the pressure ranged from 650 to 1000 bars.

The hydrothermal fluids have an average salinity of 10 wt. % eq. NaCl. Initially, they contain up to 11 mole % CO_2 and become purely aqueous. The fluids carrying W have compositions dominated by Na^+, Cl^- $^-$and HCO_3 (Na>K) and are acidic. Their corrosive activity is weak: it only causes minor alteration of the wall-rock. (Author's abstract)

NORTON, D.L., 1984, Theory of hydrothermal systems: Ann. Rev. Earth Planet. Sci., v. 12, p. 155-177.

NOTO, Pietro, NUTI, Sergio and CAPRAI, Antonio, 1984, Application of chemical and isotopic geothermometers to Pozzuoli solfatara, Phlegrean fields, Italy (abst.): Terra Cognita, v. 4, no. 2, p. 220-221.

NOVGORODOVA, M.I., VERETENNIKOV, V.M., BOYARSKAYA, R.V. and DRYNKIN, V.I., 1984, Geochemistry of trace elements in gold-bearing quartz: Geokhimiya, no. 3, p. 370-383 (in Russian; translated in Geochem. Int'l., v. 21, no. 3, p. 101-113). Authors at Inst. for the Geol. Ore Deposits, Petrography, Mineral., & Geochem., Acad. Sci. USSR, Moscow, USSR.

Geochemical indicators for gold in quartz have been identified by neutron-activation analysis of gold-bearing quartz from quartz-vein deposits in carbonatized and feldspathized Devonian and Carboniferous rocks in the Urals. A correlation is demonstrated between Au and REE in quartz. The forms taken by the trace elements have been established, many of which accumulate in the gas-liquid inclusions in the quartz. (Authors' abstract)

NOVGORODOVA, M.I., YUSUPOV, R.G., DMITRIYEVA, M.T., TSEPIN, A.I., SIVTSOV, A.V. and GORSHKOV, A.I., 1984, Khamrabaevite (Ti,V,Fe)C - new mineral: Zapiski Vses. Mineral. Obshch., v. 113, no. 6, p. 697-703 (in Russian). Authors at Inst. Geol. of Ore Deposits, Petrogr., Mineral. and Geochem. of Acad. Sci. USSR, Moscow, USSR.

Khamrabaevite in basalt most probably formed from a gaseous fluid rich in hydrocarbons; the latter were found admixed with nitrogen in porous aggregate of suessite, graphite and khamrabaevite. (A.K.)

NOVIKOVA. L.N. and NOVIKOV, Yu.A., 1984, Composition of gas-liquid inclusions and zoning of the Rubtsovsk deposit: Razved. Okhr. Nedr., no. 11, p. 19-23 (in Russian). Authors at PGO "Zapsibgeologiya," USSR.

Gas-liquid inclusions (GLI) from wall-rock lava breccias, liparite, porphyries, and aleurolites of the Rubtsovsle polymetallic ore deposit were studied to characterize the temperature and composition of the hydrothermal ore-forming solutions. Secondary GLI from quartz in veinlets had Th of 270-330°. Aq. exts. which represent relicts of the hydrothermal solutions had the composition, given as percentage molar ratios of cations and anions, as follows: K^+ 60-75, Na^+ 7-30, Mg^{2+} 7-18, Cu^{2+} 5-14/SO_4^{2-} 66-98, Cl^- 2-15, HCO_{3^-} 0-16, F^- 0-12. An alkali metal-Cl-SO_4^{2-} composition with $K^+ > Na^+$ was dominant; the gas phases present are CO_2, O_2, H_2, N_2, and CH_4. GLI from the rocks above the ore zone are depleted in HCO_{3^-} but rich in Ca^{2+}, CO_2, and O_2 concentrations and the CO_2/CH_4 ratio provides a means, together with other data, of estg. the level of erosional shear of such deposits as Rubtsovsk. Ratios (Pb/Co)-[(Ba x As)/(Co x Ni)] and Ba^2/(Mo x As) follow the zoning in the deposit and can be used to classify geochemical anomalies and to distinguish haloes over possible polymetallic deposits. (C.A. 102: 28718p)

NRIAGU, J.O. and MOORE, P.B., eds., 1984, Phosphate Minerals: Springer-Verlag, New York, 442 pp.

Includes a brief discussion (p. 232-233) of solid and fluid inclusions in apatite, with 13 references. (E.R.)

OELKERS, E.H. and HELGESON, H.C., 1984, Calculation of diffusion coefficients of aqueous species in hydrothermal systems at pressures and temperatures of 5 kb and 1000°C (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 612.

OHMOTO, Hiroshi, 1984, Applications of sulfur and carbon isotopes to ore genesis research and mineral exploration: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 44-45.

OKANDAN, Ender, 1984, Heavy crude oil recovery: NATO Advanced Study Inst. on Heavy Crude Oil Recovery, 1982, Ankara, Turkey, Martinus Nijhoff Pub., 428 pp.

Includes several chapters on CO_2 flooding that involve solubility of hydrocarbons in CO_2. (E.R.)

O'KEEFE, J.A., 1984, Natural glass: J. Non-Crystalline Solids, v. 67, p. 1-17.

OLANDER, D.R., 1984, A study of thermal-gradient-induced migration of brine inclusions in salt: final report: BMI/ONWI-538 Tech. Rept., 135 pp.

It has been proposed that high-level nuclear waste be disposed of in a geologic repository. Natural salt deposits, which are being considered for this purpose, contain a small volume fraction of water in the form of brine inclusions distributed throughout the salt. Radioactive decay heating of the nuclear wastes will impose a temperature gradient on the surrounding salt which mobilizes the brine inclusions. Inclusions filled completely with brine (the all-liquid inclusions) migrate up the temperature gradient and eventually accumulate brine near the buried waste forms. The brine may slowly corrode or degrade the waste forms, which is undesirable.

Therefore, it is important to consider the migration of brine inclusions in salt under imposed temperature gradients to properly evaluate the performance of a future salt repository for nuclear wastes. The migration velocities of the inclusions were found to be dependent on temperature, temperature gradient, and inclusion shape and size. The velocities were also dictated by the interfacial mass transfer resistance at brine/solid interface. This interfacial resistance depends on the dislocation density in the crystal, which in turn, depends on the axial compressive loading of the crystal. At low axial loads, the dependence between the velocity and temperature gradient is nonlinear. At high axial loads, however, the interfacial resistance is reduced and the migration velocity depends linearly on the temperature gradient.

All-liquid inclusions filled with mixed brines were also studied. For gas-liquid inclusions, three different gas phases (helium, air and argon) were compared. Migration studies were also conducted on single crystallites of natural salt as well as in polycrystalline natural salt samples. The behavior of the inclusions at large-angle grain boundaries was observed. (Author's abstract)

OLLILA, J.T., 1984, Fluid inclusions and tin deposition at Zaaiplaats, the Central Transvaal, South Africa: Bull. Geol. Soc. Finland 56, Part 1-2, p. 59-73. Author at Geol. Survey of Finland, P.O. Box 77, 96101 Rovaniemi 10, Finland.

Fluid inclusion heating and freezing methods were used to evaluate the depositional temperatures and composition of the ore-forming fluid of the endogranitic tin depostis of the Bushveld Complex at the Zaaiplaats mine. Daughter minerals in opened inclusions were studied with a scanning electron microscope attached with an energy dispersive X-ray analyzer.

The hydrothermal tin mineralization in the miarolitic cavities of the greisenized Lease granite was due to a low to moderate saline, CO_2-rich fluid system. The primary inclusions in quartz, which crystallized contemporaneously with cassiterite and is associated with alkali feldspar, plagioclase, scheelite, fluorite and later-stage sulphides, have homogenization temperatures between 371°C and 438°C, and salinities from 7.4 to 12.3 equiv. wt. per cent NaCl. The primary and secondary inclusions in quartz of the unaltered Bobbejaankop and Lease granites have high, albeit variable, salinities and an extremely wide range of homogenization temperatures.

The data indicate that (i) tin mineralization within the Bobbejaankop and Lease granites depends mainly on the development of an alkali chloride-rich fluid phase, and that (ii) as a consequence of second boiling, tin was enriched and transported in low-salinity, CO_2-rich fluid phase that was obviously spatially immiscible with the coexisting hydrosaline fluid. This immiscibility segregated the tin into pipes in the Bobbejaankop granite and into greisenized, lenticular orebodies in the Lease granite.

Crystallization of cassiterite with hydrolysis vapor reaction $SnCl_4 + 2H_2O \rightarrow SnO_2 + 4HCl$ is possible down to 400°C. The addition of CO_2 to the water vapor reduces the growth rate of SnO_2. (Author's abstract)

OLSEN, K.I. and GRIFFIN, W.L., 1984a, Fluid inclusion studies of the Drammen Granite, Oslo Paleorift, Norway, I. Microthermometry: Contrib. Mineral. Petrol., v. 87, p. 1-14. First author at A/S Prospektering, Postboks 83, N-1321 Stabekk, Norway.

The Drammen Granite is a subvolcanic complex, intruded during the Permian igneous activity in the Oslo Paleorift. Molybdenite deposits occur within the complex in large discrete quartz veins, accompanied by moderate alteration of the granite. Microscopic and microthermometric studies of fluids trapped in quartz from miarolytic cavities allow characterization of the late-magmatic fluids in the granites. The fluids from which the cavity quartz precipitated were present during and shortly after the magmatic stage, from 750-800°C to ca. 500°C. The salinity decreased from 20-25 eq.w.% NaCl at the earlier stages, to ca. 5 eq.w.% NaCl in the latest fluids, while the CO_2-content increased from 0-2 mol.% to 6-8 mol.%. The presence of devitrified glass in some samples is direct evidence for the coexistence of a magma and a fluid phase. The fluids were under lithostatic pressure (1,300-1,500 Kb) within most of the granite, but were under hydrostatic conditions locally near the contacts, where boiling occurred. The early separation of a fluid phase implies that only moderate concentration and extraction of metals took place. The early saline fluids became diluted, probably by introduction of ground water, after the first aliquots separated. (Authors' abstract)

OLSEN, K.I. and GRIFFIN, W.L., 1984b, Fluid inclusion studies of the Drammen Granite, Oslo Paleorift, Norway, II. Gas- and leachate analyses of miarolytic quartz: Contrib. Mineral. Petrol., v. 87, p. 15-23. First author at A/S Prospektering, Postboks 83, N-1321 Stabekk, Norway.

The Drammen Granite is a subvolcanic complex, intruded during the Permian igneous activity in the Oslo Paleorift. Molybdenite deposits occur within the complex in large discrete quartz veins, accompanied by moderate alteration of the granite. Microchemical and Sr-isotopic studies of fluids trapped in quartz from miarolytic cavities allow characterization of fluids in the granite.

The results compare well with compositions interpreted from microthermometry studies. The observed range in K/Na, Ca/Na and the calculated concentrations of metals in the original fluids suggest that different stages of development are represented. Some of the fluids probably represent early magmatic stages. K/Rb results and the average Sr-isotope composition indicate equilibrium between the fluids and the granite magma. (Authors' abstract)

OLSEN, S.N., 1984, Variations in abundance and density of CO_2-rich fluid inclusions within a migmatite (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 613. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ., Baltimore, MD 21218.

Monophase CO_2 inclusions occurring isolated, in small clusters, or in well-healed intragranular fractures are common in the leucosome quartz of the 1700 m.y.-old migmatites from the east-central Colorado Front Range. They are, however, quite rare in the mafic-selvage and paleosome (host rock) quartz. Most of these inclusions have negative crystal shapes. The mode of occurrence suggests that these are the earliest inclusions to form. In addition to the difference in abundance of the inclusions, there is a difference in CO_2-density distribution within each migmatite. Th for the leucosome inclusions range from -67°C to +20°C with two maxima (at ~-21°C and ~+1°C) while those for the paleosome and selvage ones are -37°C to +20°C with a single maximum at ~+5°C. These differences between the migmatitic zones which occur on the scale of a few centimeters suggest that the formation of these inclusions was related to the migmatization process. These inclusions must contain nearly pure CO_2 as their final melting temperatures (-56.5° to -57.2°C) are very close to that of the triple point of CO_2. It has been proposed by many workers that some CO_2 inclusions are the residual of an H_2O-CO_2 fluid from which H_2O has been lost by various mechanisms such as strong partitioning of H_2O into the silicate melt. In these migmatites, however, H_2O may have been consumed in subsolidus hydration reactions: sericitic and clayey alteration products of feldspar are extremely common in the leucosome, but virtually absent from the paleosome and selvage. The fluid concentration in a leucosome could have been either a cause and/or an effect of the presence of a melt in the leucosome: a fluid can cause partial melting or be released upon crystallization of the melt. (Author's abstract)

OLSON, R.A., 1984, Genesis of paleokarst and strata-bound zinc-lead sulfide deposits in a Proterozoic dolostone, northern Baffin Island, Canada: Econ. Geol., v. 79, p. 1056-1103. Author at Trigg, Woollett, Olson Consulting Ltd., 10504-103 Street, Edmonton, Alberta T5H 2V4, Canada.

Economically important Mississippi Valley-type zinc-lead sulfide deposits exist in middle Proterozoic Society Cliffs Formation dolostone on the Borden peninsula, Baffin Island, Northwest Territories. The Society Cliffs Formation is underlain disconformably by black shale and overlain disconformably by either shale or red clastic rocks. The Society Cliffs Formation has undergone at least four temporally distinct episodes of karstification since its deposition.

During the first karst episode an evaporite solution-collapse breccia formed ubiquitously on the western Borden peninsula.

During the second karst episode a holokarst developed and an integrated cave system of the Mammoth-Flint Ridge Cave system type was formed; that is, long, nearly horizontal, tubular passages were formed during periods when the piezometric surface was stabilized, followed by local development of subvertical karst canyons beneath the tubes when the piezometric surface dropped to a new, lower level of stabilization. The caves subsequently were filled with sulfides and carbonate minerals; several interesting sedimentary structures exist in the zinc-lead sulfide deposits, including sulfide-sparry dolomite interlayering, onlap, cross stratification, cut and fill, breccia, and stalactites. The meteoric waters which formed the caves did not form the zinc-lead sulfide deposits because the temperature of ore deposition was about 200°C, the calculated oxygen isotope composition of the ore fluid is 12.8 per mil, and mineral stabililty and isotopic data indicate the oxygen fugacity decreased during ore deposition. The sulfide sulfur isotope composition of the zinc-lead sulfide deposits has a narrow range of about 26 per mil, similar to that of sulfate evaporite (23.9‰) which exists locally within the Society Cliffs Formation. Lead isotope data indicate the lead in the deposits was derived by a two-stage process.

The ore fluid and contained metals are postulated to have been derived during a late-stage dewatering of the black shale that underlies the Society Cliffs Formation. Sulfide deposition may have been caused by chemical reduction of sulfate that existed in the ore fluid when the fluid entered hydrocarbon-filled caves. The hydrocarbons were probably derived from the same underlying organic-rich shale during an earlier stage of thermal metamorphism and dewatering.

During the third and fourth episodes of karstification only merokarst developed in the Society Cliffs Formation. Karst effects which formed during these episodes include oxidized sulfide deposits and surface solution corridors. (Author's abstract)

O'NEIL, J.R., 1984, Recent advance in the ^{18}O and D geochemistry of rocks and minerals (abst.): Terra Cognita, v. 4, no. 2, p. 224. Author at U.S. Geol. Survey, Menlo Park, CA.

Modern well-engineered mass spectrometers and advances in extraction techniques have made acquisition of both radiogenic and stable isotope analyses of rocks and minerals far less formidable than in the past. As a result projects on regional scales involving large numbers of analyses can now be completed in relatively short times. A possible negative consequence of these technical advances is the ready availability of routine isotopic analyses to relatively inexperienced workers.

Hydrogen isotope measurements are becoming increasingly important as petrological tools. Large isotopic variations observed in suites of plutonic and volcanic rocks have been explained only this year in terms of deuterium fractionations attendant on vapor exsolution from the magma. Certain low D values previously attributed to interactions with meteoric waters are now unambiguously recognized as resulting from this process.

The discovery of reversals in ^{18}O fractionations between coexisting minerals in mantle nodules has provoked considerable discussion and the initiation of experimental studies in several laboratories. Both equilibrium and non-equilibrium interpretations have been given to this unusual phenomenon with the disequilibrium interpretation now favored. The effect may provide important information on the nature of metasomatic fluids in the mantle. (Author's abstract)

O'NEIL, James, JOHNSON, Clark and CHAPPELL, Bruce, 1984, Stable isotope relations in the Tuolomne intrusive series, California (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 356 (in English).

OOSTEROM, M.G., BUSSINK, R.W. and VRIEND, S.P., 1984, Lithogeochemical studies of aureoles around the Panasqueira tin-tungsten deposit, Portugal: Mineral. Deposita, v. 19, p. 283-288. Authors at Dept. Geochem., Inst. Earth Sci., Univ. Utrecht, P.O. Box 80.021, 3508 TA Utrecht, Netherlands.

Lithogeochemical anomalies of W and Sn were found at the surface that coincide with the extent of the main ore fields. (E.R.)

ORR, F.M., Jr. and JENSEN, C.M., 1984, Interpretation of pressure-composition phase diagrams for CO_2/crude-oil systems: Soc. Petroleum Engineers J., v. 24, p. 485-497. First author at New Mexico Petroleum Recovery Research Center.

Results of single-contact phase behavior studies for CO_2/crude-oil mixtures often are presented as pressure-composition (P-X) phase diagrams. In such diagrams, regions of pressure and CO_2 mole fraction for which more than one phase forms can be identified easily. Phase diagrams for CO_2/crude-oil systems can be quite complex, however, since under some conditions such mixtures can form a liquid and a vapor, two liquid phases, or two liquids and a vapor in equilibrium. This paper examines P-X diagrams for two ternary systems, CO_2/propane/hexadecane and CO_2/methane/hexadecane, and describes transitions from one diagram to another that occur with changes in system temperature or changes in oil composition. (From the authors' abstract)

ORR, F.M., Jr. and TABER, J.J., 1984, Use of carbon dioxide in enhanced oil recovery: Science, v. 224, no. 4649, p. 563-569. Authors at New Mexico Petr. Recovery Res. Center, New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Pertinent to the problem of the possible hydrocarbon content of the CO_2 phase in fluid inclusions. (E.R.)

ORSINI, C.G., 1983, Relations between inclusion distribution, porosity and microfractures of several crystalline rocks (abst.): Symp., European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 32 (in French). Author at Geol. Appliquee ER 45 - P.M. Curie 48, rue des Bernardins Paris, 75005 France.

Only title given in original. (E.R.)

OSADCHII, E.G. and ALEKHIN, Ju.V., 1984, On the origin of native aluminium (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 131 (in English). First author at Inst. Exper. Mineral. USSR Acad. Sci., Chernogolovka, Moscow District, USSR.

The authors suggest native aluminium has formed by silicates reacting with NaCl to yield gaseous AlCl[sic] which subsequently disproportionates. (E.R.)

OSKARSSON, Niels, 1984, Monitoring of fumarole discharge during the 1975-1982 rifting in Krafla volcanic center, north Iceland: J. Volcan. & Geothermal Research, v. 22, p. 97-121. Author at Nordic Volcan. Inst., Univ. Iceland, IS-101 Reykjavik, Iceland.

Fumarole discharge chemistry in the Krafla geothermal field changed regionally during the 1975-1982 rifting activity. The discharge chemistry previously encountered in the Krafla fumarole grounds was masked by a carbon dioxide-rich gas during the first weeks of rifting. The new discharge composition remained unchanged until 1983 when the first signs of recovery of the previous equilibrium composition appeared at the margins of the area. The outgassing carbon dioxide is released from the deep aquifers beneath the area by the interaction of magmatic gas with the hydrothermal system. In addition to juvenile magmatic carbon the outgassing contains carbon released from the hydrothermal system upon reaction with acid magmatic gases. Increased boiling of the hydrothermal fumaroles was induced by the lowering of the partial pressure of steam due to increased gas content in the fumarole conduits. At the center of rifting activity above the magma chamber the fumarole discharge was temporarily mixed with magmatic gases during local effusive activity. Hydrogen was the dominating magmatic gas in the discharge due to the preferred degassing of hydrogen from magma at shallow levels. These "hydrogen pulses" increased in magnitude and duration towards the end of rifting in 1982. The discharge chemistry correlates with the expansion of the magma reservoir of the volcano (regional change of long duration) and local volcanism (short-lived change, hydrogen pulses). The chemical monitoring of fumaroles in Krafla shows that the chemical surveillance of volcanos needs rapid methods for sampling and complete chemical analysis which can be interpreted in terms of reactions and magmatic processes. (Author's abstract)

OUDIN, E., THISSE, Y. and RAMBOZ, C., 1984, Fluid inclusion and mineralogical evidence for high-temperature saline hydrothermal circulation in the Red Sea metalliferous sediments: preliminary results: Marine Mining, v. 5, no. 1, p. 3-31. First author at Bureau de Recherches Géol. et Minières, Service Géol. Nat'l., B.P. 6009, 45060 Orléans Cedex, France.

Preliminary mineralogical, geochemical, and fluid inclusion results were obtained on a core sample collected in the hydrothermally active southwest (SW) basin of the Atlantis II Deep (Red Sea). The base-metal content of chemically precipitated oxide sediments is due to epigenetic circulation, while alternating sulfide and silicate layers are probably formed by overlaping base metal-rich chemical and epigenetic precipitation. Epigenetic precipitation forms discordant-to-pseudoconcordant sulfide-sulfate-rich zones, up to 50 cm thick, at the bottom of the core. The mineral association (the presence of anhydrite, pyrrhotite, chalcopyrrhotite, chalcopyrite, or ilvaite), the coarse grain size of the minerals, the metamorphism of the host sediment at the vein contact, and fluid inclusion studies indicate the high temperature of hydrothermal circulation in the unlithified sediment. The veins are equivalent to high-temperature hydrothermal vents recently discovered near 21°N on the East Pacific Rise. In the veins there are several generations of sulfates (anhydrite or barite) corresponding to the circulation of several fluids whose different temperatures and salinities are in good agreement with the temperature and salinity fluctuation observed over the past twenty years in the hot saline brine pool overlying the sediments. (Authors' abstract)

OZIMA, Minoru and PODOSEK, F.A., eds., 1984, Noble Gas Geochemistry: Cambridge Univ. Press, New York, 1983, 367 pp.

OZIMA, Minoru and ZASHU, Shigeo, 1984, Primitive $^3He/^4He$ ratio in terrestrial diamonds and its implication of the origin of noble gases in terrestrial planets (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 362-363 (in English). Authors at Geophys. Inst., Univ. Tokyo, Tokyo, Japan.

The $^3He/^4He$ ratios measured in 27 southern Africa diamonds range from 4.2×10^{-8} to 3.2×10^{-4}, with the three stones above 1×10^{-4}. We conclude that the initial helium isotopic ratio $(^3He/^4He)_0$ in the earth was significantly higher than that of the planetary helium ($^3He/^4He = 1.42 \times 10^{-4}$), but close to the solar helium ($^3He/^4He \simeq 4 \times 10^{-4}$).

The nearly solar type $(^3He/^4He)_0$ in the earth would suggest significant contribution of the solar type helium in the earth. We suggest that during T Tauri stage, the intense solar wind contaminated the solar nebula where the earth accreted. We propose that noble gases were captured either as the gravitational confinement by planetesimals (1) (Venus, Earth, Mars and helium in meteorites) or as absorption on dust grains (2) (the heavier noble gases in meteorites). The noble gases in the present planet atmospheres are then derived as degassing from the planets (Earth, Mars) and as the mixture of the remnant of the primary atmospheric noble gases and the degassed components (Venus). (Authors' abstract)

PAGEL, Maurice and POTY, Bernard, 1984, The evolution of composition, temperature and pressure of sedimentary fluids over time: a fluid inclusion reconstruction (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 134-135 (in English). First author at C.R.P.G. & Centre Rech. sur la Géol. de l'Uranium, Vandoeuvre lés Nancy Cedex, France.

Fluid inclusions have been studied in several sandstone-filled sedimentary basins. Inclusions from quartz overgrowths, quartz veins and carbonate cements are readily available for the determination of the evolution of composition, temperature and pressure of sedimentary fluids with time. The following Precambrian examples will be described: Athabasca sandstones (Saskatchewan - Canada), Kombolgie sandstones (Northern Territories - Australia) and Francevillian sandstones (Gabon).

These case studies and other cases from the literature have shown that the following problems have been solved with fluid inclusion studies: 1) origin of the detrital material; 2) chemical concentration of fluids related to silica diagenesis: presence of brines in the Athabasca and Kombolgie sandstones and more dilute solutions in the Francevillian sandstones; similar results have been obtained with carbonate cement; 3) evolution of temperature and composition of the fluids on a vertical log at a given time, for example at the beginning of the silica diagenetic cementation (Athabasca and Francevillian sandstones); 4) change of temperature and composition of fluid during diagenesis, from the beginning of quartz overgrowth to quartz veining (Kombolgie sandstones); 5) determination of the maximum temperature peak in a basin, in good agreement with crystallinity index of illite but with larger application possibilities.

Fluid inclusions represent a good tool for studying the evolution of P-T-X diagenetic fluid over time and space. These studies should be developed in the near future in relationships to petroleum reservoir and mineralized areas. The only published data about a petroleum source-rock from Venezuela (Visser, 1982) show that there is a good agreement with maximum diagenetic temperature deduced from well logs and temperature determined by fluid inclusions. At the present time, few comparisons between coal rank and fluid inclusions are available but large discrepencies could be envisaged in relation to tectonic activities and hydrothermal processes. (Authors' abstract)

PANCHAPAKESAN, V. and DHAR, D., 1984, Geothermometric studies on secondary minerals in Deccan traps: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 27. Authors at Indian Inst. Tech., Powai, Bombay 400076.

Fluid inclusion studies were carried out in calcite and quartz crystals associated with zeolites. Samples were studied from the following different zeolite assemblages to study the temperature dependence of zeolite mineralogy.

(1) Virar area.
(2) Kandivli area...Laumontite-calcite, okenite, gyrolite etc.
(3) Powai area...Laumontite-calcite.
(4) Lonavla-Khandala...Heulandite-stilbite-mesolite-quartz.
(5) Pashan (Pune)...Heulandite-apophyllite, stilbite.

Inclusions of Kandivli and Powai show a high Th compared to the Lonavla samples. Virar and Pashwan samples have monophase liquid inclusions indicating a low T of fluid entrapment.

Geothermometric data and zeolite mineralogy agree well with the theory that the hydration is the predominant factor of zeolite paragenesis. As an execution(sic) scolecite, which is less hydrous than laumontite, is associated with lower T groups. Between these two minerals the lower level of energy of scolecite seems to have decided its lower T of crystallization. (Authors' abstract)

PANKOV, V.Yu. and OLEYNIKOV, B.V., 1983, Native copper and zinc in primary magma-crystallization products of the Great Tolbachik fissure eruption: Dokl. Akad. Nauk SSSR, v. 270, no. 6, p. 1467-1470 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 180-182, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 196, 1983. (E.R.)

PANKRATZ, L.B., 1984, Thermodynamic properties of halides: U.S. Bureau of Mines Bulletin 674 (U.S. Dept. of Interior)(Bureau of Mines), 826 pp.

PANNO, S.V., SAYRE, E.V., HARBOTTLE, Garmen and BROOKINS, D.G., 1984, A preliminary investigation of host rock alteration associated with zinc-lead mineralization in the Metaline district, Washington (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 617.

PANOV, B.S., KORCHEMAGIN, V.A., KUPENKO, V.I., KRAMARENKO, A.I., FEDOTOV, S.M. and PILOT, I., 1984, Isotopic and geochemical characteristics of the Donetsk mercury ore occurrence: Izv. Vyssh. Uchebn. Zaved., Geol. Razved., v. 27, no. 11, p. 40-44 (in Russian). Authors at Donetsk. Politekh. Inst., Donetsk, USSR.

$\delta^{13}C$, $\delta^{18}O$, and Th were determined on 14 samples. Th ranged from 49-80°C. (E.R.)

PANTELEYEV, Andre, 1984, Precious metals in the Cordillera: A focus on the transition from porphyry copper to hotspring settings (abst.): CIM Bulletin, v. 77, no. 869, p. 36-37. Author at Min. Energy, Mines & Petrol. Resources, Government of British Columbia, Victoria, Canada.

Gold and silver in the Canadian Cordillera (1982 production 10,400 kg Au and 593,000 kg Ag) has come mainly from traditional sources such as placer deposits and veins, as well as by-products from porphyry copper, skarn, and massive sulphide deposits.

Recent interest has focused on deposits of the 'epithermal-type,' also called 'bonanza ores,' 'fossil hotspring,' or 'precious metal deposits of volcanic association.' These vein or large-tonnage bulk deposits are associated with structurally controlled, zoned alteration assemblages that are commonly related to resurgent calderas in subaerial volcanic terranes. The precious metal mineralization (native gold or electrum) occurs by itself, with pyrite, or with base metal sulphides and sulphosalts in silicified zones. The zones form veins, stockworks, diffuse fractured zones, amethystine breccias, and chalcedonic lenses. Common alteration consists of propylitic and argillic assemblages with less common adularia, advanced argillic (pyropyhyllite, andalusite, diaspore), or quartz-alunite. Typical geochemical signatures show enrichment of Au, Ag, As, Sb, Hg, W, Mo, Ba, F, and Tl. Ore deposition as determined from fluid inclusion data appears to take place between temperatures of 290°C and 220°C due to intermittent boiling or effervescence, mixing of fluids, or simple cooling of hydrothermal fluids as they approach surface.

Subdivision of epithermal deposits according to host lithologies reveals two main associations: those with volcanics and those with sedimentary rocks (mainly calcareous siltstones). The volcanic-hosted deposits can be further subdivided into three precious metal associations. Andesitic terranes that commonly contain bimodal basalt-rhyolite suites host most of the gold and gold-silver deposits. Areas with predominantly rhyolitic volcanics and sub-volcanic intrusions tend to be rich in silver. Alkaline volcanic-intrusive suites have a characteristic gold-telluride association. (Author's abstract)

PAPIKE, J.J., JENSEN, M., SHEARER, C.K., SIMON, S.B., WALKER, R.J. and LAUL, J.C., 1984, Apatite as a recorder of pegmatite petrogenesis (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 617. First author at Inst. for the Study of Mineral Deposits, S.D. Sch. Mines & Tech., Rapid City, SD 57701.

Apatite is a common accessory phase occurring in most zones of granitic pegmatites and is a potentially important recorder of post-emplacement pegmatite evolution. This phase is an important "sink" for REE's and also incorporates the anions OH^-, F^-, and Cl^-. Because the partitioning of these constituents is different between apatite/melt and apatite/fluid, study of the chemistry of apatite from the various zones, fracture fillings, and replacement units may help in deciphering when a fluid phase exsolves, what parts of the pegmatite crystallize from a fluid phase, and what the nature of this phase is. To address these questions, apatites from six pegmatites from the Black Hills, S.D., were studied. These include four zoned, complex pegmatites (Dan Patch, Hugo, Peerless, Tin Mountain) and two smaller dikelike deposits (King Lithia, Warren Draw). Concentrations of approximately thirty-two elements were determined by a combination of microprobe, INAA, isotope dilution, ion selective electrode, and coulometric techniques. Preliminary conclusions include: (1) Apatite crystallizing from most zones, other than replacement units and fracture fillings, is fluorapatite, $Ca_5(PO_4)_3F$, (2) The major substitution for Ca is by Mn, 0.01 to 0.47 atoms per formula unit, (3) In general, progression from outer zones to inner zones is reflected by a decrease in the amounts of minor and trace elements (Mn, Fe, Sr, REE's), associated with a corresponding increase in Ca, (4) REE patterns and (OH + Cl)/F ratios are distinctly different for apatite from the "normal zones" compared to replacement units and fracture fillings indicating that apatite crystallized from two distinct media (melt vs. fluid phase?). High (OH + Cl)/F is a particularly diagnostic indicator of late stage, presumably fluid-derived, pegmatite units. (Authors' abstract)

PAQUET, Jacques and DHAMELINCOURT, Paul, 1984, Analysis by Raman molecular microprobe mole and by electron microprobe of glasses and tiny inclusions of an acid xenolith: Bull. Minéral., v. 107, p. 619-626 (in French; English abstract. First author at L.A.-C.N.R.S. 234, Structure et Propriétés de l'Etat Solide.

Glasses, minerals and tiny inclusions as melting products of a xenolith have been analyzed with molecular microprobe and electron microprobe. These methods permit characterization of glasses both without and with crystalline inclusions smaller than a micron. Numerous glasses without inclusions exhibit flat and featureless Raman spectra. In contrast, others exhibit broad bands which are well known in spectra obtained by conventional Raman spectrometry. The rhyolitic and mafic glasses contain tiny inclusions: the spectra exhibit peaks, the high intensity of which emphasizes the great number of microcrystals and their homogeneous distribution. The acid glasses contain inclusions of K-Na feldspars and magnetite: the mafic ones contain inclusions of olivine. The very small size inclusions in crystals can be evidenced with a similar accuracy. Their determination is obtained by using basic spectra established in larger size crystals. (Authors' abstract)

PARILOV, Yu.S, MITRYAEVA, N.M., FORMICHEV, V.I. and MIKHALEVA, V.A., 1984, Conditions of the formation of lead-zinc ores in the Karatau Range: Izv. Akad. Nauk Kaz. SSR, Ser. Geol., no. 2, p. 13-23 (in Russian). Authors at Inst. Geol. Nauk, Alma-Ata, USSR.

Determinations were made of the morphology, vacuum Th, and composition of salts, gases, and liquids in quartz and other minerals of the Karatau Range Pb-Zn deposits. The fluid inclusion studies support the idea that these deposits represent a combination of hydrothermal-sedimentary and epigenetic hydrothermal mineralizations. The hydrothermal-sedimentary ores accumulated in shallow-water marine basins, with an endogenic source of metals from thermal (<100°) brines containing 4% gases (H_2S, CO_2, N_2) and 15-22% salts (chlorides, fluorides, sulfates, and bicarbonates of Na, K, Mg, and Ca). Dislocation metamorphism of these ores occurred at 100-110°; pore solutions consisted of H_2O 54-57, gases (mainly CO_2) 10-20, and salts 25-35% (Ca and Mg bicarbonates). During the endogenic period, in two stages, the ores formed at 200-60° with involvement of hydrothermal solutions containing H_2O 71-85%; 1-8% $H_2S + CO_2 + SO_3$ and other gases; and 14-25% chlorides, fluorides, and sulfides of Na, K, Ca, and Mg. (C.A. 100: 213185j)

PARKHURST, D.A., BROWN, G.E., PARKS, G.A. and WAYCHUNAS, G.A., 1984, Structural study of zinc complexes in aqueous chloride solutions by fluorescence EXAFS spectroscopy (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 618.

PARKS, G.A., 1984, Surface and interfacial free energies of quartz: J. Geophys. Research, v. 89, no. B6, p. 3997-4008. Author at Dept. Applied Earth Sci., Stanford Univ., Stanford, CA 94305.

Water and electrolytes cause significant changes in brittle fracture strength and subcritical fracture propagation velocities in quartz and quartz rocks. The changes may be caused, in part, by changes in surface free energy. Experimental fracture surface energies of quartz range from about 400 mJ m^{-2} to about 11.5 J m^{-2}. Thermodynamic surface free energies are likely to be lower than fracture surface energies owing to dissipative energy losses and failure to achieve equilibrium surface structure. Thermodynamic surface free energies are sensitive to environmental composition. Reaction of water vapor with pristine fracture surfaces reduces surface energy by hydroxylation, but the extent of reduction is not known. Adsorption of water vapor on the hydroxylated surface and immersion in liquid water reduce surface energy by 75-230 and 72 mJ m^{-2} respectively. In an electrolyte, the surface free energy is maximum at the point of zero charge, where adsorption of ionic solutes is least. Adsorption of hydrogen ion, hydroxide ion, and electrolytes reduce surface energy as concentration increases, by tens of mJ m^{-2}. All of these surface energy changes are qualitatively consistent with changes in fracture behavior caused by the same variable. (Author's abstract)

PARRY, W.T., 1984, Fluid pressure, temperature, and composition at depth on the Wasatch Fault, Utah, <u>in</u> Proc. of Conf. 26, A Workshop on "Evaluation of Regional & Urban Earthquake Hazards and Risk in Utah," W.W. Hays and P.L. Gori, eds.: U.S. Geol. Survey Open-File Rpt. 84-763, p. 366-383. Author at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

Hydrothermally altered Oligocene quartz monzonite of the Little Cottonwood stock forms the footwall of the Wasatch Fault at the southern end of the Salt Lake segment. Hydrothermally altered and structurally deformed rocks form a partially preserved carapace up to 100 m thick on the western and southern margin of the stock. Cataclasite and phyllonite contain two syndeformational alteration mineral assemblages: an early epidote, chlorite, sericite assemblage and a later laumontite-prehnite assemblage. Fluid inclusions associated with the formation of alteration minerals are preserved in healed fractures in quartz grains.

Fluid inclusions associated with the chlorite-epidote-sericite alteration were trapped at a minimum temperature of 295°C and minimum fluid pressure of 1100 bars. The fluids average 10 mole percent CO_2 and 6.7 weight percent NaCl. Published radiometric and fission track dating suggests that the age of the alteration is about 24 m.y. and a thermal gradient of 30°C/km suggests that the depth of alteration is about 9.5 km. Estimated hydrostatic pressure at 9.5 km is 930 bars and lithostatic pressure is 2400 bars. Estimated fluid pressure on the fault is thus 170 bars in excess of hydrostatic pressure. (Author's abstract)

PARRY, W.T., BALLANTYNE, J.M. and JACOBS, D.C., 1984, Geochemistry of hydrothermal sericite from Roosevelt Hot Springs and the Tintic and Santa Rita porphyry copper systems: Econ. Geol., v. 79, p. 72-86. First author at Dept. Geol. & Geophys., Univ. Utah, Salt Lake City, UT 84112.

Compositions of hydrothermal sericite from the Roosevelt Hot Springs geothermal area, the southwest Tintic porphyry copper prospect, and the Santa Rita porphyry copper deposit were determined by electron microprobe methods and calculated to muscovite, paragonite, pyrophyllite, phengite, and fluorine end members. These data were used with thermodynamic and experimental data to estimate chemical characteristics of the hydrothermal fluid associated with the sericite.

The ratio $a(Na^+)/a(K^+)$ in the hydrothermal fluid computed from sericite composition is in agreement with the ratio estimated from solution measurements at Roosevelt Hot Springs and fluid inclusion studies in porphyry copper systems and is lower than the value predicted from albite-K-feldspar-sericite equilibria. Comparison of compositions of coexisting biotite and sericite at Santa Rita indicates they have exchanged fluorine with similar fluids. The sericite at Roosevelt Hot Springs exchanged F with the present geothermal fluid. Log $(f(H_2O)/f(HF))$ estimated from sericite composition is 5.59 to 6.45 at Roosevelt, 4.84 to 5.66 at southwest Tintic, and 5.20 to 6.01 at Santa Rita. (From the authors' abstract)

PASCAL, M.L., 1984, Nature and properties of species in solution in the system K_2O-Na_2O-SiO_2-Al_2O_3-H_2O-HCl: Ph.D. dissertation, Univ. Paris, Paris, France (in French).

PASSCHIER, C.W., 1984, Fluid inclusions associated with the generation of pseudotachylyte and ultramylonite in the French Pyrenees: Bull. Minéral., v. 107, p. 307-315. Author at Dept. Geol., Univ. College of Swansea, Swansea SA2 9PP, UK.

In the Saint-Barthelemy Massif, French Pyrenees, narrow ultramylonite and pseudotachylyte bands were generated in a major ductile shear zone at the end of a retrogressive mylonitic event. Ultramylonite bands formed partly by grain size reduction and recrystallization mechanisms and partly by ductile deformation of pseudotachylyte. Microthermometry shows that fluid inclusions in the major shear zone contain pure CO_2, and are never aqueous. The low water content of the rock probably hampered hydrolitic weakening during mylonitic deformation. As a result, ultramylonite and pseudotachylyte bands were formed at 2-3.5 kbar and 450-550°C. The relatively high temperature of the host rock is probably the main cause for ductile deformation of pseudotachylyte. Fluid inclusion study can be an important method to detect depth of pseudotachylyte generation. (Author's abstract)

PASTERIS, J.D., 1984, Kimberlites: complex mantle melts: Ann. Rev. Earth Planet. Sci., v. 12, p. 133-153. Author at Dept. Earth & Planet. Sci., Washington Univ., St. Louis, MO 63130.

A review of kimberlites, with discussion of the role of CO_2 and H_2O in forming and modifying such melts. (E.R.)

PASTERIS, J.D., WOPENKA, Brigitte and FREEMAN, J.J., 1984, Some geologic applications of the laser Raman microprobe (abst.): Abstracts of the Am. Chem. Soc. Meeting, April 1984, St. Louis, Div. of Geochemistry (unpaginated). First author at Dept. Earth & Planet. Sci. and McDonnell Center for Space Sci., Washington Univ., St. Louis, MO 63130.

The laser Raman microprobe permits spectroscopic analysis of solid, liquid, and gas phases as small as a few micrometers. In this technique, the sample is imaged through the high-power objective of an optical microscope. Then a laser beam follows the same optical path and causes Raman scattering in the sample. The technique is non-destructive, permits pinpoint analysis of materials that are enclosed in a transparent matrix, and can be used on normal polished thin-sections. Some of its important geologic applications are the analysis of fluid and mineral inclusions in grains and the structural characterization of phases (e.g., degree of crystallinity, distinguishing between polymorphs). Raman spectroscopy is well suited for analysis of such species as CO_2, CH_4, H_2S, and N_2 in fluid inclusions. Theoretical calculations permit semi-quantitative estimates of proportions of these species in multicomponent fluid inclusions. It may be possible to improve quantification by calibrating with standard fluid inclusions of precisely known compositions. (Authors' abstract)

PATIL, R.R., 1984a, Significance of fluid inclusion study in geology: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 1. Author at Wadia Inst. Himalayan Geol., Dehra Dun-248001, India.

A review. (E.R.)

PATIL, R.R., 1984b, Current research in geological applications of hydrocarbon fluid inclusion techniques and their implications for petroleum geology: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 16. Author at Wadia Inst. Himalayan Geol., Dehra Dun-248001, India.

The fluid inclusions trapped during growth of the minerals developed in the cavities in the reservoir rocks or in cements are the well preserved remnants of the fluids present in the subsurface at various times in the burial history of the rock. The inclusion petrography under the fluorescent microscope revealed their composition ranging from pure methane to solid black bitumen. Reliable data from the inclusion study are presented and the fluid inclusion evidence on the environments of diagenesis, and during oil formation and migration are discussed. The data on the applicability of this technique in learning the origin of the fractures, paleothermal gradients, pore fluid salinity, incipient fracture porosity, tectonic history, evolution of sedimentary basin, geohistory analysis and in knowing relative timing of oil migration from various basins from available literature are the basis of this paper to highlight the wide utility and scope of this microtechnique in exploration of petroliferous basins from India. (Author's abstract)

PATIL, R.R., 1984c, Petrological and tectonic significances of exploded fluid inclusions in quartz veins and fissures from Upshi-Kiari area, Ladakh Himalaya: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 24. Author at Wadia Inst. Himalayan Geol., Dehra Dun-248001, India.

Transparent well developed quartz crystals from quartz veins intruding the Indus flysch rocks of Kiari and Upshi-Gaya areas were studied in the laboratory to know their inclusion peculiarities and morphology. The doubly polished plates prepared in three orientations from prismatic quartz permitted detailed observation of the growth pattern of the individual crystal. Two distinct growth stages of the quartz are recognized: an early stage influenced by tectonic and associated metamorphism and a late stage indicative of slow and steady growth, enveloping the earlier growth stage. The inclusions characteristics of these stages varied widely in the early stage represented by highly dense carbonic inclusions (Th 318-346°C), by exploded inclusions surrounded by daughter inclusions and also by remobilized inclusions, while the late stage is characterized by biphase aqueous inclusions of higher density (Th 172-180°C). This study indicates that the syntectonic fissure development in the Indus flysch and extensive carbonic fluid circulation resulted in development of quartz crystal in the early stage while the slow and steady growth influenced by presence of water resulted in the prismatic later growth. It is also presumed that the carbonic fluid inclusions in crystals exploded after the early stage and before the late stage crystallization of quartz by the influence of post metamorphic thermal flow. Isotopic studies envisaged may throw more light on the origin of this carbonic fluid. (Author's abstract)

PATIL, R.R., 1984d, A study of the trapped gases in inclusion using an indigneously fabricated crushing stage: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 28. Author at Wadia Inst. Himalayan Geol., Dehra Dun-248001, India.

An improved version of the crushing microscope stage has been fabricated locally. The design and operation of the stage are presented. The stage, though inexpensive, has many advantages over the previously fabricated stage. It can be easily mounted on the microscope stage and permits easy operation and observation. This crushing stage is of value to obtain a semi-quantitative but exceedingly sensitive measure of vapor pressure of non-condensable gases and a rough quantitative estimate of the composition of these gases. This stage can also be used to estimate lower limit of the pressure in the inclusion, in knowing composition of trapped gases, to confirm the leakage (in or out) of inclusions and to ascertain the diffusion of gases in effusive rocks. Crushing studies on fluorite, halite, zeolite and calcite from some Indian occurrences are presented to substantiate the utility of this unit. The purpose of this paper is to highlight practical importance of this device and to identify the areas of application in relation to the Indian scene. (Author's abstract)

PAVLISHIN, V.I., MEL'NIKOV, V.S. and VOVK, P.K., 1983, Typomorphism of minerals and origin of chamber pegmatites, in Geology and genesis of pegmatites: "Nauka," Leningrad, p. 131-145 (in Russian). First author at Inst. Geochem. and Physics of Minerals, Kiev, Ukraine.

Th of melt inclusions in quartz of high-T granites are ~830°C; pegmatitic quartz yields Th from 600 (reticulate quartz) to 350°C (morion), pegmatitic albite - three Th intervals: about 400°C, 365-350°C and 320-300°C, fluorite - 415-340°C, siderite 340-290°C. (A.K.)

PAVLOVA, L.K., 1983, Gold ore mineralization in skarns of the Kuznetskiy Alatau and Gornyi Altai, in Conditions of formation and principles of prognosis and prospecting for gold ore deposits (Transactions of Inst. Geol. and Geophysics, v. 538), p. 80-94 (in Russian).

Gold-bearing skarns formed at (Th) 700-280°C (inclusions in quartz and garnets) from alkaline reducing solutions. (A.K.)

PAVLUN, N.N., 1984a Thermobarogeochemical prospecting and valuation criteria for molybdenum-tungsten greisen mineralization of Central Kazkhstan (by inclusions in minerals): Min. Sbornik, v. 38, no. 2, p. 45-54 (in Russian; English abstract).

This paper describes the significance of thermobarogeochemical criteria for the development of commercial molybdenum-tungsten mineralization on the example of Central Kazakhstan deposits. The conform of the exsposed this mineralization are recommends. The shame of the development of ore-forming fluids in the time are proposed[sic]. (Author's abstract)

PAVLUN', N.N., 1984, Thermobarogeochemical zoning of Akchatau molybdenum-tungsten deposit in Central Kazkhstan: Akad. Nauk SSSR Doklady, v. 279, no. 6, p. 1450-1454 (in Russian). Author at L'vov State Univ., L'vov, Ukraine.

Essential ore associations are developed in concentric zones in an ore-bearing granitoid massif. The earliest (central) molybdenite-quartz association is replaced by rare-metal-molybdenite-wolframite-quartz, and next by pyrite-wolframite-quartz associations. Toward the deeper parts of the deposit and toward the vein junctions the thermal gradient equals 20 to 30°C/100 m (Th data). Horizontal T change is lower - about 10°C/100 m. Increase in depth is associated with change from dilute solutions to brines and next to pneumatolytic supercritical solutions. Molybdenite-quartz association formed at 440-320°C (all Th), 1200-1000 bars, conc. (all NaCl+KCl) 41-27 wt. %, rare-metal-molybdenite-wolframite-quartz association - at 480-300°C, 1600-700 bars, 65-30 wt. %, pyrite-wolframite-quartz association - at 415-260°C, 750-500 bars, 48-28 wt. %. At deep levels parent solutions are rich in hydrosilicate ion (F 0, Li 6, $HSiO_3$ 72, Na 77), essential ore parageneses yielded the following composition of water leachates: F 14, Li 2, K 14 to 22, Cl 62 to 72, Na 73 to 78, late ore parageneses and those formed above ore levels - F 0, Li 1, Cl 54, $HSiO_3$ 46, Na 73. Such zoning was in part caused by periodic boiling of solutions, but also by T and P gradients during ore formation. The reconstruction of zoning helps in determination of thickness of eroded ore-bearing rocks and prospecting for new ore bodies. (Abstract by A.K.)

PECHER, Arnaud and BOULLIER, A.-M., 1984, High pressure/high temperature evolution of fluid inclusions in synthetic quartz: Bull. Minéral., v. 107, p. 139-153. Authors at Ecole des Mines, Lab. Géol., Parc de Saurupt, 54042 Nancy Cedex, France.

Samples from a single synthetic quartz crystal containing fluid inclusions (F.I.) have been heated in a gas apparatus at T = 448°C corresponding to an internal pressure Pi of 282 MPa in the inclusions. The argon confining pressure was either lower (eight runs at Pc = 200 MPa, duration 69 h to 3,064 h) or higher (one run at Pc = 350 MPa, duration 2,086 h) than Pi. Comparison of the F.I. before and after the runs shows major shape modifications together with measurable density variations. Two re-equilibration processes are observed and discussed:

- Some F.I. have suffered decrepitation as evidenced by microcracks which are often completely sealed (appearance of clusters of secondary F.I.). This decrepitation is associated with a strong decrease of density due to a volume increase of the cavity. Th measurements indicate the "fossilization" of a new equilibrium in which $Pi \simeq Pc$.
- Non-decrepitated F.I. show a progressive evolution of their shape and density. Negative crystal shapes are quickly reached, the L/l ratios of which decrease down to a limiting value of about 3. When Pi is greater than Pc, Th increases progressively with time (ΔTh up to +10°C, i.e. density decrease of 0.015). OH diffusion and/or rehydration of the host quartz are proposed as possible explanations of this density decrease. When Pi is lower than Pc, density increases, although the mechanism is at present unknown. (Authors' abstract)

PERCHUK, L.L., 1983, System alkali basalt-water. I. Analysis of product of experiments near the liquidus under P = 15 kbar: Essays on physicochemical petrology, v. 11, p. 103-120 (in Russian).

The paper describes phenomena of metastability in the liquidus area, Al and Fe distribution in clinopyroxene, decrease of zoning in clinopyroxene and stable association clinopyroxene + olivine approaching liquidus line.(A.K.)

PERKINS, D. and CHIPERA, S.J., 1984, Garnet-cordierite-plagioclase-quartz assemblages as indicators of water fugacity (abst.): EOS, v. 65, p. 292-293.

PETERS, Tj. and HOFMANN, B., 1984, Hydrothermal clay mineral formation in a biotite-granite in northern Switzerland: Clay Minerals, v. 19, p. 579-590. Authors at Mineral.-Petrogr. Inst., Univ. Berne, Balzerstrasse 1, Berne, Switzerland.

Clay minerals of several hydrothermally altered zones in a 1200-m biotite-granite core from a drill hole in northern Switzerland were studied microscopically, by XRD and by electron microprobe. The minerals principally affected by the hydrothermal alteration were plagioclase (An_5-An_{20}) and, to a lesser extent, biotite. Illite, regularly interstratified illite-smectite and dioctahedral chlorite-smecite dioctahedral chlorite, trioctahedral chlorite and kaolinite were detected in the alteration products. Commonly, two or more clay minerals occurred together in pseudomorphs after plagioclase. The mineral chemistry of the clay minerals showed a predominance of the substitution KAl for Si and, to a lesser extent, MgSi for Al. Fluid-inclusion data and the absence of pure smectite and epidote indicated temperatures of ~200°C for the fluid that caused this alteration. (Authors' abstract)

PETROV, P.P. and MIHAEL, K.G., 1982, Mineral-thermometry studies in the Studenec copper-molybdenum deposit: God. SU Geol.-Geogr. Fak., v. 73, 1979, no. 1, 1982, p. 175-182 (abstract from Bulgarian Acad. Sci. Abstracts of Bulgarian Sci. Literature, Geosciences, no. 1, 1984, p. 35-36).

The ores in the Studenec deposit (Plana Mt., Srednogorie metallogenic zone) consist of copper-molybdenum mineralization of porphyry copper type with quartz-magnetite-hematite, quartz-pyrite-molybdenite, quartz-bornite-chalcopyrite, quartz-molybdenite and carbonate-zeolite mineral parageneses and a later pyrite-polymetallic vein mineralization. The microthermometry studies of fluid inclusions in quartz (and partly in calcite) show low temperatures of mineral formation: 190-170°C for the Cu-Mo mineralization and 250-240°C for the polymetallic one. Compared with analogous porphyry Cu and Cu-Mo deposits, this one is of lowest temperature. The small thickness of the metasomatic zones and the low concentration of salts in the fluids are further indications of mineral formation from low-temperature solutions generated at shallow depths. (Authors' abstract)

PETRUKHA, L.M. and VERSHININ, A.S., 1983, Genesis of nickel silicate ore in solution cavities: Dokl. Akad. Nauk SSSR, v. 268, no. 5, p. 1195-1198 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 91-94, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 202, 1983. (E.R.)

PHILLIPS, G.N. and GROVES, D.I., 1984, Fluid access and fluid-wall rock interaction in the genesis of the Archaean gold-quartz vein deposit at Hunt Mine, Kambalda, western Australia, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 389-416. Authors at Dept. Geol., Univ. Western Australia, Nedlands, 6009, Australia.

Gold mineralization at the Hunt Mine, Kambalda, is situated within a major steeply-dipping schist zone cutting a thick sequence of metabasalts. The overlying more ductile ultramafic rocks and, in places, pre-existing massive Fe-Ni-Cu sulphide ore, have acted as an effective barrier to fluid flow up the schist zone and led to preferential hydraulic fracture of the more component metabasalt. An extensive set of quartz veins within the schist zone terminates abruptly at the contact with the ultramafic sequence, whether Fe-Ni-Cu sulphides are present or not. The fracturing and veining of felsic dykes within the schist zone, combined with their alteration (compatible with other wall rocks), suggest that such dykes have no direct relation to gold genesis.

Fluid-wall rock interaction has produced a series of alteration zones and auriferous quartz veins at Hunt Mine. The pattern comprises a broad zone of carbonation in which calcic-amphibole and some chlorite are replaced by ankerite and calcite, a less-extensive zone where biotite replaces chlorite, and an even narrower zone of pyritization adjacent to the quartz veins. CO_2, S and K are the main added components. The formation of pyrite at the expense of Fe-Mg silicates has stabilized more-magnesian chlorite and biotite adjacent to the quartz veins, and also caused fluid reduction. High gold values are virtually restricted to this zone of pyritization.

Fluid inclusion data suggest 300-350°C, H_2O-CO_2-rich fluids of low salinity were responsible for the Hunt hydrothermal alteration. These data, the alteration assemblages and the location of the gold suggest that gold, transported as reduced sulphur complexes, was deposited in response to fluid reduction and the lowering of total sulphur in solution, both a result of pyritization.

The Hunt gold deposit was the result of hydraulic fracture of a more competent unit near a lithologic contact, plus a chemically favorable host in which fluid-wall rock interactions resulted in deposition of gold. Regional uplift appears to have been important in triggering hydraulic fracture in the Hunt Mine environment. (Authors' abstract)

PICHAVANT, M., 1984, The effect of boron on liquidus phase relationships in the system Qz-Ab-Or-H_2O at 1 kbar (abst.): EOS, v. 65, p. 298. Author at Centre de Recherches Pétrogr. & Géoch., B.P. 20, 54500, Vandoeuvre les Nancy, France.

Liquidus phase relationships have been determined in the system Qz-Ab-Or-H_2O with added B_2O_3 (1, 4.5 wt%) at 1 kbar under H_2O-saturated conditions. Starting materials consist of boron-bearing glasses and 10 wt% distilled H_2O. Liquidus temperatures are almost unchanged for compositions in the quartz field, compared to the boron-free system. Liquidus temperatures for compositions in the alkali feldspar field are markedly decreased (30°-40°C for 1 wt% B_2O_3; 120°-150°C for 4.5 wt% B_2O_3), compared to the boron-free system. The resulting minima move progressively towards the albite corner with increasing B_2O_3 contents: $Qz_{35}Ab_{37}Or_{28}$ (1 wt% B_2O_3), $Qz_{31}Ab_{46}Or_{23}$ (4.5 wt% B_2O_3) and closely follow the locus of the minima and eutectics in Qz-Ab-Or-H_2O with increasing H_2O contents. The minimum temperatures are reduced by 30° and 90°C respectively, compared to the boron-free system. H_2O solubility in melts increases with melt boron content.

The observed shift of the minimum compositions is interpreted to result mainly from the increase of aH_2O in hydrous boron-bearing Qz-Ab-Or melts. B is considered present as $B(III)O_3$ units dispersed within the aluminosilicate network and mostly acts as a flux. The composition of boron-rich silicic magmas (up to 1 wt% B_2O_3) plot close to the boron-free, low $P(H_2O)$ minima in Qz-Ab-Or. This suggests that B alone will not have large effects upon the composition of residual melts. However, the combined effects of B and other volatiles (notably F) explain the generation of albite-rich residual silicic magmas by fractional crystallization rather than diffusion-based, liquid-state models (e.g., Macusani glasses). (Author's abstract)

PICHAVANT, Michel and MANNING, David, 1984, Petrogenesis of tourmaline granites and topaz granites; the contribution of experimental data: Physics of the Earth & Planet. Interiors, v. 35, p. 31-50.

PICKETT, D.A. and STOPLER, E.M., 1984, Thermometry of rhyolitic obsidians based on water speciation (abst.): EOS, v. 65, no. 45, p. 1128. Authors at Div. Geol. Planet. Sci., Caltech, Pasadena, CA 91125.

We have studied the effects of temperature on the relative concentrations of molecular water and OH groups in three obsidians of differing total H_2O contents (0.96, 1.39, and 1.75 wt. %) from Mono Craters, CA. Glass samples were held in air at temperatures ranging from 400 to 660°C and then quenched. Concentrations of OH and H_2O in the quenched glasses were determined by near-IR spectroscopy. The ratio of molecular water to OH varies smoothly and reversibly with temperature in these samples, decreasing with increasing temperature.

Our results suggest that H_2O/OH ratios can be used for geothermometry of volcanic glasses with appreciable water contents. Most obsidian clasts from tephra deposits from recent Plinian eruptions at Mono Craters indicate temperatures of 450-600°C. Temperatures indicated for the higher water content glasses are typically at least 50°C cooler than the lower water content glasses. These could represent actual eruption temperatures or closure temperatures for the thermometer on cooling of the obsidians.

Several lines of evidence suggest that if the glasses record closure temperatures, actual eruption temperatures could not have been much higher than the closure temperatures. Our low water sample begins to vesiculate and flow at ~610°C and our high water sample does so at ~550°C. The unvesiculated and angular nature of the clasts we have studied thus suggests that eruption temperatures were not significantly higher than those recorded by the speciation of water.

If our results represent eruption temperatures, they are much cooler than expected magmatic temperatures and than temperatures recorded by other geothermometers in low water (<0.2%) dome obsidians. This could suggest cooling of the rhyolitic magma in the vent prior to eruption or thermal equilibration of the clasts with a gas cloud at 500-600°C during the eruption. (Authors' abstract)

PICKTHORN, W.J., 1984, Stable isotope study of quartz veins in the Port Valdez gold district, in The United States Geological Survey in Alaska; accomplishments during 1982, D.M. Reed and S. Bartsch-Winkler, eds.: Geol. Survey Circular 0939, p. 67-90. Author at U.S. Geol. Survey.

Gold mineralization in the Port Valdez district occurs principally in high-grade fissure veins within greenschist facies rocks of the Cretaceous Valdez Group. Both barren and mineralized quartz veins are commonly found in the Port Valdez district. Oxygen isotope analyses of these two types of quartz veins and hydrogen isotope analyses of their inclusion waters were performed in order to determine the origins of the fluids from which the veins formed. The data suggest that meteoric water was a significant but not dominant component of the hydrothermal fluid.

Of particular importance from an exploration standpoint is the difference in measured d values for the barren and mineralized quartz veins. The mineralized quartz veins have slightly lower $d^{18}O$ and significantly lower dD values compared to those of the barren veins. (From the author's text)

PICKTHORN, W.J. and SILBERMAN, M.L., 1984, Structural relations and fluid-inclusion data for mineralized and nonmineralized quartz veins in the Port Valdez gold district, Valdez quadrangle, southern Alaska: USGS Circular

CO 868, Accomplishments in Alaska, p. 86-89.

Fluid inclusions in the metamorphic-segregation and mineralized veins have different characteristics. Th values in the range 110-235°, with most values in 140-180°C for both types. Vapor-dominated inclusions in the mineralized-vein samples suggest boiling. The metamorphic group show 8.5-10 wt.% NaCl, but the mineralized samples show <6.5 wt.% and some show metastable superheated ice. (E.R.)

PILLINGER, C.T., 1984, Light element stable isotopes in meteorites--from grams to picograms: Geochimica Cosmo. Acta, v. 48, p. 2739-2766. Author at Planet. Sci. Unit, Dept. Earth Sci., The Open Univ., Walton Hall, Milton Keynes, MK7 6AA, U.K.

Fifty years work in the study of isotopes of hydrogen, carbon, nitrogen, oxygen and sulphur in meteorites is reviewed to mark the anniversary of the first paper dealing with the subject (Manian et al., 1934). Papers up to and including those presented at the 15th Lunar and Planetary Science Conference (March 1984) are included. (Author's abstract)

PIPEROV, N.B., 1984a Brief review of modern methods for analysis of gas-liquid inclusions in minerals: 27th Int'l. Geol. Congress, Moscow, 4-14 Aug., 1984, Proc. Sect. 5-10, Mineralogy, p. 76-85 (in Russian; see also Ref. Zh., Geol., 1984, Abst. 11V172, and CA 102(4)38727e).See next item.

PIPEROV, N.B., 1984b A concise review of the up-to-date methods for the chemical analysis of the fluid inclusions in minerals: Proc. 27th Int'l. Geol. Congress, Moscow, 4-14 August 1984, Vol. 10, Mineralogy, p. 165-184. Author at Bulgarian Acad. Sci., Inst. General & Inorganic Chem., Sofia, Bulgaria.

A review (31 references) of the destructive and nondestructive methods. (E.R.)

PITZER, K.S., LI, Yi-gui, PEIPER, J.C., PHUTELA, R. and SIMONSON, J.M., 1984, Thermodynamics of the system NaCl-H_2O to 823 K with estimates to 3900 K: Earth Sci. Div., Annual Report, Lawrence Berkeley Lab., LBL-16920 UC-13, p. 169-171.

PITZER, K.S., PEIPER, J.C. and BUSEY, R.H., 1984, Thermodynamic properties of aqueous sodium chloride solutions: J. Phys. Chem. Ref. Data, v. 13, no. 1, p. 1-102. First author at Dept. Chem. & Lawrence Berkeley Lab., Univ. California, Berkeley, CA 94720.

Experimental measurements of the osmotic and activity coefficients, the enthalpy, and the heat capacity were used to derive a semiempirical equation for the thermodynamic properties of NaCl(aq) at constant pressure. This equation may be combined with results contained in the previous paper on the volumetric properties to yield a complete equation of state valid in the region $273\ K \leq T \leq 573\ K$, saturation pressure $\leq P \leq 1$ kbar, $0 \leq m \leq 6.0\ mol\ kg^{-1}$. It is shown that this equation may be extrapolated to higher solute molalities at lower pressures. An estimation of uncertainties in various quantities is given. Tables of values for various thermodynamic properties are presented in the appendix. (Authors' abstract)

POKROVSKIY, V.A. and IVANOV, I.P., 1983, Phase diagrams of state of model hydrothermal systems. I. System Al_2O_3-SiO_2-H_2O: Essays on physico-chemical petrology, v. 11, p. 143-160 (in Russian).

Thermodynamic properties, free Gibbs energies of formation, equations of reactions and their conditions, silification equilibria, isothermal diagram of solubility and several sections of Al_2O_3-SiO_2-H_2O system at 25-300°C are shown. (A.K.)

POKROVSKIY, V.A. and SOROKIN, V.I., 1983, The solubility phase diagram for the Hg-Sb-S-H_2O system: Geokhimiya, no. 6, p. 809-824 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 3, p. 110-117, 1984).

POLLASTRO, R.M. and BARKER, C.E., 1984, Geothermometry from clay minerals, vitrinite reflectance, and fluid inclusions; applications to the thermal and burial history of rocks cored from the Wagon Wheel No. 1 well, Green River basin, Wyoming: U.S. Geol. Survey Open-File Rpt. 84-753, p. 78-94. Authors at U.S. Geol. Survey, Denver, CO.

The present study uses geothermometry from changes in clay-mineral phases and composition, R_m, and homogenization temperatures (Th) from fluid inclusions to access the thermal history in gas-bearing rocks of Upper Cretaceous and Lower Tertiary age of the Pinedale anticline, northern Green River basin, Wyoming (fig. 1). This paleotemperature data and present-day temperature records for the Wagon Wheel well in conjunction with stratigraphy, have provided significant details concerning the thermal and burial history for the Pinedale area. (From the authors' abstract)

POLYAK, B.G., PRASOLOV, E.M. and CERMAK, V., 1982, Mantle helium in juvenile fluids and nature of the geothermal anomaly of the Erzgebirge (Krusne Hory), Czechoslovakia: Dokl. Akad. Nauk SSSR, v. 263, no. 3, p. 701-705 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 263, no. 3, p. 157-160, 1984).

Listed under Poliak in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 195, 1982. (E.R.)

POMÂRLEANU, Vasile and POMÂRLEANU-NEAGU, Elenora, 1984a. Fluid inclusions in hydrothermal calcite and their significance in crystallogenesis (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 146 (in English). First author at Inst. Geol. & Geophys., Bucharest, Romania.

The paper is based on a diagram that points out a correlation between Th of fluid inclusions in hydrothermal calcite and its crystallographic habitus. Th ranges between 60-80°C for the $(02\bar{2}1)$ habit and increases to 376°C for the $(10\bar{1}1)$ habit, the latter being associated with pyrite. The diagram can be used for understanding the crystallogenetic conditions of calcite and its associated hydrothermal minerals. (Authors' abstract)

POMÂRLEANU, Vasile and POMÂRLEANU-NEAGU, Eleonora, 1984b Fluid inclusions in hydrothermal calcite and their significance in crystallogenesis: Annu. Inst. Geol. Geofiz (Bucharest), v. 64, p. 77-80. First author at Inst. Geol. & Geophys., str. Caransebes 1, 78344 Bucharest.

In this paper, a diagram of crystallogenetic significance for calcite and its associated minerals on the basis of the 770 determinations on the homogenization temperatures of fluid inclusions in 134 calcite samples, from 8 hydrothermal ore deposits, is presented. The diagram gives a correlation between the habits of calcite crystals and homogenization temperatures of primary fluid inclusions from this mineral. (Authors' abstract)

POPP, R.K., NAGY, K.L. and HAJASH, Andrew, Jr., 1984, Semiquantitative control of hydrogen fugacity in rapid-quench hydrothermal vessels: Am. Mineral., v. 69, p. 557-562.

PORCELLI, D.R. and O'NIONS, R.K., 1984, He, Sr and Nd isotopes in ultramafic xenoliths (abst.): EOS, v. 65, p. 296.

POREDA, R.J. and BASU, A.R., 1984, Rare gases, water, and carbon in kaersutites: Earth & Planet. Sci. Letters, v. 69, p. 58-68. First author at Isotope Lab., Scripps Inst. Oceanography, Univ. California at San Diego, La Jolla, CA 92093, USA.

Kaersutites from Kakanui, New Zealand, and from three localities in the southwestern United States have been analyzed for rare gases, water and carbon to investigate the volatile signature of the sub-continental mantle. This study does not confirm the high $^3He/^4He$ and $^{21}Ne/^{22}Ne$ ratios reported by Saito et al. for the Kakanui kaersutite. Instead, a $^3He/^4He$ ratio of 6 R(A) and atmospheric $^{21}Ne/^{22}Ne$ ratios were measured which are consistent with our current knowledge of the earth's mantle. A low $^{40}Ar/^{36}Ar$ of 320 and more than 10^{-8} cm^3/g of ^{36}Ar confirms the argon results of Saito et al. and indicates that significant quantities of ^{36}Ar reside in this portion of the mantle. Kaersutites from the southwestern United States (Arizona) have a heterogeneous helium isotope signature, ranging from 8.8 R(A) at San Carlos to 0.46 at Hoover Dam. All D/H ratios for the water in kaersutites (-56‰ to -78‰) represent typical mantle values with no apparent correlation with $^3He/^4He$. The correlation of increasing carbon content (140-400 pm) with increasing $\delta^{13}C$ (-24.5‰ to -16.7‰) may reflect differences in the proportions of oxidized and reduced carbon in these samples. (Authors' abstract)

POREDA, R., WELHAN, J., CRAIG, H. and ARNORSSON, S., 1984, Helium isotopes and mantle methane in Icelandic geothermal fluids and volcanic rocks (abst.): EOS, v. 65, no. 45, p. 1152. First author at Scripps Inst. of Oceanography, La Jolla, CA 92093.

Helium isotope ratios and gas chemistry of geothermal fluids and volcanic rocks from Iceland are indicative of complex sources for the recent volcanism. A good correspondence exists between $^3He/^4He$ ratios in lavas and fluids, with fluid ratios ~10% higher. Using all available data, there is a gradual increase in $^3He/^4He$ ratios from the Reykjanes Ridge (13 R_A, where R_A is the atmospheric ratio) to the Peninsula (14.4 R_A). To the north and east in the Eastern Neo-Volcanic Zone, the ratios increase from 14-17 R_A reaching a maximum of 19.5 R_A near Geysir. The high $^3He/^4He$ ratios do not continue to the north, but rather follow a zone of transcurrent faulting eastward, reaching a maximum of 23.6 R_A at Landmannalaugar, Eastern Neo-Volcanic Zone in south-central Iceland. The $^3He/^4He$ ratios drop abruptly to the north: 8.8 R_A at Kverkfjoll, 10.1 R_A at Askja and 9.8 R_A at Krafla, due to the interaction with old Icelandic crust. Interestingly, Surtsey, the most recent alkali volcano and a proposed center of the Icelandic mantle plume, has a $^3He/^4He$ ratio of 15 R_A, ~40% less than the Icelandic maximum, attesting to the complexities of the $^3He/^4He$ distribution beneath Iceland.

The association of methane and volcanic helium in Iceland is described using $CH_4/^3He$ ratios vary from 3 x 10^4 to 2.6 x 10^8 (compared to ~10^6 for EPR vent fluids) with no correlation with $^3He/^4He$ ratios. The two highest temperature systems, Krafla and Askja, have the lowest $CH_4/^3He$ ratios. A $\delta^{13}C$ of the CH_4 from Fludir, near Geysir, is -23.4‰ with a $CH_4/^3He$ of 4 x 10^5 may be close to the volcanic end-member on Iceland. (Authors' abstract)

PORTNOV, A.M., 1982, Self-oxidation of mantle fluid and the genesis of kimberlite diamonds: Dokl. Akad. Nauk SSSR, v. 267, no. 4, p. 942-945 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 267, p. 166-168, 1984).

POTY, Bernard, CUNEY, Michel, LEROY, Jacques, TRUNG, N.C. and PAGEL, Maurice, 1984, Ore-forming solutions in uranium deposits (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 146-147 (in English). Authors at Centre de Rech. Géol. de l'Uranium, Vandoevre lés Nancy Cedex, France.

As a result of several studies (Naumov and Tugarinov, 1969, Leroy and Poty, 1969, Tugarinov, 1972, Poty et al., 1974, Cuney, 1978, Leroy, 1978, etc...) the role of CO_2-rich fluids is considered very important in the transportation and deposition of uranium in U deposits, particularly in the Hercynian province of Europe.

More recent studies in Hercynian deposits of western Europe, as well as in other types of deposits in the world, have shown that U-bearing fluids may have other characters which seem to be more important:

1. Some deposits located in Hercynian granites or in their surrounding rocks: France (Cathelineau, 1981), Portugal (Pagel, 1982), show fluids which are devoid of CO_2 and which have gone to high temperature (up to 400°C in Vendee). Hydrothermal U deposits in volcanites such as Pena Blanca, Chihuahua, Mexico (Aniel, 1982) contain fluid inclusions associated with U mineralization which do not contain free CO_2.

2. Unconformity-related deposits: Athabasca (Pagel and Jaffrezic, 1977, Pagel et al., 1980), Pine Creek (Ypma and Fuzikawa, 1980, Durak et al., 1983), Rouergue, Massif Central, France (George et al., 1983) show very typical fluids: concentrated brines (up to 35% equivalent NaCl salt content) which may contain CO_2. Solutions associated with U mineralizations in Shaba are also very concentrated brines (Audeoud, 1982).

3. Metamorphic albite-uraninite veins such as in Mistamisk-Labrador (Kish and Cuney, 1982) show also fluid inclusions containing brines with CO_2 and reduced gas species.

4. Even sandstone U deposits may contain warm ore-forming fluids: at Oklo (Openshaw et al., 1978) and in Utah (Mekunier, 1983), they are dilute aqueous solutions (without CO_2) at a moderate temperature (100 to more than 200°C).

These data suggest that U can be dissolved and deposited in a variety of environments and that the CO_2 regime in the ore-forming fluid cannot be the only cause of U deposition. More sensitive analytical methods are thus needed for characterizing ore-forming fluids from fluid inclusions, and new experimental geochemical studies are needed as well, to understand U transportation and deposition. (Authors' abstract)

POWELL, T.G. and MacQUEEN, R.W., 1984, Precipitation of sulfide ores and organic matter: sulfate reactions at Pine Point, Canada: Science, v. 224, p. 63-66. First author at Inst. Sedimentary & Petrol. Geol., Geological Survey of Canada, Calgary, Alberta T2L 2A7, Canada.

Bitumen is a common associate of carbonate-hosted lead-zinc deposits. On the Pine Point lead-zinc property, Northwest Territories, Canada, there are two forms of bitumen. Unaltered bitumens have atomic hydrogen/carbon ratios of about 1.4, sulfur contents of about 7.8 percent, and sulfur isotope ratios ($\delta^{34}S$) of approximately +4.6 per mil. Altered bitumens occur in proximity to sulfide ore bodies and white sparry dolomite. Their hydrogen/carbon ratios are about 1.02, the sulfur contents average 22 percent, and the $\delta^{34}S$ values are about +12.4 per mil. These data indicate that some bitumen has participated in the thermochemical reduction of sulfate to produce hydrogen sulfide required to precipitate the ores. Mass balance considerations show that the amount and degree of alteration of bitumen is more than adquate to account for the reduced sulfur species (lead, zinc, and iron sulfides) deposited at Pine Point. These reactions may provide an important means of generating the large volumes of sulfide necessary to precipitate ore bodies in carbonate rocks. (Authors' abstract)

PRICE, J.G., HENRY, C.D., ULRICH, M.R. and STANDEN, A.R., 1984, Silver-rich, gold-poor hydrothermal systems, examples in Trans-Pecos Texas (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 628. Authors at Bureau of Economic Geol., The Univ. Texas at Austin, Austin, TX 78712.

Hydrothermal Ag-Pb-Zn veins and mantos that formed during mid-Tertiary igneous activity in the Trans-Pecos region are generally Ag-rich and Au-poor. Ratios of Ag to Au commonly exceed 1,000. However, conditions of vein formation, as evidenced by gangue mineralogy, wall-rock alteration, and fluid-inclusion data, were similar to those of Au-rich epithermal systems elsewhere.

Feldspar-destructive alteration flanks quartz veins in subvolcanic, intermediate to acid intrusions in Texas. Fluorite, calcite, and siderite are additional gangue minerals. Na and Ca were leached from wall rocks of some veins and an argillic assemblage of kaolinite, montmorillonite, quartz, and pyrite formed. Na was leached and K was locally added in a phyllic assemblage of sericite, montmorillonite, kaolinite, and calcite in wall rocks of other veins. Propylitic alteration, characterized by chlorite, pyrite, and calcite, is commonly widespread beyond the argillic and phyllic zones. Veins probably formed at 220 to 320°C from fluids containing 0.2 to 13 equivalent weight percent NaCl. Similar conditions of formation are inferred for mantos. Silicification of dolomitic limestones and perhaps argillic alteration of dikes accompanied manto deposition.

Trans-Pecos ores occur in and near alkali-calcic calderas and isolated alkalic intrusions. Limited data suggest that Trans-Pecos alkalic rocks are depleted in Au relative to average calc-alkaline rocks of equivalent silica contents. The hypothesis that the igneous rocks themselves are enriched in Ag and depleted in Au relative to calc-alkaline rocks is being tested. (Authors' abstract)

PROZOROVICH, G.E., 1984, Peculiarities of catagenesis of terrigenous and carbonate rocks in saline formations: Akad. Nauk SSSR Doklady, v. 279, no. 1, p. 167-169 (in Russian). Author at Belorussian Sci.-Research Geol.-Prosp. Inst., Minsk, Belorussia.

Catagenesis of terrigenous and carbonate rocks in saline formations differs from other geological environments in a number of features: 1. pore and intercrystalline solutions are much more concentrated brines. Quartz solubility in brines is lower than in less concentrated solutions, hence the regeneration and cementation of quartz grains is less developed, and hence the rock remains more porous. Under the action of Mg-bearing brines limestones are dolomitized. 2. Halite has relatively high heat conductivity, ranging from $13 \cdot 10^{-3}$ to $17 \cdot 10^{-3}$ cal per (cm·sec·degree), whereas heat conductivity of limestones and sandstones is about one third as much. This causes less heating and less intensive catagenesis (geothermal gradient in thick halite formations is low). 3. Low density of halite rocks causes decreased lithostatic pressure. 4. Anomalous high layer pressure[sic] in halite beds is 1.5 to 3 times lower than in terrigenous rocks. 5. Hydrodynamic conditions: due to the plasticity of halite, the permeability of salt beds for L or G solutions is low, i.e., circulation of mobile phase is strongly limited. (Abstract by A.K.)

PUCHKOV, Ye.V., LAGUNOV, R.M., MATVEYETS, M.A., SHCHERBOV, D.P., LISITSINA, D.N. and IVANKOVA, A.I., 1983, Effect of organic matter on the genesis of stratiform lead-zinc deposits: Dokl. Akad. Nauk SSSR, v. 270, no. 6, p.

1438-1441 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 139-141, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 211, 1983. (E.R.)

PUCHKOV, Ye.V. and NAYDENOV, B.M., 1984, Formation of stratiform lead-zinc deposits of Atasuy type: Sovetskaya Geologiya, no. 1, p. 33-41 (in Russian). Authors at Kazakh Inst. of Mineral Raw Materials, Alma-Ata, Kazakhstan.

Main ore barite-polymetallic stage formed at 120-195°C, late hydrothermal associations crystallized during a sharp T increase to 280-300°C for coarse-crystalline barite and next T decrease to 100-120°C. At certain Atasuy-type deposit (e.g., West Zhayrem) the commerical ores are contoured by isotherm 200°C. (Abstract by A.K.)

PUGIN, V.A. and KHITAROV, N.I., 1984a, Criteria of liquation nature of variolite rocks: Akad. Nauk SSSR Doklady, v. 275, no. 6, p. 1485-1487 (in Russian). Authors at Inst. Geochem. & Anal. Chem., Moscow, USSR.

Experiments with melting of variolites from the area of Yaguba (Karelia) showed that matrix and varioles have T of liquidus 1075-1100°C, T of solidus 900-1000°C and T of solvus 1200-1250°C. (A.K.)

PUGIN, V.A. and KHITAROV, N.I., 1984b, Liquation in andesite (experimental data): Dokl. Akad. Nauk SSSR, v. 279, no. 2, p. 438-441 (in Russian). Authors at Inst. Geochem. & Anal. Chem., Moscow, USSR.

Experiments performed under P 5 and 10 kbar, T 900-1300°C with andesitic varioles of variolite sample from the Yalguby region, Karelia, showed that during splitting of andesite, melts were formed that are similar to those found earlier in naturally split variolite melt. One of the split melts has more acid composition than the primary andesite, and the other - more basic composition (see also previous item and Khitarov and Pugin, Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 132). (A.K.)

PUGIN, V.A. and KHITAROV, N.I., 1984c, Petrochemical evidences of liquation in basalt-dacite variolitic rocks: Geokhimiya, 1984, no. 1, p. 58-69 (in Russian; English abstract).

PUNGRASSAMI, Thongchai, 1984, Tin mineralization of the Thung Pho-Thung Khamin mining district, Changwat Songkhla: Conf. on Applications of Geol. & the Nat'l. Dev., Chulalongkorn Univ., Bangkok, 19-22 Nov. 1984, p. 207-214. Author at Dept. Mining Engrg., Faculty of Engrg., Prine of Songkhla Univ. Haad Yai 90112, Thailand.

Late Triassic to Early Jurassic granitic stock intruded sandstone, siltstone, and shale of Early Carboniferous in age. The granite and the country rocks were intruded by aplite dikes and quartz veins. Under the influences of pneumatolytic and hydrothermal actions gave metasomatism on medium-to coarse-grained biotite granite. The result is fine-to medium-grained leucogranite occurring in the granitic cupola and along the contacts. Types of alterations are greisenization, albitization, sericitization, tourmalinization, and kaolinization. During the process subsequently occurred dissemination of cassiterite in the leucogranite, together with columbium-tantalum minerals.

Fluid inclusions study showed that temperature of mineralization and of the alteration was below about 350°C. (From the author's abstract)

PURTOV, V.K. and YATLUK, G.M., 1982, Behavior of silica in reactions of aqueous HCl and NaCl solutions with rocks and rock-forming minerals at

600° to 800°C and 1000 kg cm^{-2} (101.9 MPa): Dokl. Akad. Nauk SSSR, v. 263, no. 2, p. 448-455 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 263, no. 3, p. 151-153, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 200, 1982. (E.R.)

PURTOV, V.K., YATLUK, G.M. and ANFILOGOV, V.N., 1984, Relations of Fe, Mg, Si, Al in chloride solutions at 873 K and 101 MPa in connection with processes of limestone skarning: Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 1003-1006 (in Russian). Authors at Inst. Geol. Geochem. of Urals Sci. Center, Sverdlovsk, USSR.

Results of experimental studies (reactions of minerals with NaCl and HCl solutions) prove that pH is the main factor determining concentrations of iron, magnesium, silicon and aluminum in hydrothermal solution. (A.K.)

PYE, L.D., O'KEEFE, J.A. and FRECHETTE, V.D., eds., 1984, Natural Glasses, Proc. of the [1983] Int'l. Conf. on Glass in Planetary & Geological Phenomena: Amsterdam, North-Holland Physics Pub., 662 pp. (also issued as J. Non-Crystalline Solids, v. 67, 1984).

QI, X.L. and CLOCCHIATTI, R., 1983, Optical thermometry and chemical composition of liquid silicate inclusions in feldspars (abst.): Symp., European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 56 (in French). First author at Inst. Geol. Res., Acad. Geol. Sci. of China, Xian, PRC.

A systematic study of the kinetics of homogenization (measure of the homogenization temperature as a function of the length of the experiment) as a function of the chemical composition of liquid silicate inclusions was carried out in order to define and normalize the optimal conditions for use of optical thermometry. The time necessary to obtain homogenization (complete disappearance of the shrinkage bubble) varied from a few minutes in the case of basic silicate liquids (bytownites from alkaline basalts of Tolbachik, USSR: Th 1190°-1160°C) to several hours for inclusions from acidic magmas (andesine from ignimbrites from the Valley of Ten Thousand Smokes, Alaska: Th 830°-840°C).

In the case of potassic lavas, (anorthoclase from Erebus: Th = 1040°C) the length of the experiment is reduced by about twenty minutes. Very high homogenization temperatures, (Th 1300°C) are characteristic of plagioclases from basic andesites (Krakatua, Indonesia; Karimski, Kamchatka).

The chemical composition of the inclusions was studied by electron microprobe before and after homogenization. In two exceptional cases (bytownite from Tolbachik and anorthoclase from Erebus) it was possible to observe and analyze the different stages of inclusion formation at the borders of phenocrysts. (Authors' abstract; translation courtesy of R.J. Bodnar)

QUAN, Richard, CLOKE, P.L. and KESLER, S.E., 1984, Potassium iron chlorides in high salinity inclusions from the Granisle porphyry copper deposit, British Columbia (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 629. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

SEM/energy dispersive analyses on opened highly salinity fluid inclusions have confirmed co-existing daughter minerals to be halite, sylvite, hematite, ± chalcopyrite, ± anhydrite, and perhaps two potassium iron chloride phases. Semi-quantitative analyses on potassium iron chloride phases reveal K/Fe ratios yielding two populations--1:1, i.e., $KFeCl_{3-4}\cdot nH_2O$; and 1:2 $KFe_2Cl_{5-7}\cdot mH_2O$, respectively. Accuracy of the method does not permit distinguishing the oxidation state of the iron. Observational studies show only one kind of potassium iron chloride exists within a single inclusion. Volume measurements show that the potassium iron chloride phases can occupy from 0 to greater than 13% of the total inclusion volume and up to 35% of total daughter salt volume. When coupled with estimates of the liquid composition in equilibrium with all daughter salts, the whole inclusion composition shows major $FeCl_3$, NaCl, and H_2O (e.g. ca. 35 wt.% $FeCl_3$, 30% NaCl, and 25% H_2O) and relatively minor KCl (ca. 10%). These proportions fall within reasonable limits derived from concomitant analyses of inclusion decrepitates by SEM/EDA. Decrepitate analyses also show minor calcium chloride (ca. 4-6%) with $CaCl_2$ remaining in solution and not appearing in any inclusion daughters. The presence of iron chloride and lesser amounts of calcium chloride in these inclusions indicates that iron and calcium must be added to the NaCl-KCl-H_2O system in order to assess adequately the origin of "halite trend" inclusion fluids observed at Granisle. Experimental studies to define these trends further are underway. (Authors' abstract)

QUAN, Richard, KESLER, S.E. and CLOKE, P.L, 1984, Iron chlorides in inclusion fluids from the Granisle porphyry copper deposit northern British Columbia (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 98. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109, USA.

Compositional data on the cation content of high salinity fluid inclusions from the Granisle (B.C.) porphyry copper deposit have been obtained by SEM/EDA observations on opened inclusions, inclusion decrepitates that produce evaporites on polished plates, and by observation of metastable phases formed during freezing runs. SEM/EDA data on individual daughter crystals within opened inclusions confirm that the major daughter minerals are halite and sylvite. At least 3 other chloride phases appear to be present. One shows K:Fe ratios of 2:1 and could be erythrosiderite ($K_2FeCl_5 \cdot H_2O$). Another shows K:Fe ratios of 3:1 and Na:Fe ratios close to 1:1 but with an additional calcium component, and approaches a Ca-rinnerite composition ($K_3NaFeCl_6$). A third possibly metastable, birefringent, irregularly-shaped phase was obtained upon freezing. This phase persisted to room temperature and was subsequently analyzed on the SEM. Results show it to be an iron chloride with a lower but consistent K and Ca component, with K:Ca ratios approaching 1:1 and Fe:K + Ca ratios variable but greater than 2.5. The presence of iron chloride and less amounts of calcium chloride in these inclusions indicates that iron and calcium must be added to the NaCl-KCl-H_2O system in order to adequately assess the origin of "halite trend" inclusion fluids observed at Granisle. Experimental studies to provide a background for this are underway. (Authors' abstract)

RAABE, K.C. and SACK, R.O., 1984, Growth zoning in tetrahedrite-tennantite from the Hock Hocking mine, Alma, Colorado: Can. Mineralogist, v. 22, p. 577-582. Authors at Dept. Geosci., Purdue Univ., West Lafayette, IN 47907, USA.

The Hock Hocking is a small Pb-Zn-Ag-Au mine within the Alma district, Park County, Colorado. Ore occurs in fissure-faults that cut a series of pre-Pennsylvanian dolomites, quartzites and shales. Ore minerals consist predominantly of pyrite, chalcopyrite, galena and sphalerite, along with lesser amounts of tetrahedrite-tennantite, jalpaite, polybasite, stromeyerite, electrum and native silver in a gangue of manganoan dolomite and quartz. Microprobe analysis of growth-zoned tetrahedrite-tennantite coexisting with sphalerite of constant composition shows that Fe/Zn is positively correlated with As/(As + Sb) in the semi-metal site. Based on fluid-inclusion temperatures, paragenetic constraints and previous experimental studies (Sack and Loucks 1983, 1985), it appears that the Gibbs energy for the reciprocal reaction $Cu_{10}Zn_2Sb_4S_{13}$ + $Cu_{10}Fe_2As_4S_{13}$ = $Cu_{10}Zn_2As_4S_{13}$ + $Cu_{10}Fe_2Sb_3S_{13}$ is temperature-independent over the range 200-500°C. (Authors' abstract)

RADKE, B.M., and MATHIS, R.L., 1980, On the formation and occurrence of saddle dolomite: J. Sed. Petrology, v. 50, no. 4, p. 1149-1168. First author at Bureau of Min. Resources, P.O. Box 378, Canberra City, A.C.T. 2601, Australia.

Saddle dolomite is a variety of dolomite that has a warped crystal lattice; it is characterized by curved crystal faces and cleavage, and sweeping extinction. Perfect saddle forms have trigonal symmetry, with crystal elongation at high angles to the 'c' axis. Saddle dolomite occurs as both a void-filling cement and a replacement mineral and is commonly associated with hydrocarbons, epigenetic base-metal mineralization, and sulfate-rich carbonates. These associations imply late diagenetic formation by sulfate reduction processes.

Saddle dolomite is slightly enriched in calcium and has significant variations in composition within individual growth laminae. Calcium is more abundant in the lattice at crystal apices and face edges that are at high angles to the 'c' axis, than towards face centers. These composition gradients along growth laminae cause the lattice distortion which has trigonal symmetry corresponding to the saddle morphology. The cause of selective ion adsorption during crystal growth is open to speculation but must be associated with the crystal as an entity. Surface-charge effects, the most probable cause, may be produced by either a pyro-electric phenomenon at elevated temperatures or pH and ionic concentrations of the precipitating fluids. Saddle dolomite has potential as a geothermometer, being indicative of elevated temperatures (60-150°C). (Authors' abstract)

The relationships between bands of fluid inclusions, cathodoluminescence, and saddle structure are discussed. (E.R.)

RAFAL'SKY, R.P., 1984, Solubility of sulphides and their precipitation in hydrothermal solutions according to the data of thermodynamic analysis (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 148 (in English).

RAFALSKY, R.P., BRYZGALIN, O.V. and FEDOROV, P.L., 1984, Transport of tungsten and deposition of scheelite in hydrothermal conditions: Geokhimiya, 1984, no. 5, p. 611-624 (in Russian; English abstract).

Using a computer, a solubility of $CaWO_4$ in NaCl solutions in a broad field of pH at temperature 100 to 300°C was calculated. Low solubility of scheelite suggests a very small migration ability of tungsten in these conditions. Based on analysis of published experimental data a conclusion was made on possibility of transport of tungsten by chloride solutions at temperatures higher than 300°C in quantities sufficient for formation of the mineable scheelite mineralization. Deposition of scheelite from hydrothermal solutions at temperatures 450-300°C can be a result of their cooling, changing of pH and interaction with calcium-rich country rocks. (Authors' abstract)

RAGNARSDÓTTIR, K.V., WALTHER, J.V. and ARNÓRSSON, Stefán, 1984, Description and interpretation of the composition of fluid and alteration mineralogy in the geothermal system, at Svartsengi, Iceland: Geochimica Cosmo. Acta,

v. 48, p. 1535-1553.

RAKCHEYEV, A.D., 1982, Thermoelectroosmotic ascending percolation of metamorphic fluids and solutions in the crust: Dokl. Akad. Nauk SSSR, v. 265, no. 2, p. 450-453 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 265, no. 2, p. 112-114, 1984).

RANAWAT, P.S., 1984, Thermobaric environment of talc-apatite formation at Undithal, Rajasthan: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 13. Author at Dept. Geol., Univ. Rajasthan, Udaipur, India.

The paper deals with fluid inclusion study of apatite, cogenetic with talc at Undithal, Udaipur district. The data indicate that steatitization of ultramafic rocks was brought about by solutions of low salinity (3.80 ± 1.64% NaCl), also low XCO_2, having temperature in the region of 300°C-400°C and pressure between 2-3 kb. PTX conditions have been deduced from the fluid inclusion study and mineral assemblage. (Author's abstract)

RANAWAT, P.S. and DASHORA, R.S., 1984, Freezing study of fluid inclusions in fluorite-barite-quartz from Karara fluorspar deposits, Rajasthan: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 15. First author at Dept. Geol., Univ. Rajasthan, Udaipur, India.

Two-phase fluid inclusions having a high degree of fill are present in fluorite, barite, and quartz of Karara area. In fluorite-I (cubooctahedral crystals or green coarse granular) bubble is [still] present in fluid inclusions upon freezing, whereas in fluorite-II (columnar or cubic crystals on fluorite-I) the bubble is generally eliminated. Barite contains two-phase fluid inclusions with a very small vapor bubble or monophase inclusions; in the latter vapor bubble nucleates on cooling the plate (not resulting in freezing) indicating that monophase fluid inclusions contain stretched liquid. Fluid inclusions in quartz-I, corresponding to fluorite-I stage of mineralization, also freeze with bubble retained.

Fluid inclusions in which the vapor bubble is eliminated on freezing may show any of the following features: (a) vapor bubble reappears between -7°C and -3°C; (b) vapor bubble does not reappear by 0°C and ice is present metastably up to +3°C; (c) strain effect and development of cracks along cavity corners, in rare cases the ice breaks open the cavity. Freezing data for fluid inclusions showing features (b) and (c) have not been included in the freezing data for salinity determination. Tm for all the minerals show that mineralizing solutions in both the stages of mineralization were of low salinity, 2.25 ± 1.99% NaCl. (Authors' abstract)

RASUMNY, Janine, 1984, Some aspects of the development of fluid inclusion research on minerals from the French Alps - An example from the Roc Tourne (Savoy): 27th Int'l. Geol. Congress, Abstracts, v. 5, p. 153 (in French). Author at Lab. Géol. Structurale et Appliqué (Bat. 504), Univ. Paris XI, France.

Scanning electron microscopy has been applied to albites from Alpine intra-crystalline cavities of Roc Tourne, originally studied by A. LaCroix (1911). The new studies establish two major findings. First, there is great morphological complexity in the irregular growth of the albites, related to presence of twinning in crystals. Second, there are regular relationships between the albite and the host rocks. On the one hand, recrystallization of the carbonate country rock has deformed albite crystals;

on the other hand, solid inclusions of carbonate have recrystallized after they were included in albites. (From the author's abstract, translation courtesy M.J. Logsdon)

REED, M.H., 1984, Geology, wall-rock alteration, and massive sulfide mineralization in a portion of the West Shasta district, California: Econ. Geol., v. 79, p. 1299-1318. Author at Dept. Geol, Univ. Oregon, Eugene, OR 97403.

Includes (p. 1316) an estimate of the NaCl equiv. molality (4.0) from freezing data on inclusions in quartz phenocrysts from rhyolite. (E.R.)

REED, Mark and SPYCHER, Nicolas, 1984, Calculation of pH and mineral equilibria in hydrothermal waters with application to geothermometry and studies of boiling and dilution: Geochimica Cosmo. Acta, v. 48, p. 1479-1492. Authors at Dept. Geol., Univ. Oregon, Eugene, OR 97403.

Using chemical analyses and 25° pH measurements of quenched high-temperature waters, we calculate in situ pH and distribution of aqueous species at high temperature. This is accomplished by solving simultaneous mass action equations for complexes and redox equilibria and mass balance equations, on all components, including a H^+ equation with as many as 60 terms (depending on water composition). This calculation provides accurate values for the activities of aqueous ions in a given water at high temperature, which are used to calculate an ion activity product (Q) for each of more than 100 minerals. The value of log(Q/K) for each mineral, where K is the equilibrium constant, provides a measure of proximity of the aqueous solution to equilibrium with the mineral. By plotting log Q/K vs. T for natural waters, it is possible to determine: a) whether the water was in equilibrium with a host rock mineral assemblage, b) probable minerals in the equilibrium assemblage and c) the temperature of equilibrium. In cases where the fluid departs from equilibrium with a host rock assemblage, it is possible to determine whether this may result from boiling or dilution, and an estimate of amount of lost gas or diluting water can be determined.

The calculation is illustrated by application to geothermal waters from Iceland, Broadlands, and Sulphur Bank, hot spring waters from Jemez, Yellowstone and Blackfoot Reservoir (Idaho) and fluid inclusions from the Sunnyside Mine, Colorado. It is shown that most geothermal waters approach equilibrium with a subsurface mineral assemblage at a temperature close to measured temperatures and that some hot springs also approach equilibrium with the host rock at temperatures above outlet temperatures but commonly below the Na-K-Ca temperatures. The log Q/K plots show that some discrepancies between Na-K-Ca temperatures on spring waters and actual temperatures result from a failure of alkali feldspars to equilibrate with the fluid and with each other.

Calculations on Sulphur Bank fluids show that boiling probably caused cinnabar precipitation near 150°C and that the boiled fluids equilibrated with secondary minerals near 150° even though temperatures up to 185° have been measured at depth. For the fluid inclusions, the measured bubble temperatures are close to those calculated for equilibration of the fluid with the observed sulfide mineral assemblage.

New estimates of stability constants for aluminum hydroxide complexes are included at the end of the paper. (Authors' abstract)

REHTIJARVI, Pentti, 1984, Enrichment of bromine and chlorine in Proterozoic serpentinites from the Outokumpu Cu-Co district, Finland: Econ. Geol., v. 79, p. 549-552.

REIF,* F.G., 1984, Microemulsion state of fluid-saturated granite magmas: Characteristics and petrological consequences: Dokl. Akad. Nauk SSSR, v. 276, no. 5, p. 1197-1201 (in Russian). Author at Geol. Inst., Ulan-Ude, USSR.

The presence of fluid and molten inclusions in magmatic quartz indicates the presence of microemulsion state of fluid-saturated magmas. The size of these inclusions reflects the particle size of the fluid phases. The Stoke's formula is modified to study the d. and uplift rate of ore-bearing granitic magmas. As exemplified by the ore-localized Dzhidinsk, Soktuisk, and the Zharchikhinsk granite intrusives, the development of microemulsion state in these magmas is studied. (CA 101: 114340v)

* See also REYF

REIF, F.G. and BAZHEEV, E.D., 1984, Thermobarogeochemical criteria of the ore content of granite intrusions as a basis for local prospecting of tungsten-molybdenum ore mineralization: Dzhidinskii Rudn. Raion, v. 133, no. 7, p. 185-195 (in Russian).

Thermobarogeochemistry criteria are evaluated for the prospecting of W-Mo ores in the Dzhida region (USSR). Conditions conducive for the development of large magmatogenic hydrothermal systems include the enrichment of the original magma in water and halogens, magmatic distn. during the early stages of crystallization of the magma, a protracted period of fluid separation, and extensive magma systems. (C.A. 102: 98594u)

REINTHAL, W.A. and BROWN, P.E., 1984, Magmatic and meteoric water signatures in a fossil precious metal bearing hydrothermal system, NE Oregon (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 632.

REYF,* F.G. and BAZHEEV, E.D., 1984, Determination principles of ore-bearing (Mo-W-Sn) granites and their thermobarogeochemical features (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 437. Authors at Geol. Inst. Buryat Div. Siberian Br. USSR Acad. Sci., Ulan-Ude, USSR.

Among the granite intrusions, which are accompanied or contain greisen vein mineralization, some may behave as passive wall rocks, others may heat underground water and initiate its convection, and the third may be the source of the metal-bearing solutions. Only the last type must be determined as ore-bearing intrusions. It is possible to recognize the role of granite in deposits forming by means of comparison of the composition of magmatic distillates and hydrothermal ore-forming solutions. When a hydrothermal solution inherits the composition of magmatic distillate, there is a reason to consider that intrusion is the main source of solutions. If the distillate inclusions contain high concentrations of ore-forming elements, the magma must be considered also as the source of metals. By this means the ore-bearing granites are recognized in Transbaikalian and Central Kazahstan. It has proved that these granite intrusions, as distinct from the ordinary ones are characterized by high water content of initial melts (4.5-5 wt.% against 2-3); intensive distillation into [from?] them begins at the early but not at the complete stages of the magmatic crystallization. Hence the main thermobarogeochemical features of the ore-bearing granites are: the presence of the melt inclusions with high water content (>5 wt.%) in products of the early crystallization and abundance of primary (accompanying) fluid inclusions in phenocrysts. A new local prospecting method of W-Mo deposits has been offered, based on these criteria. Owing to its practical application some formerly unknown ore deposits were found. (Authors' abstract) *See also REIF

REYF, F.G. and ISHKOV, Yu.M., 1983, First direct determinations of ore-forming element concentrations in inclusions of magma distillate in quartz from tungsten-bearing intrusions: Dokl. Akad. Nauk SSSR, v. 269, no. 3, p. 725-728 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 155-158, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 221, 1983. (E.R.)

REYF, F.G., ISHKOV, Yu.M. and BAZHEEV, E.D., 1984, Laser-microprobe analysis of individual fluid inclusions: technique and results (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 154 (in English). Authors at Geol. Inst. Buriat Dept. Siberian Br. USSR Acad. Sci., Ulan-Ude, USSR.

The contents of ore-forming elements in a liquid phase of the individual fluid inclusions about 0.02 mm in diameter is determined by the laser-spectral method. The standard inclusions are prepared by sealing certain solutions in polymerized epoxide composition, and then a check on the initial concentration was made by freezing and autoradiographic methods. The detected limits of some elements are ($n \cdot 10^{-12}$ g): W - 500; Mo - 50; Fe - 10; Mn - 0.8. The uncertainity of analytical data is estimated by the factor f = 1.3...3.5. With a view to calculate the concentration of metals in the natural fluid inclusions under P-T-parameters of trapping the vacuole volume was preliminarily measured, and then the inclusion was heated to filling temperature just before opening by laser beam. The metal concentration in the magmatic distillate of two W-bearing granite intrusions and in the hydrothermal solutions of Dzhida Mo-W deposit was determined. The significance of obtained results is discussed. (Authors' abstract)

Intrusion, stage	Concentration, gram per liter			
	Mo	W	Fe	Mn
Magmatic distillate				
Socktuy	n/d (0.9)	45	75	0.3
Mariktican	n/d (0.7)	21	98	144
Hydrothermal solutions of ore deposition stage				
Molybdenum	87	n/d (333)	87	38
Tungsten	n/d (4)	53	n/d (0.2)	76
	n/d (1)	22	250	98
Hydrothermal solutions of post ore deposition stage				
Tungsten	n/d (1.7)	n/d (17)	267	4.0
	n/d (1.4)	n/d (8)	123	1.3
	n/d (2.8)	n/d (25)	39	0.02
	n/d (0.3)	n/d (3.3)	n/d (0.07)	n/d (0.006)

Notes. n/d - the element is not detected; in parentheses - calculated concentration value, which guarantees a detection of this element into analyzed volume fluid, with regard for indicated detection limits.

RHODES, D., LANTOS, E.A., LANTOS, J.A., WEBB, R.J. and OWENS, D.C., 1984, Pine Point orebodies and their relationship to the stratigraphy, structure, dolomitization, and karstification of the middle Devonian barrier complex: Econ. Geol., v. 79, p. 991-1055.

RICE, J.A., 1984, The Creede Formation silver deposit (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 252. Author at Dept. Earth Resources, Colorado State Univ., Fort Collins, CO 80523.

The Creede Formation silver deposit is located within a fluvially-transported, volcaniclastic conglomerate that was deposited in a steep-walled paleovalley. Interbedded with the conglomerate is the 30'-80' thick Monkeymeyer Sandstone. At the northeastern extent of the conglomerate it is in contact with the Amethyst vein.

Alteration in the Creede Formation is dominated by silicification. The zoning of silicification decreases in intensity away from the Amethyst vein suggesting that this structure was the source of mineralizing fluids.

Argillic alteration is concentrated in the southern portion of the study area, particularly in the lower part of the Creede Formation.

Fluid inclusions define a thermal gradient that decreases away from the Amethyst vein. Average homogenization temperatures range from 195°C at a distance of 800' from the vein to 155°C at a distance of 2,500' from the vein. Boiling in the system is suggested by variable vapor to liquid ratios, vapor-dominant inclusions, wide range of homogenization temperatures, and halite-bearing fluid inclusions.

Silver mineralization occurs as acanthite in the interstices of the conglomerate matrix. Silver-bearing fluids from the Amethyst vein mixed with southward flowing meteoric water as they entered the conglomerate. Metals were precipitated in lenticular shaped bodies, concentrating in the middle of the study area, stratigraphically below the Monkeymeyer Sandstone.

Physical controls on mineralization are stratigraphic and a decrease in porosity and permeability to the south. Chemical controls on the precipitation of metals are simple cooling and increase in pH due to boiling. (Author's abstract)

RICHARDSON, C.K. and PINCKNEY, D.M., 1984, The chemical and thermal evolution of the fluids in the Cave-in-Rock fluorspar district, Illinois: mineralogy, paragenesis, and fluid inclusions: Econ. Geol., v. 79, p. 1833-1856. First author at Dept. Earth Sci., Iowa State Univ., Ames, IA 50011.

A detailed fluid inclusion and paragenetic study was undertaken on samples from the Deardorff and Hill mines in the Cave-in-Rock fluorspar district, Illinois. Fluid inclusion Th and salinity data were collected on all available transparent minerals in the paragenetic sequence: fluorite, sphalerite, quartz, calcite, and barite. The bulk of the fluid inclusion data, however, was from fluorite crystals.

The fluorite crystals from the bedded replacement deposits are color banded. The banding sequence is observable and correlated from crystal to crystal within a mine, and either the general sequence or parts of it have been observed in crystals from throughout the district. Measurements were made on fluid inclusions from each band of several large crystals from the Hill mine which contained the entire banding sequence. Inclusions in these samples yielded Th between 132° and 151°C for most of the sequence and between 115° and 120°C in the outermost band. The salinity of the fluids ranged between 18 and 20 wt.% equiv. NaCl except in the outermost band where the salinity dropped to 9 to 10 wt.% equiv. NaCl.

A group of purple fluorite bands (P3), which are easily recognizable in many deposits, was correlated from crystal to crystal at over 40 sample localities in the Deardorff mine. Measurements on inclusions in these bands yielded information on the thermal and salinity variations at a single time plane. These measurements denote a series of concentrically zoned hot areas within the mine which were areas of upwelling fluids. The temperature of the fluids changed as much as 10°C over 50 to 200 ft. The salinity of the inclusions in these samples varied only between 19 and 21 wt.% equiv. NaCl and did not correlate with either sample location or temperature.

Fluid inclusion measurements on quartz, sphalerite, calcite, and barite yield temperatures of 68.3° to 165.1°C for early quartz; 160.1° to 226.5°C for milky quartz bands; 130.4° to 160.0°C for sphalerite; 81.9° to 137.2°C for calcite, and 115.2° to 157.0°C for barite. Inclusions in sphalerite and quartz had salinities like those for fluorite of 18.3 to 21.0 wt.% equiv. NaCl, but the salinity of the fluid dropped during calcite and barite deposition: 7.0 to 8.9 wt.% equiv. NaCl for calcite and 1.2 to 1.3 wt.% equiv. NaCl for barite.

The fluid inclusion measurements on samples from the Hill mine indicate that the fluids stayed at nearly the same temperature and salinity for most of the mineralizing period. The drop in temperature and salinity in the final stages of deposition strongly suggests an influx of cooler, probably meteoric water. The temperature measurements on samples from the Deardorff mine indicate that there were thermal variations of as much as 10°C within the ore fluid. The narrow salinity range and lack of correlation between salinity and temperature or sample location seem to preclude mixing of two fluids as the deposition mechanism. Mixing of two or more fluids at depth, however, is not ruled out. A cooling mechanism for fluorite deposition requires rather large quantities of fluid to have passed through the deposit; however, cooling combined with chemical changes in the fluid is the best working hypothesis. (Authors' abstract)

RISON, W. and CRAIG, H., 1984, Helium isotope variations along the Galapagos Spreading Center (abst.): EOS, v. 65, no. 45, p. 1139-1140. Author at Isdotope Lab., Scripps Inst. Oceanography, UCSD, La Jolla, CA.

Measurements of helium isotope ratios for basalt glasses dredged from the Galapagos Spreading Center (GSC) show a jump in the $^3He/^4He$ ratios of 8 times the atmospheric ratio (R$_A$), while samples to the west have ratios of 7 x R$_A$. The locus of the $^3He/^4He$ ratio jump is not the central transform fault at 91°W, but is approximately at the west-facing tip of the most recent propagator at 93°W (Stinon et al., EPSL 62, 193, 1983).

Tectonic and chemical data imply that the Galapagos area has a hotspot close to the axial spreading center, analogous to Iceland in the Atlantic. Variations in the major and trace element chemistry and $^{87}Sr/^{86}Sr$ ratios at the GCS (Schilling et al., JGR 87, 5593, 1982; JGR 87, 10838, 1982) are of the same magnitude as at the Iceland hotspot. The variations in the $^3He/^4He$ ratios, however, are much smaller at the GSC. For the Iceland hotspot, the helium ratios vary from 10 x R$_A$ to 23 x R$_A$. The $^{87}Sr/^{86}Sr$ ratio of basalts from the GSC has a maximum at 92°W, very close to the longitude where the $^3He^4He$ ratio jumps abruptly. The proportion of plume material estimated from the Rb-Sr systematics peaks at about 50% at this point. The MORB $^3He/^4He$ ratio of these plume-enriched basalts strongly suggests that the helium of the plume component does not have a high $^3He/^4He$ ratio, as is found in the Iceland plume and in other "High-^{3}He" hotspots.

The variation in the $^3He/^4He$ ratios along the East Pacific Rise are small compared to the variations found in the Atlantic. The total variation along the EPR, exclusive of the Easter Island hotspot (Craig, Kim and Rison, this meeting), is just ±10% around the mean MORB value of 8 x R$_A$. The data are strikingly uniform in comparison to the Mid-Atlantic Ridge, where the massive Iceland plume has produced a much greater effect along the ridge both north and south of Iceland. The Galapagos hotspot, with MORB $^3He/^4He$ ratios, has not produced such large variations along the EPR or the GSC. (Authors' abstract)

RIVERS, M.L., SMITH, J.V., STEELE, I.M., JONES, K.W. and HANSON, A.L., 1984, Fluorine in peridotite and eclogite xenoliths from the mantle (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 636.

RIVERS, M.L., STEEL, I.M., SMITH, J.V., JONES, K.W. and HANSON, A.L., 1984, Analysis of fluorine in upper mantle minerals by proton activation analysis; fluorine budget of the Earth (abst.): EOS, v. 65, p. 306.

ROBERT, Francois and BROWN, A.C., 1984a Chemical exchanges between gold-mineralizing fluids and wallrocks at the Sigma mine, Abitibi region, Quebec (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with

Abstracts, v. 9, p. 100. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

The presence of flat tension veins with undeformed wallrocks provides an excellent opportunity for an alteration study at the Sigma mine, an Archean vein-type gold deposit. Mineralized veins, emplaced structurally late at Sigma, consist mainly of quartz and tourmaline with minor amounts of calcite, pyrite, chlorite, scheelite and free gold.

The flat veins are generally bordered by metasomatically zoned alteration envelopes composed of an outer cryptic zone and an inner visible zone. Unaltered wallrocks contain albite, quartz, chlorite, epidote, white mica and minor amounts of calcite, ilmenite, apatite and pyrite. Constant volume alteration processes are indicated by preserved porphyritic textures in the altered zones. Al and Ti were highly mobile in the zone of visible alteration.

Cryptic alteration is characterized by the addition of CO_2 and K which together with some leaching of Si account for the total replacement of epidote by calcite and white mica. Visible alteration involves the addition of Ca, CO_2, Na, Au, and locally S and B, and leaching of Fe, Mg, Ti, K, H_2O, Al, and locally Si; these chemical changes account for the total replacement of chlorite and white mica by calcite, albite and quartz, and for the local formation of tourmaline and pyrite.

Calculations show that Ca, CO_2, Na, Au, S and B were added to the wallrocks, whereas Fe, Mg, Al, Ti, H_2O and locally Si were released from visible alteration zones. Fe, Mg, Al and Si released from visible alteration zones may have combined with introduced Na, B and S to form tourmaline and pyrite. Most of the tourmaline, pyrite and chlorite in the veins can also be explained by reaction of Fe, Mg and Al released from wallrocks with S, B, Si and Na present in the mineralizing fluids. (Authors' abstract)

ROBERT, Francois and BROWN, A.C., 1984b, Archean gold-quartz vein formation and mineral deposition at the Sigma mine, Abitibi region, Quebec (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 636. See previous item.

ROBERT, Francois and KELLY, W.C., 1984, Gold mineralizing fluid at the Sigma mine, Abitibi region, Quebec: a fluid inclusion investigation (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 636. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109-1063.

Archean gold-bearing veins of the Sigma mine occur in deformed metavolcanic rocks intruded by two generations of pre-ore porphyries. The veins were emplaced during a late compressional tectonic event, and they consist of quartz, tourmaline and carbonates, with subordinate amounts of chlorite, pyrite, pyrrhotite, scheelite and free gold. Gold-bearing fluids were trapped at a late stage after recrystallization and brittle fracturing of the main quartz fillings.

Three types of fluid inclusions occur in the quartz. Type I inclusions are Na-Ca-Cl brines, some containing halite, calcite, ankerite, and nahcolite(?) as daughter minerals. Type II inclusions are CO_2-rich fluids. Type III inclusions contain low-salinity H_2O-CO_2 fluids of variable H_2O/CO_2. All fluid inclusions occur along healed fractures or as irregular clusters cutting across grain boundaries and deformational features in the quartz. All inclusions are secondary and post-date quartz cataclasis. Gold also post-dates the cataclasis and was probably transported by these same fluids. Current data indicate that Th of Type I inclusions increases with depth from 100°C at 300m to 250°C at 1400m. Pressures in excess of 1 kb are indicated by Type I and Type II inclusions coexisting in individual fractures.

Coexistence of Types I and II inclusions along healed fractures, and relationships between fractures suggest contemporaneity of Types I and II fluids, and a genetic link with Type III fluid. The combined composition of these three types of fluids is similar to that of the fluid that altered the wallrocks during vein filling, as deduced by mass-balance calculations. Coexistence of aqueous and CO_2-rich fluids is tentatively attributed to immiscibility in the system H_2O-CO_2-salt, and the systematic decrease of Th toward the surface may be due to progressive CO_2 outgassing from the fluids during ascent through the veins. (Authors' abstract)

ROBERTS, D.E. and HUDSON, G.R.T., 1984, The Olympic Dam copper-uranium-gold deposit, Roxby Downs, South Australia - A reply: Econ. Geol., v. 79, p. 1944-1945. Authors at Roxby Management Services Pty. Ltd., P.O. Box 405, Unley, South Australia 5061, Australia.

Preliminary inclusion work shows average Th = 165°, and salinities 7.5%, supporting a hydrothermal origin. (E.R.)

ROBERTSON, A.D., 1984, Negative inclusions in zircon from Anakie, Queensland: The Australian Gemmologist, v. 15, no. 5, p. 164-166. Author at Geol. Survey of Queensland, Australia.

Rod-like inclusions are said to be two-phase (liquid-gas) primary negative inclusions. (E.R.)

ROBINSON, Andrew and SPOONER, E.T.C., 1984, Postdepositional modification of uraninite-bearing quartz-pebble conglomerates from the Quirke ore zone, Elliot Lake, Ontario: Econ. Geol., v. 79, p. 297-321. First author at c/o Billiton Int'l. Metals BV, 19 Louis Couperusplein, Box 190, The Hague, The Netherlands.

A variety of arguments suggest that the most probable Eh-pH fields for the ground waters involved in postdepositional modification are low to moderate Eh (~-0.1 to +0.2V; field of HSO_4^--SO_4^{-2} predominance) and slightly acid pH (~3-6) for ilmeno-magnetite leaching, and low Eh (<~-0.1V; field of H_2S predominance) and near-neutral pH (~5-8) for pyrite precipitation. Both inferred Eh-pH fields fall within the thermodynamic stability fields of uraninite and coffinite in which uranium solubilities are low. (From the authors' abstract)

ROBINSON, R.W. and NORMAN, D.I., 1984, Mineralogy and fluid inclusion study of the southern Amethyst vein system, Creede mining district, Colorado: Econ. Geol., v. 79, no. 3, p. 439-447. First author at Pioneer Nuclear, Amarillo Nat'l. Bank Bldg., P.O. Box 151, Amarillo, TX 79189.

The southern Amethyst vein system, one of the most productive areas of Ag mineralization in the Creede mining district, was investigated by field, paragenetic, mineralogic, and fluid inclusion studies. Mineralization occurs as vein fillings and disseminations confined to areas of high fracture density and brecciation in the hanging wall of the Amethyst fault and vein. Mineralization is fine grained, rarely exceeding 100 µm in diameter. Disseminated mineralization occurs in brecciated silicic rhyolite (ash-flow tuffs) that has been flooded with quartz and up to 3.9 percent sulfides. Very limited amounts of pervasive sericitic alteration, such as that associated with several other vein systems in the district, occur in the southern Amethyst vein system.

The paragenesis is divided into two main stages. Stage 1 is a sulfide-poor assemblage characterized by rhodochrosite, quartz, barite, and an absence of silver. Stage 2 represents a complex event made up of three substages. Minerals found in stage 2 include quartz, galena, tetrahedrite, covellite, acanthite, and native silver. Disseminated mineralization found in the study area appears to be related to stage 2. Mineralization in the southern Amethyst vein system occurred early in the paragenesis of the ores in the Creede district.

Analysis of fluid inclusions in stage 2 vein quartz showed that average Th and salinities decrease in a regular manner from lower to upper levels of the mine. Inclusions in stage 2 quartz from the lower mine levels had an average Th = 238°C and an average salinity of 9.8 equivalent weight percent NaCl. Those in the uppermost level had an average Th = 170°C and an average salinity of 6.5 equivalent weight percent NaCl. There was no evidence that ore solutions were boiling during deposition of the quartz in the veins.

There is a linear relationship between the enthalpy of inclusion fluids and both salinity and elevation. This is interpreted as mixing of saline hydrothermal waters with cooler, less saline, shallow ground waters. It is proposed that the rapid drop in temperature and dilution of hydrothermal solutions which was a result of mixing with near-surface waters caused the deposition of the high-grade Ag ores in the southern Amethyst vein system. (Authors' abstract)

ROEDDER, E., 1984a. Occurrence and significance of magmatic inclusions and silicate liquid immiscibility: Acta Geol. Polonica, v. 34, no. 1-2, p. 139-178 + 4 plates (in English with Polish abstract). Author at U.S. Geol. Survey, National Center, Mail Stop 959, Reston, VA 22092, USA.

This paper reviews work on magmatic (particularly silicate-melt) inclusions in terrestrial and extraterrestrial samples and evaluates its significance. Particular attention is given to silicate liquid immiscibility, as it is frequently a cause for both the trapping of inclusions, and for confusion in their interpretation. This includes a discussion of immiscibility in the synthetic system K_2O-FeO-Al_2O_3-SiO_2, and in lunar and terrestrial basalts. For ordinary inclusions, formed during normal magmatic differentiation by crystal fractionation, this review details the trapping mechanisms, the three main changes that may occur within inclusions after they have been trapped (separation of an immiscible fluid phase, crystallization, and leakage), and the five main types of useful data available from such inclusions (temperature of trapping, temperatures and sequence of phase changes during cooling, constraints on maximum and minimum cooling rates, bulk composition and the liquid line of descent, and the volatile content). Other inclusions in magmatic rocks are trapped and have their composition determined by a variety of types of fluid immiscibility. (Author's abstract)

ROEDDER, E., 1984b, Final report on a study of fluid inclusions in core from Gibson Dome No. 1 bore, Paradox Basin, Utah: U.S. Geol. Survey Open-File Rept. 84-696, 16 pp.

In contrast to the evidence from bromine profiles, the samples showed major recrystallization since original formation; primary inclusions in "chevron" salt contain almost no gases, but inclusions in recrystallized salt show gas pressures in the tens or hundreds of atm. Large carnallite dms in primary inclusions in "chevron" salt dissolve at 56-57°C, whereas the much larger ones in recrystallized salt dissolve at 98-120°C, yielding minimum temperatures for diagenesis. The carnallite dms themselves correspond to K 47,000, Mg 26,000, and Cl 76,500; these values are also minima since they do not include the salts in solution at room temperature. (Considerable Ca must be present, as Te is ~-54°C, and many inclusions freeze to metastable glass.) (E.R.)

ROEDDER, E., 1984c Fluid inclusions, Reviews in Mineralogy, v. 12: Washington, Mineralogical Soc. of Am., 644 pp, 131 diagrams, 387 photographs, 2001 references, subject and locality indices.

An introduction to studies of all types of fluid inclusions, gas, liquid, or melt, trapped in materials from earth and space, and their application to the understanding of geologic processes.

Chapter titles

1. Introduction to fluid inclusions
2. The origin of inclusions
3. Changes in inclusions after trapping
4. Nondestructive methods of determination of inclusion composition
5. Destructive methods of determination of inclusion composition
6. Inclusion sample selection, preparation, petrography, and photography
7. Inclusion measurements -- heating, cooling, decrepitation, and crushing
8. Interpretation and utilization of inclusion measurements -- compositional data on liquid and gas inclusions
9. Interpretation and utilization of inclusion measurements -- temperature, pressure and density at trapping
10. Interpretation and utilization of inclusion measurements -- metastability
11. Sedimentary environments
12. Low- to medium-grade metamorphic environments
13. Medium- to high-grade metamorphic environments
14. Intrusive rock and pegmatitic environments
15. Ore deposition environments
16. Extrusive rock and volcanic environments
17. Upper mantle environments
18. Extraterrestrial environments
19. Future of inclusion studies

ROEDDER, Edwin, 1984d The fluids in salt: Am. Mineral., v. 69, p. 413-439. Author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

The fluids in salt have been used as sources of information on the geological events leading to the formation of the enclosing salt beds, and the subsequent changes to which these beds have been exposed. In recent years, however, consideration of salt beds or domes as possible sites for long-term nuclear waste repositories has added new significance to the study of such fluids.

This paper reviews the current status of the study of the types of fluid present in salt, their origin and evolution, and their significance to understanding the geological processes that have occurred. These studies are pertinent to the engineering design of a nuclear waste storage site in salt in that they tell us what might happen in the future. The fluids in salt also introduce problems in the engineering design of a safe nuclear waste installation that must be carefully evaluated at each suggested site. (Author's abstract)

ROEDDER, Edwin, 1984e Fluid inclusions in the study of ore deposits: systematics and applications: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 46-47.

ROEDDER, Edwin, 1984f Fluid-inclusion evidence bearing on the environments of gold deposition, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe Spec. Pub. No. 1), p. 129-163. Author at 959 U.S. Geol.

Survey, Reston, VA 22092, USA.

The gold in most primary gold deposits in the world was dissolved, transported, and deposited in its present location by hot aqueous solutions under pressure. Any data on the temperature, pressure, density, and composition of these fluids can aid in understanding the processes of formation and hence may help in exploration.

With few possible exceptions, the only samples of these fluids are the fluid inclusions within minerals of the deposits. This paper 1) reviews briefly the general nature of inclusions and the data they can provide; 2) details some caveats particularly applicable to inclusion studies of gold deposits; 3) summarizes the extensive literature on fluid inclusions from gold deposits; and 4) considers briefly the uses of such inclusion data in exploration and mining. Many gold ores have not yet been examined for fluid inclusions, and some of the very fine grained materials may simply not have inclusions of suitable size (i.e. >~5 μm). A literature survey of 151 pre-1978 fluid-inclusion studies of the major gold stage in a wide variety of deposits other than porphyry coppers, mainly in the USSR, showed homogenization temperatures ranging generally from 100 to 400°C. In some of these deposits, major gold deposition took place over a wide temperature range, but the average range was only 100 degrees. Inclusions in earlier and later gangue and ore-metal stages typically cover much broader ranges. When given, the salinities were generally <10 wt% NaCl equivalent. The gold-depositing fluids were frequently rich in CO_2, particularly those from metamorphic and sediment-hosted (Carlin-type) deposits. A second, gas-rich fluid phase (i.e. "boiling") was common in many of the epithermal deposits. Precipitation of only a few parts per billion from the ore-forming fluid may be adequate to form major gold deposits; the specific cause of precipitation is obscure, however, and probably differs from one deposit type to another. (Author's abstract)

ROMANKEVICH, E.A., ed., 1984, Geochemistry of organic matter in the ocean: Springer-Verlag, Berlin Heidelberg, 334 pp.

RONA, P.A., 1984a Hydrothermal mineralization at seafloor spreading centers: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 48-52.

RONA, P.A., 1984b Hydrothermal mineralization at seafloor spreading centers: Earth-Sci. Reviews, v. 20, no. 1, p. 1-104.

An extensive, thorough review. (E.R.)

RONA, P.A., 1984c Hydrothermal mineralization on the slow-spreading Mid-Atlantic Ridge and Carlsberg Ridge (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 638.

RONA, P.A., BOSTROM, Kurt, LAUBIER, Lucien and SMITH, K.L., Jr., 1984, Hydrothermal processes at seafloor spreading center: NATO Conf. Series, Series IV: Marine Sci., v. 12.

RONA, P.A., THOMPSON, G., MOTTL, M.J. and others, 1984, Hydrothermal activity at the Trans-Atlantic Geotraverse Hydrothermal Field, Mid-Atlantic Ridge crest at 26°N: J. Geophys. Res., v. 89, no. B13, p. 11,365-11,377. First author at Nat'l. Oceanic & Atmosph. Admin., Atlantic Oceanographic & Meterological Lab., Miami, FL.

The first submersible observations of the only known active submarine hydrothermal field on a slow-spreading oceanic ridge are incorporated with results of 10 prior years of investigation to derive an understanding of periodicity, duration, and varying intensity of hydrothermal activity at the Trans-Atlantic Geotraverse (TAG) Hydrothermal Field on the Mid-Atlantic Ridge crest near latitude 26°N. Hydrothermal activity has persisted at this location for at least 1×10^6 years based on the distribution of hydrothermal and hydrogenous mineralization with respect to crustal age. The hydrothermal activity has been cyclic, multistage, and episodic. Prior high-temperature hydrothermal venting stages with a periodicity of the order of 1×10^4 years and duration of the order of 10^1 years are deduced from the estimated ages of discrete sedimentary layers anomalously enriched in Cu, Fe, and Zn and correspond with the independently determined periodicity of volcanic eruptive cycles on the Mid-Atlantic Ridge. The most recent episode of high-temperature venting is inferred to have ceased in the recent past based on metal enrichment (Cu, Fe, Zn) in the surficial sediment layer. Low-temperature hydrothermal venting stages with a duration of the order of 1×10^4 years intervene between the short high-temperature stages and produce stratiform deposits of layered and earthy manganese oxide, iron oxide, hydroxide, and silicate. Bivalve-like forms with the characteristics of vent clams in various stages of dissolution are identified on bottom photographs. The fresh appearance of intact tubules composed of iron hydroxide that acted as vents on relict deposits, conductive heat flow anomalies in the sediment column, and the record of temperature anomalies and excess ^{3}He in the near-bottom water column, suggest that the low-temperature hydrothermal discharge is intermittent at individual vents on a time scale of years. (Authors' abstract)

ROSE, W.I., 1984, An assessment of volcanic gas monitoring techniques (abst.): EOS, v. 65, no. 45, p. 1137. Author at Michigan Tech. Univ., Houghton, MI 49931.

In spite of the complexity of sampling volcanic emanations and the difficulties in interpreting the significance of results, much progress has been made in recent years. Case studies of the quantitative measurement of SO_2 (correlation spectrometry) and CO_2 (IR spectroscopy) emission rates at volcanoes are reviewed at several volcanoes. In numerous cases changes in the rate of emission of SO_2 and (to a lesser extent) CO_2 have been related to activity cycles. There is increasing evidence of the order of release of gases from shallow magma bodies which 1) demonstrates that SO_2 emission increases may give pre-eruption warnings of a few days and 2) suggests that CO_2 is lost preferentially very early and could form the basis for longer term forecasts. Flux measurements are most meaningful when they can be combined with other data such as direct gas sampling, analysis of melt inclusions in phenocrysts, volcanic ash leaching, residual volatile contents in lavas, sublimate or fume particle studies, etc., because these comparisons help to constrain the many unknowns of shallow volcanic magma bodies. For example, it is now possible to estimate the total fluxes of most gaseous and particulate species at several volcanoes over extended periods. Such data can apparently constrain estimates of the size of contributing shallow magma bodies. Also we are beginning to be able to use diverse data to illuminate how gases are released and to estimate some intensive parameters in the magma body.

The continued application of multiple simultaneous and time-based methods of detecting volatile species at volcanoes will allow 1) perfection of forecasting tools based on gas studies, and 2) a more realistic assessment of the volatiles and particles released by volcanoes to the atmosphere. (Author's abstract)

ROSENBAUM, Steve and TAYLOR, B.E., 1984, Sources and temperatures of ore fluids in the northern Mother Lode, California (Alleghany district): oxygen and carbon isotope evidence (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 639.

ROSENHAUER, M. and WOERMANN, E., 1984, The role of oxygen fugacity in the Earth's upper mantle: subsolidus and melting relations on the system CaO-MgO-SiO_2-C-O-H (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 385 (in English). First author at Mineral.-Petro. Inst. Univ. Göttingen, FRG.

Solidus temperatures in the Earth's mantle are decreased drastically by several hundred degrees by the action of a fluid phase with the greatest effect caused by the presence of H_2O and less pronounced for CO_2 and CH_4 (Eggler). Under increasing pressures mantle silicates react with CO_2 to form carbonates and eventually with H_2O to form hydrates (Ellis and Wyllie). Under still higher pressures it is assumed that the only stable fluid C-O-H species are hydrocarbons, in particular CH_4. For their stability, however, lower oxygen fugacities are required. Indicators of low mantle oxygen fugacities are provided mainly from H_2O-rich gases released from natural diamonds, Cr^{2+} concentrations in olivine, native Fe as well as calcite inclusions. Intrinsic oxygen fugacity measurements and the presence of SiC in olivine nodules are pointing to the same direction. On the contrary basaltic and kimberlitic magmas are characterized by higher oxygen fugacities - in the order of the QFM-buffer. It appears that, at least occasionally, an fO_2 gradient exists in the mantle. Along such a gradient CH_4 will be oxidized to C + H_2O and eventually to CO_2 and H_2O, shifting the fluid from CH_4-rich towards H_2O-rich composition. At the same time the solidus temperature of the system decreases. Thus magmatism is explained not only by temperature and pressure but also by the variation of intensive parameters, such as oxygen fugacity. (Authors' abstract)

ROSLYAKOVA, N.V., SHCHERBAKOV, Yu.G., AGEENKO, N.F., PORTYANNIKOV, D.I., BORTNIKOVA, S.B. and RADOSTEVA, N.Ye., 1983, Conditions of gold capacity of pyrite-polymetal deposits, in Conditions of formation and principles of prognosis and prospecting for gold ore deposits (Transactions of Inst. Geol. and Geophys., v. 538), p. 31-65 (in Russian).

Salair barite-polymetallic ore field occurs in Lower Cambrian carbonate beds and it is connected with a Cambrian paleovolcanic dome of liparite-dacite and dacite porphyries, tuffs, tuffites and andesite porphyrites (dome dimensions 4 x 1.5 km). Gold-bearing quartz-carbonate mineralization forms stockworks and overlaps polymetallic mineralization in ore field. Barite-polymetallic ores yielded T (°C): silicification, sericitization, pyritization 550-450 (or 300-200 after other authors), commercial barite-polymetallic stage 400-250 (or 200-270), post-ore quartz-carbonate 150 and less; gold-bearing quartz-carbonate stockwork and veins: silicification, sericitization, pyritization 410, 350-300, 182, early quartz 500-245, commercial quartz-carbonate-sulfide with gold 300-145; quartz-carbonate veins in diabase dikes: 460-155 (quartz), 120-65 (calcite).

Ur ore field consists of dacite porphyries and tuffs, porphyrites, quartz-albite-chlorite, clayey-chlorite shales, sandstones and limestones of Cambrian age. Gold ores occur in stockworks of hydrothermal metasomatic topaz quartzites; Th of inclusions in gold-bearing quartz ranged from 570 to 60°C. (Abstract by A.K.)

ROVETTA, M.R., 1984, Microfracture growth during the high temperature creep of periodite in the presence of CO_2: Ph.D. dissertation, Univ.

Washington, School of Oceanogr.

An extensive experimental and theoretical treatment; the presence of CO_2 results in considerable changes in behavior. (E.R.)

ROYZENMAN, F.M., VALYASHKO, L.M., KARSKIY, B.Ye. and ZORIN, B.I., 1983, Some common trends in the genesis of macrocrystalline ores in muscovite, phlogopite and pollucite deposits: Dokl. Akad. Nauk SSSR, v. 269, no. 6, p. 1441-1444 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 98-101, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 229, 1983. (E.R.)

RUDNICK, R.L., ASHWAL, L.D. and HENRY, D.J., 1984, Fluid inclusions in high-grade gneisses of the Kapuskasing structural zone, Ontario: metamorphic fluids and uplift/erosion path: Contrib. Mineral. Petrol., v. 87, p. 399-406. Authors at Lunar & Planet. Inst., 3303 NASA Road One, Houston, TX 77058, USA.

Fluid inclusions in quartz grains from five samples of high-grade rocks (two paragneisses, an amphibolite, a mafic gneiss and a tonalite dike) from the 2.7 Ga Kapuskasing structural zone (KSZ), Ontario, were examined with petrographic, microthermometric and laser Raman techniques. Three types of fluid inclusions were observed: CO_2-rich, H_2O-rich and mixed CO_2-H_2O. CO_2-rich fluid inclusions are pseudosecondary or secondary in nature and are generally pure CO_2; a few contain varying amounts of CH_4. H_2O-rich fluid inclusions are secondary in nature, contain variable amounts of dissolved salts, and generally contain daughter crystals. Mixed CO_2-H_2O fluid inclusions occur where trails of H_2O-rich inclusions intersect trails of CO_2-rich inclusions. Isochores for high density (ρ = 1.03 g/cm^3) pseudosecondary, pure CO_2 inclusions intersect the lower pressure portion of the estimated P-T field for high-grade metamorphism, implying that pure CO_2 was the peak metamorphic fluid. The variable CH_4 content of CO_2 inclusions within graphite-bearing samples suggest that CH_4 was introduced locally after the formation of the CO_2 inclusions; however the origin of the CH_4 remains problematic. An aqueous fluid clearly penetrated the gneisses after the peak metamorphism (during uplift/erosion), forming secondary inclusions and contributing to the minor retrogressive hydration observed in these rocks. The presence of the pseudosecondary, high-density CO_2 inclusions in quartz crystals in the KSZ rocks constrains the uplift/erosion path for the KSZ to one of simultaneous decrease in pressure and temperature. (Authors' abstract)

RUDNICK, R.L., ASHWAL, L.D., HENRY, D.J. and GIBSON, E.K., 1984, Fluid inclusions in stony meteorites -- a cautionary note (abst): Lunar and Planet. Sci. XV, p. 701-702. Authors at NASA, JSC, Houston, TX.

In light of new observations of fluid inclusions in a variety of extraterrestrial samples, the origin of fluid inclusions in stony meteorites described by Warner et al. is in question. The lunar fluid inclusions described above are unquestionably the products of thin section preparation and their similar properties to fluid inclusions in other extraterrestrial samples places heavy doubt on the orign of these inclusions. In conclusion, any fluid inclusions observed in thin sections of extraterrestrial samples must be treated with caution; fluid inclusions observed in unprepared samples however may indeed be candidates for true extraterrestrial fluids. (From the authors' abstract)

RUI, Zongyao and ZHANG, Hongtao, 1984, Some advances in the study of copper (molybdenum) deposits in the Sanjiang region: Bull. of the Inst.

Mineral Deposits, Chinese Acad. Geol. Sci., Ser. 3, v. 11, p. 28-39 (in Chinese; English abstract). Authors at Inst. Mineral Deposits, Chinese Acad. Geol. Sci.

A series of porphyry Cu and Mo deposits occur in western Yunnan, making further exploration favorable. Various geochemical and geological studies were made of the granitoids of the area, including REE, S, O, H, and C isotopes, and fluid inclusions.

Volatiles were separated from the magma at about 700°C. Temperature range of various ore-forming stages have been determined: potassium silicate alteration, 650-400°C; quartz-sericitization, 400-200°C; quartz-argillization, 300-100°C; propylitization, 300-150°C; main metallic sulfides deposition, 300-180°C. Ore-forming fluid system was alternatively open or closed with the pressure reaching 2300 bar under closed condition and only 50-300 bar under open condition.

Sulfur, oxygen, hydrogen and carbon isotope studies suggest that isotopic composition of sulfur is analogous to that of meteoritic sulfur, and that oxygen and hydrogen isotopic compositions were governed by magmatic waters in early stage, by both magmatic and meteoric waters in middle stage, and by meteoric water in late stage.

Metallogenic model for the Yulong ore deposit and eight criteria for distinguishing ore-bearing porphyries from barren ones are also given in this paper. (Shortened from the authors' abstract and modified by E.R.)

RUIZ, Joaquin and KESLER, S.E., 1984, The behavior of rare earth elements in fluoride-bearing hydrothermal solutions and their use as tracers in hydrothermal systems (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 641.

RUMYANTSEV, V.N., 1984, Nature of hydrogeochemical zoning and chloride brines: Effects of Lechatelier principle: Akad. Nauk SSSR Doklady, v. 275, no. 4, p. 1007-1011 (in Russian). Author at All-Union Sci.-Research Inst. of Mineral Raw Materials, Moscow, USSR.

The author explains the following differentiation of underground waters found in N part of the USSR and in Priamur'ye $SiO_3 \rightarrow HCO_3(CO_3) \rightarrow SO_4 \rightarrow Cl - Br$ (predominant anion from upper to lower levels) by redistribution of primitive solution components of various volatility in a pressure-gradient field. (A.K.)

RUSSEL, M.J., 1984, Giant base-metal orebodies: Results of hydrothermal convection in submarine continental rifts; drilling evidence (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 3, p. 385-386.

RUTHERFORD, M.J., SIGURDSSON, H. and CAREY, S., 1984, The May 18 eruption of Mount St. Helens: melt composition and experimental phase equilibria (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 641. First author at Dept. Geol. Sci., Brown Univ., Providence, RI 02912.

The Mount St. Helens, May 18 light pumice is a dacite containing 60% glass and phenocrysts of plagioclase, low-Ca pyroxene, amphibole, titaniferous magnetite and ilmenite. The glass is a uniform composition rhyodacite with 73 wt % SiO_2; the phenocrysts are also uniform in composition except for plagioclase which has cores averaging An_{57} and An_{49} rims. Analyses of 7 pairs of coexisting Fe-Ti oxides in the pumice were recast using various mineral calculation procedures, and the T-fO_2 calibration of Spencer and Lindsley (1981). The resulting temperatures ranged from 920 to 940°C and $-\log fO_2 = 10.3$ to 10.1. Microprobe analyses of 57 glass inclusions trapped in the plagioclase phenocrysts in the pumice showed little deviation from an average rhyodacitic composition (69.90 ± 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.

The observed phase assemblage and residual melt chemistry is not stable when $P(H_2O) = P(Total)$. Water undersaturated experiments using CO_2-H_2O fluids reproduced the observed residual melt chemistry, and an An_{50} plagioclase at fO_2's between the NNO and MNO buffers, at a P(Fluid) of 220 MPa, and a $P(H_2O) = 110$ MPa (all at 920 to 940°C). Amphibole was not stable under these conditions, but probably would be if the $P(H_2O)/P(Fluid)$ ratio was raised to 0.7, or if the fluorine were added to the experimental system.

It is concluded that, just prior to eruption, the upper part of the May 18 Mt. St. Helens magma chamber was at a pressure of 220 ± 30 MPa corresponding to a depth of 7.2 ± 1 km, $P(H_2O)$ was at 0.5 to 0.7 P(Total), and the temperature was 930 ± 10°C. (Authors' abstract)

RYABCHIKOV, I.D., 1983, Oxidation-reduction equilibria in the upper mantle: Dokl. Akad. Nauk SSSR, v. 268, no. 3, p. 703-706 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 197-199, 1984).

RYABCHIKOV, I.D., ORLOVA, G.P. and KALENCHUK, G.E., 1984, The solubility of copper and silver in concentrated alkali-chloride aqueous fluids in equilibrium with granitic magma (based on experimental data): Geol. Rudnykh Mestoroz., 1984, no. 3, p. 96-99 (in Russian; translation available at U.S.G.S. Library).

RYABCHIKOV, I.D., ORLOVA, G.P., KOVALENKO, V.I., CHOPOROV, D.Ya., SOLOVOVA, I.P. and MURAVITSKAYA, G.N., 1983, Experimental studies of reaction of fluid with mica-bearing spinel lherzolite at elevated temperatures and pressures: Izvestiya Akad. Nauk SSSR, Ser. Geol., no. 2, p. 38-46 (in Russian). First author at IGEM, Moscow, USSR.

For quantitative evaluation of fluid mass transport, the reactions between mica-bearing spinel lherzolite and water-, and water-CO_2 fluid were studied. The experimental method is described for determination of content of petrogenic oxides in supercritical fluids and results are presented for P 4.5 kbars and T 900 and 1000°C. Data on composition of gas phase are discussed, taking into account alteration of rock minerals detected by optical and electron microprobe studies. The fluid after reaction has excess alkalis in comparison with its Al_2O_3 content. Partition coefficient Mg/Fe for the pair olivine-fluid at 900°C is equal 0.2, very close to value 0.3 characteristic of the pair olivine-melt; T increase to 1000°C causes sharp decrease of this coefficient value in the experiment. Change from H_2O to H_2O-CO_2 causes higher mobility of Mg and especially Ca and Na; this may cause formation of dolomite or an increase in the content of clinopyroxene in the rock. Subsequent melting of such rocks may give high-Ca magmas (olivine melilitite type). (Abstract by A.K.)

RYABCHIKOV, I.D., ORLOVA, G.P., MINEEVA, R.M., BERSHOV, L.V. and KORINA, E.A., 1984, Copper and silver in granite melt (according to experimental data): Geokhimiya, 1984, no. 8, p. 1181-1191 (in Russian; English abstract).

Using the method of phase equilibria quenching, experiments were made in the system "iron-free" granite-fluid-metallic phase (Cu, Ag) in the temperature range 700 to 960°C under the pressure $1.5 \cdot 10^8$ Pa and oxygen fugacity from fO_2(Ni-NiO) to $fO_2(Fe_2O_3$-$Fe_3O_4)$. In glasses obtained by quenching the contents of Cu and Ag were determined and using ESR technique the valence state of the elements under study was studied. The results show that solubility of copper and silver in the water-saturated melts depends on fugacity of oxygen. Under P, T, fO_2-parameters typical for hypabyssal acid magmatism in the absence of sulfur the saturation concentration is o.on to o.oon% of the metal and the melt contains copper and silver predominately in monoatomic form. Under $fO_2 >> fO_2(Fe_2O_3\text{-}Fe_3O_4)$ a dissolution takes place in the form of Cu^+, Cu^{2+}, Ag^+ and ions of bivalent copper occupy octahedral positions in the glass (melt). Calculations using the experimental data show that in acid magmatic melts copper and silver can be present in sulfide phases under fO_2 lying in the range from values corresponding to buffer nickel-bunsenite up to values corresponding to buffer hematite-magnetite. (Authors' abstract)

RYABCHIKOV, I.D., SOLOVOVA, I.P., DMITRIEV, Yu.I. and MURANTSKAYA, G.N., 1984, Water in an oceanic ferrobasalt parent magma: Geokhimiya, no. 2, p. 209-216 (in Russian with English abstract; translated in Geochem. Int'l., v. 21, no. 2, p. 116-122). Authors at Inst. of the Geol. of Ore Deposits, Petrography, Mineral., & Geochem., Acad. Sci. USSR, Moscow, USSR.

Thermometric methods have been applied to melt inclusions in plagioclase and clinopyroxene from oceanic ferrobasalt from the region of the Siqueiros transform fault in the Pacific. The minimal crystallization temperature for these basalts lies in the range 1160-1140°C. The resorption (crystallization) temperature for ferrohastingsite in inclusions has been used with various calculation methods to estimate the possible water concentration in the initial magma. It is concluded that the H_2O content was 1.5-3 mass %. Estimates of the water content for the parent magmas give 1.1 ± 0.4 mass %, which makes them similar to oceanic-island tholeiite. (Authors' abstract)

RYAN, Scott, 1984, Carbonate-quartz-barite veins of the Hartford Basin (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 61. Author at Dept. Geol. & Geophysics, U-45, Univ. Connecticut, Storrs, CT 06268.

Carbonate-quartz-barite veins in the Mesozoic Hartford Basin are regionally associated with a set of normal faults trending 045°. The zonation of textures and mineralogy in a vein cutting the Holyoke Basalt in New Britain, CT, indicate alternate precipitation of carbonate (ferroan dolomite, calcite) and quartz as open space fillings. Earlier zones are in places brecciated and cemented by later carbonate, quartz, and barite suggesting that faulting occurred frequently during mineral deposition. Sulphides which are commonly associated with spheres of vitreous bitumen, occur sporadically in almost all of the veins.

The major sulphide minerals are sphalerite, galena, and chalcopyrite. Minor amounts of bornite, chalcocite, covellite, and tennantite are found locally. Three types of fluid inclusions occur in the vein quartz: 1. two-phase, liquid dominant aqueous-gas inclusions; 2. two-phase gas dominant aqueous-gas inclusions; 3. a three-phase (aqueous liquid)-(CO_2 rich liquid)-(CO_2 rich gas) inclusion, types 1 and 3 homogenize to one liquid phase upon heating while type 2 homogenize to one gas phase. Temperatures of homogenization indicate mineral deposition between 200° and 123°C. Type 3 inclusions indicate that hydrothermal waters were CO_2-rich. Type 2 inclusions suggest the waters were boiling at times. Decrepitation studies on sphalerite indicate upper limits of sulphide deposition between 220° and 210°C.

The carbonates precipitated when faulting opened up unrestricted passages for ascending waters. Rapid decompression resulted [in] boiling of the CO_2-rich solutions. Quartz began precipitation once the carbonate deposition resealed the vein system. Repeated faulting resulted in alternate deposition of carbonate and quartz. Barite precipitated last at temperatures below 150°C. Sulphide precipitation was syngenetic with carbonate-quartz-barite.

Regionally heated groundwater which leached the sediments of the Hartford Basin is the probable source of the hydrothermal waters. (Author's abstract)

RYE, R.O., LUFKIN, J.L. and WASSERMAN, M.D., 1984, Genesis of tin occurrences in the Black Range, New Mexico, as indicated by oxygen isotope studies (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 642.

RYZHENKO, B.N. and BRYZGALIN, O.V., 1984, The datum marks of neutrality of redox and acid-basic properties of aqueous solutions in the field of parameters of hydrothermal ore-formation: Geokhimiya, 1984, no. 7, p. 1056-1061 (in Russian; English abstract).

Values of constants of thermal and electrolytic dissociation of H_2O in the temperature range 0-600°C and pressures of saturated vapor to 3000 bars are presented. It is suggested for all temperatures and pressures to adopt value of fugacity of hydrogen (oxygen) in equilibrium with pure H_2O as the datum mark of redox properties of aqueous solutions: Eh(neutr) = $9.921 \cdot 10^{-5}$ T[-lgfH_2(neutr)-2pH], -lgfH_2(neutr) = -1/3lgK_i-0.01, pH(neuter) = -1/2lgK_w, that is analogous to the choice of datum mark of acid-basic properties of aqueous solution (equality of activities of hydrogen- and hydroxyl-ions in pure water). A comparison of values of pK_w of dissociation of H_2O calculated from the electrostatic model with the experimental data has been carried out. (Authors' abstract)

SAFONOV, Yu.G., GENKIN, A.D., VASUDEV, V.N., RAO, B.K. and ANANTHA IYER, G.V., 1984, Genetic features of gold ore deposit at Kolar, Dharwar Craton, India: J. Geol. Soc. India, v. 25, no. 3, p. 145-154. First author at Inst. Geol. of Ore Deposits, Acad. Sci. USSR, Moscow, USSR.

Twenty-five ore minerals have been identified from a study of ore-bearing samples from different reefs of the Kolar Goldfields. The mineral association includes fifteen minerals being reported for the first time: altaite, hessite, hedleyite, tzumoite, volynskyite, gudmundite, ullmannite, brethauptite, tetrahedrite, hawleyite, cortunite, electrum and native bismuth. Besides, two new minerals, as yet unnamed, have been determined through electronprobe, -$Pb_3Te_9Cl_4S_2$ and $PbTeCl_2$. They occur along with cotunite ($PbCl_2$) and altaite.

The study of time relations of different ore and vein mineral assemblages in the Kolar gold-quartz reefs has revealed six stages of mineralization: 1) Early quartz, 2) quartz-feldspar (Pegmatite), 3) scheelite, 4) early sulphides with gold, 5) sulphide-gold-tellurides (with quartz) and 6) quartz-carbonate. Fluid inclusions indicate that the mineral association of quartz-feldspar stage has developed under high TP-conditions of 250-300°C and 1.8 and 3.5 kb. Isotope composition of sulphur in the sulphides indicate the juvenile nature of sulphur. Available data suggest that the quartz of first stage is of metasomatic origin, derived possibly from host amphibolites; gold-sulphide and gold-telluride mineralization took place through hydrothermal processes. (Authors' abstract)

SAĞIROĞLU, Ahmet, 1984, Fluid inclusion studies on the contact metasomatic deposits of Akdağmadeni-Yozgat: Bull. Geol. Soc. of Turkey, v. 27, p. 141-144 (in Turkish; English abstract).

This study covers the homogenization and freezing studies on fluid inclusions of the lead-zinc deposits of Akdağmadeni. The freezing studies reveal that the salinity of the hydrothermal solutions was high during the early stages of skarnization (20% NaCl equivalent during the magnetite-garnet-pyroxene and epidote-amphibole stages) and gradually decreased during the following stages (10% NaCl equivalent during the epidote-chlorite-sulphide stage and 3-4% NaCl equivalent during the kaolinite-muscovite stage). In addition, the freezing studies show a pressure of formation ranging from 300 to 500 bars.

The homogenization studies indicate formation temperatures for the magnetite-garnet-pyroxene, epidote-amphibole, epidote-chlorite-sulphide and kaolinite-muscovite stages as >500°C, 460-480°C, 390-430°C and <320°C respectively. All the findings of this study are in good agreement with the results from other geobarometry and geothermometry methods applied to these deposits. (Author's abstract)

SAHU, K.C. and PANCHAPAKESAN, V., 1984, Fluid inclusion studies in the interpretation of processes and pattern of ore localization: Proc. Indian Natn. Sci. Acad., v. 50, Part A, p. 483-490. Authors at Indian Inst. Tech., Bombay, India.

Importance of fluid inclusion study in minerals has been emphasized. Various parameters of fluid inclusion and the types of informations derived from, are mentioned. Two case studies of mineralization have been discussed to illustrate utility of the fluid inclusion data in interpretation of processes and pattern of ore localization. (Authors' abstract)

SAHU, K.C., PANCHAPAKESAN, V. and JADHAV, G.N., 1984, Micro inclusions in quartz from Faguni mica mine pegmatites of Hazaribagh district, Bihar, India (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 159 (in English). Authors at Dept. Earth Sci., Indian Inst. Tech., Powai, Bombay, India.

Fluid inclusions were studied in the milky and smoky quartz of different levels of mica pegmatites of Faguni mines. Three types of fluid inclusions were recognized. I. Scarce, biphase, homogenizing in liquid. II. Abundant multiphase inclusions having halite with or without sylvite and other crystals. III. Rare, all-gas inclusions with very little liquid. Micrometric and microthermometric observations led to the following descriptions: (a) Average size of inclusions is ~10 microns. (b) Almost all inclusions homogenize in liquid. (c) Sylvite disappears between 70°C and 130°C. (d) Halite dissolves in the range 175°C to 375°C. (e) The gas bubble disappears between 128°C and 330°C. (f) Halite is the last phase to disappear in multiphase inclusions. (g) Salinity of entrapped fluids varies between <28% and 50%. Melt inclusions are abundant in smoky quartz from below 260 meters. Relatively large size and moderate to high population of melt inclusions in smoky quartz indicate the initiation of crystallization of pegmatite at a slow uniform rate at levels dominated by smoky quartz. Crystallization of milky quartz having abundant fluid inclusions followed. The pneumatolytic phase of quartz formation was followed by the hydrothermal phase which is also revealed by pseudosecondary aqueous inclusions in milky quartz. (Authors' abstract)

SAHU, K.C., PANCHAPAKESAN, V. and NAYAK, D.R., 1984, Fluid inclusion characteristics of Khetri and Mosabani copper assemblages of India - a comparative study (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 159-160 (in English). Authors at Dept. Earth Sci., Indian Inst. Tech., Powai, Bombay, India.

Khetri and Mosabani are two major copper sulphide deposits in India. They show different localization patterns and dissimilar mineral assemblage variations. Fluid inclusions of the Khetri assemblage are generally polyphase and invariably homogenize in liquid. On heating, sylvite dissolves between 80°C and 130°C, halite between 180°C and 360°C and the vapor disappears between 265°C and 400°C. The dissolved potassium chloride was estimated to vary between 18 and 21.5% and the sodium chloride between 21 and 33%. Variation of these parameters correlate well with the principal types of assemblages viz. chalcopyrite-rich and pyrrhotite-rich. A clear break noted in the inclusion parameters between the two types of assemblages has been assigned to solution mixing. Mosabani inclusions are basically triphase with halite as principal daughter mineral. Sylvite has been noted in minor [amounts] among the deeper samples. Th ranges from 260°C to 340°C, having higher values in deeper levels. Inclusion population decreases with depth. In general, salinity, Th and varieties of daughter minerals in Khetri inclusions are more diverse than those of Mosabani. Besides, the filling temperature or temperature of disappearance of bubble is attained before Th in Mosabani inclusions but in Khetri inclusions the bubble is the last to disappear. (Authors' abstract)

SAITO, K., ALEXANDER, E.C., Jr., DRAGON, J.C. and ZASHU, S., 1984, Rare gases in cyclosilicates and cogenetic minerals: J. Geophys. Research, v. 89, no. B9, p. 7891-7901. First author at Dept. Earth Sci., Faculty of Sci., Yamagata Univ., Yamagata, Japan.

The component and isotopic composition of the rare gases in beryls, cogenetic pegmatite minerals, and metamorphic cordierites has been measured. Beryls contain large amounts of excess radiogenic gases and significant amounts of nonradiogenic gases. Beryls contain the most pristine samples of the rare gases in pegmatite volatile phases but have imposed significant elemental fractionations during crystallization. Both the excess radiogenic and nonradiogenic components are progressively depleted in the heavy gases relative to the light gases. Other pegmatite minerals contain rare gases with much smaller excess radiogenic components and apparently did not sample the same source as did the beryls. The other minerals exhibit varying but mineral-specific fractionation patterns for the nonradiogenic rare gases. Cordierites also contain large amounts of excess radiogenic gases and significant amounts of nonradiogenic gases. In addition, cordierites show a strong, consistent fractionation of both gas components. The fractionation pattern is significantly different from that found in beryls and is characterized by an enrichment of Xe relative to the Ar, though both gases are depleted relative to He. The cyclosilicates can serve as probes of the rare gases present in the volatile phases when the cyclosilicates crystallized. The cyclosilicates contain a record of the rare gases present in geologically interesting environments over a wide range of time and physical conditions. (Authors' abstract)

SAKAI, H., DES MARAIS, D.J., UEDA, A. and MOORE, J.G., L984, Concentrations and isotope ratios of carbon, nitrogen and sulfur in ocean-floor basalts: Geochimica Cosmo. Acta, v. 48, p. 2433-2441. First author at Ocean Res. Inst., The Univ. Tokyo, 1-15-1 Minamidai, Nakano-ku, Tokyo 164, Japan.

Fresh submarine basalt glasses from Galapagos Ridge, FAMOUS area, Cayman Trough and Kilauea east rift contain 22 to 160 ppm carbon and 0.3 to 2.8 ppm nitrogen, respectively, as the sums of dissolved species and vesicle-filling gases (CO_2 and N_2). The large range of variation in carbon content is due to combined effect of depth-dependency of the solubility of carbon in basalt melt and varying extents of vapor loss during magma emplacement as well as in sample crushing. The isotopic ratios of indigenous carbon and nitrogen are in very narrow ranges, - 6.2 ± 0.2%(sic) relative to PDB and +0.2 ± 0.6‰ relative to atmospheric nitrogen, respectively. In basalt samples from Juan de Fuca Ridge, however, isotopically light carbon ($\delta^{13}C$ = around -24‰) predominates over the indigenous carbon; no indigenous heavy carbon was found. Except for Galapagos Ridge samples, these ocean-floor basalts contain 670 to 1100 ppm sulfur, averaging 810 ppm, in the form of both sulfide and sulfate, whereas basalts from Galapagos Ridge are higher in both sulfur (1490 to 1570 ppm) and iron (11.08% total iron as FeO). The $\delta^{34}S$ values average +0.3 ± 0.5‰ with average fractionation factor between sulfate and sulfide of +7.4 ± 1.6‰. The sulfate/sulfide ratios tend to increase with increasing water content of basalt, probably because the oxygen fugacity increases with increasing water conent in basalt melt. (Authors' abstract)

SAMSON, I.M. and RUSSELL, M.J., 1984, Fluid inclusion and stable isotope studies of the Silvermines base metal-baryte deposits, Ireland (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 102. First author at Mineral Explor. Res. Inst., Campus of McGill Univ., Montreal, Quebec, H3A 2A7, Canada.

The Silvermines lead-zinc-baryte deposits comprise both stratiform, exhalative and epigenetic, vein and replacement orebodies, hosted by a Lower Mississippian transgressive marine sequence dominated by limestones and dolomites.

The epigenetic ore was deposited at temperatures of between 140 and 220°C from aqueous solutions with salinities of between 8 and 28 equiv. wt. % NaCl. Depositional temperatures of baryte were probably less than 70°C. The fluids were rich in sodium, with lesser, variable amounts of potassium and calcium and uniformly lower concentrations of magnesium (K/Na = 0.03-0.23; Ca/Na = 0.03-0.28; Mg/Ca = 0.1-0.67).

The negative correlation of homogenization temperature to salinity for the whole deposit suggests that a high temperature, low salinity, 'deep' fluid mixed with a higher salinity, lower temperature, fluid, in and below the ore zone. The latter was a near surface fluid, probably related to a brine pool. Fluid mixing was the most important precipitation mechanism with some contribution from carbonate wallrock reactions and possibly boiling.

$\delta^{18}O$ and δD values of the ore solutions range from 2.4 to 9.0‰ and from -57.8 to -23.4‰(SMOW) respectively and are most consistent with a fluid which has equilibrated with the low grade metasedimentary rocks underlying the deposit.

The data suggest little, if any, involvement of magmatic water and refute a basin brine expulsion model. A mineralizing process involving the convection of Carboniferous surface waters, probably with a meteoric component, and the mixing of such waters with Lower Palaeozoic formation waters, best fits the geological and fluid inclusion evidence. (Authors' abstract)

SANDER, M.V. and MILLS, B.A., 1984, The Round Mountain gold-silver mine, Nye County, Nevada, in Western geological excursions, v. 3, p. 176-180, Lintz, J., Jr., ed.: Publ. by MacKay Sch. Mines, Dep. Geol.

Includes statement: "A few fluid inclusions in quartz have been analyzed. Dilute fluids ranging in temperature from 210 to 268° are indicated (Nash, 1972; B. Berger, pers. commun., 1983)." (E.R.)

SANO, Yuji, NAKAMURA, Yuji, WAKITA, Hiroshi, URABE, Akiko and TOMINAGA, Takeshi, 1984, Helium-3 emission related to volcanic activity: Science, v. 224, p. 150-151. First author at Lab. for Earthquake Chem., Univ. Tokyo, Bunkyo-ku, Tokyo, Japan. Continued next page.

The helium-3/helium-4 ratio in bubbling gases from ten hot springs located around Mount Ontake, an active volcano in central Japan, ranges from 1.71 R_{atm} (1.71 times the atmospheric ratio of 1.40×10^{-6}) to 6.15 R_{atm}. The value of the ratio decreases with distance from the central cone of the volcano. Such a tendency may be a characteristic of helium-3 emission in volcanic areas and suggests more primitive helium-3 is carried with fluid flowing through a conduit during volcanic activity. (Authors' abstract)

SANTOSH, M., 1984a, Precipitation of molybdenum in the Ambalavayal molybdenite prospect, Kerala: fluid inclusion evidences: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 9. Author at Center for Earth Sci. Studies, P.B. 2235, Trivandrum-695010, India.

The Ambalavayal molybdenite prospect in Wynad Distict, Kerala, is associated with an Early Paleozoic alkali granite intrusive. Molybdenite occurs as disseminations in the granite and associated pegmatites and as flaky aggregates in quartz veins. Fluid inclusion studies in quartz from the quartz-molybdenite veins show three dominant inclusion types: CO_2-H_2O, H_2O (vapor-rich) and H_2O (liquid-rich). Wide variations in the degree of filling between coexisting primary inclusions are characteristic. The vapor-rich inclusions homogenize into liquid, both at a common T of 320-360°C, indicative of entrapment from heterogeneous "boiling" fluids. Multiphase inclusions are very rare and freezing studies indicate that the mineralizing fluids had low to moderate salinity.

It is envisaged that adiabatic decompression resulted in the generation of large volumes of vapor by the boiling of late magmatic low salinity fluids. This led to the resurgent precipitation of molybdenum which combined with available sulfur. Based on thermometric and cryometric data, fluid densities and entrapment pressures are also estimated. (Author's abstract)

SANTOSH, M., 1984b, Silicate-carbonate fluid immiscibility as recorded by fluid inclusions in quartz from the Munnar alkali granite, Kerala: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 17. Author at Center for Earth Sci. Studies, P.B. 2235, Trivandrum-695010, India.

The alkali granite of Munnar in Kottayam district, Kerala, is an E-W elongated pluton of Late Precambrian age emplaced along a probable triple-point junction. The intrusive shows a unique association of minor lensoidal bodies of syenite and carbonatite. Doubly polished plates of quartz from the granite show CO_2, CO_2-H_2O and H_2O inclusions representing the solidus and subsolidus fluids. The taphrogenic lineaments of the region are envisaged to have served as deep-seated conduits for large scale volatile transfer from the upper mantle during the granite crystallization resulting in an increased concentration of CO_2 in the residual melt. This is corroborated by the occurrence of CO_2-rich fluids with mixed CO_2-H_2O and H_2O-rich fluids among the pseudosecondary and secondary trails. Subsequent fluid immiscibility led to the separation of a carbonate-rich fraction which crystallized as minor carbonatite lenses. (Author's abstract)

SANTOSH, M., 1984c, Fluid inclusion studies of Precambrian charnockites and gneisses of the Kerala region, south-west India: implications on carbonic metamorphism: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra

Dun, India, Wadia Inst. Himalayan Geol., p. 22. Author at Center for Earth Sci. Studies, P.B. 2235, Trivandrum-695010, India.

The present study is a preliminary attempt to solve the much debated problem of the metamorphic evolution and genetic interrelationship of Precambrian charnockites and migmatitic gneisses which constitute the dominant part of the granulite facies crystalline basement of the Kerala region. Detailed fluid inclusion petrography shows that monophase carbonic inclusions are the common type in quartz from both rock types. These inclusions show a wide range in size and pattern of distribution. Mixed CO_2-H_2O inclusions occur along PS trails on a subordinate scale. Aqueous two-phase inclusions are rare and generally secondary.

Freezing studies reveal that the fluid in the monophase inclusions is dominantly CO_2. Th of $P(CO_2)$ inclusions in both charnockites and gneisses peak between -18 to -20°C, corresponding to high CO_2 densities ($1.0\ g/cm^3$). As the upper temperature limit of granulite facies assemblages in south India is established to be about 900°C from coexisting mineral pairs, the fluid densities give an estimate of up to 7 kb pressure.

The ubiquitous association of carbonic inclusions in both the rocks testifies to low $P(H_2O)$ and high $P(CO_2)$ conditions during the peak of metamorphism. The common properties of fluids entrapped in P inclusions in both the rock types are not in agreement with the contemporary hypothesis on transformation of gneisses to charnockites through CO_2 influx, but indicate that the carbonic metamorphism was superimposed over the original charnockites and gneisses which previously had independent genetic histories. (Author's abstract)

SANTOSH, M., 1984a Fluid inclusion petrography of charnockites from the granulite facies terrain of Kerala, south-west India: Neues Jahrb. f. Mineral. Monat., no. 8, p. 337-345. Author at Centre for Earth Sci., PB No. 2235, Trivandrum, 695010, India.

The study of fluid inclusions has recently been found to be of considerable importance in understanding the fluid parameters related to metamorphic evolution, in addition to its well established application in the fields of magmatic and ore-mineralization processes. The paper presents the types and setting of fluid inclusions in matrix quartz and vein and lens-type quartz associated with charnockites from three principal localities of the granulite facies terrain of Kerala. The study reveals that monophase carbonic inclusions are the dominant type which occur as diamond-shaped inclusions azonally or along healed micro-fractures. They show complete filling at room temperature with a dense, dark fluid phase which is deduced to be CO_2. These syngenetic and subsyngenetic inclusions serve as records of the activity of a high-density CO_2-rich phase during the metamorphic evolution of the charnockites.

Paucity of aqueous two-phase inclusions testifies to low PH_2O and high PCO_2 conditions for the equilibration of the "dry granulite" mineral assemblage. The fault-lineaments of the Kerala region probably served as deep-seated conduits for CO_2 access from the upper mantle to the lower crust. (Author's abstract)

SANTOSH, M., 1984e Nature of ore fluids in the Odara rare metal pegmatite, Kerala, India: Neues Jahrb. f. Mineral. Monat., no. 6, p. 241-250. Author at Centre for Earth Sci., PB No. 2235, Trivandrum, 695010, India.

The Odara pegmatite is an ideally zoned muscovite-columbite-magnetite-aquamarine-bearing variety which belongs to the pegmatite suite of Pan-African event recognized in the Kerala region. Fluid inclusion studies of quartz associated with ore minerals from the three zones of the pegmatite are used here to estimate the thermobarometric parameters of the ore fluids.

Among the primary and pseudosecondary inclusions in quartz from the various zones, the dominant phase-types are aqueous inclusions coexisting with predominantly gaseous inclusions having different vapor liquid ratios. Thermometric studies reveal that the rare metal mineralization is largely a result of resurgent boiling and metal precipitation from heterogeneous fluids at temperatures of 240-310°C. Based on the dissolution temperatures of the daughter mineral, salinity up to 32 wt.% NaCl is estimated. The density of the ore fluid was of the order of 1.0-1.1 g/cm^3.

Pressure determination from coexisting CO_2-H_2O and H_2O inclusions in the outer zone quartz shows that the initial pressures were as high as 700 bars, with an entrapment temperature of 334°C. Estimates from the boiling curve for the corresponding salinity gives an entrapment pressure of 80 bars for the boiling fluids in the intermediate and core zones. This is indicative of a sudden adiabatic and irreversible decompression, probably due to fault-controlled emplacement, which led to precipitation, estimated to have occurred at a depth of 750 m. (Author's abstract)

SASADA, M., ROEDDER, E. and BELKIN, H.E., 1984, CO_2-bearing boiling fluid trapped in the fluid inclusions from Drill Hole DW-5, Hohi geothermal field, Japan (abst.): EOS, v. 65, no. 45, p. 1133. First author at Geol. Survey of Japan, Tsukuba, Ibaraki 305, Japan.

Fluid inclusion studies have been used to derive a model for fluid evolution in the Hohi geothermal field, Kyushu, Japan. The Hohi geothermal field is a hot-water system that is located in Pleistocene volcanic terrane and produces power commercially. Drill hole DW-5 (2 km west of Hatchobaru power plant) is 1500 m deep with a maximum of 223°C at the bottom. Above 1253 m the core intersects Early Pleistocene pyroxene-hornblende and pyroxene andesite lavas whereas below 1253 m the core is Pliocene andesitic tuff breccia and basaltic andesite lava.

Five types of fluid inclusions are found in quartz, anhydrite and gypsum from the core. They are (A) primary liquid-rich, (B) secondary vapor-rich (formed by boiling), (C) secondary liquid-rich with evidence of boiling, (D) secondary liquid-rich without evidence of boiling, and (E) monophase liquid. Boiling was recognized in type (C) by widely variable gas/liquid ratios among coexisting inclusions. CO_2 was detected in all type (A) and (D) inclusions and in all type (B) and (C) inclusions, except those at 691 m, by crushing in an alkaline $BaCl_2$ solution.

Homogenization temperatures (Th) of 488 type (A), (C), and (D) inclusions were measured with a USGS-type gas-flow heating/freezing stage. Th of inclusions trapped during boiling ranges 40° and more at a given depth because of heterogeneous trapping; some of the range may stem from necking down. Minimum Th at 691 m fits the boiling point curve of pure water adjusted to 100°C at the surface, and those at 1284 m and 1394 m are about 20° lower than the boiling point of pure water. These Th values and internal gas pressures that were estimated, using a crushing stage, can be explained by an adiabatic boiling model of CO_2-bearing water.

Freezing measurements (Tm-ice) were made on 46 inclusions. Type (A) inclusions with CO_2 were judged to have a salinity of 0.2 to 0.3 wt% NaCl equivalent solid solutes at maximum. Type (C) inclusions at 691 m without evidence of CO_2 have a salinity that ranges from 1.5 to 6.9 wt% NaCl equivalent. Type (C) inclusions with evidence of CO_2 have a salinity that ranges from 1.0 to 7.0 wt% NaCl equivalent solid solutes. The high NaCl concentrations are presumed to have formed by local processes outside the main fluid conduit.

We conclude that the original boiling fluid as trapped in inclusions had 1-2 wt% NaCl equivalent and 1.3 wt% CO_2. Type (A) and (D) inclusions formed during the cooling process. Their Th is located between the present well temperature and the boiling point curve. The present cool groundwater formed type (E) inclusions that are found only in gypsum. (Authors' abstract)

SASAKI, Akira, ULRIKSEN, C.E., SATO, Kohei and ISHIHARA, Shunso, 1984, Sulfur isotope reconnaissance of porphyry copper and manto-type deposits in Chile and the Philippines: Bull. Geol. Surv. Japan, v. 35, no. 11, p. 615-622. First author at Mineral Deposits Dept., Geol. Survey of Japan, Higashi 1-1-3, Yatabe, Tsukuba, Ibaraki, 305, Japan.

Sulfur isotopes of porphyry copper and manto-type mineralization and the host granitoids in Chile and the Philippines follow the trend characteristic of the magnetite-series granitoid regime. Isotopic fractionation between the rock- and ore sulfur, $\Delta\delta^{34}S$(rock-ore), is found to be 8 ± 1 per mil on the average. This is larger than the value, 3 ± 1 for the skarn and vein-type deposits from Japanese granitic terrains and suggests that the relatively high fO_2 conditions have prevailed in the mineralizations concerned. (Authors' abstract)

SATAKE, Hiroshi and MATSUO, Sadao, 1984, Hydrogen isotopic fractionation factor between brucite and water in the temperature range from 100° to 510°C: Contrib. Mineral. Petrol., v. 86, p. 19-24. First author at Nat'l. Res. Center for Disaster Prevention, Sakura-Mura, Niihari-Gun, Ibaraki 305, Japan.

Brucite is always depleted in deuterium relative to the coexisting water, and the degree of depletion becomes larger with decreasing temperature. (From the authors' abstract)

SATO, Motoaki, 1984, The oxidation state of the upper mantle: thermochemical modeling and experimental evidence (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 389-390 (in English).

SATO, Motoaki, SUTTON, A.J. and McGEE, K.A., 1984, Anomalous hydrogen emissions from the San Andreas fault observed at the Cienega Winery, central California: Pure & Applied Geophysics, v. 122, no. 2-4 (1984), p. 376-391 (pub. 1985). First author at U.S. Geol. Survey, Reston, VA 22092.

We began continuous monitoring of H_2 concentration in soil along the San Andreas and Calaveras faults in central California in December 1980, using small H_2/O_2 fuel-cell sensors. Ten monitoring stations deployed to date have shown that anomalous H_2 emissions take place occasionally in addition to diurnal changes. Among the ten sites, the Cienega Winery site has produced data that are characterized by very small diurnal changes, a stable baseline, and remarkably distinct spike-like H_2 anomalies since its installation in July 1982. A major peak appeared on 1-10 November 1982. The occurrences of these peaks coincided with periods of very low seismicity within a radius of 50 km from the site. In order to methodically assess how these peaks are related to earthquakes, three H_2 degassing models were examined. A plausible correlational pattern was obtained by using a model that (1) adopts a hemicircular spreading pattern of H_2 along an incipient fracture plane from the hypocenter of an earthquake, (2) relies on the $FeO-H_2O$ reaction for H_2 generation, and (3) relates the accumulated amount of H_2 to the mass of serpentinization of underlying ophiolitic rocks; the mass was tentatively assumed to be proportional to the seismic energy of the earthquake. (Authors' abstract)

SATO, T., OMORI, Y. and NAMBU, M., 1984, Quantitative analysis of metallic ions associated with fluid inclusions: Springer Ser. Chem. Phys., v. 36,

no. Second. Ion Mass Spectrom., SIMS 4, p. 471-474 (in English) (also in CA: 102(14)124772x).
Indexed under Fluid Inclusions.

SAVAGE, D., 1984, The geochemical interactions of simulated borosilicate waste glass, granite and water at 100-350°C and 50 MPa: British Geol. Survey, Natural Environment Research Council, Rept. FLPU 84-3. Author at Fluid Processes Res. Group, British Geol. Survey, Keyworth, UK.

Interactions for 30 to 200 days were followed by extensive analyses of both solid and liquid phases. (E.R.)

SAVEL'YEV, V.S., OGLOBLINA, A.I., FLOROVSKAYA, V.N., RUDENKO, A.P. and KULAKOVA, I.I., 1984, Polycondensation of carbon monoxide with hydrogen-possible source of natural polycyclic aromatic hydrocarbons: Akad. Nauk SSSR Doklady, v. 275, no. 3, p. 733-736 (in Russian). Authors at Moscow State Univ., Moscow, USSR.

The amount of products of polycondensation CO + H_2 depends on temperature, duration of experiment and composition of G mixture - pertinent to inclusion opening for G analysis by decrepitation method. (A.K.)

SAWKINS, F.J., 1984, Ore genesis by episodic dewatering of sedimentary basins: Application to giant Proterozoic lead-zinc deposits: Geology, v. 12, p. 451-454. Author at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN 55455.

A primary feature of several giant, conformable, sediment-hosted lead-zinc deposits is the occurrence of sulfide ore in a series of discrete lenses interlayered with barren sedimentary units, suggestive of protracted episodic mineralization events. Recently, certain workers have invoked episodic dewatering of basin brines for the formation of Mississippi Valley-type lead-zinc deposits. Thus, each of these two types of major lead-zinc deposits could represent products of a fundamental sedimentary brine expulsion process, the former operating mainly in rift environments, the latter mainly in epicratonic basins. (Author's abstract)

SCARRATT, K. and HARDING, R.R., 1984, Glass infilling of cavities in natural ruby: The J. of Gemmology, v. 19, no. 4, p. 293-297. First author at The L.C.C.I. British Gem Testing Lab.

Includes an electron microprobe analysis (average of 5) of glass: SiO_2 59.0, Al_2O_3 28.4, FeO 0.7, MgO 0.5, Na_2O 2.6, K_2O 5.4, Cr_2O_3 <0.2, total 96.6. (E.R.)

SCHATZEL, S.J. and HYMAN, D.M., 1984, Methane content of Gulf Coast domal rock salt: Bureau of Mines Report of Investigations, RI 8889, 18 pp. Authors at Pittsburgh Res. Center, Bureau of Mines, Pittsburgh, PA.

Large-scale methane releases in domal salt mines have resulted in ignitions and mine fatalities as recently as 1979. Several past studies have implied that hazardous methane occurrences in U.S. salt domes are distributed neither uniformly nor randomly, but are geologically controlled and potentially predictable.

A first step by the Bureau of Mines is addressing the problem of methane in domal salt mines required development of a new test to determine volumes of gases in solid salt samples. This report considers the results achieved when 80 domal salt samples were tested for gas content by dissolution in a controlled atmosphere chamber. Criteria were organized to delineate salt types based on geological occurrence. Outburst samples range from 0.014 to 7.4 cm^3 CH_4/100 g NaCl, anomalous salt samples from 0.0027 to 2.6 cm^3 CH_4/100 g NaCl, and normal salts from less than 0.0003 to 0.31 cm^3 CH_4/100 g NaCl. The presence of higher hydrocarbons was most common in samples containing larger quantities of methane. The presence of higher hydrocarbons appears to be useful in detecting methane hazards where some methane may be lost before gas content testing. An exploratory rotary and/or core drilling program, dissolution testing for gas content, and up-to-date geologic mine mapping could allow a mine operator to assess methane hazards in domal salt. (Authors' abstract)

SCHERBAN, I.P., 1984, Estimation of ore content for low-temperature metasomatites through paleotemperature gradients (data on listvenites-beresites and argillizites) (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 448. Author at Inst. Geochem. & Physics of Minerals of Ukrainian SSR Acad. Sci., Kiev, USSR.

Our thermometric data on low-temperature deposits of rare metals and associated metasomatites, listvenites-beresites and argillizites in particular, bear testimony of their formation over a wide range of paleotemperature gradients. Minimum paleotemperature gradients amounting to 5°C per 100 m are peculiar to deposits occurring in platforms and continental rifts. Maximum temperature [gradients] amounting to 25-30°C per 100 m are characteristic of orogenic structures deposits, particularly of those in the active volcanic regions.

Our thermodynamic calculations and experimental data indicate the temperature of formation of listvenites-beresites does not exceed 300-350°C, that of argillizites being 250-300°C. The pressure corresponding to the temperatures was of the order of hundreds and no more than a thousand atmospheres, the relative contents of CO_2 in fluids being of the order of tens of per cent. Ore-bearing parageneses are characterized by a still lower stability limit. For mercury ores, regardless of the type of host structures, it does not exceed 150-170°C, amounting to 200-250°C for polymetallic and gold ores.

Thus, provided the decrease of the process of mineral formation for the given type of deposit occurred at 50°C, the vertical span of listvenites-beresites section is about 5-6 km in platforms and continental rifts amounting to 1 km within orogenic zones[sic] and that of argillizites ranging from 4-5 to 750-800 m. The ore peaks for these columns are about 2.5 km - 500 m for mercury ores and from 3-4 km to 500-700 m for gold and polymetallic ores. (Author's abstract)

SCHIDLOWSKI, Manfred, MATZIGKEIT, Udo and KRUMBEIN, W.E., 1984, Superheavy organic carbon from hypersaline microbial mats; Assimilatory pathway and geochemical implications: Naturwissenschaften, v. 71, p. 303-308 (in English).

SCHIFFMAN, P., ELDERS, W.A., WILLIAMS, A.E., McDOWELL, S.D. and BIRD, D.K., 1984, Active metasomatism in the Cerro Prieto geothermal system, Baja California, Mexico: A telescoped low-pressure, low-temperature metamorphic facies series: Geology, v. 12, p. 12-15. First author at Dept. Geol., Univ. California, Davis, CA 95616.

In the Cerro Prieto geothermal field, carbonate-cemented, quartzofeldspathic sediments of the Colorado River delta are being actively metasomatized into calc-silicate metamorphic rocks by reaction with alkali chloride brines between 200 and 370°C, at low fluid and lithostatic pressures and low oxygen fugacities. Our petrologic investigations of drill cores and cuttings from more than 50 wells in this field identified a prograde series of zones that include a index minerals wairakite, epidote, prehnite, and clinopyroxene. Associated divariant mineral assemblages are indicative of a very low pressure, low-temperature metamorphic facies series spanning the clay-carbonate, zeolite, greenschist, and amphibolite facies. This hydrothermal facies series, which is now recognized in other active geothermal sytems, is characterized by temperature-telescoped dehydration and decarbonation. Its equivalent can now be sought in fossil hydrothermal systems. (Authors' abstract)

SCHIFFRIES, C.M., 1984, The Bushveld hydrothermal system: Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 2, p. 385-386. Author at Dept. Geol. Sci., Harvard Univ., Cambridge, MA.

Several lines of evidence demonstrate that one or more hydrothermal systems have been active in and around the Bushveld Igneous Complex. Most compelling are the saline fluid inclusions that have been observed in numerous samples from the interior of the Complex and from the floor-, wall-, and roof-rocks. There are, in addition, many small hydrothermal Pb deposits in the contact aureole near the base and sides of the Complex, and several hydrothermal Sn deposits in the roof-rocks. Certain transgressive pegmatoids found within the Complex have been interpreted as metasomatic replacement bodies that are also due to hydrothermal circulation. In addition to the effects of localized hydrothermal activity, the distribution of fluid inclusions and the presence of turgid or saussuritized plagioclase and late hydrous minerals suggest that pervasive fluid-rock interactions occurred. The sources of the water and dissolved salts are believed to be largely external to the Complex.

Local concentrations of fluid inclusions, some of which contain a halite(?) daughter crystal, have been found in a 'pothole' in the Merensky Reef and in a sulfide-rich anorthosite horizon immediately below the Main Magnetite seam. Homogenization temperatures in excess of 300°C have been recorded for some of these inclusions. Textural evidence of host-rock alteration is consistent with the hypothesis that these areas were subjected to intense hydrothermal activity. This raises the possibility that the potholes are solution features and that certain mineralized horizons in the Bushveld that are generally regarded to be syngenetic and unaltered stratiform magmatic deposits may actually have been sufficiently influenced by hydrothermal activity so they should be considered epigenetic. (Author's abstract)

SCHMIEDL, H.D., KOCH, K., BOTTGER, T., STIEHL, G., PILOT, J. and JORDAN, H., 1984, The isotopic composition of the water of crystallization of carnallitesand their evolved fluids: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 337-346: Leipzig, Akad. Wissen. der DDR (in German).

SCHNEIDER, M.E. and EGGLER, D.H., 1984, Compositions of fluids in equilibrium with peridotite: implications for alkaline magmatism-metasomatism, in Kimberlites, v. I: Kimberlites and related rocks, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 383-394.

SCHNORR, P.H., GORMAN, J.A. and KESLER, S.E., 1984, Gas halos in hydrothermal clays associated with ore shoots at Creede, Colorado (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 41. Authors at Dept. Geosci., Univ. Michigan, Ann Arbor, MI 48109.

Although epithermal vein systems are extensive, mineable ore shoots, which are the actual exploration targets, are much more restricted in distribution. We report here preliminary tests on a method of locating buried ore shoots in epithermal vein systems by gas analysis. Laboratory tests show that CO_2, N_2, and H_2O are quickly adsorbed onto illite/smectite, even under conditions of low concentration and low temperature, and are released upon heating. Clays developed during the hydrothermal alteration accompanying mineralization have the potential to adsorb gases, especially in systems where the mineralizing fluid boiled, the process generally thought to cause ore deposition in these systems. We have tested this possibility at Creede, Colorado, where the host volcanics to the OH vein are extensively argillized. The clay cap to the vein system consists of a mixed-layer illite/smectite that is best developed in feldspar phenocrysts. Gas chromatographic analysis of the gases adsorbed onto this clay reveals a strong correlation between C-bearing gas species and proximity to mineralization. The ratio CO_2:CO_2+H_2O is high in the clay cap above the vein, low in the footwall, and decreases with increasing distance from the vein in the hanging wall. Other gas species detected (CH_4, C_nH_n, and CO) show this relationship less well. Analysis of clay for these gases is rapid (20 minutes per sample) and requires less than 0.5 g of material, making the technique applicable to large scale exploration surveys. (Authors' abstract)

SCHNORR, P.H., KESLER, S.E. and CLOKE, P.L., 1984, Micron gold-associated jasperoid: fluid inclusion chemistry and geothermometry (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 33. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Jasperoid is commonly associated with Carlin-type or micron gold deposits. It may constitute the bulk of the ore, as at Pinson, or be developed only in isolated areas, as a Carlin. Fluid inclusion studies of jasperoid utilizing traditional methods have been largely unsuccessful due to the extremely small size of the inclusions and the opacity of jasperoid. We have attempted to obtain information on the geothermometry and chemistry of these inclusions by thermal decrepitation and analysis of the evolved gases by gas chromatography. The fluid inclusions must be heated past their homogenization temperature in order to generate a sufficient internal pressure to decrepitate them. Stepheating tests indicate an optimum decrepitation temperature of 350°C. The fluids evolved from these decrepitated inclusions contain up to 14 mole percent CO_2, 2 mole percent CO, 5 mole percent N_2, and negligible CH_4. Water comprises greater than 90 mole percent of most inclusions. Gas equilibrium calculations for analyzed inclusions from Carlin indicate probable mineralization temperatures of 250°C to 270°C if the fluids were in equilibrium with graphite (e.g. carbonaceous limestone). Our inclusion analyses are permissive for a greater depth of jasperoid formation than has commonly been proposed. (Authors' abstract)

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. voor 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). Relative 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). Pressure 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)

SCHROCKE, Helmut, TRUMM, Alfons and HOCHLEITNER, Rupert, 1984, The transport of tungsten and the deposition of tungsten double oxides in fluid, aqueous solutions: Geochimica Cosmo. Acta, v. 48, p. 1791-1805. Authors at Inst. Kristal. und Mineral. der Univ., Theresienstrasse 41, 8000 München 2, FDR (in German; English abstract).

The transportation of W in aqueous gas-phases at and above 500°C is examined using thermodynamic data. The transport of W is possible as fluoride and oxifluoride. The deposition of wolframite continues with decreasing temperature and pressure. The stabilities of wolframites in hydrothermal solutions are examined for temperatures up to 300°C with Eh-pH-diagrams, exchange reactions of wolframite with oxides, sulfides and dissolved ions. Fe_2WO_6 becomes stable against $Fe_2O_3 + WO_3$ above 126°C. At 300°C its range of stability begins at high pO_2 which is not realized in hydrothermal endogenous solutions. In consequence of the very low Gibbs energies of $MgWO_4$, $CaWO_4$ and $BaWO_4$, the minerals $MgWO_4$ and $BaWO_4$ should be more important than wolframite, if Mg and Ba coexist in solution together with W. Co and Ni also should be found as trace elements in wolframite, if Co and Ni were in solution in sufficiently high concentrations together with W. (Authors' abstract)

SCHRÖTER, R., ed., 1984, ZFI-Mitteilungen, "Isotope in der Natur," nos. 84 (423 pp.) and 85 (448 pp.): Leipzig, Akad. Wiss. der DDR (in English, German, or Russian).

These two volumes contain the papers given at a meeting 15-18 November 1983, in Leipzig, on Isotopes in Nature. Only those items of particular interest are abstracted in this volume; many others may be of marginal interest. (E.R.)

SCHWANDER, J. and STAUFFER, B., 1984, Age difference between Polar ice and the air trapped in its bubbles: Nature, v. 311, p. 45-47. Authors at Physics Inst., Univ. Bern, CH-3012 Bern, Switzerland.

Air entrapped in bubbles formed in cold ice has essentially the same composition as that of the atmosphere at the time of bubble formation. The analysis of dated ice samples therefore enables the history of atmospheric composition to be investigated. The age of the entrapped air is, however, not the same as that of the surrounding ice because air bubbles only become isolated from the atmosphere during the transition from firn to ice. Typically the age of the ice a this transition is between 100 and 3,000 yr, depending mainly on firn temperature and snow accumulation rate. The mean age difference between ice and enclosed air, as well as the age distribution width for a given sample, are especially important for the investigation of the anthropogenic increase of CO_2 and trace gases in the atmosphere over the last centuries, and for the comparison of climatic parameters recorded in the ice with parameters recorded in the bubbles. For Siple Station (Antarctica), this age difference and age distribution width were deduced from the bubble volume measured as a function of depth. The values are 95 yr and 22 yr respectively. (Authors' abstract)

SCRATCH, R.B., WATSON, G.P., KERRICH, R. and HUTCHINSON, R.W., 1984, Fracture-controlled antimony-quartz mineralization, Lake George deposit, New Brunswick: mineralogy, geochemistry, alteration, and hydrothermal regimes: Econ. Geol., v. 79, p. 1159-1186. First author at 6239 Edenwood Drive, Mississauga, Ontario L5N 3B5, Canada.

The Lake George antimony deposit consists of stibnite-bearing quartz veins which transect tightly folded Silurian graywacke, siltstone, and shale of the Fredericton trough. The veins are of two orientations: 000°/35°E (Lawrence vein) and 090°/33°N (Hibbard and Prout veins). To date, approximately 1 million short tons of ore grading 3.0 to 3.5 percent Sb have been mined from Hibbard, the dominant vein.

Stibnite-bearing quartz veins transect the contact metamorphic aureole of a small granodiorite porphyry stock which flanks the Devonian Pokiok batholith. The Hibbard vein refracts through folded country rocks, resulting in troughs and crests in the plane of the vein. Approximately 80 percent of the ore mined from the Hibbard vein has come from one northeasterly trending ore shoot which formed at the intersection of the Hibbard vein with a synclinal axis in the country rocks.

Three chemically distinct alteration zones have been recognized. The first is a domain of fracture-controlled argillic alteration rich in arsenopyrite, pyrite, and pyrrhotite which transects the preexisting contact metamorphic aureole. The second is a thin siliceous rind which transects the argillic zone and is temporally and spatially related to vein emplacement along the fractures. The third is an areally extensive oxidized zone of hematite-magnetite-quartz alteration which postdates the argillic zone and is contemporaneous with the siliceous zone and associated stibnite-bearing quartz veins. Two-way chemical mass balance reveals that wall-rock alteration accompanyng stibnite quartz veins emplacement involved major additions of Sb, As, S, and volatiles, with minor introduction of K_2O, Rb, and Si. Fe_2O_3, MgO, CaO, and Na_2O along with Co, Ni, Ba, and Zn were stripped, whereas Sc, Ti, and Al behaved essentially isochemically. The argillic alteration developed at 260° to 490°C from fluids with a $\delta^{18}O$ = 10 per mil. The Hibbard vein was precipitated at 325° to 350°C from a saline hydrothermal fluid with a $\delta^{18}O$ value of 11 to 12 per mil and a δD value of -20 to -30 per mil, undergoing transient boiling at a presssure of 270 to 420 bars. Salinity is estimated at 38 to 40 weight percent NaCl. Hematitic alteration was formed at 200° to 350°C in the presence of a fluid with a $\delta^{18}O$ value fo 2 to 8 per mil. The ore-forming solutions may have been a late-stage magmatic fluid evolved off a high ^{18}O granitic intrusion, derived in turn from partial melting of the Sb-enriched sediments. Hematitic alteration is interpreted to represent an independent meteoric water convective system driven by the thermal anomaly of the cooling pluton. Alternatively, the ore solutions may have been meteoric waters which underwent large positive shifts in ^{18}O and salinity during thermally driven convective circulation of meteoric water through the Sb-enriched sediments under conditions of a low water to rock ratio. The vein has locally been modified by subsequent deformation. (Authors' abstract)

SEAL, R.R., II, CLARK, A.H. and MORRISSY, C.J., 1984, Contrasts in physicochemical controls in scheelite deposition, Lake George W-Mo stockwork deposit, New Brunswick, Canada (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 649. First author at Dept. Geol. Sci., Queen's Univ., Kingston, Ontario K7L 3N6, Canada.

Fluid inclusions, and veinlet and alteration assemblages in both veinlet-types, confirm that temperatures decreased away from the intrusion; factors controlling pH, however, were specific to each veinlet-type.

In calc-silicate/quartz veinlets with calcic alteration envelopes (Type 1), scheelite deposition occurred from 550 to 400°C from a brine (~8.5 equiv. wt.% NaCl) with $XCO_2<0.03$. Te of fluid inclusions, and veinlet and alteration assemblages, confirm the presence of $CaCl_2$ in these fluids. Thus, interaction with the wall-rocks was the dominant control on pH in Type 1 veinlets. In quartz veinlets containing minor alkali-feldspar (Type 2), mineralization temperatures ranged from over 550°C, near the cupola, to below 300°C. Fluid inclusions from these veinlets contain 3 phases: brine (~7.2 equiv. wt.% NaCl); CO_2 liquid; and CO_2 vapor. The proximal veinlets, which are weakly mineralized, contain fluid inclusions with fairly constant H_2O/CO_2 ratios (XCO_2~0.25), whereas the more strongly mineralized, lower temperature, distal veinlets contain fluid inclusions with highly variable H_2O/CO_2 ratios, suggesting fluid immiscibility at the time of entrapment. Thus, CO_2 effervescence was the dominant control on the pH in Type 2 veinlets. (From the authors' abstract)

SECORD, T.K., 1984, The geology and geochemistry of the Ore Hill zinc-lead-copper deposit, Warren, New Hampshire: MS thesis, Univ. Wisconsin, Madison, WI, 99 pp.

Indexed under Fluid Inclusions.

SEDOVA, I.S. and GLEBOVITSKIY, V.A., 1982, Migmatization and granitization during metamorphism of the andalusite-sillimanite type in the Ladoga series: Dokl. Akad. Nauk SSSR, v. 264, no. 2, p. 431-434 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 264, p. 109-112, 1984). Authors at Inst. Precambrian Geol. & Geochron., USSR Acad. Sci., Leningrad, USSR.

Study of inclusions of the mineral-forming medium in vein minerals revealed not only CO_2, CO_2-H_2O, gas-liquid and salt inclusions, but also crystallized melt inclusions. The very presence of the latter inclusions is indicative of melting during emplacement of migmatite veins. Solid phases in such inclusions began to melt at about 600° to 650°C. The total Th, i.e., solution of the gas phase, is: 678°C for inclusions in rocks of generation $\gamma(1+2)$, developed under conditions of the garnet-biotite-sillimanite-muscovite subfacies (average of 14 determinations in the range from 630° to 730°C); 711°C for inclusions in rocks of same generation, but formed under conditions of the garnet-biotite-cordierite-orthoclase subfacies (average of ten in the range from 670° to 780°C); 715°C for inclusions in rocks of generation $\gamma(3)$ (average of 15 in the range from 670° to 780°C); and 715°C for those in rocks of generation $\gamma(4)$ (average of ten in the range from 680° to 780°C). For inclusions in highly displaced granodiorite, the range of Th is wider - 650° to 1010°C (average 717°C, 20 determinations). Maximum Th of crystal-fluid inclusions range from 600° to 650°C. Temperatures calculated from the garnet-biotite thermometer and mineral parageneses in vein-enclosing high-alumina gneiss coincide well with figures for Th. They range from 630° to 680°C for the substrate of veins of generation $\gamma(1+2)$ and from 685° to 775°C for that of veins of generation $\gamma(4)$. For the latter veins, crystallization temperatures calculated from the garnet-biotite thermometer are 10° to 20°C lower than for the substrate. This could be due to the higher reactivity of postmigmatization fluid in granite than in gneiss. (From the author's text)

SEEBAUGH, W.R. and STRAUSS, A.M., 1984, Libyan Desert glass: remnants of an impact melt sheet (abst): Lunar and Planet. Sci. XV, p. 744-745.

SEGALL, Paul, 1984, Rate-dependent extensional deformation resulting from crack growth in rock: J. Geophys. Research, v. 89, no. B6, p. 4185-4195.

SELVERSTONE, Jane, SPEAR, F.S., FRANZ, Gerhard and MORTEANI, Giulio, 1984, High-pressure metamorphism in the SW Tauern Window, Austria: P-T paths from hornblende-kyanite-staurolite schists: J. Petrology, v. 25, pt. 2, p. 501-531. First author at Dept. Earth & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139, USA.

The hornblende garbenschist horizon of the Lower Schieferhulle series (LSH) in the SW Tauern Window, Austria, contains the assemblage hornblende + kyanite + staurolite + garnet + biotite + epidote + plagioclase + ankerite + quartz + rutile + ilmenite, with either chlorite or paragonite present in all samples. These assemblages are divariant in the system SiO_2-Al_2O_3-TiO_2-Fe_2O_3-MgO-FeO-MnO-CaO-Na_2O-K_2O-H_2O-CO_2. Garnet-biotite geothermometry yields temperatures of final equilibration of ~550°C, and garnet-plagioclase-kyanite-quartz geobarometry indicates pressures of 6-8 kb for the matrix assemblage and 9-10 kb for plagioclase inclusions in garnet. Quantitative modelling of zoned garnet, hornblende, and plagioclase indicates growth and equilibration along a decompression path from ~520°C, 10 kb to ~550°C, 7 kb. Fluid inclusion data constrain the uplift path to have passed through a point at ~375°C, 1·5 kb.

These data permit the construction of a relatively complete P-T loop for metamorphism associated with the Alpine orogenic cycle in the LSH of the SW Tauern Window. The maximum pressure conditions (~10 kb at 530°C) recorded along this loop are considerably higher than previous estimates of 5-7 kb for the region. Simple overthrust models developed for the Tauern Window cannot account for pressures of this magnitude; a more likely scenario involves partial subduction of the rocks to a depth of ~35 km, followed by prolonged heating in response to decay of the subduction isotherms. Initial uplift appears to have been rapid and occurred along a nearly isothermal path. Significant cooling did not occur until the rocks were within ~5 km of the surface. Detailed tectonic models for the evolution of the Tauern Window must be able to account for the quantitative features of the P-T loop. (Authors' abstract)

SENGERS, J.V. and KAMGAR-PARSI, B., 1984, Representative equations for the viscosity of water substance: J. Phys. Chem. Ref. Data, v. 13, no. 1, p. 185-205.

SERDYUCHENKO, D.P., BOL'SHAKOVA, T.N. and CHEREPIVSKAYA, G.Ye., 1984, Tourmalines from pegmatites and granites of Lipovka in the Urals: Zapiski Vses. Mineral. Obshch., v. 113, no. 4, p. 478-485 (in Russian). Authors at Inst. Mineral., Geochem. and Crystallochem. of Rare Elements, Moscow, USSR.

Th of P inclusions and P are as follows: pink variety of tourmaline - 200 to 360°C, 360 to 410 atm, green variety - 370-310°C, 750 atm. (A.K.)

SEWARD, T.M., 1984a The formation of lead (II) chloride complexes to 300°C: a spectrophotometric study: Geochimica Cosmo. Acta, v. 48, p. 121-134.

SEWARD, T.M., 1984b The transport and deposition of gold in hydrothermal systems, in Gold '82: the geology, geochemistry and genesis of gold deposits, ed., R.P. Foster: Rotterdam, Balkema (Geol. Soc. Zimbabwe

Spec. Pub. No. 1), p. 165-181. Author at Chem. Div., Dept. Sci. & Industrial Res., Private Bag, Petone, New Zealand.

An understanding of the conditions under which gold precipitates from hydrothermal ore solutions requires a knowledge of the chemistry of gold complex equilibria at elevated temperatures and pressures. Information about the stability of such complexes in response to changes in temperature, pressure, oxidation potential, pH and the activities of various complexing ligands is therefore of fundamental importance.

Gold occurs predominantly in the +1 oxidation state in geothermal fluids in the Earth's crust and hydrothermal ore solutions contain a number of components which can form stable complexes with gold. The transport of gold as complexes containing sulphide, chloride, ammine and thioarsenite ligands is of interest because these are ubiquitous components of hydrothermal fluids, although relevant experimental data upon which to base conclusions are rather sparse. With our present state of knowledge, it is concluded that thio-complexes of gold in which Au(I) is complexed by a sulphur-donor ligand such as HS^- are probably the dominant mechanism of gold transport in hydrothermal systems. In higher temperature systems (T >400°C) of high salinity and low activity of reduced sulphur, simple chloro- and hydroxochloro-complexes may be important.

Gold deposition in hydrothermal systems will be in response to changes in T, P, Eh, pH and decreasing activities of complexing ligands. In addition, amorphous arsenic and antimony sulphide sols are very efficient in extracting gold from aqueous solutions, both at ambient and elevated temperatures. (Author's abstract)

SEWARD, T.M., 1984b A spectrophotometric study of iron (II) and (III) chloride complex equilibria up to 300°C (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 165 (in English). Author at Chem. Div., Dept. Sci. and Industrial Research, Private Bag, Petone, New Zealand.

The absorption spectra of Fe (II) and Fe (III) chloride complexes in HCl solutions (0.001 to 3.0 m) up to 300°C have been measured and the transport of iron in geothermal and hydrothermal fluids will be discussed. (From the author's abstract)

SHANKS, W.C. and JANECKY, D.R., 1984, Incremental reaction modeling and sulfur isotope evolution of seafloor hydrothermal fluids: 21° N and San Juan de Fuca Rise (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 651.

SHARKOV, Ye.V., 1983a The petrological role of liquation in magmatic processes: Geokhimiya, no. 10, p. 1399-1412 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 5, p. 118-129, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 238, 1983. (E.R.)

SHARKOV, Ye.V., 1983b Petrology of magmatic processes: "Nedra," Moscow, 200 pp., 790 copies printed, price 2 rbls. 40 kopecks (in Russian).

The book presents geological regularities of structure of intrusive bodies, systems providing the physico-chemical basis of analysis of magmatic processes, petrological analysis of effusive series and general problems of petrology of magmatic rocks, including petrological role of immiscibility in magmatic processes. (A.K.)

SHARMA, Rajesh and PATIL, R.R., 1984, Fluid inclusion studies in India: it's present state and future prospects: Abstracts, Nat'l. Seminar on

Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 3. Authors at Wadia Inst. Himalayan Geol., Dehradun-248001, India.

Very little has been done, mostly due to the unavailability of modern instrumentation, but much can be done. (E.R.)

SHATAGIN, N.N., 1984a Discrimination of decreptograms and of other analytical curves into components: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 507-511.

SHATAGIN, N.N., 1984b Mathematical modelling of liquation exsolution of ore magmas: Geol. Rudn. Mestorozhd., v. 26, no. 5, p. 73-80 (in Russian). Author at Moscow State Univ., USSR.

Dispersed systems (emulsions) of various composition, including ore melt droplets in silicate melt, may form under magmatic conditions due to immiscibility. The author lists the following mechanisms of increase of the dispersed phase particles: floculation - grouping of dispersed phase droplets with formation of clusters; coalescence - joining of two droplets to form one bigger; sedimentation - gravitational accumulation of dispersed droplets. Attraction (coagulation) of droplets may be caused by the activities: 1. Brownian, 2. turbulence (convection), 3. hydrodynamics, 4. electric. Gravitational coalescence may be one of the most important factors causing magma splitting. Under certain conditions coalescence in the gravitation field may be a self-activating (i.e., developing with increasing intensity) process, causing segregation of ore and silicate melts much faster than it is accepted in traditional models. Dynamics of gravitational coalescence may be described by integral-differential equations, which may be studied by computer methods. Computer modelling leads to evaluation of time of complete splitting of the system, depending on the initial parameters of magmatic system like viscosity, densities of splitting melts, initial concentration of droplets, droplet size distribution, etc. (Abstract by A.K.)

SHAVER, S.A., 1984a Elemental dispersion at the Hall (Nevada moly) porphyry molybdenum deposit, Nye County, Nevada, and its relationship to features of alteration and mineralization (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 28. Author at Dept. Applied Earth Sci., Stanford Univ., Stanford, CA 94305.

Each of two molybdenum-bearing, quartz monzonitic stocks were emplaced at 66-70 m.y.b.p. and underwent continuous inward crystallization which was interrupted three times by the successively deeper release of hydrothermal fluids. The stocks are concentrically zoned texturally and each contains three stacked molybdenum ore bodies and overlapping zones of alteration and mineralization. Mapping and petrographic/fluid inclusion studies indicate that in each alteration/mineralization pulse, early quartz-molybdenite ± chalcopyrite-pyrite veinlets with K-feldspar envelopes (T = 470-750°C; Wt. % NaCl eq. = 8-19%) were followed by quartz-muscovite ± pyrite and fluorite (greisen) veinlets with envelopes of coarse-grained (1-23 mm) muscovite. Later fluids in some pulses formed quartz-magnetite veinlets or chlorite-enveloped quartz-pyrite-chalcopyrite ± magnetite veins, but all pulses were ultimately closed by quartz-galena-sphalerite-chalcopyrite tetrahedrite, pyrite veins having no alteration envelopes (T = 370-450°C; Wt. % NaCl eq. = 30-41%). (From the author's abstract)

SHAVER, S.A., 1984b Fluid inclusion study of alteration and mineralization at the Hall (Nevada Moly) deposit, Nye Co., Nevada (abst): Geol. Soc. Am.

Abstracts with Programs, v. 16, p. 652-653. Author at Dept. Applied Earth Sci., Stanford, CA 94305.

Each of 5 Mo orebodies (0.04-0.2% Mo) at Hall formed from hydrothermal fluids that evolved from albitic alteration (subsolidus, pre-vein albite overgrowths on plag.) to incipient potassic veinlets (1-5mm wide, qtz ± Kspar; Kspar haloes, no sulfides) to qtz-moly veinlets (2-20mm wide, qtz-moly ± py ± cp; Kspar haloes), to greisen veinlets (2-40mm wide, musc ± qtz ± py ± fluorite; coarse (1-23mm) musc haloes). Each cycle closed with qtz-mt veins (3-14mm wide, qtz-mt, no haloes), base-metal veins (20-120mm wide, qtz-gl-sph-cp ± tetrahedrite ± py, no haloes) and/or chlorite-haloed veins (20-100mm wide, qtz-py-cp ± mt, chl haloes). Five types of fluid inclusions were observed in vein qtz in heating/freezing runs on 467 inclusions--1: L-rich, L+V → L; 2: V-rich, V+L → V; 3: L-rich, L+V → critical fluid; 4: L-rich, L+V+D → L+V → L; 5: L-rich, L+V+CO_2 → L+V → L. Primary inclusion types are 1, 2, 3, or 4; secondary inclusions are 1, 2, or 5. Inclusion densities are high (500-2500/mm^3). Tabulated data below are for primary inclusions:

VEIN TYPE	INCL. TYPE	DAUGHTER MINERALS	WT.% NaCl eq.	HOMOG'N T(°C)	T(°C) OF FORMATION	PRESSURE REGIME
Qtz-moly	2	---	9-19	470-595	470-750	Litho.
Greisen	1	---	--	>370-448	>370-448	Litho.?
Qtz-mt	1,2,3	---	2.7-4.2	370-426	370-426	Hydro.(B)
Base-metal	1,4	H,S,hm,D?	30-41	370-448	370-448	Hydro.(B?)
Chl-haloed	1,4	H(?),hm,cp,D?	--	330-390	330-480	Hydro.

Differences in T, P, and salinity between early and later vein fluids are consistent with the fact that later veins are wider and more through going and suggest that the fracture system in each pulse expanded outward until fluid P dropped from litho. (.41-.94 Kb) to nearly hydro. (.23-.35 Kb) and later fluids boiled. (Abbrev.: L = liquid, V = H_2O vapor, D = daughter, "→" = homogenizes to, H = halite, S = sylvite, hm = hematite; cp = chalcopyrite, mt = magnetite, D? = unknown D, B = boiling, litho = lithostatic, hydro = hydrostatic.) (Author's abstract)

SHAVER, S.A., 1984, Greisenization at the Hall (Nevada Moly) mine, Nevada and implications for controls on greisen vs sericitic alteration in porphyry deposits (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 105. Author at Dept. Applied Earth Sci., Stanford Univ., Stanford, CA 94305.

Greisen alteration (coarse-grained white mica + qtz), typical in tin-related granites, is also common in quartz monzonite type porphyry molybdenum deposits, but absent or only weakly developed in porphyry copper deposits and Climax-type porphyry molybdenum deposits. At Hall, in each of 6 distinct pulses of alteration and mineralization which occurred during the progressively inward crystallization of 2 quartz monzonite porphyry stocks (66-70 m.y.b.p.), greisenization followed potassic alteration in time and formed cupola-shaped zones which overprinted, and extended outward of, similarly shaped potassic zones and moly orebodies. Greisenization at Hall is related to muscovite (± qtz, py, fluorite) veinlets (up to 20 vol. % in density and 2-40 mm wide) which have wide envelopes (to 20 cm) in which plagioclase, K-feldspar, and biotite are replaced by quartz, coarse-grained (1-23 mm) muscovite, py, and fluorite. Accessory fluorite (rather than the topaz locally present in granite-related greisens) is consistent with the intermediate (higher Ca), quartz monzonitic, composition of the stocks. Remnant quartz eyes are all that remain of the original porphyry texture in intensely altered areas, where the muscovite (45.7% SiO_2, 35.5% Al_2O_3, 0.0% CaO, 1.3% MgO, 0.5% Na_2O, 10.9% K_2O, 1.2% Fe_2O_3, and 0.94% F) may reach 50 vol. % for up to 1000 m^2(sic). Fluid inclusion data indicate that greisen veinlets formed from non-boiling solutions under lithostatic pressures (2.2-3.5 km) at T >370-448°C. Sericitic alteration at Hall (<0.01 mm white mica) is pervasive, unrelated to veins, and developed subsequent to all pulses of veining at T <300°C and under more nearly hydrostatic pressures. Formation of sericitization at lower temperatures and pressures than greisenization is consistent with the observation that fluids enter the muscovite field at lower temperatures in other types of porphyry deposits. (Author's abstract)

SHAVER, S.A., 1984b The Hall (Nevada moly) molybdenum deposit, Nye County, Nevada: Geology, alteration, mineralization, and geochemical dispersion: Ph.D. dissertation, Stanford Univ., Stanford, CA, 560 pp.

At Hall, each of two molybdenum-bearing, quartz monzonite porphyry stocks (66-70 m.y.b.p.: K-Ar and U-Pb) underwent continuous inward crystallization which was interrupted 3 times by the successively deeper release of hydrothermal fluids to form a concentrically zoned stock, 3 stacked orebodies, and overlapping zones of alteration/mineralization. Each stock is zoned from finer-grained, groundmass-rich, densely veined apical phases to deeper, coarser-grained, groundmass-poor, sparsely veined phases, and successively deeper orebodies are related to successively deeper phases in each stock. Regional geology, including eastward dipping (40-80°) Tertiary volcanic rocks, and paleomagnetic data indicate that the stocks have been tilted 70° about a N30W axis and plunge to the west at about 20°

Each pulse progressed in time from albitic to potassic to greisen alteration, with later veins (chlorite-enveloped, base metal, and/or qtz-mt) closing the pulse. Based on fluid inclusions, early (potassic) veins formed from high-temperature (470-750°C), moderate salinity (<19 wt.% NaCl eq.), non-boiling fluids under lithostatic pressures of 610-790 bars; later (base metal) veins formed from lower temperature (370-450°C), high salinity (31-41 wt.% NaCl eq.), probably boiling fluids under hydrostatic pressures of 227-349 bars. Fluid pressures suggest both stocks were emplaced at depths of 2.3-3.5 km.

Pb-Zn-Ag-Mn anomalies (associated with base metal veins) occur 40 to >80 meters outward of Mo anomalies; P anomalies (associated with greisen veins) occur 30-60 meters outward of Mo highs (but inward of Pb=Zn-Ag-Mn highs) and with weaker anomalies of Sn, W, and Nb. Late pervasive sericitic alteration decreases with depth and is overprinted by still later argillic alteration which is zoned with depth from kaolinite to kaolinite-montmorillonite to montmorillonite-chlorite. Neither sericitic nor argillic alteration is clearly fracture- or vein-controlled, but both probably formed from upwelling hypogene fluids. Differences between quartz-monzonite type and Climax-type porphyry molybdenum deposits in geology, alteration, mineralization, and geochemical dispersion are consistent with greater depths of emplacement of the quartz-monzonite type deposits. (Author's abstract)

SHAVER, S.A., 1984a Origin of crenulate quartz layers--evidence from the Hall (Nevada moly) molybdenum deposit, Nevada (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 254-255. Author at Dept. Applied Earth Sci., Stanford Univ., Stanford, CA 94305.

Many intrusions in Climax-type moly deposits in Colorado contain well-developed crenulate-quartz layered apices that have been ascribed to repeated pressure fluctuations that produced unidirectional inward crystallization of quartz from the melt. Field evidence from the Hall deposit and metallurgical studies suggest an alternative model for their formation. These observations suggest that the crenulate qtz layers grew from aqueous fluid, rather than magma, and metallurgical studies suggest the aqueous fluid filled incipient fractures formed by repetitive contractions of water-saturated magma undergoing rapid, unidirectional solidification. (From the author's abstract)

SHAVER, S.A., 1984, Origin of differences between Climax-type and quartz monzonite-type porphyry moly deposits (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 254. Author at Dept. Applied Earth Sci., Stanford, CA 94305.

Recent field and fluid inclusion data from the Hall moly deposit, Nevada point out important differences between Climax-type and quartz-monzonite (QM) type deposits and suggest a model for their origin. At Hall, each of 2 QM stocks underwent progressive inward crystallization which was interrupted 3 times by successively deeper releases ("pulses") of moly-bearing hydrothermal fluids to form concentrically zoned stocks, 5 moly orebodies, and overlapping zones of alteration/mineralization. Each stock is zoned from fine-grained, high-groundmass, intensely-veined, apical phases to deeper, coarser, more equigranular, weakly-veined phases; successively deeper orebodies are associated with successively deeper, and later, phases in each stock. During each "pulse," fluids evolved from albitic to potassic to greisen alteration, with late veins (chl-enveloped, base metal, and/or qtz-mt) closing the cycle. In each pulse, early veins formed from high T (450-750°C), mod. to low salinity, non-boiling fluids under lithostatic pressure; later veins formed from lower T (330-450°C), high salinity, probably boiling fluids under nearly hydrostatic pressures. Fluid inclusions indicate minimum depths of formation at Hall of 2.2-3.5 km. Shallow depths of emplacement in Climax-type deposits (0.6-2.2 km) account for their following differences from QM types: smaller intrusion size and more aphanitic groundmass, more common intrusive breccias, single ore events with each intrusion (unlike 3 with each stock at Hall), early high salinity fluids and later low salinity fluids (the reverse of Hall), vein-controlled sericitic alteration rather than greisen (coarse muscovitic) alteration as at Hall, Cannivan, Opodepe, and other QM deposits, and much better developed silicification (which is weakly developed at Hall). Emplacement depth differences may also contribute to more differentiated intrusions and more abundant end-differentiate trace elements (e.g.: Mo, F, Sn, W, Nb, and Tl) in Climax-type than QM-type deposits. (Author's abstract)

SHCHEKINA, T.I., GRAMENITSKY, E.N. and YUDINTSEV, S.V., 1984, Experimental study of miascites of the Ilmenogorsky massif: Geokhimiya, 1984, no. 10, p. 1443-1457 (in Russian; English abstract).

Experiments have been made on melting of miascite in the presence of aqueous fluid (1.5 to 6 kbar pressure). It was determined that in the presence of H_2O the temperature of melting (crystallization) of miascites is lowered by ~400° compared to the dry system and is lowered by 30-40° more if the fluid is a 1%-aqueous solution of HF or NaOH. In the range of 1.5-4 kbar water pressure a sequence of melting of the rock-forming minerals is changed from agpaitic to miascitic. In the presence of NaOH solutions the field of crystallization of nepheline is expanded. According to the experimental data the crystallization of miascites of the Ilmenogorsky massif is estimated to have occurred under 3-5 kbar and 700-800°. At temperature higher than 700° if the concentrations of HF and NaOH are not less than 1% liquation of the melt occurs, possibly corresponding to separation of pegmatite melt in nature. (Authors' abstract)

SHCHERBA, G.N. and KORMUSHIN, V.A., 1984, Hydrothermal systems of tungsten-bearing stockworks: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 437-443. Authors at Inst. Geol. Sci., Alma-Ata, USSR.

Tungsten-bearing stockworks of Kazakhstan occupying the dome-side part of plutons are genetically related to leucocratic or alaskite late orogenic hypabyssal granites. Two groups of stockworks are distinguishable: overintrusion ones in the host rocks and interintrusion ones in the ore-bearing granites.

Composition of solutions at different vertical levels was analyzed with respect to inclusions in quartz and some ore minerals. The inclusions were mainly polyphase; the ascending fluid flow was pulsating. Passing within the boundaries of the interaction column, the solution flow with high gradients caused telescoping in metasomatites and veins. Formation of the basic W mineral was defined by the composition of the ore-forming medium. (Authors' abstract)

The composition of the ore fluids at the Verkhnee Kairakty and Boguty tungsten deposits were determined in terms of Th, total salinity, density, Na, K, Ca, Mg, H_2S, CO_2, HCO_3^-, CH_4, F, Cl, SO_4, and N_2, and related to various stages in the paragenesis. (E.R.)

SHEARER, C.K. and PAPIKE, J.J., 1984, The distribution of boron among pegmatite minerals and the mass balance of boron in granitic pegmatite systems; Black Hills, South Dakota (abst.): EOS, v. 65, p. 297-298.

SHEARER, C.K., PAPIKE, J.J., SIMON, S.B., LAUL, J.C. and CHRISTIAN, R.P., 1984, Pegmatite/wallrock interactions, Black Hills, South Dakota: progressive boron metasomatism adjacent to the Tip Top pegmatite: Geochimica Cosmo. Acta, v. 48, p. 2563-2579. First author at Inst. for the Study of Mineral Deposits, South Dakota Sch. Mines & Tech., Rapid City, SD 57701-3995.

Interaction between country rock and fluids derived from the Tip Top pegmatite has resulted in a series of boron enriched assemblages between unaltered quartz-mica schist and the pegmatite contact.

The alteration zone may represent either a single episode (B-, Cs-, Li-, Rb-enriched fluid) or multiple episodes (B, Zn, Mn fluid and Cs, Li Rb fluid) of pegmatite fluid-schist interactions. In both situations, B in the aqueous fluid from the pegmatite reacts with the schist breaking down sheet silicate "traps" for Cs, Rb, Li, and K and forming tourmaline-rich assemblages. (From the authors' abstract)

SHEKHAWAT, M.S. and RANAWAT, P.S., 1984, Heating and freezing studies of fluid inclusions in calcite of Saira area, Udaipur district, Rajasthan: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 23. Authors at Dept. Geol., Univ. Rajasthan, Udaipur, India.

Pockets, lenses, and veins of calcite occur in calc-silicate rocks of Delhi Supergroup of rocks (Proterozoic) near Saira, Udaipur district. Two-phase P fluid inclusions of rhombic shape are observed in calcite samples of one of the pits. They homogenize in liquid phase at 110°C. Tm (-3°C to -1°C) show that the solutions depositing calcite were of very low salinity. Characteristic feature of freezing is that vapor bubble reduces in size during melting of ice (-31°C onwards), in some cases the vapor bubble is completely eliminated during thawing which reappears suddenly between -2.7°C and +2.2°C. (Authors' abstract)

SHELTON, K.L., 1984, Interpretation of characteristic mineral parageneses in tungsten-molybdenum quartz vein-type deposits: N. Jb. Miner. Mh., v. H.10, p. 455-460.

Similarities of mineral parageneses and temperatures of formation of wolframite (ferberite) and associated iron sulfides in tungsten-molybdenum quartz vein-type deposits of the Republic of Korea and elsewhere have been interpreted with the aid of oxygen fugacity-pH diagrams for the system Fe-W-O-H-S. The characteristic mineral parageneses observed in these deposits are shown to be the result of cooling of hydrothermal mineralizing fluids coupled with increase of pH (neutralization) of fluids originally in equilibrium with granitic rocks by reaction with surrounding wall-rock minerals. The observed paragenetic sequence of wolframite and iron sulfides suggests that the oxygen fugacity in the hydrothermal systems was controlled by granitic intrusions at values near the quartz-fayalite-magnetite buffer. (Author's abstract)

SHELTON, K.L., SO, C.-S., CHI, S.-J. and SKINNER, B.J., 1984, Cu-Pb-Zn-Ag vein deposits in Upper Cretaceous volcanic rocks, Gyeongsang Basin, Republic of Korea (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 653. First author at Dept. Geol., Univ. Missouri, Columbia, MO 65211.

The Cu-Pb-Zn-Ag vein-type deposits of the Sambong, Samsan, and Seongji mines 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 pre-existing fault breccia zones. Each stage is terminated by an onset of fracturing and brecciation events. Fluid inclusion data suggest 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 cooling mineralizing system which largely abated prior to the onset of the next stage. Fluid inclusion data from stage III, a post-ore carbonate stage, indicate a much cooler (190° to 120°C), more dilute hydrothermal system.

Fluid inclusion and sulfur isotope evidence suggest that ore minerals were deposited at temperatures between 350° and 250°C from fluids with salinities ranging from 3 to 17 eq. wt. % NaCl. Fluid inclusion evidence of boiling suggests pressures of less than 100 bars during portions of Stage I and II mineralization, corresponding to depths of 500 to 1250 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 Stage III calcites suggest meteoric water dominated the hydrothermal system at temperatures below 200°C.

The similarity of the features of the Sambong, Samsan, and Seongji mines with those of other Cu-bearing 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)

SHEPHERD, T.J. and WATERS, P., 1984, Fluid inclusion gas studies, Carrock Fell tungsten deposit, England: Implications for regional exploration: Mineral. Deposita, v. 19, p. 304-314. First author at Isotope Geol. Unit, British Geol. Survey, 64 Grays's Inn Road, London WC1, England.

A fluid inclusion investigation of the Carrock Fell tungsten deposit, Northern England, confirms that the quartz-wolframite-scheelite veins associated with the Caledonian Skiddaw Granite are almost exclusively related to an exocontact hydrothermal system developed at the margin of a local cupola. Fluid circulation, as defined by the spatial variation in temperature and H_2O/CO_2 ratios for inclusions in vein quartz, reveals a strong structural control. The zone of maximum flow, which extends 0-400 m out from the granite contact, is characterized by high H_2O/CO_2 ratios and corresponds closely with the known distribution of high-grade oreshoots. Based on the fluid inclusion "gas" signature for the Carrock Fell deposit, a distinction can be made between potentially tungstaniferous quartz veins and those related to Cu-Pb-Zn deposits in the absence of diagnostic ore minerals. Also, a regional survey of quartz veins in the Lake District suggests that at several localities the fluids have a close affinity with those at Carrock Fell. This is interpreted as the high-level, distal expression of tungsten mineralization at depth. Evidence for similar mineralization elsewhere in the British Caledonides favors those granites in the paratectonic zones of Ireland and southern Scotland. (Authors' abstract)

SHEPPARD, S.M.F., 1984, Stable isotope studies of formation waters and associated Pb-Zn hydrothermal ore deposits, in B. Durant, ed., Thermal phenomena in sedimentary basins: Technip., Paris, p. 301-317 (in French).

Sedimentary basins are associated with saline formation waters. The production and migration of such hydrothermal metalliferous brines can be considered as a normal consequence of the evolution of the basin. Hydrogen and oxygen isotope evidence indicates that these formation waters have a variety of origins: seawater, meteoric water, and water of dehydration. In subsurface zones which have temperatures between 40° and 70°C, the isotopic composition of exchangeable minerals is determined principally by the isotopic composition of the waters and by temperature. At higher temperatures, and therefore at deeper levels, a meteoric component can often be detected, but the oxygen isotope composition of the brines is determined principally by exchange with minerals. Hydrodynamically, progressive diagenesis is not necessarily a process that involves the flow of water from deeper to shallower levels. The model proposed implies that the quantity of water available for the transfer of mass and heat is greater than that which can be accounted for from a one-time dewatering of the sediments alone.

A sedimentary basin may generate and circulate metalliferous (e.g., Pb-Zn) brines during more than one episode in its evolution. The fluids may be periodically circulated as a reaction to the processes of deposition and compaction and due to the forces of gravity, tectonics or thermal events. Such processes may explain the rejuvenation and the polyphase mineralization observed in some epigenetic deposits which are found at shallow stratigraphic levels of sedimentary formations. These deposits are evidence of thermal anomalies which arise from the migration of hydrothermal fluids from deep in a sedimentary basin. (Author's abstract, translation courtesy M.J. Logsdon)

SHEPPARD, S.M.F. and LANGLEY, K.M., 1984, Origin of saline formation waters in northeast England: Application of stable isotopes: Transactions of Inst. Mining & Metallurgy, v. 93, p. B195.

SHIBUE, Yasuhiro and IIYAMA, Toshimichi, 1984, Occurrence of topaz from silica and alunite deposits at the Ugusu mine and its implication for high fluoride concentration in fossil geothermal water: Geochem. J., v. 18, p. 209-214. Authors at Geol. Inst., Faculty of Sci., The Univ. Tokyo, Bunkyo-ku, Tokyo 113, Japan.

Topaz occurs in the central part of the altered zone of the Ugusu mine. Fluorine content of topaz was obtained by X-ray diffraction technique, with an average (±SD) of 19.7 (±0.5) wt%. Based on the assumption that the hydrothermal solution responsible for the formation of topaz has a temperature of 300°C, HF/H_2O activity ratio is estimated to be $10^{-1.86}$. This activity ratio leads to 262 ppm as fluoride concentration in hydrothermal solution. Comparison with other acid geothermal waters suggests that fluoride-rich solutions existed during the formation of the topaz. Such a high fluoride concentration may be ascribed to the condensation of volcanic gases. (Authors' abstract)

SHIKAZONO, Naotatsu and TAKEUCHI, Koichi, 1984, Estimates of selenium and sulfur fugacities and formation temperature for selenium-rich gold-silver vein-type deposits: Geochem. J., v. 18, p. 263-268. First author at Geol. Inst., Univ. Tokyo, Tokyo 113, Japan.

It was theoretically derived that the iron content of sphalerite, silver content of electrum and selenium contents of argentite and galena, which all coexist with pyrite, are related to temperature, and selenium and sulfur fugacities. Based on this relation and analytical data on these coexisting minerals, selenium and sulfur fugacities and formation temperature for the selenium-rich gold-silver vein-type deposits were deduced. The temperature estimated from this assemblage (ca. 150-300°C) is in agreement with the homogenization temperature for fluid inclusions in the Kushikino and Takatama deposits. (Authors' abstract)

SHILO, N.A., GONCHAROV, V.I., VORTSEPNEV, V.V. and AL'SHEVSKIY, A.V., 1984, On the deep nature of siliceous rocks of the Okhotsk-Chukotka volcanic belt: Dokl. Akad. Nauk SSSR, v. 279, no. 3, p. 714-718 (in Russian). Authors at North-East Complex Sci.-Research Inst. of Far-East Sci. Center, Magadan, USSR.

Plutonic complex consists of quartz diorites (phase I), granodiorite-granites (phase II) and granite-leucogranites (phase III). Quartz from these rocks bears crystallized melt inclusions. Th measurements indicate that rocks of phases I and II crystallized at high (890-1050°C) temperatures from "dry" melts; only leucogranites of phase III formed at 780-860°C from melt bearing 0.3-0.4 wt.% H_2O. Volcanic-plutonic complex includes rhyodacite porphyry and rhyolites (effusives), Th 870-1040°C, nevadite rhyolites and rhyodacites (subvolcanic), Th 800-1040°C and dikes and stocks of granite porphyries, Th 810-840°C, melt inclusions bear 3.0-3.5 wt.% H_2O. Volcanic complex bears rhyodacites (effusives), Th of inclusions in quartz 1000-1010°C, in plagioclase >1200°C, rhyolites and rhyodacites plus vitrophyres (subvolcanic), T of inclusions in plagioclase >1200°C, and dikes of granite porphyries, Th inclusions in quartz 760-940°C, water content in melt 0.9-1.3 wt.%. Hence, liquidus temperature exceeds 1200°C and effusion temperature ranges from about 1000°C to about 750°C for water-rich magmas. High T (>1200°C) indicates that initial crystallization should occur under high P >10 kbar, i.e., at a depth of >35 km, which is the level of the upper mantle in this region. (Abstract by A.K.)

SHILOBREYEVA, S.N., KADIK, A.A. and LUKANIN, O.A., 1983, Outgassing of ocean-floor magma as a reflection of volatile conditions in the magma generation region: Geokhimiya, 1983, no. 9, p. 1257-1274 (in Russian; translated in Geochem. Int'l., v. 20, no. 5, p. 27-43, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 240, 1983. (E.R.)

SHIMIZU, N. and KUSHIRO, I., 1984, Diffusivity of oxygen in jadeite and diopside melts at high pressures: Geochimica Cosmo. Acta, v. 48, p. 1295-1303.

SHINOHARA, Hiroshi, IIYAMA, J.T. and MATSUO, Sadao, 1984, Behavior of chlorine in the system granitic magma-hydrothermal solution: C.R. Acad. Sci. Paris, v. 298, Ser. II, p. 741-744 (in French; English abstract).

Experimental study of chlorine in the granitic magma-hydrothermal solution system shows that the amount of this element remaining in the magma is very small under high pressures, but increases strongly with the decrease of pressure. HCl initially present in the system reacts with Na_2O and K_2O in the magma and transports them into the hydrothermal solution under high pressures. This capacity of HCl to transport Na and K from the magma toward the fluid phase decreases strongly when the pressure decreases. (Authors' abstract)

SHMAKIN, B.M., 1983, Geochemistry and origin of granitic pegmatites: Geokhimiya, no. 11, p. 1520-1528 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 6, p. 1-8, 1984). Author at Inst. Geochem., Siberian Div., Acad. Sci. USSR, Irkutsk, USSR.

The most important topics in the geochemistry and origin of all types of pegmatites are discussed. The main reason for geochemical specialization in pegmatites is the pressure in the initial stages of formation. The roles of various material sources in the formation of pegmatites are evaluated. A source distinct from the parent granites and the country rocks for various rare elements may be the mantle. Pegmatites are formed under conditions of tectonic closure in parts of the Earth's crust characterized by volatile superpressures, which does not mean that the pegmatites are isolated from the country rocks. (Author's abstract)

A discussion is presented that relates fluid inclusion data to pegmatite formation. (E.R.)

SHMULOVICH, K.I., 1984, Carbon dioxide in high-temperature processes (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 165-166 (in English). Author at Inst. Exper. Min. USSR Acad. Sci., Chernogolovka, Moscow District, USSR.

Experimental thermodynamic studies on the properties of supercritical model solutions have made it possible to detect and quantify the effect the nonideality of fluid systems produces at the temperatures and pressures where the basic H_2O-CO_2 system approaches an ideal solution, i.e. above 500°C. They are: 1) increasing activity of components in equilibrium with the mineral phases, as compared with the pure H_2O-CO_2 system; 2) supercritical salting-out to increase the CO_2 activity in electrolyte-involving systems at 500°-700°C; and 3) decreasing H_2O activity in electrolyte-involving systems.

Owing to the nonideality of high-temperature systems, the heterogeneity parameters of the fluid phase vary over a wide range. This process operates during the distillation of hypabyssal intrusions. Based on new thermodynamic evidence as applied to natural paragenetic ratios, a metamorphic fluid model has been developed in which the average concentration ratios of volatiles are the same as in the present-day lithosphere: 5-10 mol % CO_2 and 85-90% H_2O. The proposed model allows for all carbonate rock paragenetic assemblages in regional metamorphic facies. With increasing X-CO_2 local deviations of metamorphic solutions from the average composition may occur either at purely conductive heat transfer or at the early stages of contact metamorphism. (Author's abstract)

SHTEYNBERG, G.S., SHTEYNBERG, A.S. and MERZHANOV, A.G., 1984, Fluid mechanism of pressure transmission in volcanic (magmatic) systems: Dokl. Akad. Nauk SSSR, v. 279, no. 5, p. 1081-1086 (in Russian). First author at Sakhalin Inst. of Marine Geol. & Geophysics, Novoalexandrovsk, USSR.

Bubbles of non-polar gases (CO, H_2 and especially CO_2), poorly soluble in silicate melt and forming gas phase at great depths, on floating may display important role in pressure transmission in volcanic channel, starting the extrusion of lava. Most extrusions starts when the excess P in volcanic channel reaches 100-300 bars. For achieving such pressure by gas bubbles, their uplift of 300-1000 m in the channel is sufficient. If bubble radius is ~0.5 mm and viscosity $5 \cdot 10^3$ to $5 \cdot 10^4$ poises, time of uplift ranges from 1.5 to 10 years. G inclusions in diamonds prove that gas phase may exist even under P 30-50 kbar. Thus, P increment due to G uplift may appear over a wide range of depths and cause formation of high-pressure minerals at lower depths than it was hitherto supposed. (Abstract by A.K.)

SHUKOLYUKOV, Yu.A., 1984, Xe isotopes and the origin of the volatile elements in the Earth: Proc. 27th Int'l. Geol. Congress, Vol. II, Geochem. & Cosmochem., p. 233-252. Author at V.I. Vernadsky Inst. Geochem. & Anal. Chem., USSR Acad. Sci., Moscow, USSR.

An extensive review of Xe in various earth processes. (E.R.)

SHUKOLYUKOV, Yu.A., DANG, Vu.M., GOEL, P.S., and ZASLAVSKAYA, N.I., 1984, Isotopic composition of xenon and krypton of micro- and macroinclusions in iron meteorites: Geokhimiya, 1984, no. 6, p. 771-780 (in Russian; English abstract).

SIDDER, G.B., 1984, Conditions of ore formation at the Monterrosas mine in the coastal batholith of central Peru (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 655. Author at Dept. Geol., Oregon State Univ., Corvallis, OR 97331.

The Monterrosas Mine is a hypothermal deposit of copper and iron within gabbro-diorites of the Patap Superunit. Ore deposition followed crystallization of most of the gabbro-diorite magma series. Late residual fluids became enriched in volatiles such as water, chlorine, sulfur, phosphorous, and boron in addition to the ore-forming metallic constituents due to progressive crystallization of labradorite-andesine, diopside, and minor ilmenite and magnetite under relatively high oxidizing conditions. A splay off a regional fault acted as a channelway for fluids to travel through and into the gabbro-diorites. Bimetasomatic exchange of major, minor, and trace elements between hot aqueous fluids and dioritic wall rocks characterizes the mineralization. The ratio of oxides lost (SiO_2+TiO_2+CaO+Na_2O) versus oxides gained (FeO_t+MgO+K_2O) by the gabbro-diorites defines an alteration index that correlates with distance from the ore zone and degree of alteration.

Mineralization formed at a temperature of about 500°C from saline hydrothermal fluids. Fluid inclusions in gangue quartz document the high temperature and high salinity of the fluids. All halite-bearing inclusions homogenize by halite dissolution at temperatures up to 500°C. These inclusions have an average salinity of about 52 wt percent NaCl. Inclusions with daughter crystals of halite and sylvite have a salinity of about 62 wt percent NaCl+KCl and delineate a halite trend on a phase diagram of the system NaCl-KCl-H_2O. The halite trend and the high salinities and temperatures suggest that the fluids exsolved directly from a magma. The presence of abundant scapolite (Me 27) in altered wall rocks and an average $\delta^{34}S$ of about 2.5‰ in pyrite and chalcopyrite substantiates a magmatic source of the fluids. A pyrite-chalcopyrite pair with $\Delta^{34}S$ of 0.7 confirms a temperature of about 500°C. (Author's abstract)

SIDOROV, A.A. and VOLKOV, A.V., 1982, Antimonite mineralization in gold-ore deposits: Dokl. Akad. Nauk SSSR, v. 266, no. 2, p. 433-435 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 266, p. 44-46, 1984). Authors at Central Prospecting Res. Inst. for Nonferrous & Precious Metals, Moscow, USSR.

Th of inclusions from various deposits: 3 Au-Ag, 2 Au-sulfide, and one Au-rare metal are cited, in part from the literature. (E.R.)

SIGURDSSON, H., CAREY, S.N., PLANK, T. and RUTHERFORD, M.J., 1984, Pre-eruption melt compositions of 1982 El Chichon magma (abst.): EOS, v. 65, no. 45, p. 1150. First author at Graduate Sch. Oceanography, Univ. Rhode Island, Kingston, RI 02881.

The explosive eruptions of El Chichon volcano on 29 March and 4 April 1982 in southern Mexico involved crystal-rich trachyandesite magma with unusual abundance of anhydrite. Textures indicate a paragenesis of apatite (0.1%) - sphene (0.07%) - pyrrhotite (tr.)-magnetite (1%) - anhydrite (1.4%) - clinopyroxene (1.8%) - biotite (0.04%) - amphibole (7.2%) - plagioclase (18.1%).

Glass inclusions in phenocrysts and matrix glasses are homogenous and have identical trachytic composition, when recast to the same oxide sums. Low oxide totals in glass inclusions indicate a volatile content of 4.3 wt.%, after correction for Na and K-loss during microprobe analysis. This indicates a water-saturation level at 110 MPa or approx. 4 km, and a water-undersaturated condition of the magma in the seismically-defined reservoir at 5 km depth (Havskov et al. 1983). We reconfirm the analyses of Devine et al. (1984) of only 150-190 ppm S in glass inclusions and matrix glasses. These sulfur concentrations are only slightly lower than those observed (300 to 400 ppm) in internally buffered anhydrite-bearing experimental melts of the El Chichon tephra at 850°C and 200 MPa (Rutherford et al. 1984). (Authors' abstract)

SILLITOE, R.H., JARAMILLO, Luis and CASTRO, Hector, 1984, Geologic exploration of a molybdenum-rich porphyry copper deposit at Mocoa, Colombia: Econ. Geol., v. 79, p. 106-123.

SIMAKOV, S.K., 1983, Free-carbon segregation in mantle fluid upon reaction of nitrogen with methane: Dokl. Akad. Nauk SSSR, v. 268, no. 1, p. 206-210 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 182-186, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 242, 1983. (E.R.)

SIMAKOV, S.K., 1984, The possibility of diamond metastable formation from fluids under conditions of earth crust: Dokl. Akad. Nauk SSSR, v. 278, no. 4, p. 953-957 (in Russian).

SIMMONS, S.F. and SAWKINS, F.J., 1984, Evidence for a mantle helium component in inclusion fluids from two Andean metal deposits (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 656-657. Authors at Dept. Geol. & Geophy., Univ. Minnesota, Minneapolis, MN 55455.

Reported $^3He/^4He$ ratios (R) in circum-Pacific hotsprings range up to 9.5 times the atmospheric ratio (R_a) and indicate the presence of mantle helium. These hotsprings, however, have stable isotope signatures representative of local meteoric water. We have measured $^3He/^4He$ ratios in ore stage fluid inclusions from Casapalca and Pasto Bueno, two late-Tertiary metal deposits in Peru. 10 to 30 gram samples of fluid inclusion rich sphalerite, quartz, tetrahedrite, and fluorite were heated to >500°C, the helium isolated, and measured for $^3He/^4He$ in a 3.75 inch radius double-focusing Nier-type mass spectrometer.

The results (reported as R/R_a) for Casapalca range from 2.2 (± .25) to 2.78 (± .19) (six samples) and for Pasto Bueno range from 2.09 (± .13) to 3.16 (± .24) (six samples). These ratios corroborate stable isotope evidence for the role of magmatic fluids in the formation of both these deposits yet are generally lower than circum-Pacific hotspring R/R_a values. Possible causes of this may be diffusional loss of ^3He relative to ^4He, and/or in situ generation of ^4He by radioactive decay of U and Th.

Despite these difficulties, helium isotopes would seem to offer a powerful tracer technique in ore deposits research, especially in terms of identifying a deep seated component in geologically young precious metal deposits dominated by waters of meteoric origin. (Authors' abstract)

SIMOV, S.D., 1984, Migration of uranium and uranium provinces: Sofia, Tehnika, 1984, 280 pp. (in Russian; English abstract).

The book covers uranium migration during the evolution of the Earth and its crust, during orogenesis and the related metamorphic and magmatic processes as well as during sedimentation in water basins. The genesis of uranium deposits is interpreted according to the presented genetic models and on the basis of the results of studies on the fluid inclusions in the minerals, their temperature of homogenization and the geochemistry of the stable isotopes is discussed as well. (From an abstract by R. Arnaudova)

SINGH, R.P., PATIL, R.R. and THAKUR, V.C., 1984, Nature of the mineralizing fluids of the sulphide mineralization around Bamsu area, Garhwal Himalaya, district Chamoli, Uttar Pradesh: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 8. First author at C.G.W.B., M.S.U., Pune, India.

The opaque sulphides and associated transparent minerals from Bamsu area are studied for their fluid inclusion characteristics with an aim to decipher the environment of the deposition. Observations on doubly polished plates of transparent gangue minerals (quartz and calcite) showed three genetic types of inclusion. Scanning electron microscope study of opaque ore (chalcopyrite, pyrrhotite and pyrite) shows presence of inclusion cavities within them. On the basis of inclusion contents, homogenization state and phases observed at room T, the inclusions are classified into four types. The homogenization studies reveal that the mineralizing fluids attained high temperature, around 350°C initially, and then cooled down to 190°C. The presence of similar daughter crystals within gangue (under transmitted light) and ore minerals (under SEM) is suggestive of their coevalness. Presence of halite inclusions and their phase disappearance temperatures are suggestive of moderate salinity of the parent fluids. The heterogeneous entrapment of fluids brought out by saline and carbonic fluid inclusion occurrence is suggestive of immiscibility between carbonic and aqueous saline fluids from inclusions in these veins and boiling nature of the fluid at the time of deposition. (Authors' abstract)

SKVORTSOV, V.A., KAZ'MIN, L.A. and KARPOV, I.K., 1983, Mineral equilibria in the Li_2O-Al_2O_3-SiO_2-H_2O system: Dokl. Akad. Nauk. SSSR, v. 272, no. 5, p. 1220-1222 (in Russian). First author at the Irkutsk Polytech. Inst., Irkutsk, USSR.

Calculations of mineral equilibria performed for the T ranges 200-800°C and P up to 4 kbar with various proportions of oxides showed numerous errors and low precision of the works published earlier by other authors. (A.K.)

SMITH, C.L. , FICKLIN, W.L. and THOMPSON, J.M., 1984, Enrichment of arsenic, antimony, and tungsten in the waters of some modern high-temperature geothermal systems (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 660.

SMITH, D.L. and EVANS, Brian, 1984, Diffusional crack healing in quartz: J. Geophys. Research, v. 89, no. B6, p. 4125-4135. First author at Dept. Geol. & Geophys. Sci., Princeton Univ.

Annealing fractured single crystal quartz in the presence of pore fluid at 200 MPa (2 kb) pressure at 400° and 600°C for various periods resulted in the reorganization of initially planar cracks into arrays of spherical and tubular fluid inclusions, a process termed crack healing. Samples heated to 600°C for several days with no added pore fluid showed no optically measurable crack healing. The amount of healing in samples with added pore fluids is a function of the temperature, time, and initial concentration of silica in the pore fluid, and the initial crack dimensions. Several lines of evidence indicate that cracks heal as silica is locally transported by diffusion along the crack surface and/or through the pore fluid. Extensive crack healing occurs at temperatures as low as 400°C in times as short as 1-2 days. Estimation of the thermal activation parameters for crack healing suggest that microcracks in quartz will have geologically short lifetimes at temperatures of 200°C or greater. (Authors' abstract)

SMITH, F.D., REEDER, R.J. and MEYERS, W.J., 1984, Fluid inclusions in Burlington limestone (middle Mississippian)--evidence for multiple dewatering events from Illinois basin (abst.): Am. Assoc. Petrol. Geol. Abstracts, May 1984 Annual Convention (unpaginated). Authors at State Univ. New York, Stony Brook, NY.

Syntaxial calcite cements and dolomite from crinoidal limestones in the Burlington formation, southeastern Iowa and western Illinois, contain 2-phase fluid inclusions which represent samples of the diagenetic fluids. A U.S. Geological Survey-type heating/freezing stage was used to determine the homogenization temperatures, bulk salinities, and major dissolved salt compositions of the inclusions. The calcite- and dolomite-hosted inclusions have mean homogenization temperatures of 85°C (185°F) and 109°C (228°F), respectively. Mean bulk salinities are 19.4 wt. % total salts for calcite-hosted inclusions and 20.0 wt. % for dolomite-hosted inclusions. Eutectic and intermediate melting data indicate that NaCl and $CaCl_2$ are the principal brine components. The significantly higher mean homogenization temperature for dolomite-hosted inclusions suggests that the dolomitizing fluids were warmer than the fluids from which calcite cement precipitated. Petrographic relationships shown dolomitization preceded calcite cementation. The presence of high-temperature, high-salinity fluids conflicts with previously proposed low-temperature, freshwater diagenetic conditions. The shallow (<1,500 ft, 450 m) burial history of the Burlington sediments is incompatible with the generation of elevated temperature and salinity fluids intraformationally, and suggests a more deeply buried source, such as the Illinois basin. Cathodoluminescent cement stratigraphy and fluid temperatures indicate that the diagenetic history of the Burlington Limestone was complex, with several generations of hydrothermal brine migration into the porous Burlington carbonates along the northwestern edge of the basin. Two basinal brine expulsion models can account for the temperature variations seen during diagenesis, either an episodic, compaction-driven flow system or a gravity-driven ground-water flow system. (Authors' abstract)

SMITH, S.P., 1984a Two-fluid mixing in the Baca geothermal reservoir: noble gas evidence (abst.): EOS, v. 65, p. 305.

SMITH, S.P., 1984b Atmospheric and juvenile noble gases in the Skaergaard layered igneous intrusion: Geochimica Cosmo. Acta, v. 48, p. 1033-1041. Author at Dept. Physics, Univ. California, Berkeley, CA 94720, USA.

Gabbro and diorite from the Skaergaard layered igneous intrusion contain noble gases which are mixtures of atmospheric and juvenile components. Atmospheric noble gases predominate in samples that have undergone extensive oxygen isotope exchange with meteoric-hydrothermal water. The source of the atmospheric noble gas component is inferred to be the hydrothermal circulation system. A juvenile component with $^{40}Ar/^{36}Ar > 6100$ and containing fission xenon is also present. This component predominates in samples showing unaltered magmatic oxygen isotope compositions. Neon of atmospheric isotopic composition is associated with the juvenile radiogenic ^{40}Ar and fission xenon. The source of this second noble gas component may be either the crustal country rock or the upper mantle. If the neon is juvenile primordial neon from a mantle source region, terrestrial primordial $^{20}Ne/^{22}Ne$ is the same as atmospheric to within 4%. However, subduction of atmospheric noble gases into the upper mantle may provide an alternate source of neon and other noble gases in the mantle. (Author's abstract)

SMITH, T.J., CLOKE, P.L. and KESLER, S.E., 1984a Geochemistry of fluid inclusions from the McIntyre-Hollinger gold deposit, Timmins, Ontario (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 661. First author at St. Joe Am. Corp., 7880 12th Ave. South, Minneapolis, MN 55420.

Gold mineralization at the McIntyre and Hollinger mines, Porcupine camp, Ontario, consists of a large system of auriferous, quartz-carbonate veins, hosted by Archean, greenschist facies, mafic to felsic flows and pyroclastics. Heating and freezing measurements on fluid inclusions in these veins, utilizing phase relations in the H_2O-CO_2-NaCl, CO_2-CH_4, and H_2O-NaCl systems, reveal the presence of Type 1 H_2O-CO_2, Type 2 H_2O (CO_2), Type 3 H_2O-CO_2-CH_4, and Type 4 CH_4 fluid inclusions. Type 1, Type 3, and some Type 2 inclusions are pseudosecondary or primary in origin, whereas Type 4 and Type 2 inclusions are secondary. The pseudosecondary (or primary) Type 1 and 2 inclusions homogenized at temperatures of 220°C to 385°C. Secondary Type 2 inclusions homogenized at 160°C to 215°C. XCO_2 values in Type 1 inclusions calculated from visually estimated phase volumes range from 3 to 19 mole% with bulk molar volumes of 19 to 28 cm^3/mole. Gas chromatographic analyses of the fluid inclusions are consistent with the optical inclusion observations. Interpretation of these data using CO_2-CH_4-CO and H_2O-CH_4-CO_2 ternaries allow the composition of the mineralizing fluids to be specified.

Calculation of equilibrium relations between the inclusion fluids, adjusted for the probable presence of H_2 which was subsequently lost through diffusion or destroyed by reaction during cooling, and graphite indicates that the mineralizing fluids were at equilibrium at temperatures of 380° to 480°C at pressures of 1 to 3 kb respectively. Calculated isochores suggest pressures of 1300 to 2900 bars, corresponding to depths of 5 to 12 Km. Calculated oxygen fugacities lie near the QFM Buffer. Under these conditions and at neutral to alkaline pH, gold solubility is significant as bisulfide complexes (Seward 1973, 1979; Phillips and Groves, 1983). The mineralizing fluids differ compositionally from fluids in other types of ore deposits, but resemble fluids in metamorphic rocks and those associated with deep-seated felsic magmas. (Authors' abstract)

SMITH, T.J., CLOKE, P.L. and KESLER, S.E., 1984b, Geochemistry of fluid inclusions from the McIntyre-Hollinger gold deposit, Timmins, Ontario, Canada: Econ. Geol., v. 79, p. 1265-1285.
See previous item. (E.R.)

SO, C.S., 1984, Sulfur isotope, fluid inclusion and trace element studies of the Sannae tungsten deposit and its application to the ore prospecting: Chijil Hakhoe Chi (J. Geol. Soc. of Korea), v. 20, no. 4, p. 282-295 (in English) (also in CA: 102(10)81930c).
Indexed under Fluid Inclusions.

SO, C.-S., PARK, M.-E., SHELTON, K.L. and SEIDEMANN, D.E., 1984, Geology and geochemistry of the Sambo Pb-Zn deposit, Republic of Korea: Econ. Geol., v. 79, p. 656-670. First author at Dept. Geol., Korea Univ., Seoul, Republic of Korea.

The Sambo Pb-Zn mine is located approximately 45 km south of Seoul within the Precambrian metamorphic belt of the southern Korean Peninsula. The Sambo Pb-Zn deposits are composed of fissure-filling quartz-barite veins within Proterozoic biotite schist which has been intruded by granite and granodiorite stocks. K-Ar dates of biotite and muscovite from the intrusions are 177 ± 4 and 164 ± 3 m.y., suggesting a Jurassic age for Pb-Zn-Ba mineralization. This age is in agreement with data for metallogenic epochs in Korea. Ba-rich Pb-Zn deposits are related to a Jurassic-Early Cretaceous epoch, whereas Ba-poor Pb-Zn deposits are generally related to Late Cretaceous-Tertiary igneous activity.

Mineralization at Sambo consists of three distinct stages of quartz-barite veins (I, II, and III) which were separated in time by tectonic fracturing and brecciation events. Ore textures of stage II suggest rhythmic deposition. Five successive mineralization cycles of stage II, each with up to seven nearly monomineralic bands, are recognized. Fluid inclusion data suggest that each stage evolved from early high temperatures (near 300°C) to later lower temperatures (less than 200°C). Although the maximum temperature of stage III is slightly lower than the maximum temperature of stages I and II, we suggest that each stage represents a separate cooling mineralizing system that was interrupted by renewed tectonism.

Sulfur isotope and fluid inclusion evidence indicates that galena, sphalerite, and barite were deposited at temperatures near 160° to 265°C from solutions with salinities ranging from 2 to 17 equivalent weight percent NaCl. Fluid inclusion evidence of boiling suggests pressures of less than 100 bars during portions of stage II mineralization. This pressure corresponds to depths at the time of mineralization of between 500 and 1,250 m. (Authors' abstract)

SO, C.-S., SHELTON, K.L. and RYE, D.M., 1984, Geologic, sulfur isotope, and fluid inclusion studies of the Sannae W-Mo mine, Republic of Korea (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 307-308. First author at Dept. Geol., Korea Univ., Seoul, S. Korea.

The Sannae W-Mo mine is a hydrothermal fissure filling quartz vein-type deposit contained within a quartz monzonite stock. The stock intrudes middle Cretaceous sedimentary and volcanic rocks of the Gyeongsang Basin, Korea. Fluid inclusion evidence suggests that molybdenite and scheelite mineralization occurred at temperatures between 250 and 440°C. Salinities of mineralizing hydrothermal fluids ranged between 1 and 10 wt % eq. NaCl. Evidence of boiling suggests pressures during mineralization of less than 300 bars. The $\delta^{34}S$ values of sulfides within the deposit range from 5.2 to 7.1‰, suggesting a single igneous source for the sulfur. The total range of $\delta^{34}S$ values of each deposit can be explained by the separation of a sulfur-bearing fluid from an igneous melt under different oxidizing conditions. Geologic, fluid inclusions, and sulfur isotopic data from the Sannae mine are similar to data from other Korean tungsten deposits. These similarities suggest that hydrothermal tungsten deposits in Korea are genetically related to shallow Cretaceous granitic volcanism, and not to deeper Jurassic volcanism. (Authors' abstract)

SOBOLEV, A.V. and DHAMELINCOURT, P., 1984, The crystallization conditions and evolution of ultramafic magmas based on the data from magmatic inclusions studies (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 172 (in English). First author at V.I. Vernadsky Inst. Geochem. & Anal. Chem. USSR Acad. Sci., Moscow, USSR.

The magmatic inclusions in olivine and Ca-pyroxene phenocrysts from ultramafic volcanics: meimechites, north of Siberian platform (MNSP), ultramafic lavas of Cyprus (ULC) and oceanites of Reunion isl. (OR) were studied. Based on the experimental homogenization of melt inclusions and examination of their compositions with electron microprobe the compositions of primary melts for these rocks and the temperature of their crystallization were determined. It is shown that only MNSP originated from the ultramafic primary melt (MgO >30% wt) while ULC and OR are the olivine cumulates of picritic (MgO = 30% wt) and basaltic (MgO = 9.5% wt) initial melts correspondingly. The determined temperature ranges of crystallization are as follows: 1600-1400°C for MNSP, 1400-1100°C for ULC, and 1240-1190°C for OR. The detected strong correlations between temperature of melt inclusions homogenization and host mineral Mg-number indicate the fractional crystallization mode of investigated rocks. The thermometry of fluid inclusions coexisting with melt inclusions and their study with Raman laser microprobe gives the molecular compositions and pressures of magmatic fluids. The highest pressure of phenocryst crystallization was in the range of 0.5-1.5 kbar for all rocks studied. However the composition of magmatic fluids was different: enriched in H_2O for ULC, consist of CO_2 and H_2O in ratio of $P\text{-}CO_2/P\text{-}H_2O = 5/3$ - for OR, and enriched in N_2 with traces of CH_4 for MNSP. Using the methods of modelling of fractional crystallization inside melt inclusions it is shown that fractionation of primary melts for MNSP and ULC lead to the formation of full series of coexisting volcanic rocks: alkaline picrite-melanephelinite-nephelinite for MNSP and boninite-andesitic basalt-andesite for ULC. It is concluded that the primary melts of MNSP and ULC should be the initial melts for the host magmatic provinces: Maimecha-Kotui province for MNSP and magmatic complex of Troodos massive for ULC. (Authors' abstract)

SOBOLEV, A.V. and SLUTSKII, A.B., 1984, Composition and crystallization conditions of the initial melt of the Siberian meimechites in relation to the general problem of ultrabasic magmas: Geologiya i Geofizika, v. 25, no. 12, p. 97-109 (in Russian; translated in Soviet Geol. & Geophysics, v. 25, no. 12, p. 93-104, 1984).

On the basis of a study of the composition and thermometry of magmatic inclusions in minerals and mathematical modeling of fractional crystallization, it is established that the initial melt of the Siberian meimechites had an ultrabasic-alkalic composition. The intratelluric stage of crystallization occurred within the intervals of Th = 1600-1400°C and P = 0.5-1.5 kbar, according to the fractionation mechanism. The meimechite melt can be regarded as the initial melt from which the ultrabasic and alkalic rocks in the Maimecha-Kotui magmatic province were formed. (Authors' abstract)

Includes microprobe analyses of melt inclusion dm cpx, amphib., neph., ilm., phlog. and spin., as well as glass and host olivine. Also two melt inclusions in olivine in experimental runs. (E.R.)

SOBOLEV, N.V., YEFIMOVA, E.S. and YU, G., 1984, Dominant calcsilicate association of crystalline inclusions in placer diamonds from southeastern Australia: Dokl. Akad. Nauk SSSR, v. 274, no. 1, p. 172-178 (in Russian).

SOBOLEV, V.I., 1984, New data on chemical composition of chloride ground water in the Krivoy Rog iron-ore basin: Geokhimiya, 1984, no. 9, p. 1364-1377 (in Russian; English abstract).

As a result of studying chemical and isotopic composition of chloride mine water and brines in the Krivoy Rog iron-ore basin it is determined that the subsurface brines of the basin differ chemically from each other and are represented by two geochemical varieties: sodium-magnesium and sodium-calcium. It is shown that sodium-magnesium brines may originate in an interaction between sodium-calcium brines and the country rocks of the Krivoy Rog series. Following their geochemical features, sodium-calcium brines satisfy the idea of their genetic relation to the subsurface brines of the Dnepr-Donets depression. (Author's abstract)

SOBOLEVA, G.I., TUGARINOV, I.A., GOLITSINA, N.S. and KHODAKOVSKY, I.L., 1984, Study of beryllium behavior in fluorine-bearing hydrothermal solutions at 150-250°C: Geokhimiya, 1984, no. 6, p. 812-822 (in Russian; English abstract).

SOKOLOV, S.V., 1984, On the mechanism of formation of carbonatites and phase state of carbonatite-forming medium: Zapiski Vses. Mineral. Obshch., v. 113, no. 4, p. 411-418 (in Russian). Author at All-Union Sci.-Research Inst. of Mineral Raw Materials, Moscow, USSR.

In carbonatites of Siberia and Kola Peninsula silicates (nepheline, wollastonite, pyroxenes, forsterite) melt inclusions are crystallized, but carbonates and apatite bear melt and G/L inclusions, perhaps due to heterogeneity of mineral-forming media. In crystallized inclusions dms start to melt at 440-580°C, Th are 680-1020°C in liquid phase, that after rapid cooling did not quench but crystallized, indicating salt, not silicate nature of fluid. (A.K.)

SOLOVOVA, I.P., RYABCHIKOV, I.D., KOVALENKO, V.I. and NAUMOV, V.B., 1982, High-density CO_2 inclusions in mantle lherzolite: Dokl. Akad. Nauk SSSR, v. 263, no. 1, p. 179-182 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 263, no. 1, p. 110-112, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 240, 1982. (E.R.)

SOMAN, K., 1984, Carbonic fluid inclusions and their role in the petrogenesis of chrysoberyl pegmatites of Trivandrum, Kerala: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 31. Author at Center for Earth Sci. Studies, Trivandrum 695010, India.

Chrysoberyl pegmatites, spatially associated with garnet bearing granites, occur as thin bodies in parts of Trivandrum district, Kerala within the granulite-facies metasedimentary rocks of the Khondalite suite. Fluid inclusion studies on quartz and beryl from pegmatites indicate the presence of carbonic, aqueous-carbonic and multiphase inclusions. CO_2 constitutes about 12-14 vol. % of the fluids in the inclusions. Dominance of volatile-free minerals in the pegmatites possibly resulted from the pervasive CO_2 activity in the residual melts. The genesis of chrysoberyl is also attributed to the influence of CO_2. High density CO_2 inclusions allow a pressure estimate of 2.5 kb at 400°C Th, while the minimum Tf of the pegmatite minerals after pressure correction is 545°C.

Carbonic liquid phase, under high pressure, was a constraint to determine the entrapment temperature of fluids as the inclusions exploded before the final melting of the solid phase in them. This, in turn resulted in lower estimates of P and T. (Author's abstract)

SOMAN, K., NAIR, N.G.K. and DRUZHININ, A.V., 1984, Significance of chrysoberyl-pegmatites of south-western India (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 312. First author at Centre for Earth Sci. Studies, Trivandrum, India.

Recent investigations prove that the southern part of Kerala and the adjoining areas further to the south in Tamil Nadu constitute a gem-rare metal pegmatite province with an areal extension of more than 50-70 x 30-35 km in the granulite terrain of south-western India.

Gemstones like chrysoberyl with its varieties, sapphire, topaz, zircon, etc., are mostly derived from pegmatites, though some come from the alluvial beds also. Innumerable small pegmatite bodies aligned in NW-SE, N-S and NE-SW to E-W directions along fractures are found to occur in a mostly garnet-sillimanite-graphite gneissic terrain with intermittent bands of garnet-biotite and garnet-quartz-feldspar gneisses. Structural data indicate that the pegmatites of all the three directions belong to a single generation and are attributed to the post fracture-cleavage stage of evolution of the region. Geochronological data reveal that the pegmatites were emplaced 445-474 m.y. ago. A granite in the adjacent area, located along a fault system extending from the pegmatite province yielded an age of 550 m.y. Fluid inclusion studies show that the pegmatite minerals contain liquid carbon dioxide and give Th >400°C. Sillimanite-andalusite and quartz-chrysoberyl associations in the pegmatites are indicative of more than 4-5 kb of pressure. These data would suggest that the region underwent a tectono-magmatic event affecting the high-alumina metasediments leading to granite and pegmatite emplacement during early-Paleozoic times. (From the authors' abstract)

SONG, Hebin, 1984, Isotopic compositions of noble gases in granites and ophiolites from Tibet with a discussion on rock genesis: Bull. Inst. Min. Deposits, Chinese Acad. Geol. Sci., Series III, no. 1, p. 102-118 (in Chinese; English abstract). Author at Inst. Mineral Deposits, Chinese Acad. Geol. Sci.

Isotopic ratios and compositions have been measured for four granitic samples and three ophiolitic samples from Tibet. The resulting data give the impression that in granitic rocks, Xe^{132}, Xe^{134} and Xe^{136}, daughter products of U^{238}, are abnormally high while Xe^{129} and He^3/He^4 ratios are extremely low, suggesting a crustal remelting origin. As a result of mixing with atmospheric material, the ophiolites are unexceptionally similar to this material in isotopic compositions and ratios of the inert gases. Only one fresh olivine sample has He^3/He^4 values (6.7×10^{-6}) close to the He^3/He^4 values of mid-oceanic ridge basalt. These ophiolites are likely materials of oceanic crust-upper mantle. (Author's abstract)

SONNENFELD, Peter, 1984, Brines and evaporites: New York, Academic Press, 613 pp.

An extensive review, including 21 index page references to fluid inclusion studies. (E.R.)

SONNENFELD, P. and HUDEC, P.P., 1984, Flash flood records in rock salt (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 107. Authors at Dept. Geol., Univ. Windsor, Windsor, Ontario N9B 3P4, Canada.

It has long been assumed that thin but pervasive clay intercalations in evaporite deposits of salt and potash represent "freshening" of the brine body, i.e., dilution by fresh or low salinty water. However, a corresponding amount of coarser clastics is not present: sandy halites are extremely rare, sandy potash beds are unknown. Freshening is not necessary to explain the presence of clay. Laboratory tank experiments and field observations show that the clay suspension spreads out along the surface of brine or along the interface between the brine and fresher surface water. The clay suspension remains at the surface of the interface, slowly flocculates, and the clay then sinks; they are retarded along microstratification layers within the brine before reaching the bottom. Their loose, flocculated structure contains significant quantities of water which preserves the pore spaces through which epigenetic brines can later move. Fresh- and brackish-water fossils found in such clay intercalations are either swept in with the clays, or sink upon death from the freshwater layer above. (Authors' abstract)

SONNTAG, C. and SCHOCH-FISCHER, H., 1984, Deuterium and oxygen-18 in water vapor and precipitation: application to atmospheric water vapor transport and to paleoclimate: ZFI-Mitteilungen, "Isotope in der Natur," no. 84, p. 380-390: Leipzig, Akad. Wissen. der DDR (in English). Authors at Inst. Umweltphysik Univ. Heidelberg, Im Neuenheimer Feld 366, 69 Heidelberg, FRG.

Spatial and temporal variations of δD and $\delta^{18}O$ in mean monthly precipitation and groundwater are described by means of a simple water vapor advection model, which links the isotope data to the vertically integrated horizontal flow of vapor. This model yields a temperature dependence of the isotope precipitation data, which is compared with the experimental temperature effect. Short-term variations of δD and $\delta^{18}O$ in mean daily water vapor reflect the varying influence of different air masses on the local weather. A spectral analysis of these short-term variations yields predominant periodicities of about 10, 20 and 30 days, which are related to the long-wave pattern of the zonal drift in the upper troposphere.

δD and $\delta^{18}O$ in plant material (tree rings, peat), soils, lake sediments, speleothems and in other carbonates of paleoclimatic interest is primarily influenced by the isotopic composition of local precipitation, atmospheric moisture and by temperature dependent isotope fractionation. The relevance of such fossil material (paleowaters included) for paleoclimate and in particular for the reconstruction of the water vapor circulation pattern in the past is discussed. (Authors' abstract)

SORAPURE, R. and HAMILTON, D.L., 1984, The solubility of water in melts of albite composition with varying additions of fluorine: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 28-30.

SOROKIN, V.I., BOKSHA, S.S. and USHAKOVSKAYA, T.V., 1984, The P-T phase diagram for HgS: Geokhimiya, no. 1, p. 132-136 (in Russian; translated in Geochem. Int'l., v. 21, no. 2, p. 47-50).

SPERA, F.J., 1984, Carbon dioxide in petrogenesis III: role of volatiles in the ascent of alkaline magma with special reference to xenolith-bearing mafic lavas: Contrib. Mineral. Petrol., v. 88, p. 217-232. Author at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544, USA.

Kinetic and fluid dynamic constraints on deep-seated magma migration rates suggest ascent velocities in the range 10 to 30 m/s, 10^{-1} to 10 m/s and 10^{-2} to 5 m/s for kimberlitic, garnet peridotite-bearing and spinel peridotite-bearing magmas. These rates virtually demand translithospheric magma transport by a fracture as opposed to diapiric mechanism. The hypothesis that volatile exsolution accelerates magma through the deep lithosphere is tested by solution of the appropriate set of conservation, mass balance and volatile component solubility equations governing the steady ascent (decompression) of compressible, two-phase magma (melt + H_2O + CO_2) in which irreversible phenomena (friction, heat transfer) are accounted for. The results of the numerical experiments were designed to test the importance of melt bulk composition (kimberlite, nephelinite, alkali basalt), initial conditions (mass flux (M), heat transfer coefficient (B), lumped friction factor (C_f)), conduit width (D), initial magma volatile content and geothermal gradients. The fractional increase in ascent rate ($\Delta u/u_i$) is rarely greater than approximately 2 during translithospheric migration. The propellant hypothesis is rejected as a first-order mechanism driving magma acceleration during ascent. The most influential parameters governing ascent dynamics are M, C_f, D, B and the geotherm. Because of the relatively incompressible nature of the magmatic volatile phase at $P>100$ MPa, the initial magma volatile content plays a secondary (although demonstrable) role. The main role of volatiles is in controlling the initial magma flux (M) and the magma pressure during ascent. In adiabatic (B=0) simulations, magma ascends nearly isothermally. Generally, however, the assumption of adiabaticity is a poor one especially for flow through narrow (0.5 to 2 m) conduits in old (cold) lithosphere at rates $\sim 10^{-1}$ m/s. The proposed fluid dynamic model is consistent with and complementary to the magma-driven crack propagation models. The generation of mantle metasomatic fluid is a corollary of the non-adiabatic ascent of volatile-bearing magma through the lithosphere. Magma heat death is an important process for the creation of mantle heterogeneity. (Author's abstract)

SPERA, F.J., YUEN, D.A. and KEMP, D.V., 1984, Mass transfer rates along vertical walls in magma chambers and marginal upwelling: Nature, v. 310, p. 764-767. First author at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544, USA.

In an isothermal chamber, the upflow mechanism is marginally feasible in generating roofward accumulations of magma zoned in H_2O; vertical zonation with respect to silica appears to be precluded, however. (From the authors' text)

SPIERS, C.J., URAI, J.L., LISTER, G.S. and ZWART, H.J., 1984, Water weakening and dynamic recrystallization in salt (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 665.

SPIRAKIS, C.S., 1984, Effect of sulfur kinetics on redox reactions and implications for the genesis of epithermal ore deposits: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 201-203.

SPRAY, K.J., 1970, How to prepare relief-free polished surfaces of geological or refractory specimens: Indust. Diamond Review, v. 30, p. 182-186. Author at Engis Ltd., Maidstone Kent, UK.

Geological or refractory samples are seldom homogeneous. With incorrect polishing techniques, the differential hardness and poor bonding between individual grains or crystals produces undesirable relief which makes photographic identification difficult. For electron microscope examination, in addition, the edges of individual grains and crystals are required to be as flat as possible. In this article, the author describes a basic preparation technique by which such problems can be overcome. (Author's absract)

SPRINGER, Niels, 1984, Chapter 3: A geochemical study on Zechstein salt and anhydrite from the Batum-1A well, in Zechstein Salt Denmark, Salt Research Project EFP-81, Vol. II, Stratigraphy, DGU series C no. 1·1984.

This preliminary study was initiated in an attempt to distingish between grey salt of the Danish Zechstein 1 and 2 series, respectively. Anhydrite and bulk halite rock samples were recovered from core material of two small sections representing each series. The sample material was analyzed by X-ray fluorescence analysis for the major elements, S, Cl and Ca, and the traces Mg, K, Ti, Mn, Fe, Cu, Zn, Br, Rb, Sr, Y, Ba, La and Pb. Additionally, B was analyzed by an automated spectrophotometric method. It was found that the elements Ti, Mn, and Sr as well as the ratios S/Cl, Mn/Fe, Ca/Mg and Ca/Sr displayed very significant differences between the two sections. If this is a systematic difference characterizing the whole evaporite series, a geochemical stratigraphy can be established for the Zechstein salt.

Evidence is presented that the evaporation cycle episodically passed into potash-magnesia facies. This is recorded in anhydrite but not seen in the associated halite. The halite analyses also showed a very homogeneous distribution of Br through both sections. It is suggested that the very soluble K-Mg facies minerals were dissolved and carried away by a migrating fluid phase during metamorphic recrystallization of the rock salt. This event probably also homogenized the Br distribution throughout the evaporite sequence.

The regular distribution of many elements in the anhydrite, which is believed to reflect the conditions in the brine at the time of deposition, suggests that evaporite generation took place in a large marine evaporite basin. (Author's abstract)

SREBRODOL'SKII, B.I., 1984, Mineralogy and formation of the Ariks celestite: Mineral. Sb. (Lvov), v. 38, no. 1, p. 83-86 (in Russian). Author at Inst. Geol. Geokhim. Goryuch. Iskop., Lvov, USSR.

At Ariks, in southern Turkmenia, the celestite occurs in veinlets, encrustations, and druses in Paleogone dolostone which is almost pure dolomite. Three generations of celestite are present; one is represented by crystals with Fe hydroxide coatings, another by small colorless crystals, and a third generation consists of large bluish crystals. Based on the Th of fluid inclusions, the fine-grained celestite crystallized at lower temperatures (220-230°) than the coarsely crystallized (250-255°). The celestite ore is of supergene origin; Sr was leached from overlying rocks and celestite precipitated when the Sr-containing solutions encountered sulfatic surface waters. (C.A. 101: 76144z)

SRETENSKAYA, N.G., 1984, Experimental investigation of supercritical ore-forming solutions (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 406 (in English).

SRIKANTAPPA, C., 1984a, Fluid inclusion evidence for evaporites in the Archaean Sargur terrane, Karnataka, India: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 20. Author at Dept. Geol., Manasa Gangotri, Univ. Mysore, Mysore, 5790006, India.

The Archaean Sargur Group (>3.0 Ga) in Karnataka, is composed of quartzites, banded iron formations, carbonates and K-rich pelite shelf type sedimentary succession intercalated with meta-basic rocks. Chromite bearing ultramafic to mafic layered complexes have been emplaced into the Sargur series of supracrustal rocks. The rocks have been subjected to predominantly amphibolite facies metamorphism around 2.6 Ga ago.

Fluid inclusion studies were carried out on quartzite samples from the Sargur terrane. Fluid inclusions in general are 12 µm in diameter, occur either randomly distributed or found in healed fractures within the quartz grains. Most of the samples contain fluid inclusions with an aqueous fluid and/or liquid CO_2 ± a vapor phase. Many of the fluid inclusions have halite cubes of 1-5 µm in diameter with or without sylvite. Based on Th it has been estimated that the bulk density of the homogenized brine was about 1.2 g/cm^3, the NaCl content was about 30-40 wt. %.

Though several processes may produce such brines, the dissolution of a NaCl-rich evaporite unit during the prograde regional metamorphism of Sargur supracrustals is thought to be a possible mechanism. (Author's abstract)

SRIKANTAPPA, C., 1984b Fluid inclusion evidence for evaporites in the Archean Sargur terrane, Karnataka, India (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 175-176 (in English). Author at Dept. Geol, Univ. Mysore, Mysore, India.

See previous item.

STAHL, Egon and QUIRIN, K.-W., 1984, Extraction of natural substances with dense gases: Naturwissenschaften, v. 71, no. 4, p. 181-191 (in German; English abstract).

The solubility of various substances in dense gases, particularly CO_2, is discussed. Various fatty oils, steroids, alkaloids are soluble in dense CO_2. (E.R.)

STALDER, H.A., 1984, Fluid inclusions in anhydrite crystals from the Simplon railway tunnel, Switzerland: Magma, 1984, no. 5, p. 32-33 (in German).

Some facts about the CO_2-rich fluid inclusions in anhydrite and quartz from alpine fissures are given:

Th (quartz) = 290 - 340°C (without P corr.)
Density of CO_2 = 0.35 - 0.85 (in anhy.)
= 0.55 - 0.85 (in quartz)
Equiv. weight % NaCl = 4 - 8 (in anhy.)
= 5 - 10 (in quartz)

(Abstract courtesy the author)

STEDMAN, D.H., CREECH, M.Z., CLOKE, P.L., KESLER, S.E. and GADNER, Michael, 1984, Formation of CS_2 and OCS from decomposition of metal sulfides: Geophys. Res. Letters, v. 1, no. 9, p. 858-860. First author at Dept. Chem., The Univ. of Denver, Denver, CO 80208.

The unexpected observation that the common mineral iron sulfide FeS_2 produces CS_2 and OCS when incubated with water has been further investigated by testing either untreated pyrite or pyrite cleaned with acid and an organic solvent. OCS and CS_2 were produced in all experiments except those excluding oxygen or those thoroughly cleaned with acetonitrile. These results indicate that both oxygenated water and organic matter are needed to produce OCS and CS_2. Oxygenated groundwater with dissolved organic matter is widespread in most geologic environments, as are metal sulfides, suggesting that oxidative decomposition of pyrite should be investigated as a source of OCS and CS_2 to the atmosphere. (Authors' abstract)

STEIN, C.L., 1984, Authigenic quartz in halite from the Delaware Basin, southeastern New Mexico (abst.): EOS, v. 65, no. 45, p. 1126. Author at Sandia Nat'l. Labs., Earth Sci. Div. 6331, Albuquerque, NM 87185.

Authigenic quartz is found in abundance in argillaceous halites in the lower Salado Formation (Permian) of the Delaware Basin. Occurring as large (up to 2 mm long) well-developed euhedral crystals, this quartz appears to be derived from silica released by smectite-illite diagenetic alteration. A mass balance calculation shows that the amount of quartz potentially yielded by a mechanism involving clay alteration exceeds that which could be obtained from dissolved silica in seawater during evaporite deposition by approximately two orders of magnitude.

The crystals are commonly corroded and etched on the (1011) faces and occasionally show secondary overgrowths, suggesting possible exposure to multiple intergranular solutions. Textural evidence and the exclusive association of this quartz with halite containing relatively large amounts of clay minerals (up to 5 wt. percent) indicate that clay diagenesis and quartz precipitation occurred after sediment deposition but prior to halite recrystallization, without large-scale fluid movement. (Author's abstract)

STEIN, C.L. and KRUMHANSEL, J.L., 1984, Compositions of brines in halite from the lower Salado formation, southeastern New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 667. First author at Earth Sci. Div., Sandia National Lab., Albuquerque, NM 87185.

The Waste Isolation Pilot Plant (WIPP) is a Department of Energy-sponsored repository for the long-term storage of transuranic defense-related nuclear waste, located in the Delaware Basin near Carlsbad, New Mexico. During excavation a number of large fluid inclusions were recovered from an area of highly recrystallized halite in a thick salt bed at the repository horizon. Two distinct populations of inclusions were found with the following molar ratios: 182 and 417 for Mg/Ca; 4 and 8.3 for Mg/K; 0.4 and 1.4 for Mg/Na; 0.22 and 0.35 for Mg/Cl; 250 and 163 for Cl/Br; 14 and 6 for SO_4/Br. Overall, the inclusion compositions appear to reflect the changes in seawater chemistry during deposition of the Salado formation.

In addition, twenty-two samples of brine "seeps" were collected from walls of recently excavated drifts at the same stratigraphic horizon as the fluid inclusion samples. A partial analysis of these fluids shows that they differ substantially in composition from those found in the inclusions, owing to a magnesium depletion (Mg/K = 1.8). Since seeps are associated with thin clay or anhydrite seams, these fluids may have originated by dewatering of clays and/or gypsum. Their composition may also have been modified by the selective uptake of Mg during clay diagenesis, and incongruent dissolution of bittern salts (principally polyhalite).

In conclusion, the wide variety of fluids found in WIPP workings and their small volumes argue strongly against the possibility that an interconnected hydrologic system exists which could effectively transport radionuclides away from the repository. (Authors' abstract)

STEIN, H.J. and HUEBNER, M., 1984, A heavy isotope enriched sulfur source for Climax-type porphyry molybdenum deposits: molybdenite compositions (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 667.

STEMPROK, Miroslav, 1984, Liquid immiscibility in high silica melts and its role in ore-forming processes (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 407-408 (in English).

STENDAL, Henrik and GHISLER, Martin, 1984, Strata-bound copper sulfide and nonstrata-bound arsenopyrite and base metal mineralization in the Caledonides of east Greenland - a review: Econ. Geol., v. 79, p. 1574-1584. First author at Inst. Gen. Geol., Univ. Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark.

Includes a little fluid inclusion work on quartz (p. 1581); this showed boiling CO_2-bearing fluids of moderate salinity (4-9 wt.% NaCl). Th = 225-260°C; P at Th was ~1 kb. (E.R.)

STENINA, N.G., BAZAROV, L.Sh., SHCHERBAKOVA, M.Ya. and MASHKOVTSEV, R.I., 1984, Structural state and diffusion of impurities in natural quartz of different genesis: Phys. Chem. Minerals., v. 10, p. 180-186. Authors at Inst. Geol. & Geophys. of Siberian Br. of Acad. Sci. USSR, 630090, Novosibirsk 90, USSR.

Impurity inhomogeneities and other structural defects have been studied by means of transmission electron microscopy (TEM), X-ray microanalysis and electron paramagnetic resonance (EPR) in untreated and heat-treated quartz samples of three genetic types: hydrothermal, pegmatitic and magmatic. The impurities present are Al, Na and H_2O, which occupy tetrahedral (Al^{3+}) or interstitial (Na^+, H_2O) positions in the quartz lattice.

Impurities form imperfections of various degrees of segregation: from point defects to micropores with a gas-liquid content. Their size, form, density and distribution in the lattice depend on the formation conditions of the quartz, the presence of dislocations and plane defects serving as sinks for the impurity atoms, and the heat treatment regime. Experimental data indicate that gas-liquid inclusions of dimensions up to some microns are the result of impurity segregation during postcrystallizational cooling.

Crystalline quartz amorphizes upon electron irradiation. A model of structural water explaining experimentally observed features of this phenomenon is proposed whereby the water molecule, represented as a dipole, enters microregions of the silica lattice with a high impurity content and there forms a bond between 'defective' $[SiO_3]^{2-}$ and $[AlO_4]^{5-}$ tetrahedra. On irradiation, the Si---O donor-acceptor bonds trap nonelastically scattered electrons and are ruptured as a result. The water released by this lattice discontinuity forms microbubbles that diffuse along sinks into the larger micropores thus further increasing their volume. (Authors' abstract)

STERNER, S.M. and BODNAR, R.J., 1984a, Synthetic fluid inclusions in natural quartz I. Compositional types synthesized and applications to experimental geochemistry: Geochimica Cosmo. Acta, v. 48, p. 2659-2668. First author at Dept. Geosci., The Pennsylvania State Univ. University Park, PA 16802.

Synthetic fluid inclusions having a wide range of geologically applicable compositions in the C-O-H-S-Na-K-Ca-Cl-Cu-Fe system have been formed by healing fractures in inclusion-free natural quartz and by precipitating new quartz overgrowths on an original "seed" crystal. Inclusion types synthesized include: (1) liquid-rich, pure H_2O inclusions of primary and secondary origin, (2) pure H_2O inclusions with the critical density, (3) liquid-rich inclusions containing undersaturated aqueous solutions of NaCl or KCl or $CaCl_2$, or mixtures of the three salts, (4) H_2O-NaCl inclusions containing halite daughter minerals, (5) H_2O-NaCl-KCl inclusions containing halite and sylvite daughter minerals, (6) H_2O-CO_2 inclusions of various compositions containing liquid H_2O and either CO_2 vapor or CO_2 liquid, or both, at 25°C, (7) H_2O-CO_2-NaCl inclusions containing an aqueous phase, liquid and vapor CO_2, and halite at 25°C, (8) C-O-H inclusions containing liquid H_2O, a CO_2-CH_4 liquid phase and graphite daughter minerals at 25°C, (9) H_2O-NaCl inclusions that contain a chalcopyrite daughter mineral, and (10) inclusions representing trapping of the coexisting, immiscible fluids in the H_2O-NaCl, H_2O-CO_2-NaCl, and Na-C-O-H systems.

The inclusions exhibit uniform phase ratios at room temperature, and the temperatures of various phase changes within individual inclusions agree with those predicted from experimental and theoretical data, indicating that the inclusion fluid has the same composition and density as the parent solution. These 'miniature autoclaves' thus may be used to study various problems related to fluid inclusion research, to calibrate analytical equipment used to study natural inclusions, and to study phase equilibria, solubility and PVT relations of a variety of chemical systems. (Authors' abstract)

STERNER, S.M. and BODNAR, J.R., 1984, Synthesis of fluid inclusions in natural quartz (abst.): EOS, v. 65, p. 292. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

See previous item.

STERNER, S.M., KERRICK, D.M. and BODNAR, R.J., 1984, Experimental determination of unmixing in H_2O-CO_2-NaCl fluids at 500°C and 1 Kb using synthetic fluid inclusions: metamorphic implications (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 668. Authors at Geosciences, The Pennsylvania State Univ., University Park, PA 16802.

Hydrothermal experiments produced synthetic fluid inclusions in quartz that are representative samples of the parent solution. When formed in the presence of a one-phase, homogeneous fluid, inclusions exhibit identical phase ratios at room temperature suggesting that they have very uniform compositions. Inclusions formed in the presence of immiscible fluids display a wide range of fluid compositions with most inclusions having phase ratios which suggest trapping of end-member compositions. Fluid immiscibility in the system H_2O-CO_2-NaCl is indicated by the coexistence of two general inclusion types: a liquid-rich, moderately to extremely saline fluid inclusions often containing an NaCl daughter crystal at room temperature and a vapor-rich slightly saline inclusion often containing liquid CO_2 at room temperature.

Experiments at 500°C and 1 Kb were performed with selected H_2O/CO_2 ratios and NaCl salinities (rel. to H_2O) of 12 and 20 wt %. In the 12 wt % composition, fluid unmixing occurred at $XCO_2 = 0.25$ and 0.50; for 20 wt % unmixing was found at $XCO_2 = 0.25$. Preliminary experiments with identical fluid compositions generated from different starting materials (silver oxalate vs. oxalic acid) yielded similar synthetic inclusions. Our results are consistent with extrapolation of the lower temperature data of Takenouchi and Kennedy (A.J.S., 1964) and Gehrig (Ph.D. thesis, Univ. Freiburg, 1980), but suggest a more extensive two-phase region than that calculated by Bowers and Helgeson (Am. Min., 1983). Fluid immiscibility is implied for much of the P-T-X_i(fluid) region of low-to-medium grades of contact metamorphism. An extensive two-phase region is also likely for higher pressures, in agreement with fluid inclusion evidence in some regionally metamorphosed parageneses (Kreulen, A.J.S., 1980; Sisson et al., Contr. Min. Pet., 1981). (Authors' abstract)

STIEHL, G., HAENDEL, D. and GÜNTHER, U., 1984, The isotopic variations of nitrogen in granite and mica schist in contact rocks of a pluton in the Middle Erzgebirge: ZFI-Mitteilungen, "Isotope in der Natur," no. 85, p. 398-406: Leipzig, Akad. Wissen. der DDR (in German; English abstract). Authors at AdW der DDR, Zentralinstitut Isotopen- & Strahlenforschung, 7050 Leipzig, PermoserstraBe 15.

δN-15 values and nitrogen contents were determined on samples from a profile of granite and mica schists in the area of a pluton in the Middle Erzgebirge Mts. With increasing distance from the granite contact δN-15 values of the wall rock decrease and nitrogen contents increase. In the granite samples the δN-15 values are in direct correlation to the nitrogen contents. The δN-15 values of granites vary from -6.3 to +9.1‰. (Authors' abstract)

STOCKMAN, H.W., WESTRICH, H.R. and EICHELBERGER, J.C., 1984, Variations in volatile and non-volatile components in Obsidian Dome (abst.): EOS, v. 65, no. 45, p. 1127. Authors at Geochem. Div. 1543, Sandia Nat'l. Labs., Albuquerque, NM 87185.

Analyses imply that fluids lost during devitrification should be very Cl-rich (ca. 2N). (From the authors' abstract)

STOESSELL, R.K., 1984, Bromide partitioning in halite-brine systems: stoichiometric saturation, recrystallization, and thermodynamic equilibrium (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 669. Author at Dept. Earth Sci., Univ. New Orleans, New Orleans, LA 70148.

Stoichiometric saturation, without thermodynamic equilibrium, may control the Br content in halite precipitating from certain NaCl brines containing less than 1.5 molal Mg. 25°C experimental data (Braitsch and Herrmann, 1963), assumed to represent stoichiometric saturation, has been used to predict the mole fraction of NaBr in halite in thermodynamic equilibrium with a fluid as a function of the aqueous activity ratio of $Br^-:Cl^-$. The predictions have been extended to diagenetic temperatures and pressures.

The Br content in halite generally decreases during fluid recrystallization at low temperatures. This process helps explain enriched Br contents in some reservoir fluids and can be used to predict, with good agreement, the depleted Br contents in recrystallized halite from the caprock of Gulf Coast salt domes. The stability of Br in the salt lattice increases with temperature and pressure, resulting in decreasing the Br depletion in halite during recrystallization at greater depths of burial, until eventually Br enrichment may occur. Br enrichment can also occur at low temperatures by recrystallization from fluids significantly enriched in Br relative to the fluid from which the halite precipitated.

Data for trace components in other solid-fluid systems should be examined from the viewpoint of stoichiometric saturation. Such examination may explain some of the inconsistencies in observed distribution coefficients. (Author's abstract)

STOIBER, R.E., WILLIAMS, S.N. and HUEBERT, B.J., 1984, Geochemical changes during non-eruptive degassing of basaltic magma at Masaya Caldera Complex, Nicaragua (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 669.

STRAUCH, G., KÄMPF, H., STIEHL, G., THOMAS, R., GEISLER, M., HAASE, G. and VOGLER, P., 1984, Isotopic, thermobarogeochemical, and elemental geochemical investigation of a hydrothermal fluorite mineralization in southern DDR: ZFI-Mitteilungen, "Isotope in der Natur," no. 85, p. 407-425: Leipzig, Akad. Wissen. der DDR (in German; English abstract). First author at Zentralinstitut Isotopen- & Strahlenforschung der AdW, der DDR, 7050 Leipzig, Permoserstr. 15.

A hydrothermal fluorite mineralization from SW-Vogtland (GDR) has been investigated using different isotope- and element geochemical and thermogeochemical methods. The mineralization, particularly the fluorite-quartz (fq)-formation is due to the postvariscan mineralization period.

In the second paragenetic succession of the fq-formation, four phases have been recognized. The δD values of the inclusion water suggest a mixture of infiltration and endogenic water as well as marine water. A meteoric influence is excluded.

At the beginning and the end of the second paragenetic succession the content of inclusion water and CO_2 are maxima. (From the authors' abstract)

STRAUCH, G., STIEHL, G., KÄMPF, H. and BANKWITZ, P., 1984, Isotope geochemical investigations on gas-liquid-inclusions in fluorite: Freiberger Forschungshefte, Reihe C, v. 389, p. 157-168 (in German). First author at Central Inst. Isotope & Radiation Res., 7050 Leipzig, Permoserstrasse 15, GDR.

The extraction of gas-liquid phases from fluid inclusions by thermal decrepitation is described. Some results of δD determinations of water and $\delta^{13}C$ values of CO_2 from inclusions in fluorites from the middle Erzgebirge and SW-Vogtland are presented and discussed. (Abstract courtesy H.A. Stalder)

STRONG, D.F., FRYER, B.J. and KERRICH, R., 1984, Genesis of the St. Lawrence fluorspar deposits as indicated by fluid inclusion, rare earth element, and isotopic data: Econ. Geol., v.79, p. 1142-1158. First author at Dept. Earth Sci., Memorial Univ. of Newfoundland, St. John's, Newfoundland A1B 3X5, Canada.

More than 40 separate fluorspar veins are associated with the lower Carboniferous alkaline-peralkaline St. Lawrence granite of southeastern Newfoundland, with more than 3.4 million short tons mined since 1933, and a further 9 million short tons of reserves contained in the three main veins. It is estimated from these tonnages that fluorine concentrations in the magma of only 19 ppm would have been adequate to form the veins, much less than the average of 1,567 ppm F found in the granite. The fluorite is associated with calcite, quartz, barite, and sulfides, and exhibits spectacular growth zoning owing to variations in both color and grain size. Fluid inclusion studies of different growth zones show that salinities remain within the range of 5 to 15 equivalent weight percent NaCl, although homogenization temperatures fluctuate between 100° and 500°C, showing both increasing and decreasing temperatures during crystal growth. Evidence for boiling between 450° and 223°C indicates that the homogenization temperatures are trapping temperatures, at low pressures between 65 and 650 bars. For a sequence of contact rocks showing increasing intensity of carbonate alteration, oxygen isotope compositions of whole rocks and minerals indicate a magmatic origin, possibly with some ^{18}O depletion in the aqueous fluids owing to unmixing and loss of CO_2. In the fluorite veins, $\delta^{18}O$(quartz) is ~14 per mil, and calculated fluid δ values are 10 per mil (450°C) to -6 per mil (120°C); waters released from low-temperature fluorites are -10 per mil. Thus, the fluorite veins were probably deposited from high-temperature magmatic fluids which underwent transient mixing with a cool low ^{18}O meteoric reservoir. Rare earth element (REE) concentrations in individual growth zones and textural types of the fluorite are high to moderate and highly but systematically variable. They are enriched in the intermediate to heavy REEs compared to the light ones, exhibit a ubiquitous negative Eu anomaly, and are highly anomalously enriched in Y relative to the REEs. The finer grained fluorites tend to have REE patterns like those of the granite, while the coarser, more slowly crystallized varieties show systematic REE depletions in younger growth zones. Crystallization was also accompanied by changes in relative proportions of the individual REEs in response to changing stabilities of REE-fluoro complexes owing to decreasing fluorine activity in sequential pulses of hydrothermal fluid. In general we suggest that the main control of fluorite deposition was increasing pH caused by boiling of magmatic fluids, particularly the ebullition of CO_2, and possibly loss of fluorine as SiF_4 or HF. (Authors' abstract)

STRONG, D.F. and SCOTT, S.D., 1984, Fluid inclusions of Ag-Co-Ni arsenide veins in the Cobalt-Gowganda area, Ontario (abst.): Geol. Assoc. Canada/ Min. Assoc. Canada Program with Abstracts, v. 9, p. 108. First author at Dept. Earth Sci., Memorial Univ. Newfoundland, St. John's, Newfoundland, A1B 3X5, Canada.

A reconnaissance fluid inclusion (F.I.) study was conducted on mineralized and barren veins in the Cobalt and Gowganda mining camps and environs. F.I. types include, 1 (L), 2 (L+H), 3 (L+V), 4 (L+V+H), and 5 (V), with types 3 and 4 being most abundant. A histogram of homogenization temperatures for all mine data shows modes around 100°C, 230°C, and 330°C, with a range from above 560°C to below 100°C. Several samples show evidence of boiling, giving a pressure estimate of about 600 bars. The fluids were highly saline $NaCl-CaCl_2$ brines, with up to 54 wt% NaCl and highly variable Na/Ca ratios. There do not appear to be any significant differences between the mines. F.I.'s of barren veins outside the camps are not significantly different in nature from those of the mineralized veins, indicating that hydrothermal fluids were active throughout a large area beyond the known mineralization. A more detailed study of the Giroux No. 1 and Silverfields No. 8 veins suggests that fluid temperature and salinity increased with proximity to ore and the Nipissing Diabase. These data suggest that the ore fluids were formation waters of the Huronian sediments with the Nipissing Diabase serving as a heat source for mobilization of metals and circulation of fluids. (Authors' abstract)

STRUTHWOLF, Mark and BLANCHARD, D.C., 1984, The residence time of air bubbles <400 μm diameter at the surface of distilled water and seawater: Tellus, v. 36B, p. 294-299. First author at Accu-Weather, Inc., State College, PA 16801, USA.

Air bubbles from 50 to 400 μm diameter were produced from a fine capillary tip inserted through the top of a rotating tank of water. Bubble persistence on the surface was measured from the tank geometry and rotation rate, the minimum detectable time being 10^{-2} s. In distilled water, nearly all bubbles >200 μm diameter persisted <0.05 s, but smaller bubbles existed for several seconds or more. Opposite results were found in seawater. Bubbles less than about 80 μm diameter existed $\leq 10^{-2}$ s. For larger bubbles, the residence time increased with size, reaching about 0.3 for bubble diameters of 300 μm. These results, plus other experiments, suggest that bubble collisions in seawater will produce coalescence if one of the bubbles is less than about 80 μm diameter. (Authors' abstract)

STUDEMEISTER, P.A., 1984, Mercury deposits of western California: An overview: Mineral. Deposita, v. 19, p. 202-207. Author at Suite D-105, 2140 Santa Cruz Ave., Menlo Park, CA 94025, USA.

Mercury deposits in western California are near a thrust fault that separates two groups of Mesozoic rocks. The Franciscan Assemblage, a metamorphosed melange with serpentine and graywacke, is structurally overlain by the Great Valley Sequence, a sedimentary series resting on oceanic crust. These Mesozoic rocks are partly covered by volcanic and sedimentary rocks of Cenozoic age. Cinnabar with silica minerals, dolomite, native mercury, and bituminous matter occurs around the fractured margins of serpentine bodies and around hot springs that emanate from the Franciscan Assemblage. Fluid inclusions and hot springs suggest that cinnabar precipitated from CO_2-H_2O fluids with <2 wt% chlorine at T <250°C. Prograde metamorphism of Mesozoic sediments expulsed mercury-bearing fluids that migrated up serpentine-related fractures and exhaled onto the surface. (Author's abstract)

STUEBER, A.M., PUSHKAR, Paul and HETHERINGTON, E.A., 1984, A strontium isotopic study of Smackover brines and associated solids, southern Arkansas: Geochimica Cosmo. Acta, v. 48, p. 1637-1649.

SU, Zongwei and YI, Xiaoyun, eds., 1984, Porphyry copper deposits in China, Inst. of Geol. Research of Ministry of Metallurgical Industry: Beijing, Scientific Publ. House, 240 pp. plus plates (in Chinese).

SUCHSHEVSKAYA,* T.M., LUCHITSKAYA, M.I., RYZHENKO, B.N. and BARSUKOV, V.L., 1984, On the acidity during hydrothermal cassiterite deposition: Geokhimiya, 1984, no. 4, p. 515-526 (in Russian; English abstract).

As a result of the studies of the composition of inclusion fluids in quartz and cassiterite the change of acidity during precipitation of the main mass of cassiterite in a specific cassiterite-silicate-sulfide deposit has been established. The values of pH for 300 and 350°C have been calculated for the successively crystallized quartz and cassiterite. The calculation is based on the Th data for the productive quartz-cassiterite association (confined to the interval of 310-380°C). It was proved that the precipitation of the main mass of cassiterite had taken place against the background of increasing alkalinity. The values of pH, derived with the data on complex-formation taken into account, are 6.2-7.0. The data obtained are supported by mineralogical observations and experimental data on appropriate mineral equilibria. (Authors' abstract) *Sic; should be Sushchevskaya. (See also Suchshevskaya.)

SUGAKI, Asahiko, KITAKAZE, Arashi and ISOBE, Kiyoshi, 1984, On the gold-silver deposits of the Koryu mine, Hokkaido, Japan: J. Japanese Assoc. Mineral., Petrol. & Econ. Geologists, v. 79, no. 10, p. 405-423 (in Japanese; English abstract).

Ore deposits of the Koryu mine are epithermal gold and silver veins in Miocene sediments, and are composed of mainly quartz associated with some amounts of johannsenite, adularia, chlorite, vermiculite, manganoan calcite, pyrite, chalcopyrite, sphalerite, galena, hematite, electrum and various silver sulfosalts.

The homogenization temperatures and salinities of fluid inclusions in quartz are from 240° to 270°C and from 0.0 to 1.4 wt% NaCl equivalent, respectively. Temperatures and sulfur fugacitites of gold-silver mineralization in the Koryu mine are estimated as 175° to 240°C, and -15.5 to -11.5 in log fS_2 (atm), respectively, from the data of compositions of electrum with aguilarite and FeS contents of sphalerite with pyrite. (From the authors' abstract)

SUGAKI, Asahiko and 9 others, 1984, Geological study on the polymetallic ore deposits in the Quechisla district, Bolivia: Science Rpts. of the Tohoku Univ., 3rd Series, v. 16, no. 1, p. 35-129.

Geology of the Quechisla district located in the most southern part of a metallic mineralization belt along the Eastern Cordillera of Bolivian Andes consists of the Ordovician, Cretaceous and Tertiary systems with some igneous intrusions such as quartz porphyry and dacite. There are many polymetallic ore deposits of hydrothermal fissure filling type such as Tasna, Chorolque, Siete Suyos, Animas, Gran Chocaya, Tatasi, San Vicente and Asunta etc. in the district. They are composed of many ore minerals of tin, tungsten, zinc, antimony, bismuth, silver and copper, formed as the results of successive mineralizations as follows (early to late): tin-quartz (cassiterite, quartz and tourmaline), tungsten-bismuth (wolframite, bismuthinite and quartz), tin-pyrite (cassiterite, pyrite and quartz), tin-silver (stannite, silver-bearing sulfosalt minerals and pyrite) and silver-lead-zinc (silver sulfosalt minerals, galena and sphalerite). Among them, the tin-quartz mineralization is recognized as most essential one in the Chorolque mine. Both the tin-pyrite and tin-silver mineralizations are found obviously in the Siete Suyos and Animas mines, while in the Gran Chocaya mine the silver-lead-zinc mineralization is principal. The ore deposits of the Tatasi and San Vicente mines are mainly formed by the tin-silver and silver-lead-zinc mineralizations, respectively.

The zonal arrangement of ore minerals is also shown by Th data and salinity in NaCl equiv. of liquid inclusions in quartz. For example, in the Siete Suyos and Animas mining area, Th and salinities of liquid inclusions are 228° to 379°C and 4.7 to 11.9 wt% NaCl (tin-pyrite zone), 178° to 279°C and 3.8 to 4.9 wt% NaCl (tin-silver zone), and 176°-268°C and 4.6-5.2 wt% NaCl (silver-lead-zinc zone), respectively. Also, at the Tatasi mine, Th and salinities of fluid inclusions are 232°-345°C and 1.8-8.9 wt% NaCl (tin-pyrite mineralization) and 180°-299°C and 8.2-1.6 wt% NaCl (tin-silver mineralization), respectively. Those for fluid inclusions in quartz from the tin-quartz and tungsten-bismuth zones in the Chorolque mine indicate very high values as 261°-500°C, 24.9-53.2 wt% NaCl and 268°-493°C, 33.2-48.2 wt% NaCl, respectively. Also Th and salinities of fluid inclusions in quartz crystallized by tungsten-bismuth mineralization at the Tasna mine show 250°-499°C and 24.6-50.4 wt% NaCl, respectively. Some $\delta^{34}S$ data were obtained for common sulfide minerals. (From the author's abstract)

SUSHCHEVSKAYA, T.M. and ĎURIŠOVÁ, J., 1984, Chemical composition of fluids forming cassiterite-quartz deposits (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 183-184 (in English). First author at V.I. Vernadsky Inst. Geochem. & Anal. Chem. USSR Acad. Sci., Moscow, USSR.

Chemical features of tin-bearing hydrothermal solutions responsible for the formation of quartz-cassiterite deposits were estimated from fluid inclusion chemical data for minerals of productive associations from the Cinoveć, Krupka, and Iultin Sn-W deposits. The similar mineralogical assemblages and their consequences are essential for these deposits as well as the close spatial and time association with highly differentiated granitic intrusions.

The formation of the identical productive greisen and quartz vein associations are found to be characterized by notable variations in salinity (S) and macrocomponent composition (Na, K, Ca, Cl, HCO_3, F, CO_2) of ore-forming solutions. S values usually do not exceed 10% wt and are rarely greater than 20%. Macrocomponent composition is not specific. As a rule Na and Cl predominate, while K, Ca, HCO_3, F contents vary to such extent that Na/K, Cl/HCO_3, Cl/F, HCO_3/F ratios reach 1 sometimes. The values of these ratios depend on the actual conditions of the evolution of hydrothermal systems. As for the gaseous components of the solutions, CO_2 always predominates over N_2, CH_4, CO, and H_2.

The process of the formation of deposits of the given type cannot be characterized unambiguously by the direction of the change of CO_2 concentration and by the ratios of different forms of carbon. The sign of this change can be different for the deposits belonging to the same type. For Krusné Hory (Erzgebirge) deposits (Cinoveć, Krupka) transition from greisen to vein quartz associations is accompanied by a noteable increase in CO_2 and CO_2/CO. One may suppose that additional CO_2 enters the system and the latter becomes less reducing. The formation of Sn-W deposit of Panasqueira was accompanied by a decrease in CO_2 content, and, according to the isotopic data, no admixtures of waters of different composition and genesis took place (Kelly, Rye, 1979). Computer simulation in which the equilibrium of the solution with solid phases was taken into account, has shown that in tin-bearing solutions at the temperature of the ore deposition the macrocomponents are present in complex forms (especially Ca, Mg, HCO_3, F). (Authors' abstract)

SVERJENSKY, D.A., 1984a Mobility of trace elements during hydrothermal alteration processes (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 671.

SVERJENSKY, D.A., 1984b Oil field brines as ore-forming solutions: Econ. Geol., v. 79, p. 23-37. Author at Dept. Earth & Space Sci., State Univ. New York at Stony Brook, Stony Brook, NY 11794.

The hypothesis that oil field brines can become ore-forming solutions and can transport base metals and reduced sulfur to sites of ore formation by large-scale migration along aquifers out of sedimentary basins is examined using data on the chemical compositions of present-day heavy metal-bearing oil field brines and the petrography of their reservoir rocks, and is a theoretical evaluation of the chemistry of possible water-rock interactions in the aquifers during migration.

Analyses of oil field brines from the Pleasant Bayou in the upper Texas Gulf Coast and the Rayleigh field in central Mississippi were used to calculate the pH of the brines under reservoir conditions by assuming equilibrium with the reservoir mineral assemblages. The calculated pH values are less than 5.7 for the Pleasant Bayou brines at 138°C and 787 bars and 4.3 (± 0.3) for the Rayleigh field brines at 130°C and 390 bars. According to theoretical and experimental evidence of metal sulfide solubilities, brines with pH's as low as the Rayleigh field brines could contain parts per million quantities of zinc, lead, and reduced sulfur under reservoir conditions. Low pH oil field brines with small, approximately equal quantities of base metals and reduced sulfur are potential ore-forming solutions. It is proposed that during the migration of such potential ore-forming solutions, water-rock interactions in the aquifer strongly influence the compositions of the solutions, thereby controlling the evolution of the chemistry of the solutions at distant sites of ore formation. Typical water-rock interactions have been investigated by theoretical evaluation of the thermodynamic consequences of the reactions of a hypothetical low pH oil field brine with quartz sandstone and dolostone aquifers that contain about 3 percent K-feldspar, 0.2 percent muscovite, and 0.01 percent pyrite by volume. The oil field brine was initially close to saturation with respect to quartz, kaolinite, muscovite, dolomite, pyrite, and galena but undersaturated with respect to sphalerite. During reaction with both aquifer types and simultaneous cooling from 125° to 124°C about 0.088 moles of K-feldspar were destroyed per kilogram of H_2O, and the Na/K and Zn/Pb atomic ratios of the aqueous phase changed from 136 to 23 and 2 to 34, respectively. The first stage of ore formation from such solutions would be sphalerite rich and would contain fluid inclusions with the low Na/K ratios characteristic of Mississippi Valley-type deposits. In contrast, when the reaction capacity of the aquifer is exhausted, solutions undersaturated with respect to sphalerite reach the site of ore formation and deposit a second, galena-rich stage. The relative lengths of the two stages of ore deposition determine the overall Zn/Pb ratio of the deposit, although the bulk of the sphalerite is deposited before the bulk of the galena. The correlation of lead-rich (southeast Missouri and Laisvall, Sweden) and zinc-rich (upper Mississippi Valley and east Tennessee) deposits with sandstone and dolostone aquifers, respectively, suggests that the reaction capacity of sandstone is more efficiently exhausted than that of dolostone.

The concept of water-rock interactions in the aquifers of sandstone and carbonate-hosted base metal sulfide ore deposits is clearly of potential importance in explaining geochemical characteristics of such deposits, including the Na/K ratios of the fluid inclusions, the lead isotope compositions of galena, the paragenesis sphalerite followed by galena, and the overall Zn/Pb ratios of the deposits. It is because of these water-rock interactions that a single brine carrying base metals and reduced sulfur can evolve chemically in its aquifer so that brines with a spectrum of geochemical characteristics arrive as a function of time at a distant site of ore formation. (Author's abstract)

TAGGART, J.E., Jr., 1977, Polishing technique for geologic samples: Am. Mineralogist, v. 2, p. 824-827. Author at New Mexico Bureau of Mines & Min. Resources, Socorro, NM 87801.

By the use of only one piece of equipment, exceptionally flat, polished thin sections and plugs having a few defects may be produced from a variety of geologic materials. A horizontal lap unit, with exchangeable lap wheels and an automatic polisher, is used for all steps from grinding to final polish. Diamond abrasive compounds are used exclusively. The compounds are embedded in a chemotextile material, producing fixed grain laps that remove material by planing action until scratches are no longer visible with light optic microscopes. After each step, sections are cleaned with an ultrasonic cleaner. Meticulous lab technique is important. (Author's abstract)

TAGUCHI, Sachihiro, HAYASHI, Masao, MIMURA, Toshimitsu, KINOSHITA, Yasumi, GOKOU, Kazunori and ABE, Isao, 1984, Fluid inclusion temperature of hydrothermal minerals from the Kirishima geothermal area, Kyushu, Japan: Japan Geothermal Energy Assoc. [Journal], v. 21, no. 2 (Ser. 82), p. 55-65 (in

Japanese; English abstract).

Th of fluid inclusions in secondary minerals such as quartz and calcite from the Kirishima geothermal area has been measured. The fluid inclusion temperature generally ranges from 140 to 320°C and has a wide range at each depth in a well. It is 45 to 100°C in the North Kirishima field, and 20 to 45°C in the West Kirishima field. Of these temperatures, the maximum value at each depth is on, or slightly below the boiling point curve of water whose water table is set at the surface (surface boiling point curve). On the other hand, the minimum value has a close correlation with the present subsurface temperature. The present temperature at depths is estimated to reach almost 300°C at the eastern part of the west Kirishima field. Moreover, at various depths of a well, the temperature range is almost constant in general. The above characteristics suggest that the Kirishima geothermal system was once at the state of maximum, or almost maximum geothermal activity, and then cooled down to some extent. As the system cools, the ground water level has become deeper, and the geothermal fluids have become compressed, resulting in almost constant difference between maximum and minimum Th at each level in a well. However, when the fluids are not strongly compressed, the subsurface temperature increases downward almost along the boiling point curve of the present water table (water table boiling point curve), resulting in the formation of a distribution pattern of fluid inclusion temperature which is wide at shallow levels as compared with at deeper ones. (Authors' abstract)

TAKENOUCHI, Sukune, 1984a Fluid inclusion study of the Kawarage, Akita, and the Ugusu, Shizuoka, silicified body: Mining Geol., v. 34, no. 4, p. 263-273 (in Japanese; English abstract). Author at Dept. Min. Dev. Engrg., Faculty of Engrg., The Univ. Tokyo, Tokyo 113, Japan.

Fluid inclusions of the Kawarage and Ugusu silicified bodies were studied in connection with the basic study of the hot spring-type gold mineralization. The Kawarage silicified body is formed in Miocene dacitic tuff and intruded quartz porphyry, mainly due to leaching of rock-forming materials except silica through hydrothermal activity. The Ugusu silicified body occurs in Miocene and Pleistocene andesitic lava and tuff. Acid hydrothermal alteration zones are not formed extensively around the Kawarage body but widely around the Ugusu body. Besides devitrified glass inclusions, abundant secondary fluid inclusions are found in quartz grains of the altered rocks in the Kawarage silicified body. They are mostly gaseous and liquid inclusions, but saline polyphase inclusions are also rarely observed. The coexistence of gaseous and liquid inclusions in a cluster, which suggests boiling phenomena of hydrothermal solutions, is occasionally found throughout the body but more commonly in the marginal zone. Homogenization temperatures of fluid inclusions are distributed in a range between 180°C and 290°C, but most frequently in ranges of 220°-230°C, 250°-260°C and 270°-280°C. The lowest homogenization temperature of the inclusion cluster which shows boiling phenomena, varies from 215°C to 285°C, and the depth estimated from the lowest one among these temperatures, i.e. 215°C, is about 230 m. Some clusters having different boiling temperatures occur in the same specimen. This suggests that intermittent boiling of solution took place at various temperatures during the hydrothermal activity. Samples preferable to the measurement of homogenization temperature of fluid inclusion are very few in the Ugusu silicified body. A temperature range between 195° and 305°C with a high frequency range at 240°-285°C, was determined on a single sample. Boiling phenomena were recognized in a temperature range of 295°-305°C. Homogenization temperatures of fluid inclusions in an alunite sample range between 205° and 220°C with a high frequency peak at 210°C. It is presumed from the present result that the thermal conditions of silicification in the Kawarage and Ugusu silicified bodies were similar to those of the Nansatsu-type gold deposits, but the reason why gold mineralization is not known in these two areas remains unsolved. (Author's abstract)

TAKENOUCHI, Sukune, 1984, Hydrothermal fluids inferred from fluid inclusions: Materials Sci. of the Earth's Interior, I. Sunagawa, ed.: Tokyo, Terra Sci. Publ. Co., p. 515-544. Author at Dept. Mineral Dev. Engrg., The Univ. Tokyo, Tokyo, Japan.

A review, with 70 references, of fluid inclusion studies mainly of Japanese ore deposits, including vein and skarn, Kuroko, and porphyry-Cu types, plus details on the behavior and interpretation of CO_2-rich inclusions. (E.R.)

TAKEUCHI, Koichi and SHIKZONO, Naotatsu, 1984, Mineralization of the Arakawa No. 4 vein of the Kushikino mine, Kagoshima Prefecture, Japan: Mining Geol., v. 34, no. 3, p. 187-195. First author at Inst. Ceramics of Nagasaki Prefecture, Hasami, Higashisonogi-gun, Nagasaki Prefecture 859-37, Japan.

Mineralization of the Arakawa No. 4 vein, one of the representative veins in the Kushikino mine, was investigated. Four periods of mineralization are recognized. They are, from earlier to later stages, period I (quartz-calcite zone), period II (high grade "Ginguro" ore zone containing polybasite, electrum, pyrite and tetrahedrite), period III (brecciated quartz-calcite-clay zone), period IV (banded "Ginguro" zone containing polybasite, electrum and pyrite). Period II can be divided into earlier one (period IIa containing polybasite and pyrite) and later one (period IIb containing electrum, polybasite, pyrite, sphalerite and chalcopyrite). No compositional variations were found in electrum and tetrahedrite. On the other hand, decrease of iron content of sphalerite, and increases of selenium contents of polybasite and naumannite-acanthite series minerals from earlier to later stage were observed. Filling temperature of fluid inclusions decreases slightly from earlier to later periods; 240-200°C for period I, 240-180°C for period II and 220-170°C for period IV. Based on the variations in the iron content of sphalerite and Th of fluid inclusions, sulfur fugacity for period II is estimated to be 10^{-11} - 10^{-13} atm. Decreasing of temperature under the relatively oxidizing environments can explain the variations of selenium contemts of polybasite and naumannite-acanthite series minerals. (Authors' abstract)

TALKINGTON, R.W., WATKINSON, D.H., WHITTAKER, P.J. and JONES, P.C., 1984, Platinum-group minerals and other solid inclusions in chromite of ophiolitic complexes: occurrence and petrological significance: TMPM Tschermaks Min. Petr. Mitt., v. 32, p. 285-301.

Platinum-group mineral, silicate and other solid and fluid inclusions occur in disseminated and massive chromite in a variety of lithologies from ophiolitic and other mafic-ultramafic complex-types. The inclusions are small (<250 microns) and randomly distributed throughout their host. Silicate inclusions are modally more abundant than the other inclusion types. Platinum-group mineral phases are ruthenium-rich sulphides and PGE alloys are osmium-rich. Mafic silicates (olivine, pyroxenes, pargasitic-amphiboles, micas) are magnesium-, titanium-, and alkali-rich and felsic silicates are sodium-rich (albite, nepheline).

The intimate association of these inclusions with chromite suggest that their origin must be considered within a chromite crystallization model. A hypothesis of origin is suggested wherein the platinum-group minerals and silicates are trapped as discrete, crystalline euhedral phases and silicate liquid during the precipitation of chromite. The similarity of physical characteristics, modal mineralogy and chemical compositions indicates that this model may be applicable to all mafic-ultramafic complex-types. (Authors' abstract)

Fluid inclusions are mentioned only from literature data. (E.R.)

TAMER, Nuran and DORA, Ozcan, 1984, Fluid inclusions study on the quartzes from the young volcanic rocks and the Menderes Massif, western Anatolia (Turkey): Doga, Seri B, v. 8, no. 1, p. 65-77 (in Turkish).

Td, Th and salinity were determined. (Abstracted from CA 101: 41172e)

TANAKA, Kiriko, KOIZUMI, Morito, SEKI, Riki and IKEDA, Nagao, 1984, Geochemical study of Arima hot-spring waters, Hyogo, Japan, by means of tritium and deuterium: Geochem. J., v. 18, p. 173-180. First author at Div. Environ. Health, Nat'l. Inst. Radiological Sci., Anagawa, Chiba 260, Japan.

Tritium, deuterium and chloride concentrations in the Arima hot spring waters were measured as a clue to their origin and subsurface behavior. T-D-Cl^- relationships clearly indicate that the saline brine of deep origin (T = 0 TR, $\delta D = -30‰$ and $Cl^- = 43$ g/l) is mixed with young meteoric water having T = 30 TR, $\delta D = -50‰$ and $Cl^- = 0$ g/l in varying proportions to form a group of high chloride hot spring waters. The young meteoric water in a shallow aquifer is also mixed with the older meteoric water in a deeper aquifer characterized by high tritium concentration (~100 TR), forming another group of low chloride waters. The mixing ratio of the two meteoric waters varies with season. (Authors' abstract)

TANGER, J.C., IV and HELGESON, H.C., 1984, Revised equations of state for calculating the standard molal thermodynamic properties of aqueous species in hydrothermal systems at pressures and temperatures to 5 kb and 1000°C (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 673.

TARAN, Yu.A. and PILIPENKO, V.P., 1984, Hydrothermal solutions and gases of the first producing wells of the Severo-Mutnovskoye vapor-hydrothermal area, Kamchatka: Geokhimiya, 1984, no. 7, p. 1062-1074 (in Russian; English abstract).

A detailed gas-hydrochemical study of the first three steam-water wells of the area and the most powerful natural steam discharges has been made. The data on ion-salt composition of the steam-water mixture from the wells, vapor content, gas and isotope (δD and $\delta^{18}O$) composition as well as on radon content for all sampled natural steam and well discharges are given. Based on these parameters using ionic (Na-K and SiO_2), gaseous ("methane" and "ammonia" equilibria) and isotopic (from fractionation of D and ^{18}O) geothermometers the aquifer temperatures were calculated. A calculation of gas equilibria was made taking into account a partition of components between liquid and vapor phases. It was shown that variations of radon contents for all the objects depend mainly on temperature in the boiling zone and on phase composition of the steam-water mixture. Temperature at the interior of the hydrothermal system is estimated as large as 260 to 280°C under a partial pressure of CO_2 near to 0.3 atm. (Authors' abstract)

TATARINOV, A.V., 1983, Minerals of silica and conditions of amethyst formation in skarn-magnetite fields of the southern Siberian Platform: Mineralogy and genesis of precious stones in Eastern Siberia, p. 34-41, Siberian Br. "Nauka" Publ. House, Novosibirsk (in Russian).

Maximum Th of P G/L inclusions in amethysts from the Angara-Kat region (380-400 and 400-420°C) occurs in the root and heads of crystals; minimum Th (375-385°C) - in the central parts. (A.K.)

TAUSON, V.L., ABRAMOVICH, M.G. and PARADINA, L.F., 1983, Stoichiometry and relative stability of the α and β modifications of mercury sulfide: Geokhimiya, no. 12, p. 1706-1719 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 6, p. 1-13, 1984).

TAYLOR, B.E. and GERLACH, T.M., 1984, Mantle CO_2 degassing at Long Valley, Steamboat Springs, and the Coso Range (abst.): EOS, v. 65, no. 45, p. 1153. First author at 209 Irving Place, Ottawa, Ontario, Canada K1Y 1Z7.

We have investigated the chemical and isotopic composition of steam-vent and hotspring gases emitted at several sites along the eastern Sierra Nevada front, particularly at the Coso Range, Long Valley, and Steamboat Springs. All gas samples were collected in evacuated bottles containing alkaline solutions and in a manner that minimized atmospheric contamination. The gases (other than water vapor) consist mainly of CO_2 with minor H_2S, H_2, SO_2, CH_4, N_2, Ar, and O_2. Carbon isotope analysis of separated CO_2 gives $\delta^{13}C$ of -4.0 to -8.2 per mill (±0.2 per mill reproducibility) for the entire sample set. Differences do exist among adjacent sites, but they are slight. The $\delta^{13}C$ values become somewhat lower to the northwest from Coso (-4.2 to -6.2 per mill) to Long Valley (-4.8 to -7.5 per mill) to Steamboat Springs (-7.5 to -8.2 per mill). Chemical and isotopic analytical studies as well as hydrothermal extraction experiments on potential sources of igneous carbon, which could become remobilized by water-rock interactions, have so far yielded negative results. For example, chemical, isotopic, and extraction investigations of the Bishop Tuff caldera fill indicate it is not a significant source of the CO_2 emitted at Long Valley. Our preliminary interpretation of the observations is that the CO_2 originates largely from widespread magma and/or mantle degassing and is a geochemical manifestation of the Basin and Range extension and associated intrusion of mantle magma postulated by Lachenbruch and Sass (1978). (Authors' abstract)

TAYLOR, B.E., HANNAH, J.L., STEIN, H.J. and GANSTER, M.W., 1984, The Mount Emmons porphyry molybdenum deposit, Colorado: magmatic degassing and meteoric water overprinting (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 674. First author at Dept. Geol., Univ. California, Davis, CA 95616.

The data suggest ore deposition from magmatic fluids, which degassed to relatively low water pressures. Alteration by meteoric water occurred at very low water/rock ratios (<0.1) after emplacement of UP, and was not directly related to ore deposition. (From the authors' abstract)

TAYLOR, B.E. and SLACK, J.F., 1984, Tourmalines from Appalachian-Caledonian massive sulfide deposits: textural, chemical, and isotopic relationships: Econ. Geol., v. 79, p. 1703-1726. First author at Dept. Geol., Univ. California, Davis, CA 95616.

Extensive studies of tourmalines are reported, including petrography, associated minerals, chemical variations (major and trace elements, F, and Cl).

Tourmalines from tourmalinites and massive sulfide deposits are typically characterized by heavier $\delta^{18}O$ values (9.5-15.5‰) and less variable, heavier δD values (generally -45 to -60‰) than tourmalines from unmetamorphosed igneous pegmatites. The latter typically have $\delta^{18}O$ <9.5 per mil and $\delta D \leq -60$ per mil. Oxygen isotope fractionations between quartz and tourmaline ($\Delta = 1.27-4.01$) do not correlate directly with inferred grade of subsequent metamorphism, although in areas of high metamorphic grade the Δ values approach those of igneous quartz-tourmaline pairs. The $\delta^{18}O$ values of quartz and tourmaline are believed to reflect variation in the oxygen isotope compositions of the host lithologies. The similar, narrow range in hydrogen isotope composition for tourmaline in all studied deposits is compatible with a modified seawater orign for the tourmaline- and sulfide-forming fluids.

These geochemical and isotopic signatures are attributed to the original environment of formation of the associated sulfide deposits and suggest that Mg-rich tourmaline may be a valuable prospecting guide in the search for massive sulfide deposits. (From the authors' abstract)

TAYLOR, G.R. and COMSTI, E.C., 1984a Hydrothermal fluids from the Hillgrove tungsten-gold-antimony deposits (abst.): Abstracts 7th Australian Geol. Cong., Sydney, 1984, no. 12. First author at Univ. New South Wales, Sydney, Australia.
See next item.

TAYLOR, G.R. and COMSTI, E.C., 1984b Hydrothermal fluids from the Hillgrove tungsten-gold-antimony deposits (abst.): Abstracts 7th Australian Geol. Cong., Sydney, 1984, no. 12. First author at Univ. New South Wales, Sydney, Australia.

Fluid inclusions within quartz and scheelite accompanying several stages of mineralization at Hillgrove are described. Earliest formed scheelite from the deepest levels contains numerous very small inclusions (less than 5 mm) [sic; presumably μm meant?] of both a two-phase vapor-dominated type and a two-phase liquid-dominated type. These indicate that scheelite deposition occurred during boiling of the ascending fluids. Two-phase, liquid-dominated inclusions within pyrite-arsenopyrite-gold mineralization have uncorrected Th between 195°C and 250°C and within stibnite-antimonide-siderite and stibnite-calcite mineralization have Th between 100°C and 195°C and a bimodal distribution of temperatures peaking at 175°C and 145°C. These peaks possibly correlate with the two latest stages of mineral deposition (Comsti and Taylor, 1984, in press). Secondary included fluids within an earlier generation of deformed barren quartz veins are derived from hydrothermal fluids contemporary with the main-stage mineralizing fluids described above. Primary inclusions within barren late-stage, crosscutting quartz-chlorite-calcite veins show these veins to be unrelated to the mineralization. No daughter crystals were observed in any of these inclusions.

Although, because of their very small size, no homogenization or salinity data are available for the scheelite fluid inclusions, it is unlikely that they are comprised of fluids significantly more saline than the 5% equivalent salinity determined for their later-stage fluids. The observed restriction of scheelite to the deeper part of the vein system coincidently with inclusions suggestive of boiling, would be compatible with a deposition mechanism in which the boiling or unmixing of a CO_2-H_2O fluid at depth causes tungsten-bearing carbonate/bicarbonate complexes to become unstable.

A correlation between Th and salinities of inclusions within quartz accompanying later stibnite mineralization indicates that this mineralization occurred during the mixing of a hot, partly saline, fluid (at 5% equivalent NaCl) with cooler, less-saline meteoric or connate water. Over a vertical distance of 200 m, equivalent mineral assemblages were deposited over the same temperature ranges. Studies on single crystals suggest rapid deposition with fluid temperature dropping 45°C during their growth.

It is concluded that mineral parageneses and fluid inclusion data suggest that the metals were transported by sulphur-poor, moderate temperature, low-salinity solutions, possibly as carbonate/bicarbonate complexes. A vertical zonation of the W-Sb-Au mineralization is compatible with the boiling of this hydrothermal fluid and then subsequent mixing with cooler groundwater. Regional metallogenic and geological considerations suggest that ore metals are derived from the remobilization of deep-seated stratabound deposits (Plimer, 1982) or from metamorphic fluids expelled from deep-seated volcanoclastic sediments. (From the authors' abstract) See Comsti and Taylor, 1984, this volume. (E.R.)

TAYLOR, H.P., Jr. and BEATY, D.W., 1984, Oxygen and hydrogen isotope studies of hydrothermal interactions in volcanic plutonic complexes, with applications to the formation of submarine ore deposits: Int'l. Conf. on Recent Advances in the Geochemistry of Ore Deposits [Abstracts], Mineral Explor. Research Inst., Montreal, Quebec, p. 53-58.

TAYLOR, J.R. and WALL, V.J., 1984, The mobilization of tin from granitoid magmas (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 474. Authors at Dept. Earth Sci., Monash Univ., Clayton, Victoria, Australia.

Understanding the evolution of magmatically derived tin deposits requires quantitative evaluation of the physicochemical constraints on the extraction of tin from granitoid magmas and its subsequent hydrothermal transport. We report our experimental investigations on melt-aqueous phase tin partitioning and the solubility of cassiterite in high temperature hydrothermal solutions. Such data enables modelling of the magmatic-hydrothermal transition in the development of tin mineralization.

Partitioning experiments (700-800°C, 1-3 kb), examined the distribution of tin between haplogranite melts and an aqueous phase (0-8 molal (Na + K)Cl) over a range of oxygen fugacities (QFM - 1 log unit to Hm/Mt - 1 log unit), utilizing a double Au capsule method. K(Sn) for vapor/melt increased strongly with increasing chloride molality and also with decreasing fO_2 in the higher range. The solubility of SnO_2 in NaCl/KCl-bearing fluids coexisting with albite/k'spar-sillimanite-quartz also increases markedly with chloride molality, with an fO_2 and pH dependence which suggests the predominance of Sn^{2+} hydroxy-chloro complexes. These results attest to the efficacy of tin mobilization and transport by acid, chloride-bearing fluids under high temperature, relatively reducing conditions.

Using models based on natural systems, such fluids, generated by resurgent boiling, can account for economic tin enrichment. Adequate concentrations and quantities of tin may be extracted from comparatively common granitic compositions or more effectively from geochemically fractionated variants. SnO_2 deposition from the magmatic aqueous phase is favored by decreasing temperature, decreasing acidity of increasing fO_2. (Authors' abstract)

TAYLOR, T.W. and SCLAR, C.B., 1984, A petrological and geochemical study of the O.K. copper-molybdenum deposit, Beaver County, Utah (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 257. Authors at Dept. Geol. Sci., Lehigh Univ., Bethlehem, PA 18015.

The O.K. deposit in the Beaver Lake Mountains of southwestern Utah consists of concentrations of chalcopyrite and molybdenite in a pipe-shaped mass of quartz which is enclosed in a Tertiary quartz monzonite intrusion. Based on field relationships and geochemical trends as shown by whole-rock XRF analysis, the quartz pipe and the ore minerals appear to have been precipitated from hydrothermal fluids which traveled along a fissure system.

The quartz monzonite around the quartz core has been transformed into a concentric series of alteration zones which contain mineral assemblages similar to those found in much larger porphyry copper deposits. The zone closest to the quartz core consists of sericitized and silicified quartz monzonite which defines the phyllic zone of alteration, respectively. Fluid-inclusion studies revealed the occurrence of both gas-rich and halite-bearing fluid inclusions which are common in porphyry copper deposits.

Although the O.K. deposit and typical porphyry copper deposits show similar alteration zones, ore mineralization, and fluid inclusions, several unique features at the O.K. deposit suggest that they are not genetically equivalent. These differences include the massive quartz core, the concentration of the ore minerals in this core, and the lack of pyrite. It is concluded that the unique features of the O.K. deposit are due to a different mode and environment of emplacement of the hydrothermal fluids. The O.K. deposit appears to be controlled by a fissure system whereas a typical porphyry copper deposit is the product of a more uniformly distributed hydrous metal-bearing fluid. (Authors' abstract)

TERRELL, D.J., 1984, Ne, Ar, Kr and Xe in sea floor basalts from the FAMOUS area (abst.): EOS, v. 65, no. 45, p. 1139. Author at Instituto de Geofísica, UNAM, 04510 D.F. Mexico.

Theories about the degassing of the earth have been based on studies of noble gases (mainly He and Ar) in the atmosphere and samples from the sea floor. There is, however, great uncertainty in the way in which sea water reacts to modify the noble gas pattern in submarine rocks. K-Ar dating of submarine rocks has been difficulted due to K exchange by hydrothermal alteration as well as halmyrolysis, and due to the presence of "initial" argon. The presence of this "initial" argon could be assessed if the pattern and initial concentration of the other noble gases was known.

Noble gas data obtained from 4 samples from the FAMOUS area (Mid Atlantic Ridge at ~36°N) show the effects of halmyrolysis in the noble gas pattern. These results also give some indication for the possibility of using the noble gases in the study of mantle source inhomogeneities. (Author's abstract)

TEZUKA, Machiko, NAKAMURA, Morio and OMI, Katsuo, 1984, Some problems in natural gas-dissolved-in-brine analyses: J. Japanese Assoc. Petr. Tech., v. 48, no. 3, p. 239-246 (in Japanese; English abstract).

THEODORE, T.G., HOWE, S.S., BLAKE, D.W. and WOTRUBA, P.B., 1984, Geochemical and fluid zonation in the skarn environment at the Tomboy-Minnie gold deposits, Lander County, Nevada (abst.): Exploration for ore deposits of the North American Cordillera, a Symp. of the Assoc. Exploration Geochemists, Reno, Nevada, March 25-28, 1984, Abstracts with Program, p. 29. First author at U.S. Geol. Survey, 345 Middlefield Road, MS 901, Menlo Park, CA 94026.

The Tomboy-Minnie gold deposits are related to the middle Tertiary porphyry copper system centered at Copper Canyon. Fluid inclusion studies suggest wide variations in temperature and chemistry prevailed in the fluids associated with mineralization at the Tomboy. Early fluids associated with diopside-salite-quartz assemblages probably were dominantly

$MgCl_2$-rich brines and were boiling at temperatures higher than 500°C. These fluids were progressively enriched in Na and K over time, and during the hydrosilicate stages, temperatures probably ranged from 320°C to 500°C at the time chlorite was dominant. Sulfur isotopic data suggest that magmatic sulfur with a $\delta^{34}S$ of 4 ± 1 per mil was transported by hydrothermal fluids as aqueous H_2S to the West, East, and Tomboy deposits. (From the authors' abstract)

THEODORE, T.G. and MENZIE, W.D., 1984, Fluorine-deficient porphyry molybdenum deposits in the western North America Cordillera: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 463-470.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 250. (E.R.)

THOMAS, A.V. and SPOONER, E.T.C, 1984, Petrological evidence for inward and upward non-replacive crystallization in the growth sequence lower wall zone, Ta(-Sn) bearing banded albitite, beryl fringe to quartz core, Tanco pegmatite, Manitoba (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 111. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

A major host lithology for economic Ta (~0.2% Ta_2O_5) (-Sn) mineralization in the sub-horizontal 1.44 x 0.82 km TANCO pegmatite in S.E. Manitoba is the banded albitite of the eastern ore-body. Field and petrographic observations summarized below indicate that these albitites belong to a non-replacive paragenetic sequence which developed upwards from the base of the pegmatite. Lower wall zone material includes large microcline perthite crystals up to 1.75 m in height with wedge shapes which broaden and branch upwards away from the footwall amphibolite contact. Fine grained, banded albitite (g.s. <0.5 mm), initially occurring interstitial to K-feldspar crystals, increases in amount upwards providing a gradational contact with the overlying massive albitite. Banding in the saccharoidal albitite is defined by variations in the relative proportions of albite, quartz, muscovite and Ta(-Sn) minerals. No traces of a replaced previous lithology have been observed, and fine intergrowths of euhedral albite laths enclosed in Ta(-Sn) minerals indicate direct crystallization. Occasional coarse (~2-7 cm) crystals of beryl and quartz occur oriented with c-axes normal to the sub-horizontal (on average) banding. Upward broadening wedge morphologies for these crystals indicate unimpeded growth into liquid/vapor filled space and, therefore, a depositional origin for the bands. Similarly oriented euhedral beryl crystals of the beryl fringe grow off truncated albitite, and are overgrown by the quartz core. The quartz core represents the latest stage of this sequence. Fluid inclusion observations indicate that a separate H_2O-CO_2 fluid phase undergoing phase separation existed at the time of fine-grained albitite crystallization. This observation indicates that the occurrence of a free volatile phase or phases, need not necessarily cause growth of large crystals. (Authors' abstract)

THOMAS, R., 1984, Thermobarogeochemical investigations on melt and fluid inclusions in minerals of the postmagmatic tin-tungsten-mineralization of the Erzgebirge and some remarks to the physico-chemical evolution of mineral-forming solutions in the magmatic and postmagmatic stages (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 188 (in English). Author at VEB Spurenmetalle Freiberg, Freiberg, GDR.

By means of thermobarogeochemical investigations of minerals of the tin-tungsten-mineralization of the Erzgebirge (at the northern margin of the Bohemian Massif) it is demonstrated that this method provides genetic statements of basic importance for the understanding of mineral-forming processes (for example: the processes of the magmatic and/or postmagmatic K- and Na-feldspathization and postmagmatic greisenization). Among other things, these statements include data on the formation temperature and formation pressure as well as information on the composition, concentration, and order of magnitude of the pH-values of the mineral-forming solutions. It is shown that by correlation of the thermobarometric investigation results and the results of other mineralogic-geochemical methods, e.g., stable isotope studies, significant genetic conclusions can be drawn. This allows one to deduce general regularities of the physico-chemical evolution of mineral-forming solutions in the magmatic and postmagmatic stages. (Author's abstract)

THOMPSON, T.B., TRIPPEL, A.D. and DWELLEY, P.C., 1984, Mineral deposits of the Cripple Creek district, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 675. Authors at Colorado State Univ., Dept. Earth Resources, Fort Collins, CO 80523.

The Cripple Creek district, discovered in 1891, has produced nearly 21 million oz gold 1) from narrow veins within Precambrian and Tertiary rocks and 2) from bulk-tonnage deposits within tectonic and hydrothermal breccias. The district is localized within and adjacent to a 27.9 to 29.3 + 0.7 m.y. nested diatreme-intrusive complex.

The veins are radial or concentric to the diatreme system. Vein-related hydrothermal alteration of adularia, dolomite, roscoelite, pyrite, sericite, montmorillonite, and magnetite occurs in a narrow zone. Five vein mineral stages contain low sulfide concentrations, gold tellurides, acanthite, fluorite, quartz, carbonates, and hematite. Fluid inclusion analyses indicate that stage 1 fluids were saline (33 to >40% eNaCl); the fluids were boiling at 206 to 328°C and contained CO_2. Stages 2 and 3 exhibit progressively lower temperatures with markedly lower salinities (0 to 8.3% eNaCl). The telluride ore (stage 4) was deposited from weakly boiling (<150°C), dilute (1.4 to 3.5% eNaCl) fluids. Trapping pressures range between 360 and 400 bars, corresponding to an estimated maximum depth of formation of 4,000 m.

The bulk-tonnage deposits are within the diatreme complex in tectonic and hydrothermal breccias. Four structural events have produced mineralized breccias. Breccia fragments and wallrock exhibit alteration assemblages of sericite, quartz, chlorite, pyrite, montmorillonite, and hematite. Veins and breccia matrix contain the base and precious metals. Anhydrite, celestite, fluorite, and quartz exhibit fluid inclusions suggestive of a dilute, boiling (<200°C) ore fluid. The hydrothermal breccias exhibit upward-flaring geometries, indicating shallow development. Weakly boiling ore fluids were transmitted along faults to shallow levels where strong boiling generated the hydrothermal breccias and their ores. (Authors' abstract)

THURMOND, V.L., POTTER, R.W., II and CLYNNE, M.A., 1984, The densities of saturated solutions of NaCl and KCl from 10° to 105°C: U.S. Geol. Survey Open File Rept. 84-253, 10 pp. First author at Rosenstiel Sch. Marine & Atmosph. Sci., Univ. Miami, 4600 Rickenbacker Causeway, Miami, FL 33149.

Experimental data and regression coefficients for equations describing the density of saturated NaCl and saturated KCl solutions in the temperature range 10-105°C are presented and compared with the available literature values. Data were obtained using calibrated hygrometers. (Authors' abstract)

TICHINSKY, A.A., AKUL'SHINA, E.P., BAULINA, M.V., GIBSHER, N.A. and SHIPILOV, L.D., 1984, Evolutionary processes and geochemical peculiarities in the ore-forming Precambrian stratiform Pb-Zn deposits (Pribaikallian region) (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 6, p. 325-326. Authors at Inst. Geol. & Geophys. of Siberian Br. USSR Acad. Sci., Novosibirsk, USSR.

The Pb-Zn deposits in the Pribaikalian region (with fluorite and barite) are confined to terrigenous-carbonate rock series adjoining the peri-craton miogeosynclinal depression of Riphean age, controlled by the regional tectonic dislocations in the margins of the Siberian Platform.

Investigation of the mineral-forming environment has shown that there were two types of solutions taking part in the ore-forming processes: juvenile solutions (fluid heated to 200-250°C with relatively low salt concentration, K dominate over Na) and solutions inherent to the buried sea brines (highly concentrated solutions enriched in hydrocarbons and hydrosulphur, Na salts dominate over K-salts, T = 140-160°C). (From the authors' abstract)

TINGLE, T.N. and FENN, P.M., 1984a, Transport and concentration of molybdenum in granite molybdenite systems: Effects of fluorine and sulfur: Geology, v. 12, p. 156-158. First author at Dept. Geol., Univ. California, Davis, CA 95616.

To investigate the effects of F and S on the transport and concentration of Mo in granite molybdenite deposits, we prepared four synthetic granite compositions with Mo, S, and F. Each composition was run at 1000°C and 100 MPa with 6 wt% H_2O to stabilize the phase assemblage liquid + aqueous vapor. In all compositions, Mo is partitioned into the vapor phase and deposited on the capsule walls, in vapor bubbles in the quenched glasses, or in silica-rich spherules. F and S do not affect the partitioning of Mo. However, S plays a critical role in the deposition of Mo from the vapor phase. Thus, the initial water content of the magma, which controls the timing of vapor phase evolution, and the presence of S are primary controls on Mo ore deposition in these deposits. (Authors' abstract)

See also Isuk and Carman, 1984, and following item. (E.R.)

TINGLE, T.N. and FENN, P.M., 1984b, Reply to comment on "Transport and concentration of molybdenum in granite molybdenite systems: Effects of fluorine and sulfur:" Geology, v. 12, p. 569.

A reply to Isuk and Carman, 1984 (this issue). (E.R.)

TINGLE, T.N., GREEN, H.W., II and FINNERTY, A.A., 1984, Carbon in olivine at high pressure: preliminary results (abst.): EOS, v. 65, p. 282-283.

TOURAY, J.-C. and GUILHAUMOU, Nicole, 1984, Characterization of H_2S bearing fluid inclusions: Bull. Minéral., v. 107, p. 181-188. First author at Dept. Sci. de la Terre, ERA 601 du C.N.R.S., Univ. Orléans, 45046 Orléans Cedex, France.

Rarely described until recently, fluid inclusions with H_2S as a major component have been studied in various samples of quartz, fluorite and calcite. The phase behavior at low temperatures of H_2S-bearing inclusions (sometimes containing solid S or C) and previously analyzed with the Raman microprobe, is presented. The temperatures of the phase changes are compatible with phase diagrams for the systems CO_2-H_2S and CH_4-H_2S, as well as temperature conditions for clathrate formation.

Simple thermochemical calculations indicate that in the presence of solid carbon and liquid water, only CH_4 + H_2S or pure H_2S fluid inclusions may be stable at room temperature; CO_2 + H_2S + CH_4 mixtures are metastable;

the fact that they actually exist could be explained by a very low reduction rate of CO_2 at 25°C. (Authors' abstract)

TOURAY, J.C., HUBERT, P. and BOURRAT, X., 1981, Geochemical study of the Burc fluorite vein (analysis of trace lanthanides, study of fluid inclusions): Comparison with other veins in the Tarn District: Delegation generale a la recherche scientifique et technique. Report no. DGRST 79-7 1309, Paris, 1981, 22 pp. (in French). Authors at Orleans Univ., Lab. Applied Geol., Domaine Univ., 45046 Orleans, Cedex, France.

Fluid inclusion and rare-earth element geochemical studies were conducted on fluorite from the Burc vein in the Tarn District, France. Early blue and blue-white fluorite contains primary, two-phase inclusions which homogenize to liquid at 130-140°C and have salinities of 17-26 wt% NaCl equiv. Late yellow fluorite contains primary, two-phase fluid inclusions with Th of 105-115°C and salinities of ≥16 wt% NaCl equiv. Intermediate age white (clear) fluorite (later than blue, earlier than yellow) contains both single-phase liquid and two-phase liquid-vapor inclusions; the latter homogenize over a wide temperature range (40-140°C) and are thought to represent original high density inclusions which decrepitated during a later heating event. This later overheating did not affect inclusions in the earlier blue fluorite.

Rare earth element contents of the fluorites were determined using neutron activation analyses. The fluorites all showed a characteristic depletion in the light rare earths. Several possible sources of the mineralizing fluids are considered and, based on the fluid inclusion data and rare earth element patterns, the fluorites are thought to have been precipitated from brines of deep origin which leached fluorine and rare earth elements from Cambro-Ordivician black schists containing phosphate nodules. (Abstract courtesy R.J. Bodnar)

TOURET, Jacques, 1984a, Inclusion fluids: history of a paradox: Bull. Minéral., v. 107, p. 125-137 (in French). Author at Inst. voor Aardwetenschappen, Vrije Univ., Pb 7161, 1007mc Amsterdam, The Netherlands.

A review of the work of Sorby (1858) on inclusions and the present-day interest in the field. Includes a reprinting of Sorby's 4 classic plates of inclusion drawings. (E.R.)

TOURET, Jacques, 1984b, Fluid regime, redox state and partial melting in the lower crust and upper mantle: a direct approach (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 419 (in English). Author at Free Univ., Inst. Earth Sci., Amsterdam, The Netherlands.

Early fluid inclusions in many rock-forming minerals from lower crust and upper mantle derivates (granulites, ultrabasites) contain CO_2-rich fluids, while later fluids are CH_4-, N_2- or (mostly) H_2O-rich. The fluid composition is thus represented in the C-O-H-N system; at each P and T, it is basically controlled by 2 closely interrelated mechanisms: buffering of the oxygen fugacity by oxide/silicate reactions and differential solubility of various gaseous species in silicate melts. A detailed investigation of selected examples (partial melting of amphibolite and metapelite) show that many features are well explained by available experimental data, but also that some aspects (separation of CO_2 and N_2) require other buffers which remain very hypothetical in the present stage of our knowledge. (Author's abstract)

TOURET, Jacques, 1984a, CO_2 inclusions in granulites (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 188 (in English). Author at Free Univ., Inst. Earth Sci., Amsterdam, The Netherlands.

Various types of CO_2 inclusions occurring in most granulites are reviewed. Two major categories are observed: "Primary" inclusions, which contain high-density CO_2 closely matching P-T conditions inferred from mineral paragenesis, and "secondary" inclusions of grossly variable and mostly lower density. The relative abundance of both types varies from place to place and it gives an indication of the flux of CO_2 which has streamed through the rocks during or after peak metamorphic conditions. The origin of the CO_2 and possible effects of this flux on the depleted versus undepleted geochemical character of the granulites are discussed. (Author's abstract)

TOURET, J., 1984b Fluid inclusions in rocks from the lower continental crust (abst.): Geol. Soc. [G.B.] Newsletter, v. 13, no. 5, p. 17. Author at Free Univ., Amsterdam, The Netherlands.

In granulites, which constitute a major, if not exclusive, rock type of the lower continental crust, fluid inclusions are often abundant in many rock-forming minerals. Most contain a characteristic "carbonic" fluid, high density CO_2 possibly mixed with variable quantities of N_2 and, more rarely, CH_4. Oversaturated brines have been recently found in granulite metasediments, coexisting immiscibly with the carbonic fluids. Comparable densities (0.9 to 1.1 $g \cdot cm^{-3}$) suggest that local buffering and density control are important mechanisms for the individualization of the fluid phase in the lower crust. Carbonic inclusions provide important constraints for P-T estimates during and after peak metamorphism. Vertical movements seem to be the common rule, with important exceptions and complications caused by the emplacement of depth of volatile-bearing, mantle-derived intrusives. In southern Norway isotopic data and direct observation indicate that the greatest part of CO_2 originates ultimately in the mantle, being formed by the breakdown of carbonates in carbonatite (or carbonatite-like) melts emplaced in the lower crust during granulite metamorphism. The phenomena is probably not unique in time. (Author's abstract)

TOUYSINHTHIPHONEXAY, Yen, GOLD, D.P., DEINES, Peter, ULMER G.C. and KORN, Rosemary, 1984, Some properties of graphite from the Stillwater complex, Montana, and the Bushveld igneous complex, South Africa (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 677. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Carbon-rich samples from the platiniferous zones of the Stillwater Complex, Montana, and the Bushveld Complex, South Africa, were analyzed for $^{13}C/^{12}C$ ratios. Leaching with warm 50% HCl eliminated carbonate as possible contributor to the $\delta^{13}C$ values. The $\delta^{13}C$ values (reported vs. PDB) for the Stillwater Complex samples range from -14.7 to -16.3‰, whereas three samples from the Bushveld Complex have values of -16.4, -16.5, and -20.2‰. Diamond carbon isotope data from the Premier, Roberts Victor, and Koffiefontein kimberlite, South Africa, and the Orapa kimberlite, Botswana, indicate that in the mantle regions of similar ^{13}C depletion may exist. This is also suggested by the isotopic composition of fluid inclusions in ultramafic xenoliths.

The crystallinity of the graphites studied was established through X-ray diffraction analysis. At fixed XRD settings, one can define a "crystallinity index" of peak width at half height for the (0001) graphite reflection. In French's (1964) study of the metamorphism of the kerogen in the sedimentary Biwabik Iron Formation in proximity to the emplacement of the Duluth Gabbro, XRD data was used to document the degree of graphitization as a function of the distance from the igneous event. Both in French's data and in studied Bushveld and Stillwater graphite, an index value of .05 to .10 2θ appears in those samples thought to have been exposed to igneous temperatures. In the Stillwater and Bushveld carbonaceous samples, both phase and textural analyses support the idea that there is igneous graphite and graphite associated with metamorphic silicates. (Authors' abstract)

TREIMAN, A.H. and ESSENE, E.J., 1984, A periclase-dolomite-calcite carbonatite from the Oka complex, Quebec, and its calculated volatile composition: Contrib. Mineral. Petrol., v. 85, p. 149-157. First author at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109, USA.

The eutectic mineral assemblage calcite-dolomite-periclase-apatite-forsterite-magnesioferrite-pyrrhotite-alabandite in a carbonatite dike within the Oka complex, Quebec, buffers the fugacities (and partial pressures) of all gas species in C-O-H-S-F, assuming vapor saturation. At the inferred eutectic (640°C, 1 kbar), the most important gas species and their partial pressures (bars) were: H_2O, 882; CO_2, 110; H_2, 4.6; H_2S, 2.7; CO, 0.5; and CH_4, 0.1. Oxygen fugacity was near the QFM buffer, $\log f(O_2) = -18.6$, and sulfur fugacity was near the QFM-pyrrhotite buffer, $\log f(S_2) = -5.9$. Fluorine fugacity was low, $\log f(F_2) = -43.9$, consistent with the absence of fluoride minerals other than apatite. Presence of a water-rich gas phase is consistent with experiments on synthetic carbonatite systems (e.g. Fanelli et al. 1981), although compositions of the gas phase in published experiments cannot be determined exactly. (Authors' abstract)

TRIAL, A.F., RUDNICK, R.L., ASHWAL, L.D., HENRY, D.J. and BERGMAN, S.C., 1984, Fluid inclusions in mantle xenoliths from Ichinomegata, Japan (abst.): EOS, v. 65, p. 306. First author at Dept. Geol., Univ. Dayton, Dayton, OH 45469.

Opx and cpx grains in a spinel lherzolite and the websterite portion of a composite lherzolite-websterite xenolith from Ichinomegata Crater, NE Japan contain CO_2 fluid inclusions with 0 to 30 vol% H_2O. The mixed inclusions (MI) in the spinel lherzolite occur in a planar array, and some have negative crystal shapes. These inclusion trails are crosscut by healed fractures containing irregular to oval CO_2 + glass inclusions. Late CO_2 + glass inclusions also occur in olivine grains. The MI in the websterite are oval to tubular and occur along healed fractures, sometimes along with a brown plate phase.

Homogenization temperatures (Th: $V+L \rightarrow L$) of the CO_2 phase in the MI from the spinel lherzolite range from -11.4° to +30.5°C. The average composition of the MI is 0.55 mole fraction CO_2; the maximum density observed (whole inclusion) in the 32 MI studied is 1.01 g/cm^3. Th for the pure CO_2 inclusions associated with the glass phase range from -12.3° to +30.2°C. A CO_2 melting point depression of 1-2°C in some inclusions indicates the presence of an additional component(s), which will be identified using laser Raman spectroscopy. Assuming entrapment at temperatures between 800°C and 1100°C, the corresponding minimum depth of entrapment is 25 to 37 km for both types of inclusions in this sample (Moho = 25-30 km beneath this part of Japan).

The above observations show that: 1) free H_2O exists in the upper mantle beneath NE Japan, 2) the CO_2-H_2O inclusions in the spinel lherzolite were trapped prior to entrapment of the pure CO_2/glass inclusions, 3) the H_2O may have been derived from the subducting slab beneath Japan, since nearly all other fluid inclusions in mantle xenoliths are pure CO_2. (Authors' abstract)

TRIPPEL, A.D., 1984, Hydrothermal alteration and mineralization of the Globe Hill deposit, Cripple Creek district, Colorado (abst.): Geol Soc. Amer. Abst. Prog., v. 16, p. 258.

TROFIMUK, A.A., MAKOGON, Yu.F. and TOLKACHEV, M.V., 1983, On the role of gas-hydrates in the process of hydrocarbon accumulation and formation of their fields: Akad. Nauk SSSR, Sibirskoe Otdelenie, Geol. i Geofizika, no. 6, p. 3-15 (in Russian; English abstract).

The paper considers in brief the questions on the conditions of formation of gas-hydrate fields in the earth's crust and the role of gas-hydrates in the making and development of the Earth. Study of the conditions for gas-hydrate formation and hydrate features has exposed their influence upon the formation and conservation of hydrocarbon fields on the continents and in the oceans. A working hypothesis is proposed on the formation of the atmosphere and hydrosphere of the planet and the part of gas-hydrates in volcanic energy. The composition of volcanic gas is shown to be influenced by the composition of introduced gas in hydrate state. (Authors' abstract)

TROKHAN, A.M., LAPSHIN, A.I. and GUDZENKO, O.I., 1984, Cryoluminescence of liquids: Akad. Nauk SSSR Doklady, v. 275, no. 1, p. 83-86 (in Russian). Authors at All-Union Sci.-Research Inst. of Physico-Tech. & Radiotech. Measurements, Mendeleevo near Moscow, USSR.

The paper presents spectra of cryoluminescence of water, aqueous solutions of rare earth salts and several organic liquids (acetone, methanol, etc.); the method may be the basis of possible technique for cryometric fluid inclusion studies. (A.K.)

TROSHIN, Yu.P., BOYKO, S.M., GREBENSHCHIKOVA, V.I., PIVOVAROVA, L.Yu., ZAMALETDINOV, R.S. and PLYUSNIN, G.S., 1983, Geochemistry and genesis of the Sherlovaya Gora deposit of aquamarine and topaz: Mineralogy and genesis of precious stones in Eastern Siberia, p. 18-33, Siberian Br. "Nauka" Publ. House, Novosibirsk (in Russian).

Topaz crystals in greisens from Sherlovaya Gora formed at 450°C. (A.K.)

TRUDU, A.G., 1984, Petrology, structure and origin of the K-1 scheelite orebody, Westfeld Sector, Felbertal, Austria: MS thesis, Queen's Univ., Kingston, Ontario, Canada, 383 pp.

Indexed under Fluid Inclusions.

TRUSCOTT, M.G. and SHAW, D.M., 1984, Boron abundance and localization in granulites (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 677. Authors at Dept. Geol., McMaster Univ., Hamilton, Ontario L8S 4M1, Canada.

Some may be located in inclusions. (E.R.)

TRZCIENSKI, W.E., Jr., 1984, Paragonite-zoisite-quartz-plagioclase-H_2O equilibria at Mt. Albert, Gaspe, Quebec, Canada (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 678.

TSERTSVADZE, Z.Y., 1984, Ore-forming hydrothermal systems of mercury, arsenic and antimony deposits of the Caucasus: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 209-214.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 254. (E.R.)

TSUZUKI, Yoshiro, 1984, Simple calculation models to study mineral zoning in the Kuroko deposits: Mem. Ehime Univ., Sci., Ser. D (Earth Sci.), v. 10, no. 1, p. 1-8 (in Japanese; English abstract). Author at Dept. Earth Sci., Faculty of Sci. Ehime Univ., Matsuyama, 790 Japan.

The Kuroko deposits usually have a mineral zoning, such as black ore which mainly consists of sphalerite and galena, yellow ore whose main minerals are chalcopyrite and pyrite, and pyrite ore, in descending order. Some theoretical mineral zonings are shown by the calculation of dissolution and precipitation of ore minerals in flowing solutions, based on several models. Temperature, PO_2 and pH change with time and with migration of ore solution or seawater, in the models. (Author's abstract)

TU, Dengfeng, 1984, Inclusions in minerals in the Shangbao pyrite district, Hunan: Geol. Rev., v. 30, no. 3, p. 270-274 (in Chinese; English abstract). Author at Lianyungang College for Professional Training of Chem. Mining Industry.

Orebodies in the Shangbao pyrite district occur in a contact zone between granites and dolomitic marbles and in cracks of marbles. A preliminary study has been made on the formation temperatures, composition of trace gases, pH values and salinities of the inclusions in phlogopite, pyrite, quartz, dolomite, fluorite, etc. The formation temperatures of phlogopite were measured to be 455°-540°C. The contents of CO, CH_4 and H_2 in phlogopite are 5-8 times higher than those in quartz and fluorite. The formation temperatures of the essential minerals pyrite and quartz in this area range from 200°-300°C. It is clear that the former was formed in the stage of skarns, while the latter in the intermediate-temperature hydrothermal stage. According to their pH values (5.30-4.28) and composition of trace gases, phlogopite and pyrite must be formed under the conditions of acidic medium and in reducing environments. The salinities of quartz and dolomite are also relatively high. (Author's abstract)

TU, Guangzhi, et al. (eds.), 1984, Geochemistry of stratabound deposits in China, v. 1, 359 pp.: Scientific Pub. House, Beijing, v. 359 pp. (in Chinese).

Some of the chapters include fluid inclusion studies. (E.R.)

TUGOVIK, G.I., ZAYKIN, I.D. and KIRASIROVA, V.I., 1982, Fluid composition of inclusions in platinum minerals from rocks of the granulite complex and some problems of their genesis: Dokl. Akad. Nauk SSSR, v. 266, no. 3, p. 704-706 (in Russian, English abstract; translated in Dokl. Acad. Sci. USSR, v. 266, p. 125-127, 1984). Authors at Amur Interdisciplinary Res. Inst., Far Eastern Sci. Center, USSR Acad. Sci., Blagoveshchensk, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 254-255. (E.R.)

TUREK, E.A., METCALFE, R.S., YARBOROUGH, Lyman and ROBINSON, R.L., Jr., 1984, Phase equilibria in CO_2-multicomponent hydrocarbon systems: experimental data and an improved prediction technique: Soc. Petr. Engrs. J., v. 24, no. 3, p. 308-324.

TURNER, D.R. and BOWMAN, J.R., 1984, A petrologic and fluid inclusion study of the sphalerite skarns at the Empire and Pewabic mines, Hanover, New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 678. Authrs at Dept. Geol. & Geophy., Univ. Utah, Salt Lake City, UT 84112-1183.

Sphalerite (Sph) skarns at the Empire and Pewabic mines replace calcitic marbles of the Miss. Lake Valley Limestone and Penn. Oswaldo Fm. at the intrusive contact of the Tert. Hanover-Fierro Granodiorite. Garnet (Gn)-rich zones occur above the altered [Epidote (Ep)] Parting Shale at the base of the Oswaldo Fm., with Pyroxene (Px)-Gn-Quartz (Qz)-Sulfide (sphalerite, pyrite) skarns developed below this unit. The sphalerite-rich lower skarns evolved in at least four stages: (I) Px [Hd(38-70); Joh (7-27); Di(10-39) Burton, 1982] + Gn [Ad(65-100); Gr(0-35) Burton, 1982] + Qz (earliest); (IIa) Amphibole (Amph) + Calcite (Cc) + Qz + Ep; (IIb) Sulfides + Amp + Cc + Qz + Magnetite (Mt) + Ilvaite; (III) Cc + Qz + Hematite + Mt + Sulfides.

Fluid inclusion studies indicate two types of liquid-dominated inclusions, neither of which contain daughter salts. Type I inclusions are rare and occur solely in Stage I garnets. Freezing measurements yield Te (-42° to -48°C) and Tm (-23° to -34°C) indicating a possible $CaCl_2$ component of the fluid, with $CaCl_2$:NaCl ratios as high as 2.3:1 and an overall salinity of $\sim$25 wt%. Type II inclusions are far more abundant and occur in rims of Stage I garnets, Stage II sphalerite, and Stage III quartz. Freezing measurements indicate a predominantly $NaCl-H_2O$ system with NaCl equiv. salinities of 12 to 20 wt% for garnets, and 1.5 to 10 wt% for quartz. Th temperatures: Stage I: $T = 360 \pm 28°C$ (1σ); Stage II: $T = 335 \pm 10°C$; Stage III: $T = 320 \pm 26°C$. Th and salinity for Stage I do not vary significantly over a sampled area extending 250 m from the exposed igneous contact.

Applications of phase equilibria to observed skarn assemblages at the estimated P-T limit Stage I formation conditions to: $-31.0<\log(f(O_2) <-29.5$; $\log f(S_2)<-9.2$. (Authors' abstract)

TVALCHRELIDZE, A.G., 1984, Ore-bearing hydrothermal systems of stratiform pyrite deposits: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1, p. 215-224. Author at Caucasian Inst. Mineral Resources, Tbilisi, USSR.

Includes some discussion of a δD vs δO plot for various ore deposits. (E.R.)

UHLER, A.D. and HELZ, G.R., 1984, Solubility product of galena at 298°K: a possible explanation for apparent supersaturation in nature: Geochimica Cosmo. Acta, v. 48, p. 1155-1160.

ULRICH, M.R. and BODNAR, J.R., 1984, Systematics of stretching of fluid inclusions in barite at 1 atm confining pressure (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 680. First author at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78713.

Fluid inclusions in barite frequently exhibit a wide range in Th within a group of supposedly coeval inclusions. Anomalously high homogenization temperatures are common. Failure to consider post-entrapment changes such as necking down, leakage, or stretching may lead to erroneous interpretations of fluid inclusion data. The relationship between the amount of stretching (measured as an increase in Th) and the amount of overheating (heating above the Th) was determined by systematically overheating 36 inclusions in barite. Stretching occurred in 42% of the inclusions with less than 10°C of overheating, regardless of inclusion shape or size. Stretching occurred in 8% of the inclusions before Th was reached. Once stretching began, the stretching paths followed by the fluid inclusions were non-systematic. Generally, inclusions stretched by an amount slightly less than or equal to the amount of overheating; some stretched by an amount greater than the amount of overheating.

The non-systematic manner in which inclusions in barite stretch suggests that the mechanism of stretching is by the formation of fractures in the inclusion walls as the internal pressure increases during heating. Calculated internal pressure necessary to initiate fracturing of the inclusion walls is only a few tens to perhaps a few hundred bars. Our studies suggest that at 1 atm, some inclusions in barite will begin stretching at 20°C below their homogenization temperature. Although barite is a poor choice for fluid inclusion studies, being careful not to overheat samples during preparation and heating runs will increase the probability of obtaining accurate data. (Authors' abstract)

URABE, Tetsuro, 1984, Magmatic hydrothermal fluid and generation of base metal deposits: Mining Geol., v. 34, no. 5, p. 323-334 (in Japanese; English abstract). Author at Geol. Inst., Faculty of Sci., Univ. Tokyo, Hongo, Tokyo 113, Japan.

Magmatists' view of hydrothermal ore formation is evaluated and assessed on the basis of experimental results and computer simulation. The present investigation revealed that the hydrothermal fluids separated from granitic magma have enough potential to generate hydrothermal ore deposits of base metals like copper, zinc, lead, and molybdenum if the granite has the following characters: (1) saturated with aqueous fluid; experiments (Kiling and Burnham, 1972; Shinohara et al., 1984) revealed that chlorine is in favor of the fluid phase. High temperature chloride solution is eligible to transport metals, (2) aluminous; because aluminous granite magma has high partition ratios of metals between coexisting fluid and melt (Urabe, 1984), (3) high-level pluton; because metals are strongly partitioned to fluid phase at lower pressures, and (4) magnetite-series; probably because of partitioning of sulfur to the fluid phase in the form of SO_2 under high oxygen fugacity of the magnetite-series granite. Computed "ore-forming fluid" is considered to be capable of forming the base metal deposits. (Author's abstract)

URAI, J.L., 1983, Water assisted dynamic recrystallization and weakening in polycrystalline bischofite: Tectonophysics, v. 96, p. 125-157. Author at Inst. voor Aardwetenschappen, State Univ. Utrecht, P.O. Box 80,021, 3508 TA Utrecht, The Netherlands.

Artificially prepared specimens of bischofite ($MgCl_2 \cdot 6H_2O$) have been experimentally deformed at temperatures between 20 and 100°C, strain rates between 10^{-4} and $10^{-8} s^{-1}$, and confining pressures between 0.1 and 28 MPa. Development of microstructure with strain was studied by in-situ deformation experiments, and results of these were correlated with observations made on thin sections of deformed samples.

In a first series of experiments the effect of grain size, impurity content and water content on the flow behavior was investigated. Addition of about 0.1 wt.% water to dry samples was found to decrease the flow stress by a factor of 5. This effect was found to be associated with the formation of a thin fluid film on grain boundaries, strongly enhancing dynamic recrystallization due to the movement of high-angle grain boundaries, and possibly also to enhanced intracrystalline plasticity due to excess water present in the lattice. In a second series of experiments the strain-rate sensitivity of the flow stress of selected samples was investigated. Two regimes could be distinguished: one with a stress exponent $n = 4.5$ in the power law creep equation for values of the differential stress above 2.0 MPa, and one with $n = 1.5$ for stresses below this value.

The main deformation mechanisms were intracrystalline slip, twinning, and grain-boundary sliding. Recrystallization occurred by subgrain rotation and high-angle grain-bounary migration. The rates of grain-boundary migration fell into two different regimes, one regime being distinguished by extremely fast migration rates. The applicability of the experimentally found flow law to the behavior of bischofite rocks in nature is discussed. (Author's abstract)

URASHIMA, Y. and IZAWA, Eiji, 1982, Hydrothermal alteration observed from drilling into the Hishikari gold deposit, Kagoshima Prefecture, Kyushu, Japan: Mining & Metallurgical Inst. of Japan (MMIJ) Autumn Meeting, 1982, Kitakyushu, Preprint Sec. G, p. 13-16 (in Japanese; see Translation Section).

URSCHEL, S.F. and FRIEDMAN, G.M., 1984a, High fluid-inclusion homogenization temperatures in carbonates of Lower Ordovician Beekmantown Group in northern Appalachian Basin (abst.): AAPG Bull., v. 68, no. 12, p. 1930. Authors at Rensselaer Polytechnic Inst., Troy, NY.

Data from analysis of fluid inclusions in carbonates of the northern Appalachian Basin indicate higher paleotemperatures and greater depths of burial than have been inferred for the rocks of this region.

Preliminary research has revealed fluid homogenization temperatures averaging 96°C (205°F) for the formation of saddle dolomite, 114°C-170°C (237°F-338°F) for calcite vein fillings, and 290°C (554°F) for calcite cements in samples from the Mohawk and Champlain valleys of New York state.

The calcite-filled veins sampled in the Champlain valley of eastern New York display higher average homogenization temperatures than similar veins from the Mohawk valley of central New York. This difference may reflect a higher post-Early Ordovician paleogeothermal gradient operative in eastern New York.

Drusy calcite cements in samples from central New York are interpreted as precipitates from saline brines having temperatures between 267°C (512°F) and 302°C (576°F). These temperatures support conondont alteration data obtained by others for the rocks of this area.

Using a geothermal gradient of 25°C/km (72°F/mi), a former depth of burial in excess of 9 km (5.6 mi) is implied. Seismic and gravity data do not show evidence of the presence of post-Early Ordovician shallow plutons. Therefore, it appears unlikely that precipitation at the high temperatures measured resulted from magma-derived hot meteoric fluids. (Authors' abstract)

URSCHEL, S.F. and FRIEDMAN, G.M., 1984b, Paleodepth of burial of Lower Ordovician Beekmantown group carbonates in New York State: The Compass of Sigma Gamma Epsilon, v. 61, no. 4, p. 205-215. Authors at Rensselaer Center of Applied Geol., P.O. Box 746, 15 Third St., Troy, NY 12181.

Data from analysis of fluid inclusions in the Beekmantown carbonates of the Northern Appalachian Basin indicate higher paleotemperatures and greater depths of burial than have been inferred for the rocks of this region.

Th values average 141°C for the formation of coarse crystalline dolostones, 117°C to 147°C for calcite and dolomite vein fillings, and 223°C for calcite cement. These temperatures are supported by oxygen isotope and conodont-alteration data.

Petrographic evidence in conjunction with stable isotope and fluid-inclusion data suggests that dolomitization of a precursor limestone and neomorphism of syngenetic dolomite has occurred under burial conditions.

Using a geothermal gradient of 26°C/km a former depth of burial in excess of 7 km is implied. Seismic data show no evidence of post-Lower Ordovician shallow plutons. It therefore seems unlikely that precipitation at the high temperatures measured resulted from magma-derived hot meteoric fluids. (Authors' abstract)

USPENSKAYA, A.B., 1983a Effect of polymorphic transitions on physical properties of rocks: Dokl. Akad. Nauk SSSR, v. 271, no. 6, p. 1465-1467 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 114-116, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 274, 1983. (E.R.)

USPENSKAYA, A.B., 1983b Effect of gas-liquid inclusions on the physical properties of vein quartz of tin-ore deposits: Dokl. Akad. Nauk SSSR, v. 271, no. 5, p. 1218-1221 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 175-177, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 274, 1983. (E.R.)

UVAROV, N.F., KHAYRETDINOV, E.F. and BOLDYREV, V.V., 1984, Prognosis of diffusion properties of crystals on the basis of thermodynamic characteristics of melting: Akad. Nauk SSSR Doklady, v. 274, no. 3, p. 661-664 (in Russian). Authors at Inst. Chem. of Solid State and Mineral Raw Material Dressing, Novosibirsk, USSR.

The paper presents correlation equations for evaluation of the diffusion properties of solids; pertinent to the problem of diffusion of inclusion volatiles through the crystal lattice. (A.K.)

VALLEY, J.W., BOWMAN, J.R., PEACOR, D.R., ESSENE, E.J. and ALLARD, M.J., 1984, Crystal chemistry of Mg-vesuvianite and implications for its phase equilibria in the system $CaO-MgO-Al_2O_3-SiO_2-H_2O-CO_2$ (abst.): EOS, v. 65, p. 293.

VALLEY, J.W. and O'NEIL, J.R., 1984, Fluid heterogeneity during granulite facies metamorphism in the Adirondacks: Stable isotope evidence: Contrib. Mineral. Petrol., v. 85, p. 158-173. First author at Dept. Geol. & Geophys., Univ. Wisconsin-Madison, Madison, WI 53706, USA.

The preservation of premetamorphic, whole-rock oxygen isotope ratios in Adirondack metasediments shows that neither these rocks nor adjacent anorthosites and gneisses have been penetrated by large amounts of externally-derived, hot CO_2-H_2O fluids during granulite facies metamorphism. The data suggest that these rocks were not an open system during metamorphism; that fluid/rock ratios were in many instances between 0.0 and 0.1; that externally-derived fluids, as well as fluids derived by metamorphic volatilization, rose along localized channels and were not pervasive; and thus that no single generalization can be applied to metamorphic fluid conditions in the Adirondacks.

Analyses of coexisting minerals show that isotopic equilibrium was attained at the peak of granulite and upper amphibolite facies metamorphism. Thus the isotopic compositions of metamorphic fluids can be inferred from analyses of carbonates and fluid budgets can be constructed.

The range of Adirondack carbonate $\delta^{18}O$ values (12.3 to 27.2) can be explained by the highly variable isotopic compositions of unmetamorphosed limestones in conjunction with minor ^{18}O and ^{13}C depletions caused by metamorphic volatilization suggesting that many (and possibly most) marbles have closely preserved their premetamorphic isotopic compositions. For larger xenoliths and layers of marble there is no evidence of exchange at distances greater than 10 m from meta-igneous contacts. (From the authors' abstract)

VANKO, D.A., 1984, Chlorine-rich amphiboles and chlorine-rich fluid inclusions in quartz: evidence for high-salinity oceanic hydrothermal systems (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 682. Author at Geol. Dept., Georgia State Univ., Atlanta, GA 30303.

Petrologic study of plutonic rocks dredged from the Mathematician Ridge (MR), a failed spreading center in the E. Pacific, provides strong evidence for the presence of high-salinity (S‰) oceanic hydrothermal systems. The salient observations are (1) late-stage hornblende (hb) in metagabbro and diabase contains up to 4.02 wt. % Cl, and (2) quartz veins in the metagabbro and amphibolite may contain primary high-T and high-S‰ fluid inclusions (FI's). These features are important in understanding the spatial and temporal variability of oceanic hydrothermal systems.

The MR was a fast-spreading ridge that was abandoned about 3.5 Ma in the dredged region (approx. 17°N, 111°W). Rocks dredged from the axial rift valley walls include metagabbro, amphibolite and diabase. Fresh gabbros contain plag, cpx, ± opx, and oxides. Metagabbros include some at amphibolite grade (with brown hb formed at ~600°C) and some at greenschist grade (with actinolitic hb and actinolite (act)).

The common hb in the plutonic rocks contains an average 0.2 to 0.5 wt. % Cl, and undetectable F. This background Cl level may have been formed as seawater-derived fluids of near-s.w. S‰ altered the fresh gabbro. High-Cl ferro-hb containing up to 4.02 wt. % Cl is associated with chlorite and actinolitic hb in a metagabbro, and with act in a diabase. This high-Cl hb is a late-stage greenschist-facies mineral that was irregularly developed probably in response to high-S‰ parts of the hydrothermal system.

Locally the high-Cl hb occurs with quartz-epidote veins that contain primary saline FI's. Several 4-phase FI's have been observed, and halite daughter crystals in FI's show that S‰ exceeds 26 wt. % equivalent NaCl. Preliminary homogenization Ts are about 400°C to >500°C. (Author's abstract)

VAREKAMP, J.C. and BUSECK, P.R., 1984, The speciation of mercury in hydrothermal systems, with applications to ore deposition: Geochimica Cosmo. Acta, v. 48, p. 177-185. First author at Dept. Earth & Environ. Sci., Wesleyan Univ., Middletown, CT 06457.

Hg in hydrothermal systems is generally thought to be transported as Hg-S complexes. However, the abundance of Hg^0(vap) in geothermal emissions suggest that Hg^0(aq) is present in the liquid phase of geothermal systems. Calculations for reducing fluids (HS^- dominant over $SO_4^=$) in equilibrium with cinnabar indicate that Hg^0(aq) can be quite abundant relative to other species at temperatures above 200°C. Increasing pH and temperature, and decreasing total S, ionic strength, and pO_2 all promote the abundance of Hg^0(aq). When a vapor phase develops from a geothermal liquid, Hg partitions strongly into the vapor as Hg^0(vap). Vapor transport at shallow level then results in the formation of Hg halos around shallow aquifers as well as in a flux of Hg to the atmosphere. Hg deposition may occur in response to mixing with oxidizing or acidic water, turning Hg^0(aq) into Hg^{++}, with subsequent cinnabar precipitation. When pyrite is the stable Fe-sulfide, cinnabar solubility is at its lowest, so cinnabar + pyrite assemblages are common. Cinnabar + hematite ± pyrite can precipitate from more oxidized or S-poor water. Hg^0(liq) can occur as a primary mineral, in coexistence with all common Fe-sulfides and oxides. Cinnabar ± Hg^0(liq) cannot coexist with pyrrhotite or magnetite at temperatures between 100° and 250°C. Evidence from Hg deposits indicates that many formed from dilute hydrothermal fluids in which Hg probably occurred as Hg^0(aq). In S-rich systems, Hg may occur as Hg-S complexes, and in saline waters it can occur as Hg-Cl complexes. (Authors' abstract)

VARMA, O.P., 1984, Applications of fluid inclusion techniques to problems of metallogenesis and mineral exploration: Abstracts, Nat'l. Seminar on Sci. and Industrial Applications of Fluid Inclusions in Minerals, 21-22 October 1984, Dehra Dun, India, Wadia Inst. Himalayan Geol., p. 18. Author at Indian Sch. Mines, Dhanbad, India.

Fluid inclusion study may be of great value in various aspects of mineral exploration in India. (E.R.)

VARSHAL, G.M., VELYUKHANOVA, T.K. and BARANOVA, N.N., 1984a, Stability of fulvic acids in natural waters under hydrothermal conditions: Geokhimiya, no. 2, p. 279-283 (in Russian; translated in Geochem. Int'l., v. 21, no. 3, p. 24-28).

VARSHAL, G.M., VELYUKHANOVA, T.K. and BARANOVA, N.N., 1984b, The geochemical role of gold (III) fluvate complexes: Geokhimiya, no. 3, p. 413-420 (in Russian; translated in Geochem. Int'l., v. 21, no. 3, p. 139-146).

VAUGHAN, P.J. and BYERLEE, J.D., 1984, Mechanism of permeability reduction during flow of hot aqueous solutions through Westerly granite (abst.): EOS, v. 65, no. 45, p. 1126. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

In a permeability experiment on a cylindrical sample of Westerly granite, fluid was forced from the central borehole in the sample down a temperature gradient to the outer edge. The fluid in the borehole was heated by a gold-coated resistance heater. The permeability of the rock decreased by a factor of 25 during the 2-week experiment. The run conditions were: confining pressure = 60 MPa, pore water pressure = 20 MPa, pore pressure difference = 1 MPa, T = 300°C at the borehole, and T = 92°C at the sample jacket. Scanning electron microscope examinations were made in areas 1 mm from the borehole and 1 mm from the outer edge. Comparison with the starting material indicates: (1) about half the grain boundaries in the starting material that involve quartz are cracked, as are most such grain boundaries in the experimental sample; (2) grain boundaries between feldspars in all three samples are almost always closed; (3) intragrain cracks in the starting material are usually open; at the outer edge of the experimental sample most cracks contain an Si-rich filling and, near the borehole, half are filled; (4) some intragrain cracks in quartz are transgranular; these number about 2 per grain near the outer edge but are fewer than 1 per grain near the borehole and in the starting material. In all three samples, transgranular cracks are less common in feldspars than in quartz owing to the larger grain size of the feldspars. Thus, the intragrain cracks in quartz form a network with the cracked open grain boundaries, and this network provides a more efficient fluid pathway through the quartz than that through the feldspars. Fluid moving through the sample dissolved the quartz near the borehole and deposited some form of silica in the lower temperature zone. Other minerals were affected by the fluids but to a lesser degree. The crack fillings probably caused the reduction in permeability. (Authors' abstract)

VELEZ, C., 1984, Metallogenic study of the porphyry Cu-Mo deposit of La Caridad, Sonora (Mexico): These 3eme Cycle, I.N.P.L., in CRPG Ann. Rapport 1984-1985, p. 74-75 (in French).

In this study of a major mineralized district, the author addresses particularly the crystal chemistry of micas, the characterization of the fluid phase and the fO_2-fS_2 conditions, the origin of sulfur, and, finally, the La Caridad mineralization.

Before the period of fracturing, the porphyry is characterized by reducing conditions, evidenced by the existence of microparageneses armored within crystals of pyrite of: pyrite-pyrrhotite-$(\text{annite})_{SS}$ or pyrite-chalcopyrite-cubanite HT-$(\text{annite})_{SS}$.

These observations contrast with the more widely held hypothesis of oxidizing conditions (e.g., Ohmoto and Burnham, 1980). The oxidizing conditions, which post-date the original reducing conditions, are the consequence of the rapid isenthalpic lowering of fluid temperature combined with the opening of numerous fractures. These new conditions are shown by the formation of hematite trapped in quartz crystals and in pyrite which lines the fractures. This mineralogic and structural argument is consistent with the data from microthermometric studies of fluid inclusions in quartz crystals from pre-fracturing rhyolites and from post-fracturing veinlets. The former contain a dilute fluid (~2 - 7 wt% eq NaCl) which homogenize at the critical point. The latter show two types of inclusions in the same fractures, V+L and V+S, which homogenize at temperatures between 340 and 390°C. In the absence of evidence for primary brines, fluids homogenizing in the critical state, and the assemblages V+L and V+S are considered to represent, respectively, the initial state and the final state of an isenthalpic evolution by which a relatively dilute fluid generates a vapor-rich phase and a brine. Based on the isenthalpic model, the initial pressure and temperature of the fluid are estimated to be approximately 0.8 kb and 600°C.

Based on measurement of sulfides from La Caridad, from a volcanic collapse breccia (Pilares), and from a sedimentary breccia in Ordovician sediments (San Martine), $\delta^{34}S$ measurements (principally on pyrites) are remarkably uniform ($+1‰ < \delta^{34}S < +5‰$), with an average isotopic composition in each case near +3.5‰. Present only in the molybdenum-rich zone of La Caridad, there is anhydrite with a uniform isotopic composition of +12‰ to +15‰.

In the three examples of sulfide mineralization for which $\delta^{34}S$ was measured, the pyrite which formed after chalcopyrite or molybdenite was deposited at the end of an hydraulic fracturing which led to a rapid fall in temperature. Consequently, there was a relative increase in oxidation state of the fluids, as shown by the assemblage chalcopyrite-bornite-hematite armored inside fissure-type pyrite crystals. Thermodynamic analysis of these data indicates that the sulfur isotope composition of the mineralizing fluids was between +12 and +15‰. These data are inconsistent with a magmatic origin for the sulfur, indicating instead a contamination with sulfur very high in ^{34}S. The contamination could have been caused either by introduction of anhydrite into the porphyry during its emplacement or post-emplacement contamination with sulfur derived from the sulfides in the Cambro-Ordovician sedimentary substrata. Taking into account the initial reducing conditions and the very low Ca content of the porphyry, the author prefers the hypothesis of contamination from sulfur derived from the sulfides in the Cambro-Ordovician sediments. (Author's abstract, translation courtesy M.J. Logsdon)

VERKHOVSKIY, A.B., YURGINA, Ye.K. and SHUKOLYUKOV, Yu.A., 1983, Element and isotope ratios in juvenile noble gases: Geokhimiya, no. 11, p. 1559-1576 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 6, p. 37-54, 1984).

VERKHOVSKY, A.B., ROZHKOV, A.M., SIMONOVSKY, V.I., SAVIN, O.R. and SHUKOLYUKOV, Yu.A., 1984, A method of determination of relative abundance of noble gases in the natural thermal fluids: Geokhimiya, 1984, no. 10, p. 1474-1482 (in Russian; English abstract). Continued next page.

A method of preparation of gas samples from thermal springs for the mass spectrometry analysis and the analysis itself for determination of relative abundance of noble gases are described. A peculiarity of the new method consists in the using of mass spectrometer MI-1201 on line with PRM-2 electronic control. This permits making measurements in a wide range of masses with registration of isotopes of various (2 to 3) gases in one measurement in an automatic regime. The dependences of changing of sensitivity of mass spectrometer to various gases on pressure were revealed that permits determining the true values of the elements' ratios. The average reproducibility of measurements is no worse than 5%. The results of analysis of natural gases are given. (Authors' abstract)

VERNON, R.H., 1984, Micrograngitoid enclaves in granites-globules of hybrid magma quenched in a plutonic environment: Nature, v. 309, p. 438-440. Author at Sch. Earth Sci., Macquarie Univ., North Ryde (Sydney), New South Wales 2113, Australia.

Microgranitoid enclaves (autoliths, cognate xenoliths, mafic inclusions) are common in high-level granitoid plutons. They have relatively fine-grained igneous (microgranitoid) microstructures, and many show evidence of having flowed in a magmatic condition. These features counter interpretations that the enclaves represent transformed solid fragments of diverse wall rocks or restite. An alternative interpretation is that the enclaves represent globules of mafic magma that have mingled ('commingled') and quenched in the granitoid host magma. A detailed review of the literature, occurrence, morphology and composition of microgranitoid enclaves strongly supports this view, but indicates that the enclave magmas range in composition from mafic to felsic, and that magma-mixing may be involved in their formation. I summarize here the main features of microgranitoid enclaves and briefly outline the possible processes leading to their incorporation as magma globules in the host granitoid. (Author's abstract)

VERSLUIS, S. and LINDNER, E., 1984, Geotechnical behavior of salt under repository conditions, in Radioactive waste management, Proc. Int'l. Conf., Seattle, 16-20 May 1983, v. 3, p. 433-441 (IAEA-CN-43/462): Vienna, Int'l. Atomic Energy Agency. Authors at Battelle Proj. Mgmt. Div., Ofc. Nuclear Waste Mgmt., Columbus, OH, USA.

Includes some discussion of the formation of voids in salt by various processes during deformation. (E.R.)

VESNIN, Yu.I., 1984, Certain regularities of formation of solid solutions by replacement: Akad. Nauk SSSR Doklady, v. 275, no. 6, p. 1428-1431 (in Russian). Author at Inst. Inorganic Chem., Novosibirsk-90, USSR.

The paper presents characteristics of solid state replacement and exsolution in the systems KCl-NaCl, KBr-NaBr, KI-NaI, KI-KBr, RbI-RbBr; pertinent to dm investigations. (A.K.)

VIETS, J.G., ROWAN, Lanier and LEACH, D.L., 1984, Composition of fluids extracted from sphalerite, galena, and dolomite in Mississippi Valley-type deposits of the Mid-Continent: implications for the origin of the fluid (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 682. Authors at U.S. Geol. Survey, P.O. Box 25046, Denver Fed. Center, MS 955, Denver, CO 80225.

Sodium, potassium, calcium, magnesium, fluoride, chloride, bromide, and sulfate concentrations were determined for fluid inclusions in minerals from Mississippi Valley-type deposits in the Viburnum trend and the Tri-state and northern Arkansas districts and in unmineralized rock distant from these deposits. Fluids extracted from sphalerite, galena, and hydrothermal dolomites from these occurrences have remarkably similar compositions considering that they are hosted by Cambrian-through-Pennsylvanian rocks and separated by hundreds of kilometers. The fluids typically contain 16 to 24 percent dissolved solids, and have the following weight ratios: Na/Cl, 0.40 to 0.48; Na/K, 18 to 22; Ca/Mg, 8 to 12; and Cl/Br, 75 to 250. Chloride-to-bromide weight ratios are variable but are consistently less than the seawater ratio (292). The variability of bromide may be due to bromide derived from organic matter during fluid migration.

Fluid compositions in the three areas studied are different from fluid compositions in other midcontinent Mississippi Valley-type districts. Average Na/K weight ratios of fluids from southern Illinois, central Tennessee, and the upper Mississippi Valley are 14.7, 8.2, and 16.5, respectively, and average Ca/Mg ratios are 6.5, 17.3, and 7.3, respectively.

Although no known evaporites exist regionally, the fluids from southern Missouri and northern Arkansas have a composition very similar to formation waters of south-central Texas, interpreted by Land and Presbindowski (1981, J. Hydrol., 54, p. 51-74) to have been evolved from the dissolution of deeply buried evaporites of the Gulf of Mexico basin. (Authors' abstract)

VIGLINO, J.A., GRAHAM, C.M. and HARMON, R.S., 1984, Experimental hydrogen isotope fractionation factors in the system chlorite-H_2O (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 683.

VINCENT, Denis, CLOCCHIATTI, Roberto and LANGEVIN, Yves, 1984, Fission-track dating of glass inclusions in volcanic quartz: Earth & Planet. Sci. Letters, v. 71, p. 340-348. First author at Lab. Pétrogr., 91405 Orsay, France.

We have extended fission-track dating techniques to volcanic pyroclastic rocks, using quartz-bearing uranium-rich glass inclusions. We use both the glass itself and the surrounding quartz as track detectors, the latter having a much higher resetting temperature. We can thus derive the age of the last low-temperature thermal event, as well as that of the most recent deposition of quartz on the walls of the inclusions. This method has been applied to a Sardinian sample and to a Moroccan Precambrian sample. (Authors' abstract)

VLASOVA, D.K., PODLESSKIY, K.V., KUDRYA, P.F., BORONIKHIN, V.A. and MURAVITSKAYA, G.N., 1984, Zoning of garnets in skarn deposits: Zapiski Vses. Mineral. Obshch., v. 113, no. 5, p. 560-577 (in Russian). Authors at Inst. Geol. of Ore Deposits, Petrogr. Mineral. and Geochem. of Acad. Sci. USSR, Moscow, USSR.

Garnets from skarn-magnetite deposits yielded Th for grain centers 500°C and for margins 420°C (Blagsdat' Mt., Urals) and for centers 630-550°C, margins 550-430°C (Irbin, Altae-Sayan). (A.K.)

VOGEL, L.M., McCLURE, D.S. and CRERAR, D.A., 1984, Changes in coordination geometry of ferrous iron as a function of temperature and chloride concentration in hydrothermal solutions (abst.): EOS, v. 65, no. 45, p. 1123. First author at Dept. Chem., Princeton Univ., Princeton, NJ 08544.

One of the most popular hypotheses for the mechanism of metal transport in hydrothermal solutions is the formation of chloride complexes. To date very little is known about the nature of these complexes at higher temperatures. For transition metals it is possible to determine species' structures from their ligand-field spectra. Co(II) and Ni(II) have been observed to undergo a coordination change from octahedral (or pseudooctahedral) to tetrahedral (or pseudo-tetrahedral) at higher temperatures and chloride concentrations. We postulate similar behavior for Fe(II) and have found some substantiating evidence for this claim. In acidic deuterium oxide solutions of ferrous chloride, at total chloride concentrations of >9 molal (LiCl added) and at T >45°C, we observe the ingrowth of a new spectroscopic peak at an energy consistent with that predicted for a tetrahedral Fe(II) complex. The stoichiometries for the various complexes at equilibrium in the system have not yet been ascertained. Analysis of the charge-transfer bands for these solutions will help us to determine whether 1, 2, 3, or 4 chloride ligands (the remainder being water molecules) reside in the coordination sphere of the ferrous ions. (Authors' abstract)

VOLFINGER, Robert, VIELZEUF, NEIVA and SCOUDLAREC, [sic] 1984, partition of chlorine between hydroxyl silicates and hydrothermal solutions (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 430-431 (in English).

VON DAMM, K.L., 1984, Chemistry of submarine hydrothermal solutions at 21°N, East Pacific Rise and Guaymas basin, Gulf of California: Ph.D. dissertation, Massachusetts Inst. Tech.

VONGDARA, B., GRIGOR'EV, I.F., GROMOV, A.V., DOLOMANOVA, E.I. and NOSIK, L.P., 1984, Conditions for the formation of tin ore deposits in the Nam Pa Tien (Laos) region determined from data on the thermobarogeochemistry and isotopic composition of carbon in carbon dioxide and sulfide sulfur: Izv. Vyssh. Uchebn. Zaved., Geol. Razved., v. 27, no. 8, p. 24-30 (in Russian). Authors at IGEM, USSR.

Thermobarogeochemical studies of inclusions of mineral-forming solutions in vein quartz (Q) and cassiterite (Ct) of the Nam Pa Tien deposit agree with geological and mineralogical data classifying the Sn ore veins into Ct-Q and Ct-sulfide formations. The veins of these two genetic formations differ in mineralogy, wall-rock alteration, mineral geochemistry, and crystallization temperature. Most of the vein and ore minerals crystallized at 300-320° in the Ct-Q formation and 250-280° in the Ct-sulfide formation. Based on the $\delta^{13}C(CO_2)$ values of fluid inclusions and $\delta^{34}S$ of sulfides, the Nong Syn deposit is of Ct-Q type and genetically related to biotite granites, whereas the Fon Tyu deposit is of Ct-sulfide type, related to microgranites, and has sulfides crystallized at 260-280°. (CA 101: 214213z)

VOROB'EV, E.I., KONEV, A.A. and MALYSHONOK, Yu.V., 1984, Calcite-quartz rocks of graphic structure in the Murunskii alkaline massif: Zap Vses. Mineral. O-va, v. 113, no. 3, p. 300-308 (in Russian). Authors at Inst. Geokhim., Irkutsk, USSR.

In the Murumskii syenite massif of the Aldan Shield (USSR) calcite (Cc)-quartz (Q) rocks with graphic intergrowths are closely associated with carbonatites and high-K alkali syenites. The Cc-Q rocks, which are named torgolite, form independent vein bodies which traverse quartz sandstones, altered dolostone and marls, syenites, syenite porphyries, granites, and fenites. The torgolites are comprised of SiO_2 ~67, $CaCO_3$ ~33 vol.%. Spherulites with a radial arrangement of Cc and Q intergrowth were observed in thin section. The Cc-Q rocks are of magmatic origin; they crystallized from carbonate-silicate melts which existed at low pressure and at temperatures possibly as low as 650-750°. (CA 101: 134481v)

VOROB'YEV, Yu.K. and SERGEYEV, V.I., 1984, The temperature of formation of chalcopyrite-pyrrhotite ores in the Darasun deposit: Izvestiya AN SSSR, seriya geologicheskaya, 1984, no. 9, p. 61-67 (in Russian; translated in Int. Geol. Rev., v. 26, p. 1311-1318, 1984).

Indicates how solid-state and fluid inclusion homogenization geothermometry can be used together to determine the thermal history of ore deposits. (Authors' abstract)

VOSS, R.L. and HAGNI, R.D., 1984, A cathodoluminescent microstratigraphy for sparry dolomite from the Viburnum trend, southeast Missouri (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 683. First author at Geol. Dept., Cominco Am. Inc., Magmont Operations, Magmont Mine Rd., Bixby, MO 65439.

The cathodoluminescent microstratigraphy of sparry dolomite confirms a common origin for the dolomite-depositing fluids for all of the deposits in the Viburnum Trend. The intense banding found within all of the major bands demonstrates the pulsating nature of the mineralizing fluids. The gradational northward decrease in band width and dolomite abundance suggests that a major source for the fluids was from the south. (From the authors' abstract)

VOZNYAK, D.K., MATYASH, I.V., BRICK, A.B., LARIKOV, A.L. and MAZYKIN, V.V., 1984, On formation of the honeycomb quartz: ESR study: Geokhimiya, 1984, no. 4, p. 534-540 (in Russian; English abstract).

Using the ESR technique a distribution of Al-O^--centers in zoned crystals of honeycomb quartz was studied. A correlation was revealed among the content of structural aluminium in the crystal zones, the value of the honeycomb fracturing and inversional Dauphine twins. Formation of inversional (honeycomb) fracturing is due to metastable $\beta \rightarrow \alpha$ transformation of quartz[sic] in the process of smooth changing of P-T-parameters of the mineral-formation media. If in the moment of the honeycomb fracturing formation the mineral was under the pressure of mineral-forming solution the values deduced from the honeycomb inclusions correspond to P-T-parameters of the mineral-formation fluid at the moment of transformation. If the crystal was under a lithostatic pressure, the deduced values are less than the P-T-parameters of transformation. (Authors' abstract)

VROLIJK, P.J., 1984, Stable isotope and paleohydrologic evolution of veins in the Kodiak Accretionary Complex (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 684.

VROLIJK, P.J. and BYRNE, Tim, 1984, Fluid evolution during early melange deformation (abst.): EOS, v. 65, no. 45, p. 1147. First author at Earth Sci., U.C. Santa Cruz, Santa Cruz, CA 95064.

Concretions and veins preserve a continuous record of carbonate fluid evolution during early melange deformation in the Ghost Rocks and Sitkalidak Fms of the Kodiak accretionary complex, Alaska. Pre-deformation fluids are preserved as homogeneous carbonate cements in ellipsoidal concretions. Syn-deformation fluids are preserved as (oldest to youngest): 1) irregularly shaped and heterogeneously cemented, and veined concretions or homogeneously cemented concretions overgrowing web structure (cataclastic shear zones); 2) dirty calcite veins (some detrital phyllosilicates in calcite and irregular vein walls); 3) clean mosaic calcite veins (pure calcite in sharply defined veins); 4) fibrous calcite veins. Veins record extension in boudins and concretions. Concretions that overgrow web structure at concretion margins and not in the core record continuous pre- to syn-deformation cementation. Outcrop distribution of concretions suggests their occurrence and growth may be structurally limited.

Carbon and oxygen stable isotopic values of the calcite veins shift a small but significant degree from oldest to youngest veins: (δ13-C(PDB) ~-15/-9‰; δ18-O(SMOW)~14/13‰). Isotopic analysis of limestone and organic matter preserved in the Ghost Rocks Fm plus consideration of petroleum generating diagenetic processes suggests that with increasing deformation, the carbon isotopic system is less strongly affected by diagenetic processes. (Authors' abstract)

VYNAR, ON., KALYUZHNYI, V.A., TELEPKO, L.F. and KADURIN, V.N., 1984, Thermometric and geochemical characteristics of mineral-forming fluids for vein fluorites of the Bobrinets massif (Ukrainian Shield): Mineral. Sb. (Lvov), v. 38, no. 1, p. 40-48 (in Russian). Authors at Inst. Geol. Geokhim. Goryuch. Iskop., Lvov, USSR.

Fluorite of veins in granites of the Bobrinets massif consists largely of zoned aggregates showing color changes, expressed by alternation of violet, yellow, or green and change from colorless to strongly colored. Emission spectral analysis of the fluorite showed that Sr and Y are constantly present but with high, irregular variation in Y content. Solid inclusions of opaque minerals, especially pyrite, occur in the fluorite. Fluid inclusions of the fluorite indicate that the zoned aggregates formed from low-temperature (285-300°) solutions having low concentrations of solute (5.4-9.2%); their formation was followed by crystallization of even lower temperature (~150°) violet fluorite. During the early stages of fluorite formation, the gas phase in the solutions had a dominantly CH_4-CO_2 composition but this changed to CH_4-N_2-CO_2 in later stages and to N_2-rich in the final stages of fluorite crystallization. (C.A. 101: 76140v)

WACKER, J.F. and ANDERS, Edward, 1984, Trapping of xenon in ice: implications for the origin of the Earth's noble gases: Geochimica Cosmo. Acta, v. 48, p. 2373-2380. Authors at Enrico Fermi Inst., Univ. Chicago, Chicago, IL 60637.

Although the Earth's atmosphere contains Ne, Ar, and Kr in about C1, 2-chondrite porportions, Xe is depleted about 20-fold. To test the suggestion that the "missing" Xe is trapped in Antarctic ice, we have measured distribution coefficients for Xe in artificially formed frost at -20 to -60°C, using Xe^{127} tracer. The values are 0.098 ± 0.004 cc STP/g atm for trapping and <5 cc STP/g atm for trapping plus adsorption. If these results are representative of natural ice, then the Antarctic ice cap contains less than 1% of the atmospheric Xe inventory, or $\leq 10^{-3}$ the amount needed for a C1,2-chondrite pattern.

Two possibilities remain for the "missing" Xe, both on the premise that the Earth's noble gases, along with other volatiles, came from chondritic material. (1) Xenon is preferentially retained in the mantle and lower crust, due to the strong affinity of Xe for clean silicate surfaces and amorphous carbon. (2) The source material of the Earth's volatiles had high, relatively unfractionated, Ar/Xe and Kr/Xe ratios, like the non-carbonaceous noble gas carriers in C3O and E-chondrites. (Authors' abstract)

WALKDEN, G.M. and BERRY, J.R., 1984, Natural calcite in cathodoluminescence: Crystal growth during diagenesis: Nature, v. 308, no. 5959, p. 525-526. Authors at Dept. Geol., Univ. Aberdeen, Marischal College, Aberdeen AB9 1AS, UK.

Some of the largest crystals found as pore-filling cements in ancient limestones are those which develop as single-crystal (syntaxial) overgrowths on crinoid grains. Although originally porous and polycrystalline, such grains normally behave as monocrystalline substrates during diagenesis, facilitating the relatively rapid growth of optically contiguous calcite haloes. The crystal form and growth morphology of pore-fill cements can yield important information about the diagenetic environment, but growth features cannot easily be detected with the light microscope. Chemical stains have been used to study internal growth zonation but cathodoluminescence has proved a more satisfactory technique and our own studies of calcite have revealed a variety of novel growth phenomena. We distinguish four styles of syntaxial overgrowth, the morphologies of which appear to depend on three main factors: grain surface conditions, surrounding pore conditions and the nature of diagenetic environment. (Authors' abstract)

WALSH, J.F., CLOKE, P.L. and KESLER, S.E., 1984, Fluid (CO_2-H_2O) immiscibility and fO_2 as factors in gold deposition: Pamour No. 1 mine, Timmins, Ontario (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 686. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

The coexistence of CO_2-rich and CO_2-poor fluid inclusions located along healed fractures in vein quartz from the Pamour No. 1 mine, a greenstone-hosted gold deposit of Archean age, suggests an origin related to the miscibility gap in the CO_2-H_2O salt system. Salinities determined by freezing point depression of the aqueous inclusions range from 5 to 10 equivalent wt. % NaCl. Microthermometry also enabled the estimates of densitites of coexisting CO_2-rich and aqueous inclusions. The method of intersecting isochores yielded pressures and temperatures on the order of 1-2 kb and 250-350°C, respectively. At these P-T conditions, an originally homogeneous CO_2-H_2O fluid with a salinity of six equivalent wt. % NaCl would have unmixed to two fluids of the compositions we now observe.

Many of the CO_2-rich inclusions contain methane, as confirmed by the observation of the CO_2 triple point and by critical point depressions. CO_2-rich inclusions located along a single healed fracture tend to show consistent methane abundances. However, variability in $X(CH_4)$ on a larger scale suggests fluctuating $f(O_2)$ during entrapment of these fluids. Oxygen fugacities calculated from the reaction $2\ H_2O + CO_2 = CH_4 + 2\ O_2$, tend to parallel the QFM buffer but may deviate from it significantly (up to three log units). Separation of immiscible fluid phases and changing oxygen fugacities may have been important factors affecting gold deposition. (Authors' abstract)

WALSH, J.F., HAYNES, F.M., KESLER, S.E., VAN HEES, Edward and DUFF, Damien, 1984, Fluid inclusion analyses of auriferous vein quartz from the Porcupine district, Ontario (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 114. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Heating/freezing measurements on fluid inclusions in auriferous vein quartz from past and present gold-producing mines in the Porcupine District, Ontario yield homogenization temperatures ranging from 200°C to 400°C. CO_2 is noted in many inclusions in amounts of up to 15 mole %. Salinities of 1.5 to 3.5 equivalent weight % NaCl are indicated by freezing point depression values.

In addition to these traditional methods we have applied SEM energy dispersive analysis to further constrain the composition of the inclusion fluids. Fluid inclusions decrepitated at 500°C yield salt precipitate mounds clearly visible on the SEM. Analyses of these decrepitates reveal the presence of significant Na, Ca and Cl with lesser amounts of K, Mg, S, Zn and Fe. The predominant decrepitate type is NaCl-rich with trace S and exhibits a small anion deficiency suggesting limited CO_3 contents. Less commonly encountered are decrepitates in which Ca is the dominant cation, S and Cl are both abundant anions and a large anion deficiency may signal high CO_3 contents. (Authors' abstract)

WALTHER, Johannes, 1984, Application of a VX-diagram in geothermo-barometric interpretation of CO_2-H_2O fluid inclusions (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 4, p. 484-485. Author at Mineral. Inst. der Univ. Karlsruhe, BDR.

Inclusions in minerals very often contain CO_2-H_2O fluid mixtures. The minerogenetic interpretation of such inclusions, however, is limited because volume data and phase diagrams suitable for geothermo-barometric interpretations are rather fragmentary in this important system.

A volume-composition diagram of the CO_2-H_2O system is presented here which easily allows:

1. simultaneous determination of compositions and densities in CO_2-H_2O fluid inclusions from Th in the heating stage.
2. combination of subsolvus and hypersolvus data and thus construction of suitable sections through the four-dimensional PVTX-space, especially isopleth, polychoric PT graphs, necessary for geothermo-barometric interpretation of microthermic measurements.

The constructions and properties of the diagrams presented will be discussed and their application in fluid inclusions research demonstrated. (Author's abstract)

WANG, Bixiang, 1984, A study of igneous rocks and their mineral inclusions in some areas of Xizang (Tibet) (abst.): Himalayan Geol, Int'l. Symposium Abstracts, p. 101-102. Author at Inst. Geol. Chinese Acad. Geol. Sci., Beijing, China.

See next item. (E.R.)

WANG, Bixiang, ZHANG, Yuanqi and ZHOU, Jianxiong, 1984, Melt inclusions in volcanic rocks from the Lhasa-Margyang area, Xizang (Tibet): Himalayan Geol., v. II, Cooperation in the Himalayas in 1981: Beijing, Geol. Publ. House, p. 185-204 (in Chinese and English). First author at Inst. Geol., Chinese Acad. Geol. Sci.

A variety of types of melt inclusions were found, in terms of accidental solid inclusions, devitrification and daughter crystals. Th (Leitz 1350°C) ranged from 900-1180°C (10-20-hr. runs). Small inclusions had lower Th than larger ones. Large inclusions that cracked during heating were not homogeneous at 1200°C (from loss of volatiles). Th of inclusions from welded tuff were >Th nonwelded (from loss of H_2). Some were analyzed by electron probe and ranges are given for 9 elements, and are compared with bulk rock analyses. (E.R.)

WANG, Fubao and WANG, Wenying, 1984, On the temperature of formation of plutonic rocks in the central south Xizang (Tibet) and its geological significance (abst.): Himalayan Geol., Int'l. Symposium Abstracts, p. 102-103. First author at Inst. Geol. Chinese Acad. Geol. Sci., Beijing, China.

Temperatures of formation (possibly based on Th of melt inclusions?) range from 370°C (one granite) to 1102°C (gabbro or monzonite). (E.R.)

WANG, Liankui, ZHU, Weifang, ZHANG, Shaoli and YANG, Wenjin, 1984, Classification of series and types of granites and their spatial distribution in South China: Acad. Sinica, Developments in Geoscience, Contr. to 27th

Int'l. Geol. Congress, 1984, Moscow, p. 299-309. Authors at Inst. Geochem., Acad. Sinica.

Based on the geological characteristics, the bulk petrochemical composition, biotite composition, accessory mineral assemblages, trace elements and volatiles in whole rock and in accessory mineral, inclusion temperatures, content of Pt group elements, δEu, δO^{18}, δS^{34} and initial $Sr(Sr^{87}/Sr^{86})$ ratio, the granites in South China can be classified into two petrogeno-mineralization series: Nanling Series (I) mainly derived from remelting materials in crust and Yangtze Series (II) mainly derived from lower crust or upper mantle materials. Th ranges: I 600-680°C; II 980-1140°C. (Modified from the authors' abstract)

WANG, S.-Y., EUGSTER, H.P. and WILSON, G.A., 1984, Solubility of magnetite in supercritical HCl and NaCl solutions (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 686.

WANG, Xiuzhang, CHENG, Jingping, SHI, Jishi, LI, Benchao and FAN, Wenling, 1984a Postmigmatization-reworked gold deposits and postmigmatization-metasomatic-remelting magmatic hydrothermal gold deposits in China, in Academia Sinica, Developments in Geoscience, Contribution to 27th Int'l. Geol. Congress, 1984, Moscow: Science Press, Beijing, China, p. 385-395. Authors at Inst. Geochem., Academia Sinica.

This paper describes the geological and geochemical characteristics of two types of gold deposits in China which are widely distributed in Precambrian migmatized metamorphic rocks and were formed by later tectonic activation. Compared with those deposits with Archean age in greenstone belts, it is suggested that they are products of different mineralization. In addition, the mechanism of formation and the genetic relationship of both types of gold deposits in activation zones are discussed in this paper. (Authors' abstract)

Includes a table of data, derived from inclusions, comparing the two gold deposit types in terms of chemical constituent ratios, $\delta^{34}S$, δD, and T. (E.R.)

WANG, Xiuzhang, CHENG, Jingping, SHI, Jixi, LI, Benchao and FAN, Wenling, 1984b Geochemistry and genesis of postmigmatization-reformed gold deposits in China: Scientia Sinica, Ser. B, v. 27, no. 8, p. 837-851. Authors at Inst. Geochem., Acad. Sinica, Guiyang, China.

This paper deals with the geological, mineralogical and geochemical characteristics of a new type of strata-bound gold deposit of postmigmatization-reformed type occurring in Archean metamorphic rocks of North China Platform. The integrated results of geologic studies, stable and radioactive isotopic compositions, constituents in minerals inclusions and trace element data provide evidence to show that ore-forming materials and ore-fluids are mainly from Archean gold source beds, and ore bodies are the products of tectonic-hydrothermal reforming process at the Hercynian and the Yenshanian times. By a comparison of the nature of this type to the gold deposits in Archean greenstone belts abroad, it is suggested that they are different in genesis. Postmigmatization-reformed gold deposits are formed under special conditions. They are mainly developed in later activation zones of platform along the west coast of the Pacific Ocean. This paper presents a model for the formation of this type of gold deposits. (Authors' abstract)

Includes four analyses of fluid inclusions for H_2O, CO_2, H_2S, K, Na, Ca, Mg, Cl, SO_4, F, HCO_3, δD. (E.R.)

WARREN, P.H., 1984, Primordial degassing, lithosphere thickness, and the origin of komatiites: Geology, v. 12, p. 335-338. Author at Inst. Geophys. & Planet. Phys., Dept. Earth & Space Sci., Univ. California, Los Angeles, CA 90024.

It is proposed that parts of the Archean mantle, probably mainly beneath centers of continents, remained volatile-poor from the primordial degassing of Earth. Melting temperatures (Tm) were hundreds of degrees higher in dry parts of the mantle than in wet parts. Effective viscosity in the mantle is related to T/Tm. Thus, in dry parts of the Archean mantle the lithosphere was almost two times thicker than would otherwise have been the case. Genesis of komatiites (ultramafic volcanics) was facilitated because the geotherm remained conductive ("steep") to higher temperatures before turning convective (approximately adiabatic). Partial melts of dry parts of the mantle left more pyroxene in their residua than would otherwise have been the case, leading to two further advantages for komatiite petrogenesis: the melts had higher MgO contents (due to higher normative olivine/pyroxene ratios), and dT/df was smaller during melting. Gradual homogenization of the mantle with reference to volatiles, even more than diminishment of radiogenic heating, probably caused the dwindling of ultramafic volcanism about 2700 Ma. (Author's abstract)

WATANABE, Hidefumi, 1984, Gradual bubble growth in dacite magma as a possible cause of the 1977-1978 long-lived activity of Usu volcano: J. Volcanol. Geotherm. Res., v. 20, p. 133-144. Author at Usu Volcano Observatory, Hokkaido Univ., Sapporo 060, Japan.

The observational evidences suggest that a possible cause of the long-lived activity might be the gradual bubble growth in the dacite magma which had been isolated from deeper sources, but partly supersaturated with volatiles even after the pumice eruptions.

Numerical calculations based on a bubble growth model indicated that the observed time-variations of the upheaval rate of the cryptodome could be well explained by the model, if the water diffusivity in the dacite magma of Usu volcano were of the order of 10^{-9} cm^2 s^{-1} and the degree of supersaturation had been a few percent after the pumice eruptions in August 1977. (From the author's abstract)

WEDEPOHL, K.H., MENGEL, K. and OEHM, J., 1984, Depleted mantle rocks and metasomatically altered peridotite inclusions in Tertiary basalts from the Hessian Depression (NW-Germany), in Kimberlites, v. II: The mantle and crust-mantle relationships, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 191-201.

WEEKS, R.A., UNDERWOOD, J.R., Jr., and GIEGENGACK, Robert, 1984, Libyan Desert Glass: A review: J. Non-Crystalline Solids, v. 67, p. 593-619. First author at Dept. Mech. & Materials Engrg., Vanderbilt Univ., Nashville, TN 37235, USA.

Libyan Desert Glass occurs as a concentration of glass fragments of a broad range of sizes strewn across the desert surface between the NNW-SSE-trending linear sand dunes along the southwestern margin of the Great Sand Sea in western Egypt; it was discovered by the international scientific community in 1932.

Despite the difficulty of access to the region where the glass occurs, at least 20 geologists have examined its field context in the course of at least 10 expeditions since 1932. Many more individuals have undertaken laboratory analyses of materials brought back by the various field parties.

These analyses have established that the gross chemical composition of Libyan Desert Glass approximates that of both the sandstone of the Nubia Formation that underlies the Great Sand Sea and the quartz aggregate of the dunes. A fission-track age of 28.5 x 10^6 y has been assigned to the glass. The quality of internal equilibration among various components distributed through the glass supports the inference that the fusion process that presumably formed the glass occurred at a high temperature: that temperature was sustained for a long time; and that the glass cooled to ambient temperature slowly.

The 1981 expedition, described herein, established that the present mass of glass exceeds 1.4 x 10^9 g; the original mass of glass may have been 10,000 times greater. The glass has been dispersed across a limited area of the desert surface by Earth-surface processes during a period of erosional lowering that is still in progress. No glass fragment representing an edge of the original mass of glass or a transition zone with the precursor material from which it presumably formed has yet been found.

The origin of Libyan Desert Glass remains as much a physical and geologic enigma today as it was in 1932. (Authors' abstract)

Includes a brief discussion (p. 612) of the gas bubbles in the glass. (E.R.)

WEI, Jiaxiu, 1984, Characters of fluid inclusions and mechanism of mineralization alterations for the volcanic deposits in the Lujiang-Zunyang basin: Bull. of the Inst. Mineral Deposits,Chinese Acad. Geol. Sci., Ser. 3, v. 11, p. 40-55 (in Chinese; English abstract). Author at Inst. Mineral Deposits, Chinese Acad. Geol. Sci.

Located in Lower Yangtse valley, the Lujiang-Zunyang Mesozoic volcanic basin is bordered in the west by the Tanchen-Lujiang rift. A series of known iron, copper and pyrite deposits, such as Lohe, Dabaozhuang, Dalin, Xiaolin, Yangshan, Niutoushan and Fanshan, are mostly distributed in the NE direction.

The volcanic eruption and hydrothermal activities resulted in extremely intense mineralization which have vertical and lateral zoning characterized by a gradual transition from dark color to light color.

The data concerning salinities, densities and pressures of the ore-forming fluids have been obtained through the microscopic examination and measurement of inclusions: the temperatures of the alterations are from 620°C to 140°C, salinities from 43-40 wt% to 8 wt%, and pressure from 1000 atm to 550 atm. It is obvious that mineralization alteration proceeded under a pressure-decreasing condition.

Ore-forming temperatures, salinities, densities and pressures for various deposits are determined as follows: magnetite deposits: 450-350°C, 20.10 wt% - 12.50 wt%, 009-0.7 g/cc and 470-450 atm; massive pyrite deposits; 325-205°C, 18.25-8 wt%, <550 atm: alumstone deposits: <200°C, around 8 wt%, with pressures even lower than ore-forming pressures of pyrite.

The ascent of the juvenile gaseous-thermal fluids from depth led to the spread of mineralization from the center outward. Gaseous-thermal fluids caused replacement by means of a combined process of infiltration and diffusion in both concentration gradient field and temperatures and concentration of ore-fluids, the parallelism between temperature isolines of magnetite or pyrite and alteration boundary as well as their correspondence with TiO_2, CO_2, and Ni isolines have furnished convincing evidence for the statements in this paper. (Author's abstract)

WEIR, R.H., Jr. and KERRICK, D.M., 1984, Mineralogic and stable isotopic relationships in gold-quartz veins in the southern Mother Lode, California (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 688. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

In the Coulterville area, Au-bearing quartz veins associated with the Melones Fault Zone are hosted by serpentinites, phyllites, and metagabbros. The serpentinite has been metasomatically altered to talc-chlorite-carbonate-quartz. Dolomite is restricted to the inner alteration envelope, and magnesite is pervasive farther from the veins. A paragenetic sequence for vein ore minerals (early to late) is: Py, millerite, Sp, Td, Cp, Gn, altaite, hessite, petzite, gold, and melonite.

Magnesite and dolomite have similar $\delta^{13}C$ ratios (-3 to -5‰), but $\delta^{18}O$(SMOW) ratios (mag: 14 to 15‰ and dol: 15 to 16‰) are reversed from equilibrium values. These results suggest early higher T, Ca-poor metasomatic fluids widely altered the serpentinite to talc-chlorite-magnesite, followed by lower T, Ca- and metal-rich fluids producing quartz veins and dolomite alteration. Isobaric T-X(CO_2) diagrams limit the talc-magnesite-quartz assemblage to ≤400° ± 50°C and the inner quartz-dolomite to ≤350° ± 50°C. The $\delta^{13}C$ of vein graphite and dolomite (Taylor, 1981) and ore mineralogy imply that the metal-rich fluids were relatively oxidized.

Quartz oxygen ratios (16 to 18‰) suggest a metasomatic fluid of metamorphic origin. Euhedral, vug quartz crystals are 1 to 2‰ higher than adjacent milky vein quartz. This evidence and fluid inclusions in the vugs (mean Th=120°C, low salinity and CO_2) suggest late, lower T, H_2O-rich fluids during vug quartz precipitation. Vug quartz with dendritic gold crystals in the Colorado Quartz Mine (Eastern Gold Belt) shows similar features (Th=150°C, low salinity and CO_2).

These data suggest that the temperature of hydrothermal fluids was continually dropping from early serpentinite alteration to the main quartz precipitation to late vug mineralization. Gold mineralization may have accompanied the latest stage. (Authors' abstract)

WEISS, D.S., 1984, A study of the petrography, phase chemistry, volatile inclusions and intrinsic oxygen fugacity of composite group II ultramafic xenoliths from San Carlos, Arizona: MS thesis, Temple Univ., Philadelphia, PA, 133 pp. plus appendices.

Composite ultramafic xenoliths were collected at Peridot Mesa, San Carlos, Arizona. These nodules were analyzed petrographically, by electron microprobe, and for intrinsic oxygen fugacity (IOF).

Textures proved to be transitional between those of igneous and those of metamorphic petrogenetic environments. Phase chemistry interpretations were not totally consistent with either igneous or metamorphic models of formation. IOF data could not be used to unravel equilibrium relationships between solid phases, but were overprinted by reactions with volatiles contained in the minerals, chiefly CO_2.

These results indicate that the nodules were derived from a complex upper-mantle source region characterized by multi-phase igneous events with important intervening, probably sub-solidus, i.e. metamorphic, reactions between phases. (Author's abstract)

WENDLANDT, R.F., 1984, An experimental and theoretical analysis of partial melting in the system $KAlSiO_4$-CaO-MgO-SiO_2-CO_2 and applications to the genesis of potassic magmas, carbonatites and kimberlites, in Kimberlites, v. I: Kimberlites and related rocks, J. Kornprobst, ed., Proc. of the "Third Int'l. Kimberlite Conf.": Elsevier, Amsterdam, p. 359-370.

WENKUI, Guo, 1984, Metallization of the Xihuashan tungsten deposit - an example linking magmatic deuteric infiltration with hydrothermal lodes: Proc. of the Sixth Quadrennial IAGOD Symp., Tbilisi, USSR, 1982, Vol. 1,

p. 339-344. Author at Research Inst. Geol., Chinese Acad. Geol. Sci., Beijing, PRC.

The conditions of metallization are discussed for the productive tungsten lodes confined to the igneous body. During the ore formation the physical-chemical conditions of the vein and the country rocks seem to be quite similar. It is proposed that at least part of the hydrothermal ore-bearing solution is derived from deuteric magmatic fluid. (Author's abstract)

Includes some discussion of the composition of fluid inclusions and isotopes of O, H, and C. (E.R.)

WERLE, J.L., IKRAMUDDIN, Mohammed and MUTSCHLER, F.E., 1984, Allard stock, La Plata Mountains, Colorado - an alkaline rock-hosted porphyry copper-precious metal deposit: Can. J. Earth Sci., v. 21, p. 630-641. Authors at Dept. Geol., Eastern Washington Univ., Cheney, WA 99004, USA.

The Allard stock, which hosts a porphyry Cu-Ag-Au-Pt metals deposit, is an epizonal Laramide pluton at the southwest end of the Colorado mineral belt. The stock and associated mineralization evolved by a complex interaction of igneous and metasomatic processes.

The stock shows enrichment of volatiles (CO_2, F, and S), high concentrations of Ba and Sr, low concentrations of Rb, high concentrations of Cu, Ag, Au, Bi, Te, Pt, and Pd, with little or no enrichment in Nb, U, Y, and Zr.

The Allard stock and its associated mineralization are unlike the calc-alkaline porphyry copper deposits of the western United States and Canada. Although the Allard syenites are silica saturated (quartz-normative), some aspects of Allard alteration and mineralization show affinities with copper and (or) precious metal deposits hosted by alkaline silica-undersaturated (nepheline- or leucite-normative) plutons and carbonatite complexes including the "alkaline suite" porphyry copper deposits of British Columbia, the Palabora, South Africa, copper deposit, and the Cripple Creek, Colorado, gold telluride deposit. Computer-assisted evaluation of major-element analyses of igneous rocks suggest that Allard-type Cu-precious metal deposits may occur in other North American alkaline rock provinces. Epithermal gold telluride deposits in subvolcanic alkaline rocks may grade downward into alkaline porphyry Cu-precious metal deposits. (From the authors' abstract)

WESTRICH, H.R. and EICHELBERGER, J.C., 1984, Water content and lithology of the Obsidian Dome flow (abst.): EOS, v. 65, no. 45, p. 1127. Authors at Geochem. Div. 1543, Sandia Nat'l. Labs., Albuquerque, NM 87185.

The water analyses together with D/H isotopic compositions, suggest that vesiculation of the magma occurred in the conduit at water pressures of about 30 bars. Progressive degassing to near atmospheric conditions occurs upon extrusion at the vent, followed by bubble collapse and vapor resorption. (From the authors' abstract)

WHELAN, J.F., RYE, R.O. and DeLORRAINE, William, 1984, The Balmat-Edwards zinc-lead deposits -- synsedimentary ore from Mississippi Valley-type fluids: Econ. Geol., v. 79, p. 239-265. First author at U.S. Geol. Survey, Bldg. 21, Mail Stop 963, Denver Fed. Center, Denver, CO 80225.

Isotopic study of S, C, and O in various minerals are used to establish the origin. (E.R.)

WHITE, A.F. and CHUMA, Nancy, 1984, Chemical evolution of hydrothermal fluids in the Valles Caldera, New Mexico (abst.): EOS, v. 65, no. 45, p. 1126. Authors at Lawrence Berkeley Lab., Univ. California, Berkeley, CA

94702.

The EQ3/EQ6 reaction code is used to model effects of thermal equilibration and ground water mixing on chemical changes in the central 300°C reservoir and in outlying hot springs. In situ chemistry, pH, and Eh are calculated from well head enthaply, fluid and gas data; amount of meteoric water mixing by $D/^{18}O$ and B/Cl ratios; and extent of water/rock reaction by Li concentrations.

Observed alteration mineral assemblages are accurately reproduced. Model results are compared to Na-K and Na-K-Ca geothermometer ratios and are in agreement except for reactions involving K feldspar. New entropy and heat capacity values are tabulated for adularia. Minimum equilibration temperatures of 200°C for the hot springs indicate a high temperature carbonate reservoir beneath the caldera which prevents lower temperature equilibration of the silicate mineral assemblage. (Authors' abstract)

WHITNEY, Gene and NORTHROP, H.R., 1984, Reconstructing an ancient fluid-flow regime using the mineralogy and stable isotope geochemistry of diagenetic clays in sandstone (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 693.

WHITNEY, J.A., 1984, Fugacities of sulfurous gases in pyrrhotite-bearing silicic magmas: Am. Mineralogist, v. 69, p. 69-78. Author at Dept. Geol., Univ. Georgia, Athens, GA 30602.

Thermodynamic data are used to determine the fugacities of sulfurous gases S_2, SO_2 and H_2S along the pyrrhotite saturation surface within the system $Fe-S_2-O_2-SiO_2$. The fugacities of these species are contoured on diagrams of log fO_2 versus T (°C). These diagrams allow the fugacities of sulfurous species for silicic magmas to be estimated assuming that the temperature and oxygen fugacity are determined from coexisting magnetite and ilmenite, and the pyrrhotite inclusions represent magmatic conditions. In cases where the pyrrhotite was analyzed and the fugacities calculated, the results are consistent. This method is widely applicable because it may be used for any rock for which iron-titanium oxide data are available and igneous pyrrhotite is present.

Both S_2 and SO_2 are highly dependent on fO_2 and T, decreasing with both variables. Sulfur ranges from 10 to 10^{-4} bars whereas SO_2 varies from 10^3 to 10^{-3}. Hydrogen sulfide is less variable, ranging between 100 and 10 bars, but it also decreases with log fO_2 and temperature.

The initial volatile phases evolved at high temperatures from oxidized magmas are rich in SO_2. Volatile separation depletes the magma in sulfur and causes reduction of the magma by oxidation of HS^- in the melt to SO_2 in the vapor phase. Such magmatic volatile phases can be an important source of sulfur for some types of ore deposits. (Author's abstract)

WHITTEMORE, D.O., 1984, Geochemical identification of salinity sources, in R.H. French, ed., Salinity in watercourses and reservoirs: Proc. of the 1983 Int'l. Symp. on State-of-the-Art Control of Salinity, July 13-15, 1983, Salt Lake City, UT, p. 505-514: Boston, Butterworth Pub.

WIDOM, Elizabeth, WEATHERS, M.S., BASSETT, W.A., KOHLSTEDT, D.L. and ANDERSON, A.T., 1984, Microanalysis of glass inclusions in grain boundaries of Kilauea olivine aggregates (abst.): EOS, v. 65, no. 45, p. 1131. First author at Dept. Geol. Sci., Cornell Univ., Ithaca, NY 14853.

Aggregates of olivine crystals from the 1959 summit eruption of Kilauea Iki were studied using optical and electron microscopy. Lenticular glass inclusions on the order of several microns in length were found along several grain boundaries. One of the glass inclusions has been analyzed using a JEOL 200CX scanning-transmission electron microscope. It has the following average composition (in weight percent): 57.08% SiO_2, 3.34% TiO_2, 14.52% Al_2O_3, 7.66% FeO, 2.72% MgO, 13.20% CaO, 0.89% Na_2O, 0.50% K_2O. This composition is significantly lower in FeO and MgO and higher in SiO_2, CaO and TiO_2 than the matrix glass. The difference in composition between the matrix glass and inclusion may be due to crystallization of olivine and other phases within the inclusion. Consistent with this interpretation is the fact that the olivine in contact with the glass inclusion is zoned from Fo_{74} at the edge of the inclusion to Fo_{86} at a distance of 0.6 microns into the olivine crystals. The average composition of the olivine is Fo_{86}-Fo_{87}, determined by microprobe analyses. The lenticular shape of the glass inclusions along the grain boundaries and the compositional zoning in the olivine is consistent with formation of the olivine aggregates by synneusis. (Authors' abstract)

WILKINS, Ronald and DUBESSY, Jean, 1984, Relative chronology of retrograde metamorphic fluids in the host rocks of the stratiform Broken Hill orebody (New South Wales, Australia): C.R. Acad. Sci. Paris, v. 299, Series II, p. 1045-1050 (in French; English abstract). First author at C.S.I.R.O., P.O. Box 36, North Ryde 2113, Australia.

From microstructural relationships such as the intersection of fluid inclusion surfaces, and the analysis of inclusion gases by Raman microprobe, a relative chronology can be established between the different relic metamorphic fluids in the gneissic host rocks of the stratiform Broken Hill ore deposit, and in the associated discordant quartz-sulphide veins and shear zone quartz. The origin of the fluids is also discussed. (Authors' abstract)

WILLIAMS-JONES, A.E., 1984, Alteration, fluid inclusion, and isotopic studies at the Madeleine copper mine Gaspe, Quebec (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Program with Abstracts, v. 9, p. 116. Author at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec H3A 2A7, Canada.

The Madeleine deposit is a bornite/chalcopyrite stockwork located within the contact aureole of the late Devonian McGerrigle Mountains granitic pluton. The deposit contained ≈8.7 x 10^6 tons grading 1.15% Cu in 5 steeply plunging chimney shaped orebodies each crudely zoned with a bornite core surrounded by shells of chalcopyrite and chalcopyrite-pyrrhotite. The orebodies are hosted by biotite-(cordierite) hornfels units containing some calc-silicate interbeds. Several stages of veining and alteration are recognized. The early veins are surrounded by biotite haloes and contain biotite. They are commonly folded/boudinaged and may be flattened about or cut-off by cordierite porphyroblasts indicating emplacement before the peak of metamorphism. Later veining is characterized by the following gangue and alteration assemblages: muscovite-tourmaline; chlorite-muscovite; chlorite-tremolite; and tremolite-epidote. Liquid-rich H_2O, vapor-rich H_2O-CO_2, and halite ± sylvite ± anhydrite?-bearing fluid inclusions are common in gangue quartz. The earliest veining is interpreted to have occurred at temperature of up to 450°C and fluid pressures up to 550 bars. The temperature during later stages was 300° to 350°C. Early fluids were very saline and potassic with K/Na ratios of 0.55 to 0.60. Subsequent fluids were also saline but more calcic. The δS^{34} of chalcopyrite displays an unusually broad range from +27‰ to -15‰. This is interpreted to indicate multiple sulphur sources and sharply varying fO_2-pH conditions during deposition. A model is proposed relating the formation and nature of the Madeleine deposit to CO_2 effervescence and steep pH and water/rock gradients caused by interaction of an orthomagmatic/meteoric hydrothermal system with pelitic and calcareous metasediments during the emplacement of the McGerrigle pluton. (Author's abstract)

WILSHIRE, H.G., 1984, Mantle metasomatism: The REE story: Geology, v. 12, p. 395-398. Author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

Refractory rocks with light REE/heavy REE ratios greater than chondrite are common as xenoliths in basalts and kimberlites and are found in some oceanic peridotite massifs. This has led to the supposition that large parts of the upper mantle have been metasomatically altered by addition of light REE and other hyperfusible constituents.

Structural and major-element geochemical evidence from xenoliths and alpine peridotites, however, suggest that metasomatic effects are local and are related to emplacement of partial melts. The melts are represented by dikes of pyroxenite, hydrous minerals, and gabbro that occur in mantle peridotites of all origins and were emplaced in them in the same sequence as indicated by crosscutting relations. REE distributions in both the peridotite and the dikes may be explained as a result of metasomatic interaction between dikes and peridotite wall rock in which the peridotite is enriched in light REE and the dikes depleted in light REE relative to the original liquid. Differentiation of the intrusions and separation of residual liquids may further reduce the light REE/heavy REE ratio in pyroxenite dikes; these residual liquids (hydrous mineral veins) enriched in light REE extend the volume of metasomatized peridotite as they too interact with their wall rocks. Differences in the relative abundances of altered peridotite (reacted wall rock) in xenoliths and massifs are seen as a sampling problem rather than a difference in process. (Author's abstract)

WILSON, G.A. and EUGSTER, H.P., 1984, Cassiterite solubility and tin-chloride speciation in supercritical solutions (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 696.

WILSON, G.C. and RUCKLIDGE, J.C., 1984, Mass spectrometric studies of carbonaceous materials from Archean gold deposits (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 696.

WILSON, K.S., 1984, The geology and epithermal silver mineralization of the Reymert mine, Pinal County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 100 pp.

Field and laboratory studies show that the Reymert Vein, Pinal County, Arizona, is an epithermal fissure filling emplaced in Precambrian Pinal Schist and is related in time and space to mid-Tertiary volcanism. Three stages of mineralization are delineated. The earliest stage is black calcite-rich, the intermediate one cryptocrystalline quartz-rich, and the latest stage barite-rich. Fluid inclusion studies show that temperatures attending vein deposition ranged from 138°C to 452°C. Fluids were moderately saline, at 9.7 to 23.2 weight percent equivalent NaCl. Silver mineralogy and distribution were delineated with the aid of a scanning electron microprobe quantometer. Silver occurs as acanthite, jalpaite, native silver, and argentiferous manganese and iron oxides. The vein system is unusual in the non-volcanic nature of its wall rocks, but resembles other epithermal vein occurrences in that it consists of silver-bearing veins exhibiting classic epithermal textures and mineralogy. (Author's abstract)

WILSON, T.P. and LONG, D.T., 1984, The behavior of bromide during the dissolution of halite at 25°C and 1 atm (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 697.

WITT, G. and SECK, H.A., 1984, Melt formation due to amphibole breakdown in xenoliths of mantle peridotite (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 438 (in English). Authors at Mineral.-Petro. Inst., Univ. Köln, Köln, FRG.

Amphibole breakdown to clinopyroxene, olivine, spinel, and melt during the ascent in hot magma is widespread in mantle xenoliths from Tertiary and Quaternary volcanics of Western Germany. In xenoliths from the Quaternary West Eifel transported to the surface by maar type explosions, melts are quenched to glass due to fast cooling. The origin of melts was related to amphibole breakdown either from textural evidence if relics of amphibole are still present or from the fact that the bulk composition of the breakdown products yield compositions typical of mantle amphiboles. Melt compositions observed range from 48 to 60% SiO_2 and MgO contents from 3 to 4%, and total alkalies up to 10%. The K_2O/Na_2O ratio of the melts is controlled by the same ratio in the amphibole.

Xenoliths from Tertiary volcanics without exception occur in massive lavas and cooled much slower. In the absence of amphibole relics, the former presence of amphiboles in those nodules had to be inferred from the bulk compositions of their breakdown products. Due to much slower cooling, melts formed by amphibole breakdown fractionated to an extent that alkali feldspar liquids were reached. These melts were recorded within blebs consisting of amphibole breakdown products as well as in small veinlets cutting the nodules, and on grain boundaries. Glasses of feldspar compositions were also found as minute inclusions 5 to 10 μm in size in pyroxenes. (Authors' abstract)

WŁODYKA, R., 1983, Electron microprobe analysis in mineralogy (summary): Prace Univ. Sl. no. 614; Geologia, v. 7, p. 106-108 (in Polish). Author at Faculty of Earth Sci. of Silesian Univ., Sosnowiec, Poland.

The published summary briefly presents method of opening of inclusion vacuole for microprobe analysis of precipitate from evaporated inclusion filling. (A.K.)

WOJDAK, P.J. and SINCLAIR, A.J., 1984, Equity Silver silver-copper-gold deposit: alteration and fluid inclusion studies: Econ. Geol., v. 79, p. 969-990. First author at Westmin Resources Ltd., P.O. Box 49066, The Bentall Centre, Vancouver, British Columbia V7X 1C4, Canada.

The Equity Silver mine is a silver-copper-gold-antimony deposit 600 km northwest of Vancouver, British Columbia, mined at present from two open pits by Equity Silver Mines Ltd. The deposit is contained within tilted fragmental dacites of inferred Cretaceous age that are intruded by two Eocene stocks and surrounded by flat-lying younger plateau lavas. The two zones being mined occur along a continuous 1,500-m mineralized zone that is crudely parallel to the Cretaceous strata.

In the larger Main zone, ore minerals, principally pyrite, chalcopyrite, and tetrahedrite, are finely disseminated in the matrix of a volcanic breccia and are intimately associated with an aluminous and borosilicate alteration assemblage. Andalusite, distinctive blue scorzalite, tourmaline, corundum, and sparse dumortierite are developed from a monotonous groundmass of fine illite-sericite and quartz. Zones of aluminous minerals are concentric and broadly outline the mineralized zone but are asymmetric to it, extending up to 300 m into the hanging wall where alteration seems to terminate abruptly against comparatively fresh welded ash-flow tuff. Chlorite and carbonate in the Main zone occur with economically unimportant late ore-stage sulfide veins. Chlorite is also a prominent retrograde alteration.

The smaller Southern Tail deposit contrasts with the Main zone. Ore minerals, principally pyrite, arsenopyrite, chalcopyrite, and tetrahedrite with quartz and chlorite gangue are moderately coarse grained and fill open space in a crudely tabular brittle fractured zone. The breccia and halo of buff sericite alteration transect aluminous alteration which in this area consists of an andalusite-pyrophyllite-chlorite assemblage. The presence of pyrophyllite and abundant early chlorite implies a lower temperature than the Main zone, approximately 350°C. Study of fluid inclusions, mainly from the Southern Tail, indicates that ore was deposited from a low-salinity fluid at temperatures that decreased from 400° to 200°C corresponding to the sulfide paragenetic sequence.

Whole-rock K-Ar dates of Southern Tail wall rock and a highly tourmalinized breccia more than 1 km from the Main zone both correspond closely to the older and more distant of the two Eocene stocks, a 59.4-m.y.-old quartz monzonite (cf. Wetherell, 1979). Although these features are distant from each other, mineralogical evidence also suggests a link between very weak sulfide development in the stock, the tourmaline breccia, and the ore zones. Fluid in the quartz monzonite was highly saline, whereas the tourmaline breccia was moderately saline and the ore-zone fluid was moderately saline initially but evolved to a gradually decreasing low-salinity fluid during the bulk of ore deposition. The data are consistent with an epithermal ore genesis model in which intrusive activity of quartz monzonite age heated acidic meteoric water to a high temperature and contributed a saline magmatic component to create an ore fluid. Movement of the ore fluid was controlled by structures and stratigraphy of the volcanic host rocks. Aluminous minerals formed mainly by an acid leaching reaction between the ore fluid and the wall rock but also involved desilication reactions that progressed under disequilibrium conditions. (Authors' abstract)

WOOD, J.R., 1984, Diagenesis '80: a review and a preview (abst.): EOS, v. 65, no. 45, p. 1125. Author at Chevron Oil Field Res. Co., P.O. Box 446, La Habra, CA 90631.

Diagenetic research has accelerated in the past decade, both in industry and in academia, primarily in response to hydrocarbon exploration and recovery. Intensified drilling programs and more liberal access to core material and log data have combined to provide investigators with new opportunities. The result has been a number of new insights into subsurface processes. Foremost among these has been: (1) the recognition of widespread secondary porosity, (2) the determination of paragenetic sequences for large volumes of rock, and (3) the documentation of a variety of discontinuous reaction fronts involving cementation, mineral replacement, and phase transformations.

Recent directions in theoretical diagenetic research have concentrated on the driving forces and dynamics involved in diagenetic processes. Much attention has been devoted to the determination of the consequences of pore fluids moving across isotherms while rock-fluid equilibrium is maintained. This theory, termed advective diagenesis, predicts both large-scale mass transfer by dissolution and precipitation of the mineral matrix and the existence of discontinuous reaction fronts as the result of either local mineral depletion or incongruent dissolution.

Future research seems to be aimed toward refinement of the sample-dependent technology (isotope measurements, SEM and TEM characterization, pore-fluid chemistry, fluid inclusions, and vitrinite reflectance) and integration of measurements and theory. Computer modeling, on both mainframes and microcomputers, is becoming and increasingly important tool for implementation of such integration. (Author's abstract)

WOOD, P.C., THOMAS, A.V., BURROWS, D.R., MACDONALD, A.J., NOBLE, S.R. and SPOONER, E.T.C., 1984, CO_2-bearing low-moderate salinity fluids in Archean gold-quartz-carbonate-(W-Mo) vein deposits and magmatically derived Mo, W, Ta and Sn mineralization (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 700. Authors at Dept. Geol., Univ. Toronto, Ontario M5S 1A1, Canada.

Fluid inclusions in Archean gold-quartz-carbonate-(W-Mo) vein deposits in the Yilgarn block (Australia) and the Superior province (Canada) are characterized by significant CO_2 contents, low-moderate salinities (1-6 equiv. wt.% NaCl) and moderate total Th of 200°C-400°C. Selected <u>primary</u> inclusions in early scheelite, main stage scheelite and quartz from the Hollinger mine in the Porcupine Camp, Ont. indicate the following: (i) CO_2-H_2O phase separation did not occur, or was limited, (ii) liquid CO_2 is reasonably pure (CO_2 m.pt. = 56.7 ± 0.7°C, n = 100), (iii) salinities determined from clathrate melting points for pure CO_2 vary from 0.4 to 7.7 (4.3 ± 1.8, n = 58), and (iv) formation temperatures were ≥ Th of 271 ± 47 (n = 33). The Archean gold data show close similarities in terms of CO_2 content, CO_2 composition and H_2O salinity to data for fluid inclusions in four studied magmatic systems: Boss Mtn. Mo, B.C., Logtung W-Mo, Y.T., Mink Lake Mo, N.W. Ont., and Tanco Ta-Sn, S.E. Manitoba. For example salinities are moderate at 5.8 ± 2.3 (n = 98), 4.3 ± 1.4 (n = 95), 45.6 ± 1.2 (n = 48) and 7.5 ± 2.9 (n = 96) respectively. Hence, the properties of Archean gold-quartz-carbonate-(W-Mo) vein fluids are compatible with a magmatic derivation, as is the carbon isotopic composition (Burrows & Spooner, 1984). The similarity between the published ages for the Wawa domal tonalite gneiss granodiorite-quartz-monzonite terrain which intrudes the base of the supracrustal sequences (2707-2668 Myr), and the estimated age for the late to post tectonic pluton intrusion and gold mineralization (2700-2680 Myr) suggests that components of the former might be possible sources for Archean gold fluids. (Authors' abstract)

WOOD, S.A., CRERAR, D.A., BRANTLEY, S.L. and BORCSIK, M., 1984, Mean molal stoichiometric activity coefficients of alkali halides and related electrolytes in hydrothermal solutions: Am. J. Sci., v. 284, p. 668-705.

WOOD, S.A. and SPERA, F.J., 1984, Adiabatic decompression of aqueous solutions: Applications to hydrothermal fluid migration in the crust: Geology, v. 12, p. 707-710. Authors at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544.

Adiabatic decompression may result in the heating of geologic aqueous fluids on the order of tens of degrees Celsius. Adiabatic expansion may be either reversible, in which case geologically important fluids cool on decompression, or irreversible. If the irreversible adiabatic expansion involves a significant pressure loss due to internal work generation (and kinetic and gravitational effects can be ignored) and the Joule-Thompson coefficient is large and negative, fluids heat up upon decompression. The Joule-Thompson coefficient becomes increasingly negative (i.e., the heating effect dominates) at high pressures, low temperatures, high m(NaCl), and high XCO_2. We predict that high concentrations of divalent and trivalent ions in solution will also increase the magnitude of the heating effect. (Authors' abstract)

WOODBURY, J.L. and VOGEL, T.A., 1970, A rapid, economical method for polishing thin sections for microprobe and petrographic analyses: The Am. Mineralogist, v. 55, p. 2095. First author at Buehler Ltd., 2120 Greenwood St., Evanston, IL 60204.

Polished thin sections suitable for microprobe and microscopy are prepared in routine fashion using a semi-automatic polisher, rough polishing with diamond abrasive and finishing with alpha-alumina. (Authors' abstract)

WORNER, G. and FRICKE, A., 1984, Fluid inclusions in corundum from a contact metamorphic xenolith of the Quaternary Wehr volcano (East Eifel, Germany): Neues Jahrb. Mineral., no. 1, p. 39-47. Authors at Inst. Mineral., Ruhr-Univ. Bochum, 4630, Bochum, FRG.

Fluid inclusions filled with two liquids and vapor in contact metamorphic corundum from a xenolith of the Quaternary phonolitic to trachytic Wehr volcano (East Eifel, Germany) have been studied by micro-thermometry. Freezing stage measurements confirmed the presence of mainly CO_2; H_2O is a minor immiscible component. Temperatures for homogenization of liquid and vapor CO_2 range from 27 to 31°C with a mean value of 29.7 ± 0.9°C. These correspond to densities of the CO_2 fluid at entrapment of 0.55 to 0.64 g/cm^3 (mean = 0.60 g/cm^3). Based on independent temperature estimates and the PVT-data of the CO_2 one component system, the inferred pressure of entrapment is in the range of 1.3 to 2.0 kbar PCO_2 (for a realistic temperature range of 600 to 700°C). The basement rocks thus seem to have been affected by contact metamorphism at a depth of 4.0-7.0 km, in good agreement with previous estimates of the depth of the Wehr magma chamber and the existence of basement rocks within the upper East Eifel crust. (Authors' abstract)

WÜRNER, G. and SCHMINCKE, H.-U., 1984, Mineralogical and chemical zonation of the Laacher See tephra sequence (East Eifel, W. Germany): J. Petrology, v. 25, p. 805-835. Authors at Inst. Mineral., Ruhr-Univ. Bochum, Postfach 102148, D-4630 Bochum, Germany.

Includes four analyses of glass inclusions for 11 constituents (including Cl), and 18 analyses through the stratigraphic sequence for H_2O, CO_2, C, F, and S. (E.R.)

WRONKIEWICZ, D.J., NORMAN, D.I., PARKISON, G.A. and EMANUEL, K.M., 1984, Geology of the Cochiti mining district, Sandoval County, New Mexico: New Mexico Geol. Soc. Guidebook, 35th Field Conf., Rio Grande Rift: Northern New Mexico, 1984, p. 219-222. First author at Dept. Geol., New Mexico Inst. Mining & Tech., Socorro, New Mexico 87801.

Three types of primary fluid inclusions consist of 2-3% G, >90% gas, and 2-30% G plus an additional liquid H_2S phase. No dms. Th = 193-377°, salinities 0-5 wt.% NaCl equiv. Higher Au and Ag values correlate well with Th = 240-315°C. Average gas composition (mole %) H_2S 3.50, organic cpds, 3.30, CO_2 2.15, N_2 1.65, H_2O 89.40. (E.R.)

WU, Bihao, TANG, Jiayou and DUAN, Zhenhao, 1984, The variation of ^{18}O content of water in the Qaidam basin (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. 440 (in English). Authors at Inst. Mineral Deposits, Chinese Acad. Geol. Sci., Beijing, China.

Isotopic and geochemical studies of saline lakes and drainage system of Qaidam Basin have been made. It was found that $\delta^{18}O$ of the river waters vary from -8 to -12‰, indicating they orignated from the snow and glacier ice on the mountains around the basin. The $\delta^{18}O$ of intercrystalline brine in the salt beach of various lakes fluctuates between -4 and -9‰. In the processes of evaporation and salt formation the heavy isotope (^{18}O) in the lake increased with increasing salinity and reached its maxium (+2‰ ±) at the stage of halite precipitation. After that the value of $\delta^{18}O$ decreased gradually down to -17‰ ± at the stage of bischofite precipitation. The $\delta^{18}O$ values of brines vary from lake to lake in the basin. It may be due to variation of proportion of river water to intercrystalline brine in the lakes, and the attained stages of salt mineral precipitation. Therefore, the $\delta^{18}O$ can be used to distinguish sources of lake brine and the genesis of underground brines and oil-field waters. (Authors' abstract)

XIA, Linqi, 1984a Highly dense CO_2 fluid inclusions in peridotitic inclusions in some alkali-basalts from East China: Acta Mineral. Sinica, no. 2, p. 133-142 (in Chinese; English abstract). Author at Xian Inst. Geol. & Mineral Resources, Ministry of Geol.

Highly dense CO_2 fluid inclusions, usually containing glass and daughter minerals (clinopyroxene), were found in olivine, clinopyroxene, and orthopyroxene of lherzolite inclusions associated with alkali-basalts in East China. These fluid inclusions are largely of secondary origin, trapped during the closing of fractures, and partly of primary origin.

The fluid inclusions were examined under the petrographical microscope equipped with a Chaixmeca heating-cooling stage. In this paper Th, Tm and densities of the fluid inclusions were measured, and data on their sizes, shapes, modes of occurrence and the numbers of phases present at room temperature were reported as well, and interpreted in accordance with experimental data on phase equilibrium:

(1) Early fluid inclusions contain pure CO_2, and most of the late inclusions contain almost pure CO_2, in some cases, with minor N_2.

(2) The density of late fluid inclusions ranges from 0.26 to 1.03 gm/cm^3 and that of early ones from 1.05 to 1.14 gm/cm^3.

Th (1260-1300°C) for melt inclusions were also measured on the petrographic microscope equipped with a Leitz 1350 heating stage. Assuming Tt to be 1260°C, this implies a confining pressure of more than 13.3 kb at the time the densest fluid inclusions were trapped.

The presence of glass in many of the fluid inclusions, which is similar to alkali-basalt in composition as revealed by electron microprobe analysis, implies the coexistence of CO_2 as the major volatile phase with a melt phase at depth.

Obviously, the studies of fluid inclusions in ultramafic inclusions as well as of the composition of associated glass are of great importance in understanding the role of volatiles in the lower crust-upper mantle, the mechanism of partial melting in the upper mantle and the origin of basalt magma. (Author's abstract)

XIA, Linqi, 1984b Kinetic behavior of the homogenization process of silicate melt inclusions: Scientia Geologica Sinica, no. 3, p. 312-329 (in Chinese; English abstract). Author at Xian Inst. Geol. & Mineral Resources, Xian.

Homogenization thermometry is an important part of the study of silicate melt inclusions. Besides the choice of convenient melt inclusions, it is necessary to establish a thermometric rule for homogenization thermometry. The author has carried out a systematic study of the kinetics of homogenization process according to the chemical composition of included silicate liquid, in order to define and normalize the optimal conditions for thermometry. During heating the observation of disappearance of the shrinkage bubble provides an understanding of the kinetics of the homogenization process. In light of the relation between the viscosity and the necessary time for the homogenization of inclusions, we can define the rate of homogenization equilibrium of different types of silicate melt inclusions. For melt inclusions in basic lavas, the time necessary for homogenization equilibrium is of the order of 5-10 minutes; for andesitic lavas and intermediate alkali-lavas, it is about 20 minutes; for acid lavas, about 1-2 hours. The viscosities of silicate liquids trapped in different types of inclusions have been also calculated. The curve of the relation between the viscosity and the necessary time for homogenization equilibrium shows that the lower the viscosity, the shorter the necessary time to realize the homogenization equilibrium. The total time of each experiment is: 2-4 hours for basic lavas, 4-8 hours for intermediate lavas and 6-12 hours for acid lavas. (Author's abstract)

XIA, Lin-Qi, MASSARE, Dominique and CLOCCHIATTI, Robert, 1983, Thermobarochemistry of some peridotitic nodules in the neogene alkali-basalts from East China: C.R. Acad. Sci. Paris, v. 297, Ser. II, p. 675-680 (in French; English abstract). First author at Inst. Recherches Geol. & Resources Min. Xian Acad. Sci. Geol. Chine, Xian, PRC.

The early stages of the crystallization of the minerals: olivine, clinopyroxene, orthopyroxene of spinel-lherzolite nodules associated with alkali-basalts from the Hanluo Dam and Square Hill volcanoes are characterized by the trapping of a dense carbonic fluid (1.14 g/cm^3). The density of this fluid decreases progressively with the nodule raising and reaches 0.26 g/cm^3 in the latest stages. The basaltic silicate liquids saturated by CO_2, with crystallized olivine and endiopside, penetrate into the fragile zones of crystals and are preserved as polyphasic melt inclusions. The nature and physicochemical conditions of entrapment of the mantle fluids are consistent with the data obtained through the study of inclusions in peridotite minerals from other regions of the world. (Authors' abstract)

YAN, Zheng, YE, Lianfang, ZHAO, Shusen, LIU, Minglin, LIU, Rongmo and ZHAO, Dinghua, 1984, Oxygen isotope composition, paleotemperature and ^{230}Th/^{234}U dating of speleothem from the fourth cave of Peking Man Site, in Academia Sinica, Developments in Geoscience, Contribution to 27th Int'l. Geol. Congress, 1984, Moscow: Science Press, Beijing, China, p. 177-183. First author at Inst. Geol., National Seismological Bureau.

Oxygen isotopic analyses of speleothem samples from the 4th cave of Peking Man Site have demonstrated that the formation of speleothem was in oxygen isotopic equilibrium with their parent seepage waters. The cross section of this speleothem can be divided into three zones by oxygen isotopic composition. The $\delta^{18}O$ of the inner zone ranges from -6.48 to -7.43% . Its formation temperature is 13.2°C and its formational age is 78x10^3 yr B.P. by ^{230}Th/^{234}U dating. The average value of $\delta^{18}O$ of the mediate zone is -7.58 ± 0.11% , and the formation temperature is 18.6°C. Its age is 63x10^3 yr B.P. That suggests that paleoclimate during that period might be more moderate. The average value of $\delta^{18}O$ of the outer zone is -6.43% , its formation temperature is 9.2°C, and the age is 51x10^3 yr B.P. (Authors' abstract)

YANG, Weihua and LIU, Youmei, 1984, Implications of organic matter in the genesis of strata-bound deposits, in Academia Sinica, Developments in Geoscience, Contribution to 27th Int'l. Geol. Congress, 1984, Moscow: Science Press, Beijing, China, p. 645-655. Authors at Inst. Geochem., Academia Sinica.

Continued next page.

In the stratabound deposits mineralogenetic contributions of organic matter are as follows: (1) Origin of light-color strata bearing copper and uranium ores suggested that CH_4 from thermal cracking of kerogen in the underlying carbonaceous rocks at temperature >100°C nonbiogenically reduced sulfates to H_2S which could reduce Fe^{3+} into Fe^{2+}, thus leading to the fading of the strata. (2) Brine carrying hydrocarbons and attacking oil beds can extract a lot of ore-forming elements from the strata and then the elements are largely absorbed on hydrocarbons and concentrated. (3) The plant organic fragments and asphalts could all absorb a lot of hydrocarbons which may reduce sulfates into H_2S, then forming a microcosm characterized by reducing conditions around kerogen to precipitate ore-forming elements. (Authors' abstract)

YERMAKOV, N.P., NAUMOV, V.B. and KHITAROV, D.N., 1984a Fluid inclusions in minerals and their significance in the study of hydrothermal ore formation (abst.): Int'l. Geol. Congress, 27th, Moscow, Abstracts, v. 5, Sections 10, 11, p. [205] (in English). First author at Moscow State Univ., Moscow, USSR.

It is shown that among the methods which can give reliable quantitative information about natural processes of mineral crystallization and about the formation conditions of deposits of useful minerals the methods of the study of the inclusions of mineral-forming media are being widely developed during the last years. The literature data on results of the study of fluid inclusions in minerals concerning the most important indices of geological processes: temperature, pressure, aggregate state and density of mineral-forming fluids, their chemical composition and concentration are summarized and discussed. The most favorable temperatures for the formation of many ore (cassiterite, scheelite, wolframite, sphalerite, antimonite, cinnabar and others) and vein (fluorite, calcite, barite and others) minerals are determined on the basis of more than 4000 measurements of Th. The analysis of more than 1500 determinations of the pressures characterizing the fluid regime of upper parts of earth's crust and the processes of ore formation especially is given. The importance of fluid inclusions in the practice of the prospecting of the deposits of useful minerals is emphasized. (From the authors' abstract)

YERMAKOV, N.P., NAUMOV, V.B. and KHITAROV, D.N., 1984b Fluid inclusions in minerals and their significance in the study of hydrothermal ore formation: Proc. 27th Int'l. Geol. Congress, Moscow, 4-14 August 1984, Vol. 10, Mineralogy, p. 185-203. Authors at Moscow State Univ., Inst. Geochem. & Anal. Chem. of Acad. Sci. USSR, Ministry Geol. USSR, Moscow, USSR.

A review (32 references) of fluid inclusion studies. Includes tabulations of the number of inclusion papers published per year; the "most favorable" temperature of formation and the state of aggregation of the fluids for various minerals; the data on 3 types of beryllium deposits; the range of salinities for 2301 determinations; the P-T ranges for 1526 determinations; and the anion and cation ratios for various types of deposits. (E.R.)

YEROKHIN, V.Ye. and TITKOV, G.A., 1983, First data on hydrogen-isotope distribution in methane from mud-volcano gases of Azerbaidzhan and Turkmenia: Dokl. Akad. Nauk SSSR, v. 271, no. 3, p. 715-717 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 190-192, 1984).

YIN, Hanhui, YU, Cimei, ZHANG, Guoxin and LU, Jialan, 1984, Sedimentary-reformed Pb-Zn deposits in China: Scientia Sinica, Ser. B., v. 27, no. 8, p. 852-864. Authors at Inst. Geochem., Acad. Sinica, Guiyang, China.

This paper considers the geological characteristics and stable isotopic compositions of sedimentary-reformed Pb-Zn deposits of China, the physical and chemical properties and sources of reformed fluids, and the experimental studies of migration and deposition of Pb and Zn in them. It is suggested that after ore substances were synchronously deposited with source beds, they were reformed through later geological events, thus making the sedimentary deposits further enriched. There is no obvious genetic relation between ore formation and magmatic activity. (Authors' abstract)

Includes δD and $\delta^{18}O$ data on fluid inclusions, in 11 samples from Fankou, Siding, Lemei, and Jinding deposits, as well as Th and salinity data. (E.R.)

YONOVER, R.N., 1984a, Laser decrepitation and analysis of fluid inclusion from the Meguma Complex, Nova Scotia: nature of the ore-forming fluids: MS thesis, Florida State Univ., Tallahasse, FL, 129 pp.

One hundred and three fluid inclusion-bearing quartz veins from the Cambro-Ordovician Meguma Complex of Nova Scotia were analyzed for water and carbon dioxide using laser decrepitation volatile extraction coupled with a sensitive and calibrated capacitance manometer and separately with a gas chromatograph-mass spectrometer. This new analytical technique circumvents the need for whole sample analysis through the selective decrepitation of individual fluid inclusions, which are free of CO_2-containing contaminants, such as carbonate and secondary CO_2-rich inclusions. This method was employed in combination with microthermometric (heating/freezing stage) fluid inclusion temperature determinations, mass spectrometry, and field observations. Primary fluid inclusions were analyzed in triplicate from each of the various metamorphic zones of the Meguma. Heating stage analysis show homogenization temperatures clustering into three thermal groups; ≈266 ± 10°C, ≈328 ± 10°C, >390°C, which persist throughout all the metamorphic grades. The salinity of these primary inclusions, as determined by freezing point depression, range from 5.0 to 8.5 equiv. wt. % NaCl with a mean of ≈6.5%. Molalities of CO_2 obtained by laser decrepitation analysis are variable, with a large number of relatively low values of $mCO_2 \approx 2.000$ associated with the higher grade metamorphic veins. Oxygen isotope internal geothermometry performed on K-feldspar/quartz mineral pairs provide formation temperatures of ≈322°C for the biotite grade and ≈597°C for the staurolite-andalusite-cordierite grade, respectively. Pressure determinations from the fluid inclusions suggest emplacement depths on the order of 1500 meters for the biotite grade, which agrees with the pressure calculations using the mCO_2 laser decrepitation parameters. Carbon isotope mass spectrometry of carbonate in equilibrium with both the low and high grade quartz veins give extremely light isotopic signatures ($\delta^{13}C(PDB) \approx 23$), suggesting a sedimentary organic origin for the carbon in the ore containing quartz veins. (Author's abstract)

YONOVER, R.N., 1984b Laser decrepitation and fluid inclusion analysis of the Meguma Complex, Nova Scotia: nature of the ore-forming fluids (abst.): EOS, v. 65, no. 45, p. 1125. Author at Univ. Hawaii, Geol. & Geophy., Honolulu, HI 96822.

See previous item.

YONOVER, R.N., SOMMER, M.A. and HAYNES, S.J., 1984, Laser decrepitation and analysis of fluid inclusions from the Meguma terrane, Nova Scotia:

nature of the ore forming fluids (abst.): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 72. First author at Florida State Univ., Dept. Geol., Tallahassee, FL 32306, USA.

Fluid inclusions in quartz veins from the Meguma Terrane of Nova Scotia were analyzed for water and carbon dioxide using laser decrepitation volatile extraction, coupled with a sensitive calibrated capacitance manometer, and separately with a gas chromatograph-mass spectrometer. These methods were employed in combination with heating and freezing stage fluid inclusion temperature determinations and field observations. Primary fluid inclusions were analyzed in triplicate from each of the various metamorphic zones of the Meguma. Fluid inclusions in the chlorite zone have homogenization temperatures of 263°C, salinities of 6% NaCl, and carbon dioxide/water ratios of 0.010 ($mCO_2 = .556$). The higher metamorphic grade quartz vein fluid inclusions exhibit trimodal homogenization temperature distributions of 260°C, 325°C, and over 350°C and salinities clustering around 6% NaCl. The carbon dioxide/water ratios are 0.006 ($mCO_2 = .333$) for Isaac's Harbour/Bakers House (biotite grade), 0.004 ($mCO_2 = .222$) for South Isaac's Harbour (biotite grade), and 0.003 ($mCO_2 = .167$) for Cochrane Hill (staurolite/andalusite grade). The CO_2 content of the ore fluid is inversely proportional to metamorphic grade. The volatile species present in the South Isaac's Harbour fluid inclusions as determined by gas chromotograph-mass spectrometry after laser extraction are H_2O (98%), CO_2 (1%), CH_4, Ar, and other trace components. (Authors' abstract)

YORK, Derek, HALL, C.M., GASPAR, M.J. and LYNCH, Michael, 1984, Laserprobe 40Ar/39Ar dating with ultrasensitive mass spectrometer (abst.): EOS, v. 65, p. 303.

YOSHIDA, Yutaka, 1984, Origin of gases and chemical equilibrium among them in steams from Matsukawa geothermal area, northwest Japan: Geochem. J., v. 18, p. 195-202. Author at Geotherm. Dev. Div., Japan Metals & Chem. Co., Ltd., 24 Ukai, Takizawa-mura, Iwate-gun, Iwate 020-01, Japan.

Gas components contained in geothermal steams discharged from wells at the Matsukawa geothermal areas were examined geochemically. The original deep seated gases of northeast Japan are suggested to be uniform with respect to He, Ar and N_2 and are emitted through geothermal wells and/or fumaroles after mixing in various proportions with atmospheric air dissolved in ground water.

Geothermal wells of the Matsukawa area are divided into two groups by the geological structure of the area which controls the variation in concentrations of tritium and major gas components. The influence of the geological barrier can be considered to be limited in a shallow horizon.

The correlation between gas components indicates that the reaction, $2NH_3 = N_2 + 3H_2$, is in equilibrium, but the reaction, $CH_4 + 2H_2O = CO_2 + 4H_2$, is not in equilibrium under the condition of the Matsukawa geothermal reservoir. (Author's abstract)

YOULES, Ian, 1984, Painter uranium deposit (abst.): Abstracts of Papers of the 27th Int'l. Geol. Congress, Moscow, 1984, v. 9, pt. 1, p. 383.

The Mt. Gee, Armchair, Streitberg Ridge and Radium Ridge primary uranium deposits consist of uraninite, pyrite, chalcopyrite, molybdenite, monazite, fluorite and barite in a matrix of chlorite and hematite, which infilled and replaced as layers a potash rich (10% K_2O) partly sericitized granitic breccia in the Radium Ridge beds. Minor amounts of sandstone, siltstone, diamictite and arkose also occur. Uranium content averages 0.1% along with Cu 0.05%, Mo 0.03%, Co 0.035% and Ce group 0.5%. Isotopic data indicate a magmatic origin and fluid inclusions show temperatures of

300-400°C with aqueous solutions of low salinity. (From the author's abstract)

YOUNG, I.M., 1984, Mixing of supernatant and interstitial fluids in the Rhum layered intrusion: Mineralogical Mag., v. 48, p. 345-350. Author at Dept. Geol., Univ. St. Andrews, Fife, Scotland KY16 9ST.

An alternative explanation for the occurrence of chrome-spinel layers in the Eastern Layered Series of the Rhum intrusion is suggested by extreme concentrations of chrome-spinel in small-scale structures in the layer at the unit 7-8 boundary (Brown, 1956). These take the form of downward pointing cones several centimeters across and deep, and lined or wholly filled with chrome-spinel; lamination in the underlying allivalite exhibits quaquaversal dips around these cones. By comparing these structures to fluid escape structures in clastic sediments, it is proposed that spinel is the product of mixing and reaction of upward moving interstitial liquid and more primitive liquid newly emplaced in the chamber. Further evidence of the presence of a second liquid during spinel crystallization is provided by spherical silicate inclusions within spinel grains. Complex zoning in feldspars in the underlying allivalite suggests that the newly emplaced primitive liquid was able to penetrate the crystal mush on the intrusion floor. (Author's abstract)

YPMA, P.J., 1984, The lead-zinc mineralization at Box Hole Bore, Georgina basin, Northern Territory: The Aus. I.M.M. Conf, Darwin, NT, p. 339-345. Author at Dept. Econ. Geol., Univ. Adelaide, Adelaide, South Australia.

The inclusions are only moderately saline (18% NaCl), very high temperature (495-520°C), at very low density and low pressure (700 bars), hence the Box Hole Bore mineralization is not a variant of the Mississippi Valley-type, as commonly thought. (E.R.)

YPMA, P.J., DE BOORDER, H., VAN GILS, H., KEHRENS, P., ORMSBY, W. and PETERS, M., 1984, Geology and mineralization of the Jervois Range, N.T.: The Aus. I.M.M. Conf., Darwin, N.T., p. 319-321. First author at Dept. Econ. Geol., Univ. Adelaide, P.O. Box 498, Adelaide, SA 5001.

Fluid inclusion studies indicate a cooling hydrothermal event in a closed system: starting at a temperature of 390°C and 2 kb pressure, the fluids segregated into a CO_2-rich fluid and a brine of increasing salinity during regional cooling. The copper-silver mineralization was affected by the high temperature end of this cooling fluid (300-200°C); scheelite mineralization followed in the 200-100°C domain and lead-silver-zinc mineralization was the last to be affected (150-90°C) by brines with salinities of up to 30% equivalent $CaCl_2$. (From the authors' text)

YU, Tiejie, 1984, [Fluid inclusions in minerals], p. 113-123, in Su, Zongwei and Yi, Xiaoyun, eds., Porphyry copper deposits of China, Inst. Geol. Research of Ministry of Metallurgical Industry, Beijing, Sci. Pub. House (in Chinese).

A review of the literature (note that the specific authorship of individual sections in this book is not listed). (E.R.)

YUDINTSEV, S.V., XUAN, P.T., GRAMENITSKIY, Ye.N. and SHCHEKINA, T.I., 1983, Experimental modeling of formation of nepheline syenite pegmatite: Dokl. Akad. Nauk SSSR, v. 268, no. 2, p. 409-413 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 270, p. 119-122, 1984).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 296, 1983. (E.R.)

ZAIKIN, I.D., 1984, New method for increasing the reliability of the determination of compositions of gas-liquid inclusions in hydrothermal minerals: Dokl. Akad. Nauk SSSR, v. 274, no. 5, p. 1179-1181 (in Russian). Author at Amur. Kompleksn. Naushno-Issled. Inst., Blagoveshchensk, USSR.

Determination of the CO_2 content of fluid inclusions can be difficult because of separation of CO_2 from impurities in the inclusion-hosting mineral when it is heated. A method is proposed for determining the temperature boundaries of fluid separated from gas-liquid inclusions in hydrothermal minerals, which is based on results of experimental study of the thermokinetics of CO_2 and H_2O separation during the heating of samples within narrow intervals. The curves of CO_2- and H_2O-separation (of the CO_2 or H_2O concentration vs. temperature) for quartz used as an interlaboratory standard are sigmoid, with the CO_2/H_2O ratio remaining nearly constant at 0.060. In heating of a cassiterite sample the CO_2/H_2O ratio remained constant over the 180-380° interval and then began to systematically decrease, due to increased separation of H_2O. In heating of fluorite sample, the CO_2/H_2O ratio remained constant over the 150-400° interval and then increased due to addition of CO_2, accompanied by separation of CH_4. The upper temperature limit for determining the composition of fluid inclusions by chromatography of gases separated during heating is thus ~400° for cassiterite and fluorite. (CA 100: 213145w)

ZAIKIN, I.D., SHAKHRAI, S.A. and MOISEENKO, V.G., 1984, Device for chromatographic determination of gas constituent in inclusions in minerals: Zhurnal Analiticheskoi Khimii, v. 39, no. 5, p. 861-865 (in Russian; translated in J. Anal. Chem. of USSR, v. 39, no. 5, p. 691-695). Authors at Amur Joint Sci.-Res. Inst., Far-East Sci. Center, Acad. Sci. USSR, Blagoveshchensk.

A device has been designed and constructed for the thermal breakup of inclusions in minerals and the introduction of the gases into the chromatograph; this device is distinguished by very tight sealing of the connecting elements, and it is designed so that the gas constituent of the inclusions can be analyzed for different temperature intervals, using a single sample. The detection limits for H_2, N_2, CO, CH_4, and CO_2 when using the LKhM-8MD chromatograph, were found to be $(C(min) \cdot 10^{-4}$ mg): 2.2, 0.6, 0.9, 0.4, and 1.9, respectively. (Authors' conclusions)

ZAIKOWSKI, A., KOSANKE, B.J. and HUBBARD, N., 1984, Progress on radiometric dating of Wolfcamp brines using ^4He and ^{40}Ar: Materials Research Soc. Symp. Proc., v. 26, p. 943-949. First author at Bendix Field Engrg. Corp., Grand Junction, CO 81502.

Ground water samples (brines) from deep wells in the Palo Duro Basin, Texas are being analyzed for noble gases in an attempt to obtain radiometric ages for these brines. The brines contain radiogenic ^4He and ^{40}Ar produced from the radioactive decay of U, Th, and K. Consideration of hydrochemical data for the brines, various isotopic, chemical, and mineralogical data for the aquifer rocks and noble gas production rates allow estimating the age of the brines to be about 130 million years at two wells. At a third well interaquifer mixing has occurred and the age is presently indeterminate. (Authors' abstract)

ZAKIROV, I.V., 1984, P-V-T relations in the system H_2O-CO_2 under 300 and 400°C at the pressure up to 1000 bar: Geokhimiya, 1984, no. 6, p. 805-811 (in Russian; English abstract).

Values of molar volumes of mixtures of H_2O and CO_2 of various composition along isotherms 300 and 400°C were measured in experiments. Surplus molar volumes v^E vs. P has a gap at the pressure corresponding to pressure of water at its critical density. Based on the obtained results and published data isochore plots up to 1700 bar and 700°C were made. It was shown that isochores of real mixtures are linear up to the immiscibility dome that gives a possibility to extrapolate scarce experimental data in calculation of pressures of mineral formation from the gas-liquid inclusions. (Author's abstract)

ZASHU, S. and OZIMA, M., 1984, $^3He/^4He$ ratio in diamonds and its implication on the early history of the earth (abst.): EOS, v. 65, p. 304.

ZATSIKHA, B.V., 1983, Metacinnabarite from mercury deposits at Transcarpathians and its typomorphism: Zapiski Vses. Mineral. Obshch., v. 113, no. 3, p. 317-324 (in Russian). Author at Ivano-Frankovsk Inst. of Oil and Gas, Ivano-Frankovsk, Ukraine.

Polymetallic mineralization with gold formed at 205-299°C (Th of inclusions in quartz). Quartz, calcite and cinnabar from mercury mineral-bearing paragenses yielded Th in ranges (°C) 100-270 (in cinnabar 120-150, realgar 80-90), pH of solution in individual inclusions - 6.5-8.9, gases (vol. %) CO_2 9-98, N_2 1.3-70.9, H_2 0.3-44.5, CH_4 0.03-83.9. (A.K.)

ZATSIKHA, B.V., 1984, Fluorite of the Ukraine: Mineral. Zh., v. 6, no.4, p. 104 (in Russian).

Fluorites from pegmatites, greisens, and hydrothermally altered dolostones and limestones are described. Green fluorite (Ft) from pegmatites of Volyn formed syngenetically with topaz and shows enrichment in yttrian-group rare earths. Bluish violet to violet Ft from pegmatites shows color zones and formed at temperatures from 300-340 to 150-160°. Fluorites from Ft greisen formed at 320-340°, pH 5.8-6.2 (cubic crystals), 125-130°, pH 5.0 (cubooctahedral crystals), and 145-155°, pH 5.8-6.2 (blue-violet cube). The gas phase of fluid inclusions in Ft from carbonate rocks of the Donets Basin had Th 150-160° and contained CH_4 60.38, C_2H_6 0.59, and C_3H_8 0.33%. Dark violet Ft crystallized at 220-280° and the light colored to transparent variety crystallized at 80-190°. (CA 101: 174840t)

ZATSIKHA, B.V., KVASNITSA, V.N., GALIY, S.A. and MATKOVSKIY, O.I., 1984, Typomorphism of minerals from polymetal and mercury deposits of Transcarpathians: "Naukova Dumka," Kiev, 168 pp., 500 copies printed, price 1 rbl. 50 kopecks (in Russian). Authors at Inst. of Geochem. & Physics of Minerals, Kiev, Ukraine.

The wall-rocks of ore (Au-polymetallic and mercury) bodies of the Sredneslovatskaya-Apusenskaya and Presov-Hargit zones in Transcarpathians consist of Cretaceous flysch, probably Triassic-Jurassic carbonates and Riphean-Paleozoic shales and siliceous rocks, plus locally Miocene-Pliocene volcanic-sedimentary molasse. Neogene volcanites are of liparite-ignimbrite and andesite-basalt formations. Polymetallic ores occur in the Beregovskoe and Vyshkovo ore fields in fault zones; ore rocks are propylites, alkaline metasomatites and secondary quartzites and they bear five essential ore types: 1) gold-pyrite-galena-sphalerite, 2) gold-galena-sphalerite, 3) gold-quartz-hematite, 4) gold-quartz-adularia, 5) gold-quartz-barite-kaolinite-hydromica. Mercury ore formation occurs in Vyshkovo (deposits Grendesh, Borkut etc.), Olenevskoe and Dubrinskoe ore regions, including three mineral types: 1) cinnabar, 2) metacinnabarite-cinnabar, 3) sphalerite-galena-cinnabar; common but less important are mercury-rare metal (gold) and mercury-arsenic-antimony formations.

Galena from Beregovskoe deposit bears gases in inclusions: CO_2 28.6-20.2 vol.% + N_2 70.2-64.8 vol.% + traces of hydrocarbons and H_2; salts in inclusion fluids consist of K, Na, Ca, Mg and SO_4, pH of leachates 8.5. Galena from Beganskoe deposit formed at 265-190°C, gases consist of N_2 64.8-70.2 vol.%, CO_2 up to 20.2 vol.%, He up to 11.1 vol.% and CH_4 2.7 vol.%; salts include Ca, Na>K, Mg, plus Cl, HCO_3 and SO_4 in central part of the deposit, pH of water leachates 8.5. Sphalerite from the same deposits contains inclusions of Th 155-250°C, frequently with 5-10 vol.% LCO_2. Quartz and calcite paragenetic with metacinnabarite yielded Th 120-210°C, pH of inclusion solution measured directly in inclusions 5-7, hydrocarbons are present in inclusion fluids. Cinnabar bears inclusions of Th 150-120°C, gases consist of CO_2 (50 vol.%), N_2 (4.5 vol.%), CH_4 (4.4 vol.%) and H_2 (40.5 vol.%).

Quartz from ores gave Th 120-262°C, pH of inclusion solutions 6.5-8.9, T frz -2.0 to 0°C, gases: CO_2 89.1-40.0, N_2 62.0-8.8, H_2 1.0-16.0, CH_4 nil to 20.5 (vol.%); calcite yielded Th 100-270°C (early) and 60-80°C (late). (Abstract by A.K.)

ZATSIKHA, B.V. and SVOREN, J.M., 1984, The role of natural gases in the transportation and concentration of ore elements and their value in the search for minerals, using hydrothermal ore formation and abiogenic synthesis of hydrocarbons as an example: Min. Sbornik, v. 38, no. 2, p. 37-45 (in Russian; English abstract).

Study of the composition of gases showed that postmagmatic solutions of high temperature contain CO_2 of high density (0.7...0.9 g/cm^3) and the change of its concentration results in appearance of geochemical barriers and formation of rare-metal ore parageneses. Mercury parageneses (Donbass, Khardarkan, Transcarpathia) contain CO_2 of density of 0.24...0.09 g/cm^3. Deposits of volcanogenic type were formed from solutions containing both CO_2 and hydrocarbons (CH_4, C_2H_6 and others). Constant association of hydrocarbons and mercury can indicate their abiogenic origin and the possibility of transportation of mercury in the form of organic complex mercury compounds. (Authors' abstract)

ZAW, U.K., 1984, Geology and geothermometry of vein-type W-Sn deposits at Pennaichaung and Yetkanzintaung prospects, Tavoy Township, Tennasserim Division, southern Burma: Mineral. Deposita, v. 19, no. 2, p. 138-144. Author at Applied Geol. Dept., Post-graduate Training in Min. Explor., Rangoon Univ. Thamaing College P.O., Thamaing, Rangoon, Burma.

The Pennaichaung and Yetkanzintaung W-Sn Prospects are located in Tavoy Township, Tennasserim Division, southern Burma. The W-Sn mineralization at the Pennaichaung is closely related with a small, satellitic granitoid pluton of presumably Late Mesozoic age, which intruded the metaclastic rocks of Mergui Group (mostly Carboniferous). The mineralized quartz veins at the Pennaichaung penetrated the granitoid-metasedimentary rocks contact. In contrary to the Pennaichaung deposit, the W-Sn veins at the Yetkanzintaung are exclusively in the metasedimentary rocks of slates and quartzites of Margui Group. Mineralized quartz veins in the Pennaichaung area trend NNE-SSW, NW-SE and NE-SW with a maximum thickness of 30 cm, but only quartz veins trending NNE-SSW are found to be productive and contained economically workable wolframite and cassiterite. Majority of the mineralized quartz veins in the Yetkanzintaung area trend approximately N-S with easterly dip of 50°-70°. The thickness of the ore veins in the Yetkanzintaung area are thinner than those of the Pennaichaung and range from 1 cm to 20 cm with an average width of 5 cm. Fluid inclusion studies of the quartz from the ore veins cutting the granitoid in the Pennaichaung area have yielded a filling temperature range of 170°-270°C with a maximum mode of 220°C, while quartz crystals from the ore veins in the nearby metasedimentary rocks gave a filling temperature range of 140°-220°C with a maximum mode of 160°C. Hence, the Pennaichaung deposit was thought to have emplaced under a filling temperature range of 140°-270°C, whereas the fluorites associated with the mineralized quartz veins gave a temperature range of 140°-160°C. Limited freezing runs indicate a salinity of less than 5 NaCl equivalent weight percent for inclusions in quartz from both orebodies. No fluid inclusion evidence of boiling of ore fluids nor presence of liquid CO_2 was observed in this study. Thus, the ore fluids responsible for the W-Sn mineralization at the Pennaichaung and Yetkanzintaung areas were of low temperature, diluted, CO_2-deficient, NaCl brines. (Author's abstract)

ZAYKIN, I.D., 1983, A new method for increasing the reliability of the determination of the composition of two-phase inclusions in hydrothermal minerals (in Russian; translated in Int. Geol. Rev., v. 26, p. 1331-1333, 1984).

See Zaykin and Moiseenko, 1982 (Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 297, 1983). (E.R.)

ZAYKIN, I.D., 1984, New method of increase of reliability of determination of gas-liquid inclusion composition in hydrothermal minerals: Akad. Nauk SSSR Doklady, v. 274, no. 5, p. 1179-1181 (in Russian). Author at Amur Complex Sci.-Research Inst. of Far-East Sci. Center, Blagoveshchensk, USSR.

The main problem that arises during thermal release of volatiles from fluid inclusions is that of distinguishing between fluid inclusion content and contamination coming from organic matter (→CO_2) and trapped hydrous minerals. The author proposes studies of the thermokinetics of gas- and water release in narrow T intervals (40-50°C) as the solution of the problem. The recommended upper T limit of CO_2 and H_2O release is determined by a constant CO_2/H_2O ratio in the above T intervals. Change of the CO_2/H_2O ratio proves contamination of volatiles from decomposition of mineral admixtures. For correct results samples of 3-5 g should be used. The method was checked for quartz, cassiterite and fluorite specimens. (Abstract by A.K.)

ZAYKIN, I.D. and MOISEYENKO, V.G., 1982, A new method for determining the true crystallization temperatures of minerals: Dokl. Akad. Nauk SSSR, v. 265, no. 6, p. 1486-1488 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 265, no. 6, p. 147-149, 1984). Authors at Amur Interdiscipl. Res. Inst., Far Eastern Sci. Center, USSR Acad. Sci., Blagoveshchensk, USSR.

The method is based on a mathematical treatment of the thermokinetics of gas liberation from inclusions on heating. (E.R.)

ZENG, Rongshu and MacKENZIE, W.S., 1984, Petrogeny's residua system at $P(H_2O)$ 5 kb: NERC, Progress in Experimental Petrology, Sixth Progress Report, Natural Environment Research Council, Cambridge, Publication Series D, no. 25, p. 23-25.

ZENG, Yishan and LIOU, J.G., 1984, Experimental study of basalt glass Na-carbonates (± NaCl) solutions reaction at 300°C and 500 bars: formation of altered minerals and solution chemistry: Scientia Sinica, Ser. B, v. 27, no. 4, p. 420-435 (in English). First author at Dept. Geol., Peking Univ., China.

In order to understand the mechanism of basalt-seawater interaction, including the role of CO_2-species, the change in solution chemistry and the formation of the secondary minerals in the reaction between JB-2 basalt glass and hydrothermal solution have been studied by both Dickson gold cell and sealed capsule techniques at 300°C and 500 bars and solution/rock mass ratio of about 10. Solutions used are H_2O, 0.5% Na_2CO_3, 0.5% $NaHCO_3$, 0.14% $NaHCO_3$, NaCl-$NaHCO_3$ with different Cl^-/HCO_3^- ratio, and 0.1% NaCl solutions. The results clearly indicate that the two types of experiments have a basically identical alteration mineralogy. The basalt glass-Na-salt solution (including seawater) reaction at 300°C and 500 bars essentially is a reaction between basalt glass and water. The presence of CO_2-species causes a decrease of Na-content in the reacted solution and the formation of the secondary carbonate. (Authors' abstract)

ZEUCH, D.H. and GREEN, H.W., II, 1984, Experimental deformation of a synthetic dunite at high temperature and pressure. I. Mechanical behavior, optical microstructure and deformation mechanism: Tectonophysics, v. 110, p. 233-262. First author at Geomechanics Div. 1542, Sandia Nat'l. Labs., Albuquerque, NM 87185, USA.

The optical textures of highly recrystallized experimental specimens are essentially identical to naturally produced porphyroclastic textures and the deformation mechanism in both the experimental and natural specimens is probably dislocation creep with recovery by dynamic recrystallization. (From the authors' abstract)

ZHANG, Baogui and LIANG, Weiyi, 1984, Strata-bound mercury ore deposits in carbonate strata in China: Scientia Sinica, Ser. B, v. 27, p. 199-209 (in English). Authors at Inst. Geochem., Acad. Sinica, Guiyang, PRC.

China is abundant in mercury. The mercury ore deposits are mostly strata-bound and occur mainly in carbonate strata and are strictly controlled by certain horizons. Characterized by low mineralizing temperature, simple mineral composition and rare wallrock alteration, the strata-bound mercury ore deposits have no genetic relationship with the magmatic rock. The formation of mercury ore is a result of reforming process in which the mercury substances in source bed are transported and concentrated under a series of epigenetic thermodynamic events as well as tectonic activities. (Authors' abstract)

Most inclusions in the Wanshan deposit are one-phase liquid, but some gas inclusions, some with dm NaCl, and some with organic matter were seen. (E.R.)

ZHANG, Zheru and LIN, Chuanxian, 1984, A thermodynamic study of physicochemical conditions for the formation of Meishan iron deposit: Geochimica, 1984, no. 2, p. 138-144 (in Chinese; English abstract).

ZHANG, Zhixian, 1984, A study of inclusions in the minerals from granites of eastern Heilongjiang Province: Bull. Shenyang Inst. Geol. Min. Res., 1984, no. 9, p. 107-115 (in Chinese; English abstract).

1. In the granites of eastern Heilongjiang there are common crystal-liquid inclusions which are closely similar to fluid inclusions in external form, but are intermediate between melt and fluid inclusions in nature. Tt ranges from 800°C to 900°C, much higher than that of the fluid inclusions and lower than that of the melt inclusions.

2. Many kinds of inclusions have been found in the syntexis type of granite. Among them, melt inclusions consist of crystal, glass, and crystal-liquid inclusions, and the fluid inclusions are characterized by the presence of gas and fluid phases as well as multiphase inclusions containing halide daughter crystals. These formed during magma evolution with graudally decreasing T. Sometimes, they appear in the same field under the microscope, reflecting the nonuniform composition of the primary magma.

3. Characteristically, melt inclusions are common in syntexis granites, crystal-melt inclusions predominate in slowly cooled hypogene rock bodies, and vitreous-melt inclusions predominate in fast-cooled hypabyssal rock bodies. The dominant inclusion in the transformation type of granites has a small gas-fluid proportion, is small, and occurs in oriented array. When highly granitized, melt inclusions occur.

4. To compare Xingkaiian, Indosinian and Yanshanian rock bodies, the inclusions show a regular variation with age of the granite, from old to young. Generally, the kinds of inclusion vary from fewer to more, the compositions vary from simple to complex, and the forming temperatures vary from lower to higher. (Author's abstract)

ZHAO, Xicheng, 1984, Information of inclusions in the minerals of porphyry copper (molybdenum) deposit and its application in deciphering deposit genesis and for ore prospecting: Changchun Dizhi Xueyuan Xuebao, no. 2, p. 103-112 (in Chinese). Author at Changchun Coll. Geol., Changchun, PRC.

Fluid-inclusion studies were made to determine the formation conditions of a Cu-Mo porphyry deposit in China. Three types of inclusions are present: polyphase fluid, gaseous, and liquid inclusions. Th of the inclusions is commonly 250-400° and the salinity is 26-62 wt. %. Present in the inclusions is H_2O, CO_2, CO, N_2, Cl, F, K, Na, and other components. The polyphase fluid inclusions are concentrated mainly in the interior part of orebodies; the gaseous inclusions are localized especially in the peripheral part and in the contact zone of these bodies. Also, the inclusions with high salinity are distributed in the orebodies. The salinity is ≥20 wt. % even at the periphery of orebodies. Halite, sylvite, gypsum, pyrite, hematite, and carbonates occur as daughter minerals in the polyphase fluid inclusions. When only halite is present ore mineralization is absent. The Cu and Mo were transported as alkali metal halide complexes and sulfuosalt complexes in alkaline to weakly acidic hydrothermal solutions. Extensive tectonic fracturing of rocks, lowering the pressure and causing the boiling of hydrothermal fluids and gas release, was a factor in ore formation. Mixing of ore-bearing solutions with groundwaters and reaction with wall rocks also led to the precipitation of ore minerals. (C.A. 102: 9919p)

ZHU, Bingqiu and XU, Waisheng, 1984, Geochemical characteristics of mineralization of porphyry copper deposits: Geochimica, 1984, no. 2, p. 107-117 (in Chinese; English abstract).

ZHUYKOVA, T.L., VDOVYKIN, G.P., LEBEDEV, V.S., IL'CHENKO, V.P., MUSIN, M.Kh. and AIMENKOVA, O.I., 1983, Gaseous hydrocarbons in igneous rocks of eastern Siberia: Dokl. Akad. Nauk SSSR, v. 272, no. 4, p. 956-960 (in Russian). Authors at All-Union Research Inst. of Nuclear Geophy. & Geochem., Moscow, USSR.

Igneous rocks occurring as sills in the Siberian Platform bear hydrocarbon gases. Samples for studies were collected from drill cores of the deep boreholes at the Kuyumbin, Sredne-Botuob, Poliguss, Nedzhelin, Mirmyi, Baykit, Sobolokh, Listvyanka, Verkhne-Rechka oil and gas deposits and gabbro and diabase from dikes of Caucasus. Gases were released by heating to 200, 350, 500 and 700°C and analyzed by gas chromatography. Siberian samples are the following rocks: dolerite, granite-gneiss, anorthositic gabbro dolerite, tuffite, granite and syenite (41 samples). Content of gases (in cm^3 per kg of rock) are in the following ranges: CH_4 0.003-15, C_2H_6 0.001-4.4, C_2H_4 0.001-4.5, C_3H_8 0.001-1.48, C_3H_6 0.003-2.7, i-C_4H_{10} 0.002-0.96, n-C_4H_{10} 0.001-0.70, i-C_4H_8 0.015-7.2, n-C_4H_8 0.001-1.5, i-C_5H_{12} 0.011-0.89, n-C_5H_2 0.03-2.6, sum of hydrocarbons 0.04-48.8, CO_2 81.4-641.

Occurrence of hydrocarbons may be connected with the adjacent oil and gas deposits. (Abstract by A.K.)

ZIERENBERG, R.A., 1984, The Mattagami Lake mine Archean Zn-Cu sulfide deposit, Quebec: Hydrothermal coprecipitation of talc and sulfides in a sea-floor brine pool--evidence from geochemistry, $^{18}O/^{16}O$, and mineral chemistry--a discussion: Econ. Geol., v. 79, p. 1951-1952. Author at Dept. Geol. & Geophys., Univ. Wisconsin-Madison, Madison, WI 53706.

Discussion of Costa et al., 1983 (Fluid Inclusion Research--Proceedings of COFFI, v. 16, p. 54). See also Costa et al., this volume. (E.R.)

ZIERENBERG, R.A. and SHANKS, W.C., III, 1984, Oxygen isotope geothermometry of Red Sea metalliferous sediment (abst): Geol. Soc. Am. Abstracts with Programs, v. 16, p. 704.

ZIERENBERG, R.A., SHANKS, W.C., III and BISCHOFF, J.L., 1984, Massive sulfide deposits at 21°N, East Pacific Rise: Chemical composition, stable isotopes, and phase equilibria: Geol. Soc. Am. Bull., v. 95, p. 922-929. First author at U.S. Geol. Survey, Br. of Pacific Marine Geol., 345 Middlefield Road, Menlo Park, CA 94025.

Study of massive sulfide deposits at 21°N, East Pacific Rise (EPR) indicates that coexisting sulfide minerals are not in isotopic equilibrium. Sulfur isotope values of sulfide mineral separates range from 1.5 to 4.5 per mil and indicate isotopic disequilibrium. Isotopic fractionation between coexisting minerals is small (<0.5). Larger differences between samples can be attributed to temporal variations in the isotopic values of H_2S in the venting fluids. Sulfur isotope values of anhydrite and barite indicate disequilibrium with coexisting sulfides and show that ambient sea-water sulfate, not the hydrothermal fluid, is the sulfur source for anhydrite and barite. Oxygen isotope geothermometry applied to anhydrite sulfate provides temperatures of 194 and 222°C. Detailed petrographic study of mineral paragenesis shows that the initial hydrothermal precipitates form from a fluid with fO_2-fS_2 values that are below the pyrite-pyrrhotite boundary. High-iron wurtzite may initially precipitate within the pyrrhotite stability field, but most wurtzite co-precipitates with pyrite as the fluid evolves into the pyrite stability field by mixing with cold oxygenated sea water. Precious-metal values, with the exception of silver, are uniformly low, especially for the platinoid metals. Silver content ranges to 240 ppm. Silver is predominantly associated with zinc-sulfide phases and does not occur in significant amounts as a discrete silver-bearing mineral. (Authors' abstract)

ZILBERFARB, Arieh, LANG, Barbu and VADAI, David, 1984, Fluid inclusion studies on pegmatites from southern Sinai: Geol. Survey Israel, Current Research 1983-84, p. 5-7.

Pegmatitic veins commonly occur in the Precambrian of Sinai. Two genetic varieties were described by Ziberfarb (1982), the first variety associated with granitic intrusives, and the second related to migmatites.

This study reports the results of fluid inclusion measurements of pegmatitic veins associated with granitic activity. The analyzed samples are from the Wadi Asala area, where pegmatitic and quartz veins occur in association with biotite to leucocratic granite. The veins strike NW-SE and are concentrated near the contacts between the granite and later diabase dikes. The mineral association of the veins typically consists of quartz, orthoclase and sometimes fluorite and beryl. (From the authors' abstract)

Th range 216 to >450°C; Tm (ice?) -0.6 to -5.5. (E.R.)

ZIL'BERSHTEYN, A.Kh., 1984, Determination of temperature and pressure of formation of nonhomogeneous crystals by polarization-optical method: Zapiski Vses. Mineral. Obshch., v. 113, no. 1, p. 106-109 (in Russian). Author at All-Union Sci.-Research Geol. Inst., Leningrad, USSR.

The paper describes use of solid inclusions (quartz) in fluorite for finding of true P and T of mineral formation. (A.K.)

ZIMMERMANN, J.L., 1982, Fluids in natural and synthetic obsidians of similar chemical composition; kinetics of their liberation (abst.): PIRPSEV (Programme Interdisciplinaire de Recherches et de Surveillances des Eruptions Volcaniques), Workshop, held March 8-9, 1982, at Gif sur Yvette, France, Abstracts (unpaginated).

Gas analyses of two natural obsidians from Lipari and Iceland and a "Lipari type" synthetic obsidian (750°C, 2 kbars) has shown that the latter has a fluid content about a hundred times greater than the natural material; 95% of the essentially aqueous phase contained in the synthetic glass is liberated on heating before a temperature of 500°C is reached. Grinding of the synthetic glass causes a reduction in water content of almost a half (7.3 weight % before grinding compared with 4.2 weight % after); consequently this water is weakly bound.

Natural obsidians from Lipari and Iceland have very low fluid contents; besides water (0.1 - 0.2 weight %) there is a little hydrogen and traces of carbon compounds (CO_2, CO, CH_4) as well as cracking mass of heavier organic material, especially in the Lipari sample.

The kinetic study of the dehydration of synthetic obsidian has shown that water is already substantially removed at 300°C; little remains in the vitreous mass. Multiple activation energies (generally two) seem to indicate that water occupies different "energetic sites" which correspond either to different types of occupation of the glass structure (by hydrogen bonding, as hydroxyl radical, and as hydrogen-bonded H_2O pseudomolecule) or to the effect of the presence of mineral phases within the glass (e.g. quartz and feldspar phenocrysts). Consequently water in natural obsidian is considered to be juvenile, trapped at the time of solidification.

The release of carbon dioxide at relatively high temperatures indicates that it was already dissolved in the glass at the time of solidifcation. There is only one activation energy for its liberation which is the same for both natural and synthetic materials; this seems to indicate that this gas occupies a "single site." (Author's abstract)

ZINCHUK, I.N., KALYUZHNYI, V.A. and SHCHIRITSA, A.S., 1984, Fluid regime of hydrothermal mineral formation of Central Donbass, 104 pp., 580 copies printed, price 75 kopecks, "Naukova Dumka," Kiev (in Russian). Authors at Inst. Geol. & Geochem. of Mineral Fuels, L'vov, Ukraine.

The oldest rocks known in Donbass are Riphean; they are covered by Devonian sediments and transgressive Carboniferous beds. The latter are 4 km (NW) to 22 km (SE) thick and include hydrothermal bodies of the Nagol'nyi zone and Nikitovka ore region. The main Au-polymetallic deposits of the Nagol'nyi zone occur in the Bobrikovo, D'yakovo, Nizhniy Nagol'chik, Ostryi Bugor, Esaulovka and Orekhovo-Tarasovka regions (anticlines). Sb-Hg deposits occur in the domes in the W end of the Gorlovskaya anticline (Nikitovka). Quartz and quartz-carbonate veins with sphalerite, pyrite, arsenopyrite, galena, chalcopyrite are the main hydrothermals plus rarer tetrahedrite, boulangerite, jamesonite, apatite, dickite, donbassite and other silicates. They form associations: 1) pyrite-arsenopyrite, 2) polymetallic (sphalerite-galena with chalcopyrite and pyrite), 3) rectorite-cinnabar. Mercury deposits bear quartz, calcite, aragonite, siderite dolomite and ankerite as gangue minerals.

Sb-Hg deposits yielded Th and P: quartz-arsenopyrite association 290-175°C, >16 MPa, cinnabar-antimonite association 150-120°C, 1.6-12 MPa, Th for cinnabar 145-105°C; post-cinnabar quartz gave Th 110-90°C, pH changed from alkaline to weakly acid.

Minerals of Au-polymetallic deposits of W part of Nagol'nyi zone (Ostryi Bugor, Nizhniy Nagol'nik, Esaulovka) bear 3 genetic groups of inclusions: 1) early S 50-70 vol.% LH_2O + 50-30 vol.% LCO_2, sometimes 5-10 vol.% G, Th $LCO_2 + G \rightarrow LCO_2$ at 10-21°C, Th $LH_2O + LCO_2$ (in L or at the critical) 300-350°C, but inclusions frequently decrepitate; inclusion size 0.1 to 0.05 mm. Refractive index of LH_2O in inclusions is 1.340 ± 0.003, hence solution concentration ~4%, P ~60 MPa. 2) S or early S LH_2O + LCO_2 + G, various phase proportions, characterize inclusion-type LH_2O + LCO_2 parent solution. Th LCO_2 + G is in ranges 13-23°C, total homogenization at 180-150°C. 3) P, early- and late S 75-90 vol.% LH_2O + 5-0 vol.% LCO_2 + 25-10 vol.% G. In solutions of individual inclusions K was found in very low concentration (about 0.01%), BO_3 gives distinctly positive reaction, Pb and Fe were not found in inclusion solutions in quartz and sphalerite, pH 8.0 ± 0.2. Th >350°C, P 60-70 MPa; following this, the solutions heterogenized at 180-150°C and after escape of CO_2, solutions had T 270-130°C and P <40 MPa.

Au-polymetallic mineralization at Bobrikovo is characterized by high P-T parameters (T 350°C, P 170 MPa for sphalerite; quartz paragenetic with galena, Th 252-260°C, bears in inclusions LCO_2-LH_2O solutions). Gold-polymetallic stage yielded Th 246-248, 265-276 and 285-292°C; the earliest siderite bears inclusions with Th 320-325°C. Nagol'no-Tarasovskoe ore field has quartz-ankerite (siderite) veins with galena, sphalerite, chalcopyrite, tetrahedrite, arsenopyrite, pyrite and accessory native gold, Th 205-115°C and about 315°C, solutions frequently rich in CO_2. Rock crystal veins of Northern zone of Nagol'nyi with scarce sulfide mineralization yielded Th of P inclusions I 255-267°C, early S inclusions I - 260-265°C, early S inclusions II - 185-190°C, P inclusions II - 140-152°C, inclusions are filled by $LH_2O \pm LCO_2 + G \pm$ trapped mineral (frequently muscovite). By water leachates, salts dissolved in inclusion solutions in the studied area consist of the following ions (in mol.%): Na 88.2-98.8, K 0.4-3.5, Li nil to 2.0, Ca nil to 12.0, Mg nil to 7.0, Cl 13.5-97.1, SO_4 nil to 33.6, HCO_3 2.4-75.6, F nil to 10.5, total mineralization 40.7 to 104 mg/kg of quartz, pH of leachate 7.0-8.8 (24 samples analyzed). Cryometry of LH_2O in inclusions in quartz with Th 145-256°C yielded the following data: Te -6 to -30°C, but mostly -20.0 to -24.0°C, T of melting of last ice crystal -0.5 to -9.0°C, mostly -5 to -7.3°C, concentration of NaCl equiv. 3.3 to 12.9 wt.% (12 samples). Gas analyses by mass spectrometry indicated presence of the following gases (in vol.%): CO_2 31.8-92.6, N_2 3.5-64.7, CH_4 nil to 20.6 (15 bulk analyses); two individual inclusion analyses (also by mass spectrometry) yielded the following results: Bobrikovo Au-polymetallic deposit, ankerite-quartz vein with bournonite, inclusion in quartz: CO_2 23.9%, N_2 76.1%, CH_4 traces; Ostryi Bugor Au-polymetallic deposit, inclusion in quartz: CO_2 1.1%, N_2 96.6%, CH_4 1.8%, C_2H_6 0.5%. The authors discuss also the possible use of CO_2 content in fluid inclusions for prospecting for Au-polymetallic deposits. Special attention is paid to CH_4-H_2O fluids in hydrothermal mineral formation in Donbass. T of methane melting in inclusions was from -184 to -181°C, Th of methane fluid from -81 to -70°C, mass-spectrometric bulk analysis gave composition of methane fluids as follows: CO_2 0.9-7.4, N_2 0.5-5.6, CH_4 90.8-100.0, C_2H_6 nil to 1.0, water was determined only in one sample (1.7%), all in %, seven samples analyzed. Calculated P from LCH_4 inclusions are 30-45 MPa. Variations in T, P and fluid compositions in various deposits of the studied area are relatively small. (Abstract by A.K.)

ZINGG, M.A., 1984, The Tertiary Pb-Zn-Cu sulfide mineralization at Sackgraben, Engstlingental (Berner Oberland): Schweiz. Mineral. Petrogr. Mitt., v. 64, p. 215-225 (in German). Author at Inst. Kristal. & Petrogr., ETH-Zentrum, CH-8092 Zurich, Switzerland.

The Pb-Zn-Cu sulfide mineralization at Sackgraben, Engstlingental (Berner Oberland) has been studied geologically, mineralogically and geochemically. Field observations, S and Pb isotope analyses and fluid inclusion data on quartz indicate that the formation of the ore deposit took place after the major alpine orogene in Triassic and Tertiary rock sequences. The sulfides were deposited hydrothermally under low P-T conditions. (Author's abstract)

ZOLOTAREV, V.G., 1984, Peculiarities of location of gold ore mineralization in the progressive stage of development of the thermal fields of granitoid: Dokl. Akad. Nauk SSSR, v. 278, no. 2, p. 421-425 (in Russian). Author at Sci.-Research Inst. Geology of Foreign Countries, Moscow, USSR.

The paper bears some Th for gold mineralization quoted from papers of the other authors. (A.K.)

Translations

Items presented here are selected on the basis of (1) availability of a translation that has not been published elsewhere; (2) significance to inclusion research; and (3) date of publication. Thus particularly significant older items are sometimes included. Further iterations between translator (or author) and editor would make for a more polished translation, but more rapid publication was considered more important than polish. The Editors would welcome suggestions from readers as to other papers that should be translated, and would particularly appreciate copies of privately-made translations not here-to-fore published.

ANONYMOUS, ed., 1984, Studies of fluid inclusions in minerals, Symp. Nat'l. Meeting on Composition Research and Decrepitation Method of Fluid Inclusions in Minerals, Vol. 2: Geol. Pub. House, Beijing, 246 pp. (in Chinese).

The first national conference, on experimental studies of inclusions, was held in 1978 and the resulting collected papers were published in 1981 (see Acad. Sinica, 1981, in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 1, 1981). The next two national meetings were on the composition of fluid inclusions (1980) and the decrepitation of inclusions (1981). This book, although published in 1984, and called "Volume 2," contains the collected papers given at these two national conferences on fluid inclusions in PRC, 15 on composition and 51 on decrepitation.

In addition to the following 66 papers listed in the Contents (some are just abstracts), 35 "Titles of unpublished papers or those included in other publications" were listed at the end of the book. The titles are as given, unedited. The editorship is listed as "Anonymous," since no name is given in print, but I am told that Mrs. Jiaxue Wai of Beijing was the senior editor. (E.R.)

CONTENTS

Titles of unpublished papers or those
included in other publications

KOZLOWSKI, A. and SACHANBINSKI, M., 1984, Remarks on genesis of Polish chrysoprase as indicated by inclusion studies: Spraw. Pos. Kom. Nauk PAN, v. 28, no. 1., p. (in Polish). First author at Inst. Geochem., Mineralogy and Petrogr., Warsaw Univ., 02-089 Warzawa, al. Zwirki i Wigury 93, Poland.

Two largest occurrences of chrysoprase in Poland have commercial importance: 1) in the serpentinite massif of Szklary; 2) in the magnesite mine "Wiry" in the E. part of the serpentinite massif Gogotow-Jordanow, both in Lower Silesia. These deposits have similar geological structure. At Szklary the larger accumulations of chrysoprase are connected with serpentinite weathering that preserves primary rock structure and with increased nickel concentration. The Szklary massif consists of an inner core of serpentinized peridotite rocks with an outer zone of granitoids and metamorphic-mylonitic rocks. The whole massif is cut by leucocratic and melanocratic veins and pegmatites. All the above rocks are covered by weathered material in situ. In the mine "Wiry" chrysoprase occurs in the bottom part of the weathering zone, in the belt adjacent to the contact of the serpentinite massif with gabbro and granite intrusions. This massif especially in the contact zone is disjunctive and cut by leuco- and, melanocratic veins.

Two opposing hypotheses exist on the chrysoprase origin, which were formed to explain the genesis of the Ni-bearing weathering waste, exploited as nickel ore. One of the hypotheses (Foullon 1882, Aschermann 1887, Spangenberg and Muller 1948, Niskiewicz 1984) suggests that due to serpentinite weathering, significant amounts of silica-bearing solutions were mobilized, and the solutions, after penetration to deeper parts of weathering crust, precipitated various minerals of the silica group, including chrysoprase.

The second hypothesis (Kosmann 1893, Iller 1902, Beyschag and Krusch 1913, Brooks 1964, Haranczyk 1970) invokes the inflow of hydrothermal silica solutions from depth from which chalcedony and opal would precipitate in the fractures in serpentinite.

The first attempt of determination of Td of chrysoprase from Szklary was made by Natkaniec-Nowak and Pitera (1983). The chrysoprase samples yielded decrepigrams with two maxima, at 220-420 and 500-650°C and these authors suggested a moderate or high-temperature hydrothermal origin for the minerals. A separate group is formed by milky-white varieties of chalcedony with Td max. 120-180°C, indicating conditions close to supergene.

The present authors tried to perform microscopy on inclusions and measurements of their Th. The opal is isotropic and the surfaces of natural pores and fractures in it are covered with a thin chalcedony layer. Neither opal nor these chalcedony layers bear fluid inclusions.

Chrysoprase specimens consist mainly of chrysoprase and a small amount of specific silica grains (Fig. 1)* that in thin sections display the shape of quartz crystal sections but between crossed polars they show a very fine radial-fibrous structure forming an extinction cross (Fig. 2), but they seem not to be an aggregate of separate fibers.

Chalcedony aggregates do not bear objects which may be undoubtedly called fluid inclusions. Several objects were found that have diameter 2-3 µm and isometric habit that possibly have connection with relics of mineral-forming solutions, but their observable features are ambiguous.

However, the above described quartz grains occurring in chalcedony masses bear rare inclusions of several types. Small dimensions of those inclusions (1-5 µm) cause troubles during investigations. Three kinds of inclusion filling were recognized: gas-liquid (gas occupies a few vol. % of inclusion vacuole), liquid without gas bubble, and inclusions that seem to be filled only by gas or by gas with small amount of liquid (Fig. 3). All these inclusions are primary. All three types of inclusions occurred in one growth zone: one crystal bears usually two distinguishable growth zones (core and rim), very rarely three (core and two rims). In a given growth zone in a grain section up to ten inclusions may be found: one or two are of liquid or gas>>liquid, and the remaining are liquid plus a few percent of gas. Probably exclusively liquid inclusions were recognized only in two crystal sections.

Observations of the positions of the three types of inclusions strongly suggest that liquid inclusions with a few percent of gas and liquid inclusions from crystals which do not bear other kinds of inclusions represent the parent solutions. Gas and liquid inclusions from zones of gas-liquid inclusions formed most probably by necking down of ordinary gas-liquid inclusions.

Determinations of Th were extremely difficult because of the very small size. Only two inclusions were large enough for Th measurements: an inclusion 12 µm long in chrysoprase sample from Szklary had Th = 97°C and an inclusion with dia. 10 µm in chrysoprase from "Wiry" mine yielded Th = 114°C. The possible Th were evaluated for thirty seven other inclusions on the basis of phase ratio, with the supposition that total salt concentration in liquid does not exceed 5-10 weight %, and maximum pressure was <100 bars.

Fig. 1

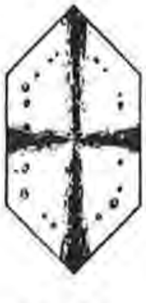


Fig. 2

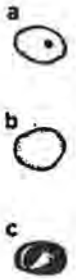


Fig. 3

Fig. 1. Chrysoprase, thin section, nicols crossed; arrows indicate chalcedony-type aggregates of quartz crystal habit. Longer side of picture equals 0.8 mm.

Fig. 2. "Quartz grain" with light extinction typical of chalcedony aggregate, two growth zones are marked by row of inclusions. Grain length is 100 µm.

Fig. 3. Fluid inclusion types: a - liquid with small gas bubble, b - liquid, c - gas, probably sometimes with minor liquid. Inclusion dimensions 3-5 µm. (All drawings by A.K.)

*Figures were not printed with the Polish text and they are given here the first time. (A.K.)

The evaluated temperatures for chrysoprase from Szklary were from about 70 to about 100°C (one sample contained also quartz grains bearing only liquid inclusions that formed at ≤40-50°C), and for chrysoprase from Wiry - from about 80 to about 120°C. Probably temperatures of formation of quartz may be extended for formation conditions of chalcedony mass. On the basis of the obtained temperatures one may conclude that chrysoprase from Szklary and Wiry formed under action of endogenic heat, although the origin of parent solutions still remains enigmatic - they might be heated supergene solutions, telethermal endogeneous fluids connected, e.g., with vein intrusions, or mixture of both. (Translated by A.K.)

URASHIMA, Y. and IZAWA, Eiji, 1982, Hydrothermal alteration observed from drilling into the Hishikari gold deposit, Kagoshima Prefecture, Kyushu, Japan: Mining & Metallurgical Inst. of Japan (MMIJ) Autumn Meeting, 1982, Kitakyushu, Preprint Sec. G, p. 13-16 (in Japanese; translation courtesy K. Okano, via J. Hedenquist). First author at Univ. Kagoshima, Japan.

1. Introduction

In the Neogene volcanic rock region in the northern part of Kagoshima prefecture, a number of gold and silver deposits in quartz veins (Ookuchi, Yamgano and Kushikino, etc.) form the Hokusatsu gold-silver deposit network. Since 1975 MMAJ (Metal Mining Agency of Japan) has explored this area. At the beginning of 1981 drilling at Yamguoh, Hishikari, Isa-gun (see Fig. 1), discovered a high grade gold deposit in a quartz vein in the Shimanto group near the surface. In the autumn of 1981 subsequent drilling to the east and west of the previous drilling area confirmed the development of a high grade gold and silver deposit in the Neogene volcanic rock region (Fig. 2, symbol 6 and 7) and Shimanto group (MMAJ, 1982). The deposits are to be explored by Sumitomo Kinzoku Koozan Ltd.

The present paper discusses characteristics of the hydrothermal activities which formed the gold deposits by describing veins and the hydrothermal minerals.

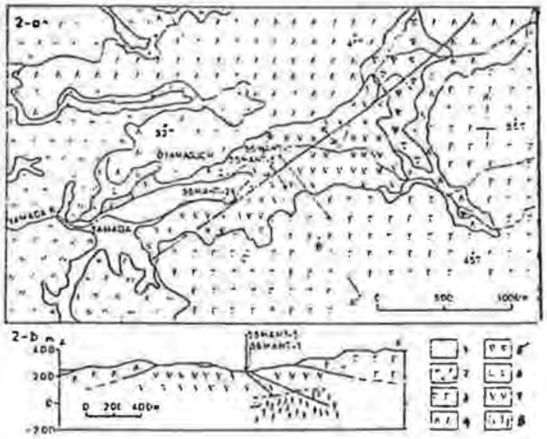
2. Geological Features and Deposits

Geological features in Hishikari deposit region are shown in map 2. The Shimanto group basement of this area (Fig. 2, symbol 8) was discovered by the last drilling. It consists of sandstone and shale layers, with slump structures developed. The sandstone is grey with medium or large particles and includes fragments of shale.

The Hokusatsu Older Andesite (symbol 7) layer lies over Shimanto group (MMAJ, 1977). It has an unconformable boundary with the Shimanto group, with much undulation. The layer is approximately 200 m thick, mainly comprising lava and pyroclastics. We recognized several red beds including hematite, which are considered to indicate intervals of eruptions. The Hokusatsu Older Andesite group underwent propylitic alteration, forming chlorite of the Green Tuff. Yamano rhyolite (symbol 6) is exposed only in small quantity in the west side of the region.

Hokusatsu New Volcanic Rock group (MMAJ, 1979) consists of grey to dark grey andesite, covering the Hokusatsu Old Andesite group and Yamano Rhyolite with unconformity in the northern part of the region. Kurozonoyama rhyolite (MMAJ, 1977) covers the Hokusatsu Older Andesite group and the Hokusatsu New Volcanic Rock group with an unconformity in the southeast part of the region. It is covered by young pyroclastic flow deposits in the western part.

Concerning geological structure in this area, a northeast-southwest anticlinal axis was observed (MMAJ, 1977 and 1979). Furthermore, gravity



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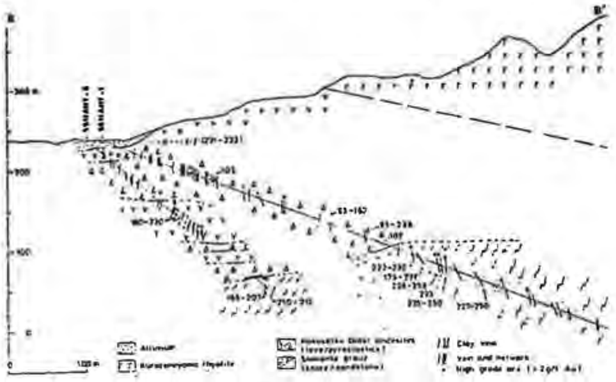
examination indicated an abnormal high gravity in a direction of northeast-southwest and a possibility of Shimato group lying relatively shallowly (MMAJ, 1976). An electric investigation estimated a rise of the lower layers and the presence of mineral alteration belts (MMAJ, 1979).

Although there are prospects and mining pits of Hishikari Koozan nearby, details of its discovery and development in Meiji era (1868-1910) were not recorded. Also collapse of these pits precluded the investigation of geological features in them. The main veins in these pits are vein No. 1, No. 2, and No. 3 in Hokusatsu Older Andesite. They are made up of clay veins or quartz veins which include a high portion of calcite and



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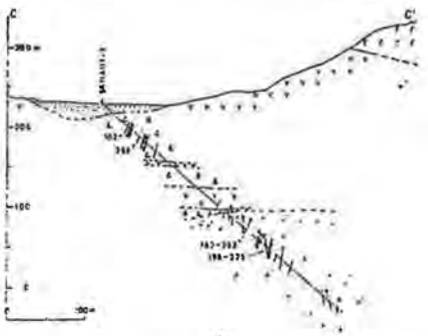

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trend N60°E, dipping 80°NW → 90°. The width of the veins are 0.5-1 m, and grade Au 18-30 g/t, Ag 5-26 g/t (Kinoshita, 1961). Th of liquids included in calcite in waste rock outside the mining pits was 231-233°C (MMAJ, 1980).

3. Veins and Content Minerals

One drillhole in fiscal year 1980 (55MAHT-5) and two in 1981 (56MAHT-1,2) led to the discovery of many quartz veins (see Figs. 3 and 4). Since the veins were estimated to run northeast-southwest, the direction of drilling was selected to intersect the veins perpendicularly. 56MAHT-1 with an inclination of 20° crosses perpendicular to a quartz vein, confirming its 70°NW inclination. Thus, since veins of this region were considered to have steep inclinations, directions of inclinations recognized by drill cores are shown in the cross sections. The veins shown in Figs. 3 and 4 are 10 cm to 1 m wide, and some exceed 5 m. Grades of gold and silver in the main veins are presented in Table 1. Characteristics of veins depend on the country rock. In the Shimanto group we saw milky whitish or greyish white homogeneous or banded quartz veins, while clay veins were

Table 1.

Drillhole	Interval (m)	[Core length] (m)	Grade	
			Au (g/t)	Ag (g/t)
55MAHT-5	291.70 ~ 291.85	0.15	290.3	167.0
56MAHT-1	465.25 ~ 466.00	0.75	102.0	50.3
	476.35 ~ 476.60	0.25	149.7	52.0
56MAHT-2	261.40 ~ 265.15	3.75	81.9	52.8
	277.65 ~ 283.10	5.45	220.3	57.6

Table 2.

Drillhole		Weight %			Mole %	
		Au	Ag	Sum	Au	Ag
56MAHT-1 465.50	A-31-1	71.99	27.53	99.52	58.9	41.1
	32-2	73.06	26.70	99.75	60.0	40.0
	33-3	72.85	27.97	100.82	58.8	41.2
	34-4	73.02	27.93	100.95	58.9	41.1
56MAHT-2 263.84	D-31-1	69.49	30.24	99.73	55.7	44.3
	31-2	69.58	30.27	99.85	55.7	44.3
	32-3	68.26	30.15	98.41	55.4	44.6

observed in Hokusatsu Older Andesite group. The difference is obvious from examination by x-ray diffraction.

The veins in Shimanto group are mainly quartz and K-feldspar, in some cases accompanied by pyrite and kaolinite formed at the end of mineralization. Calcite was formed only in parts of the veins while lamellar quartz was widely observed. We consider that much of the calcite was dissolved in the latter period. Dolomite was also found in some veins. Liquids included in quartz, K-feldspar and calcite homogenize at 160 to 260°C.

The veins in Hokusatsu Older Andesite group are mainly quartz and calcite, with many veins accompanied by zeolites. In 55MAHT-5, wairakite was observed in veins near the unconformity boundary. Montmorillonite and clay are included in upper veins. Liquids included by quartz and some calcite homogenize at 160-260°C. In other calcite, the temperature is inclined to be less than 120°C.

For some of the quartz veins containing high grade gold and silver, metallic minerals were examined by reflected light microscope and EPMA. All of them are veins in shale of Shimanto group, and consist of bands of white-whitish grey- semi-transparent quartz, or bands of differing minerals such as quartz-K-feldspar-kaolinite-calcite. We also observed light red bands including minute hematite particles, and grey bands containing pyrite.

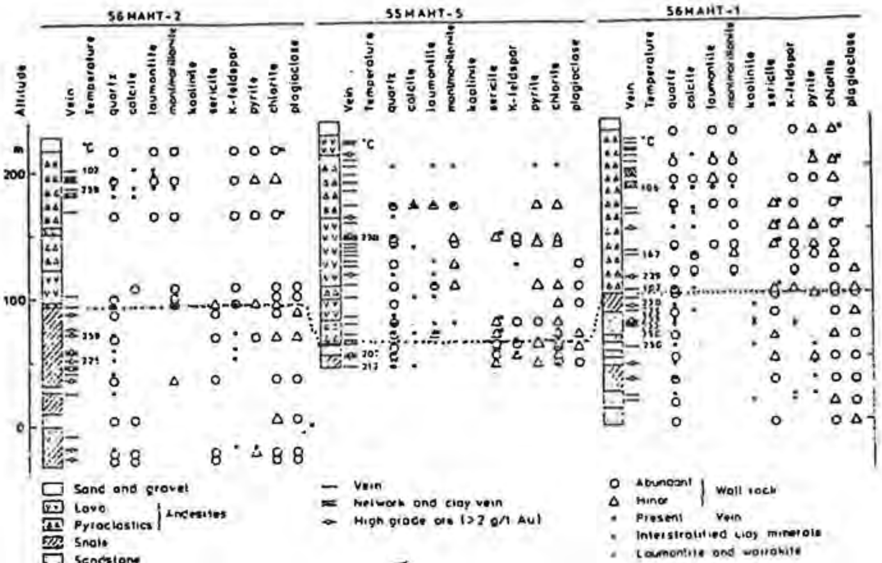
In some cases gold and silver are densely present in grey quartz bands, in addition to the situations where they are present sparsely in quartz. Further bands of much gold and silver and those of pyrite are adjacent and form 'silver black.' The size of gold particles is approximately several µm to ~10 µm, and EPMA analysis indicates the electrum is Au 70 wt%. As is shown in Table 2, the variation in the chemical composition of electrum is very small.

Concerning silver, a qualitative analysis found Ag-Se-S minerals such as 'silver glance' (comprising argentite, selenian argentite and agularite), Ag-Sb-S minerals and Ag-Sb-S minerals with Pb. Other metallic minerals are marcasite accompanied by pyrite, sphalerite accompanied by chalcopyrite and stibnite which is formed as needle-shaped crystals approximately 2 mm long.

4. Alteration of Wall Rocks and Features of Hydrothermal Water

Great differences are observed in the composition of minerals between the wall rocks of the Shimanto group and Hokusatsu Older Andesite group. Fig. 5 shows changes based on matching of minerals examined by x-ray diffraction analysis. [The temperatures listed in Fig. 5 are from fluid inclusions. E.R.]

The shale in the Shimanto group consists of quartz plagioclase-green tuff-selenite. The sandstone mainly consists of quartz-plagioclase with a small quantity of green tuff and sericite. X-ray diffraction analysis indicates that the plagioclase is low-temperature albite. Differences are not observed in the combination of these minerals except within several mm from the veins, and thus it is considered that the impact of hydrothermal fluids on the wallrock was not significant. However, the hydrothermal alteration is distinct near unconformity boundaries; in some cases K-feldspar and mixed layer minerals of sericite/montmorillonite are formed.



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In the Hokusatsu Older Andesite group, hydrothermal alteration such as chloritization, silicification, and clay formation are observed extensively around the veins. Particularly, alteration zones are extremely distinct in the matrix of the tuff breccia. Low-temperature plagioclase and green Fe-chlorite are considered to have been formed by propylitic alteration. We estimate that K-feldspar, green chlorite/saponite mixed layer minerals and sericite/montmorillonite mixed layer minerals are products of mineralization-related alteration. Other than these, zeolite and montmorillonite are extensively formed.

We infer characteristics of the hydrothermal activity from features of minerals composing wall rocks and veins as well as geological structure mentioned above. In the Hishikari region, the rise of the basement rock, development of anticlinal structures, formation of fractures, and rise of deep hydrothermal fluids are interrelated. Hydrothermal fluids rose through fractures in the Shimanto group, and permeated widely through fractures and volcanic ash rocks with many fissures in Hokusatsu Older Andesite group.

Shale in the Shimanto group contains a large amount of carbonaceous matter and therefore hydrothermal fluid rising from deep in the earth would have been in a reduced state. The hydrothermal fluid was approximately 250°C, and if K-feldspar in the vein and sericite in the wallrock maintained equilibrium, the waters pH would be weakly alkalic to neutral. It is possible that when the hydrothermal water permeated to the unconformity boundary and the andesites located near the surface, the water decreased its temperature and became acidified. Some quartz and K-feldspar veins in the Shimanto group form kaolinite later than formation of the 'silver black.' This indicates that gold and silver deposition occurred due to the hydrothermal fluid decreasing its temperature and pH. Thus alterations of temperature, the degree of oxidation and the pH of the water around unconformity boundaries appears to have provided facilitative conditions for deposition of gold and silver.

As the deep hydrothermal fluid activities declined, more surficial water permeated into the underground, and thus terminated gold mineralization. At the end of this activity, the hydrothermal water decreased its temperature to less than 150°C, and formed zeolite-calcite veins under conditions of neutral-weakly alkaline pH.

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 COFFI to the next, and even within a given volume consistency cannot be claimed, so caveat emptor. Where several different items in the given category occur on the same page, the number of such items is put in parentheses after the page reference. Some items may continue on to following pages. As all entries in the Translation section are also cited in the Abstracts section in alphabetical order, no Author index is needed. Starting with the previous volume, the subject matter of meetings announced in the front material of these volumes will also be indexed.

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 pertinent 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 not indexed. 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 409. 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. Cyrillic (and Chinese) place names are listed as they were given in the original transliteration; various transliteration procedures yield different endings: 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.

TEXT Volume	Page	Item†	Line	
16	214-215	5	1	Item should be filed under XIA, L.G.
16	294	2	1	Insert here XIA, L.Q., 1983, from p. 214, there listed incorrectly under QUI, X.L., 1983.
17	38	5	6	Copyright date for translation is given here as 1984; the printed translation has both 1984 and 1985 copyright dates.

†Partial items are also counted.

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