FLUID INCLUSION RESEARCH

Proceedings of COFFI

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

Volume 16

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Fluid Inclusion Research

Volume 16

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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. Notices of past and future meetings and symposia are also published.

Most of the 316 items from Russian sources in this volume were translated or abstracted by Associate Editor Kozlowski; this represents an enormous contribution by Kozlowski toward achieving the aims of COFFI. Part of these abstracts are from several meetings in the Soviet Union, for which proceedings volumes have yet to be published. There are 719 items from other foreign language sources and English language literature for a total of 1035 abstracts, citations, or annotated citations, plus subject and locality indices, and translations of five Russian and one Japanese papers.

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 that are eventually to be 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 in the abstract citations. Translations and other help have also been received from Drs. H.A. Stalder (Bern, Switz.); P. Lattanzi (Firenze, Italy); C. Eastoe (Tucson, AZ); G. Landis (Denver, CO); R. Bodnar (Blacksburg, VA); R. Thomas (Freiberg, DDR); K. Fuzikawa (Belo Horizonte, Brazil); M.J. Logsdon (Denver, CO); and Huan-Zhang Lu (Guiyang, PRC). P.R. Bannes (Viburnum, MO) translated one Russian article. 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 (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, 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 volume; Volume 14 was sent to press just 5-1/2 months after Volume 13, Volume 15 followed 4 months later, and the present volume (16) followed exactly 5 months after Volume 15.

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.

August 27, 1985 Edwin Roedder, Editor

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Past Meetings

An International Conference on Mississippi Valley Type Lead-Zinc deposits was held October 11-14, 1982, at the University of Missouri-Rolla. A volume including a number of papers of pertinence to COFFI was published in 1983; abstracts of pertinent papers will be found this volume of COFFI.

A meeting on European Current Research on Fluid Inclusions ("ECRFI"), sponsored by the Soc. fr. Minéral. Cristallogr., was held at Univ. Orleáns, 6-8 April, 1983. Forty-six papers were presented (nine in a poster session). A short summary of the meeting was given by J.-C. Touray, (Bull. de Minéralogie, Vol. 106, Suppl., p. 55-56, 1983). Abstracts of the papers were published in Bull. de Minéralogie, Vol. 107, no. 2, and will be found in this volume of COFFI.

A meeting on Geothermometry and Geobarometry was held 13-19 January, 1983, at Aussois, Ecole D'Hiver, France, organized by the Soc. fr. Mineral. Cristallogr.

The Fourth International Symposium on Water-Rock Interaction was held August 29 - September 3, 1983, in Misasa, Japan, under the aegis of the Inst. for Thermal Spring Research, Okayama, Univ., and the International Association of Geochemistry and Cosmochemistry. A number of papers pertinent to fluid inclusion studies were presented. Abstracts of these will be found in this volume of COFFI.

The Fifth New Zealand Geothermal Workshop was held in 1983 at Auckland, New Zealand, under the aegis of the Geothermal Institute, University of Auckland. Abstracts of pertinent papers will be found in this volume of COFFI.

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 this volume 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 Vol. 17 of COFFI (1984).

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 COFFI, Vol. 17 (1984).

A 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 will be found in COFFI, Vol. 17 (1984).

A meeting on Diagenesis and Metamorphism was held April 12-13, 1984, at the University of Bristol, England; pertinent abstracts will be found in Vol. 17 of COFFI (1984).

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 will be abstracted in Vol. 17 of COFFI.

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

A meeting of 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.

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.

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

The Second International Symposium on Hydrothermal Reactions was held August 12-14, 1985, at the Pennsylvania State University, University Park, Pennsylvania.

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 symposium 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.

Future Meetings

An international conference on Concentration Mechanisms of Uranium in Geological Environments will be 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 will be held 22-25 September, 1985, in Cornwall, England.

The Society of Economic Geologists will hold a Short Course on The Epithermal Environment, October 24-27, 1985, at Port St. Lucie, Florida.

The Seventh All-Union Conference on Thermobarogeochemistry will be held in L'vov, USSR, September 1985. Dr. V.A. Kalyuzhnyi of L'vov is the convenor.

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

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.

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 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: Dr. H.M. El Shatoury,
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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 pressure. 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, 1983

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.

ACKERMANN, L., CEMIC, L. and LANGER, K., 1983, Hydrogarnet substitution in pyrope; a possible location for "water" in the mantle: Earth & Planet. Sci. Letters, v. 62, p. 208-214. Authors at Inst. Mineral. & Kristallogr., Tech. Univ., D-1000 Berlin, FRG.

Single-crystal specta of pyropes, synthesized on the 3:1:3 composition of the system $MgO-Al_2O_3-SiO_2$ at $P(H_2O)$ = P(total) = 25 kbar and 1000°C, show a broad band centered at around 3400 cm^{-1} due to $P(H_2O)$ of $(H_2O)_n$ aggregates in fluid inclusions and a sharp intense band near 3600 cm^{-1} due to $\nu(OH)$ of $(HO)_4^{4-}$ clusters introduced by the hydrogarnet substitution $Si^{4+} = 4\ H^+$. The water contents in the synthetic pyrope, due to $(HO)_4^{4-}$ clusters are estimated near 0.05 wt.% H_2O from spectroscopic data. Si deficits in microprobe analyses of the pyropes studied support the hydrogarnet substitution. These results show that the hydrogarnet substitution in pyrope may contribute to water contents in the mantle. (Authors' abstract)

AINES, R.D., KIRBY, S.H. and ROSSMAN, G.R., 1983, Hydrogen speciation in synthetic quartz and its relevance to hydrolytic weakening (abst.): EOS, v. 65, p.839.

AITKEN, B.G., 1983, $T-XCO_2$ stability relations and phase equilibria of a calcic carbonate scapolite: Geochimica Cosmo. Acta, v. 47, p. 351-362.

AKANDE, S.O. and ZENTILLI, Marcos, 1983, Genesis of the lead-zinc mineralization at Gays River, Nova Scotia, Canada: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 546-557. First author at Dept. Geol., Univ. Ilorin, Nigeria.

The Gays River deposit consists of stratiform bodies and discordant fault-controlled vein systems within a Mississippian dolomitic reef that overlies unconformably a Lower Paleozoic metasedimentary basement, and is overlain by Mississippian evaporites. Detailed underground mapping and laboratory studies suggest 3 main stages of evolution: 1) pre-ore evaporite deposition, pervasive reef dolomitization and growth of marcasite, 2) precipitation of ore sphalerite, galena, chalcopyrite and calcite, and 3) post-ore deposition of calcite, fluorite, barite, marcasite, pyrite and selenite. Fluid inclusions homogenize at the following temperatures: sphalerite, 215°C; ore-stage calcite, 173°C; post-ore calcite, 142°C; fluorite, 142°C and barite, 137°C. Salinity is approximately 20.4 equivalent weight percent NaCl in post-ore fluorite and calcite. Gypsum and anhydrite in the overlying evaporites and barite within the ore, are enriched in heavy sulfur ($\delta^{34}S$ + 13.1 to +16.5‰); ore-stage sphalerite, galena, and chalcopyrite show a limited spread of $\delta^{34}S$ (+8.0 to +13.65‰), whereas post-ore marcasite and pyrite give widely scattered light $\delta^{34}S$ values (-9.7 to -46.9‰). The similarities of the $\delta^{34}S$ values of gypsum, anhydrite and barite with that of Mississippian seawater confirm this as the dominant sulfur source for the sulfates. The heavy sulfur of the ore-stage sulfide minerals is either directly contributed from seawater or from a solution in equilibrium with evaporites. A biogenic source is preferred for the sulfur in the post-ore marcasite and pyrite. Mineralized carbonates are significantly depleted in the heavier isotopes of carbon and oxygen with respect to their unmineralized equivalents. Preliminary lead isotope data for galena suggest that the source of the lead is in the metasedimentary basement. Our present evidence eliminates the possibility that the lead-zinc ores are an early low-temperature diagenetic cement of the dolomitic reef as previously envisaged. Contact relationships and remarkable similarities between the stratiform and vein ores suggest that the discordant veins acted as feeders for the epigenetic conformable mineralization. The data are compatible with a genesis involving deeply circulating brines released during basin dewatering and gypsum dehydration under increased geothermal gradients in the Late Paleozoic. (Authors' abstract)

AKHUNDOV, T.S., IMANOVA, M.V. and ARUTYUNYAN, G.S., 1983, Thermal properties of aqueous solutions of sodium iodide with concentrations 20 and 50 g per liter: Doklady Akad. Nauk SSSR, v. 271, no. 5, p. 1146-1149 (in Russian). Authors at Inst. of Oil and Chemistry, Baku, Azerbaydzhan.

The paper gives tables of NaI solution densities at T 298.15K (25°C)-598.15K (325°C) and P 39.9-0.2 MPa. (A.K.)

ALDERTON, D.H.M. and RANKIN, A.H., 1983, The character and evolution of hydrothermal fluids associated with the kaolinized St. Austell granite, SW England: Geol. Soc. London, v. 140, p. 297-309.

A complex assemblage of fluid inclusions is present in quartz from the St. Austell granite. Th ranges from below 100°C to above 570°C, and salinities vary from <1 to 42 wt % NaCl equiv. On a regional scale the fluid inclusion populations show marked variations in their abundance and distribution of types. These variations can be correlated with the petrology of the host rock. Low-temperature, low-salinity fluid are most abundant in extensively-kaolinized granite. These represent the latest phase of fluid activity in the St. Austell granite and were probably responsible for the formation of the extensive 'china clay' deposits in the region, at temperatures ranging from about 150°C to below 70°C. The most saline fluids (with halite as a daughter mineral) are restricted to the lithionite [i.e., lepidolite] and fluorite granites. They could either represent the earliest fluids associated with these granites or the concentrated residue formed by boiling of an earlier, more dilute fluid. In the biotite granite, the earliest fluids have salinities of about 10-20 wt % NaCl equivalents, and it can be demonstrated that these fluids boiled at temperatures around 520°C. Abundant gas-rich inclusions in all rock types show further that episodic boiling did occur during the evolution of the hydrothermal phase associated with all these granites. (Authors' abstract)

ALEXANDER, D.H. and HEINRICH, E.W., 1978, Petrogenesis of an orbicular lamprophyre dike, Fremont County, Colorado, USA, in Proc. of the First Int'l. Symp. on Carbonatites, Pocos de Caldas, MG, Brazil, June 1976, Brazilian Ministry Mines & Energy, p. 243-253.

The orbicules are believed to have formed by the physical response of magmatic flow-differentiated layers to local turbulent disturbances of the lamellar flow regime. (From the authors' abstract)

ALLEGRE, C.J., STAUDACHER, Th., SARDA, Ph. and KURZ, M., 1983, Rare gas isotope systematics in oceanic basalt: constraints on the formation of the atmosphere and structure of the mantle (abst.): EOS, v. 64, p.348.

AL'MUKHAMEDOV, A.I., TRUFANOVA, L.G., LAPIDES, I.L., PETROV, L.L., MATVEENKOV, V.V. and TAUSON, L.S., 1983, Volatile components in low-potassium basalts in the axial zone of Red Sea: Geokhimiya, no. 1, p. 315 (in Russian; English abstract). First author at Inst. Geochem. of Siberian Branch of Acad. Sci. USSR, Irkutsk.

Total pressure of volatiles in basalts was ≤500 bars, average water content 0.28 wt.% using T of release from glassy rocks 840-1020°C. Other volatiles are present in amounts: B 4.9 ppm, F 205 ppm, Cl 568 ppm, P_2O_5 0.08%, total S 0.072%, CO_2 0.05%. (A.K.)

ALTEBAUMER, F.J., LEYTHAEUSER, D. and SCHAEFER, R.G., 1983, Effect of geologically rapid heating on maturation and hydrocarbon generation in Lower Jurassic shales from NW-Germany: Advances in Organic Geochem., 1981: J. Wiley & Sons Ltd., 1983, p. 80-86.

AMIRZHANOV, A.A., VORONTSOV, A.Ye. and PLAKHOVA, G.S., 1982, Nature of globular alkaline basaltoids from diatremes of the south of Siberian Platform: Akad. Nauk SSSR Doklady, v. 264, no. 6, p. 1472-1477 (in Russian). Authors at Inst. Geochem. of Siberian Branch of Acad. Sci. USSR, Irkutsk, USSR.

The globular basaltoids (analcite tephrites) or basic foidites (analcimites) formed by splitting of primitive magma to two immiscible melts: drops of more acid melt in matrix of more basic melt. Pertinent to heterogeneous melt inclusions. (A.K.)

ANDERSON, G.M., 1983, Some geochemical aspects of sulfide precipitation in carbonate rocks: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 61-76. Author at Dept. Geol., Univ. Toronto, Canada.

A review of the controls on sulfide mineral solubilities and the available data for galena and sphalerite leads to the conclusion that it is unlikely that ore-forming quantities of metal and H_2S could be transported in the same aqueous solution in the Mississippi Valley-type situation. Some of the consequences of addition of H_2S to the solution at the site of deposition are then explored, emphasizing the idea that as long as the sulfate-reduction site is separated from the sulfide-precipitation site, the precipitation of sulfides releases acid which must inevitably dissolve the carbonate host rocks, causing brecciation or perhaps aiding in replacement. However, if sulfate reduction takes place at the site of sulfide deposition (the ore zone), much less carbonate dissolution should result. Sulfate reduction in the absence of aqueous metal ions should result in secondary dolomite or calcite, which should alternate with sulfides as metals are made available by the hydrothermal system. The importance of an impermeable formation such as shale overlying the ore zone to contain the H_2S and retard oxidation of organic matter is also stressed. (Author's abstract)

ANDERSON, R.N., 1983, The physics and chemistry of Iceland versus mid-ocean ridge hydrothermal systems: Contrasting boundary conditions, *in* Hydrothermal Processes at Seafloor Spreading Centers, P.A. Rona et *al.*, eds.: Plenum Press, p. 279-290. Author at Lamont-Doherty Geol. Observatory, Columbia Univ., Palisades, NY 10964.

Includes discussion of the occurrence of boiling conditions in oceanic geothermal systems. (E.R.)

ANGELL, C.A., 1983, Supercooled water: Ann. Rev. Phys. Chem., v. 34, p. 593-630. Author at Dept. Chem., Purdue Univ., West Lafayette, IN 47907.

An extensive review of the theoretical and experimental studies of supercooled water. (E.R.)

ANIEL, B.M., 1983, The uraniferous deposits associated with Tertiary acid volcanism of the Sierra de Pena Blanca, Chihuahua, Mexico, *in* Geol. & Min. Resources of North-Central Chihuahua: El Paso Geol. Soc., Guidebook for 1983 Field Conf., p. 351-352. Author at Centre de Recherches Geol. de l'Uranium, B.P. 23, 54501 Vendoeuvre les Nancy, France.

A series of fluid stages are proposed: 1) post-magmatic CO_2-rich fluids at 400°C; 2) hydrothermal low-salt, boiling, U-depositing, at 300-350°C; 3) kaolinizing, at 250-150°C; 4) montmorillonite-carbonate-zeolite at 100-150°C; 5) ferric oxides-opal-uranophane at 150°C alunite or jarosite; 6) supergene. These values are probably established by inclusion microthermometry. (E.R.)

ANONYMOUS, 1983, The fluid inclusions laboratory: The Smilodon, v. 23, no. 1, p. 1-4.

A review and listing of the fluid inclusion studies performed as senior theses, master's theses, and doctoral dissertations in recent years at Princeton Univ., Princeton, NJ. (E.R.)

ANTHONY, E.Y., REYNOLDS, T.J. and BEANE, R.E., 1983, The use of energy dispersive analysis to identify daughter minerals from the Santa Rita porphyry copper deposit, New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 516. First author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

A widely used technique for characterization of daughter minerals in fluid inclusions employs a combination of scanning electron microscopy, which gives a tantalizing glimpse of crystal morphology, and energy dispersive analysis, which yields a spectrum of characteristic X-radiation. Raw peak intensities have been used as a measure of what elements are present, without benefit of standard corrections. We have found that, despite the small size of the crystals and their spatially irregular disposition within the fluid inclusion cavity, data reduction programs work sufficiently well to yield stoichiometric ratios of elements which characterize the mineral.

For the high-salinity inclusions associated with early potassic alteration from the Santa Rita deposit, the following minerals were identified: halite, sylvite, chalcopyrite, calcium sulfate (anhydrite?), potassium feldspar, phengitic muscovite, iron-rich trioctahedral mica (siderophyllite?), and biotite. This assemblage is similar to that of the mesoscopic vein minerals with two important exceptions: 1) mineralization is associated with later, lower-salinity fluids, and 2) magnesium content of most daughter micas is very low. This seeming paucity of magnesium contrasts with the chemical composition of the associated alteration biotite which is enriched in magnesium relative to igneous biotite. (Authors' abstract)

APLONOV, V.S. and SEREDA, E.V., 1983, Temperatures of formation of the quartz and hisingerite in the massive copper-nickel ores of the Talnakh ore deposit: Geol. i Geofizika, v. 24, no. 3, p. 62-67 (in Russian; translated in Soviet Geol. & Geophys., v. 24, no. 3, p. 56-60).

The authors discuss earlier published papers listing Th for inclusions in quartz from ore parageneses in Talnakh and they present their own values of Td (quartz 270-330°C, hisingerite 20-140°C, late chalcopyrite 20-120°C, late pyrrhotite 40-140°C, calcite 60-160°C and 240-320°C, apophyllite 100-200°C, gypsum 20-120°C.) (Abstract by A.K.)

APPS, J.A. and NEIL, J.M., 1983, Albite solubility in the aqueous phase between 125°C and 350°C, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 290-316.

AREVADZE, D.V., GOGISHVILI, V.G. and YAROSHEVICH, V.Z., 1983, Geology and genesis of the Madneuli copper-barite-polymetal deposit (southern Georgia): Geol. Rudn. Mestorozhd., v. 25, no. 6, p. 10-23 (in Russian). Authors at Caucasian Inst. of Mineral Raw Materials, Tbilisi, Georgian SSR.

The deposit occurs on the S edge of the Transcaucasian central massif activated from early Mesozoic. Ores (copper sulfide, copper-zinc, barite-polymetal including barite-Cu-Zn, barite-Pb-Zn and barite varieties) occur in metasomatic rocks: below the ores - quartz + biotite, quartz + biotite + epidote, quartz + muscovite; in the ore horizon - quartz + sericite + chlorite and secondary quartzites; above the ores - in the covering liparites occur veinlets and nests of chalcedony + quartz + zeolites. Quartz from Cu-sulfide ores bears inclusions with chlorite(?) or transparent trapped minerals, homogenizing at 380-330°C. Two-phase inclusions in anhydrite and barite yield Th from 365-340°C and 338-305°C, respectively, down to <100°C; the high-T inclusions in barite are P ones (down to 280°C). Dark sphalerites bear fluid inclusions with Th 295-255°C, light ones - with Th 270-180°C. In upper levels barite typically shows Th <180°C. Fluorite yielded Th 138-106°C. Total salinity was determined by cryometric method as 1.2 to 3.0 wt. % of NaCl equiv.

Quartz bears gas components in inclusions in range about 10^{-7} g per 1 g of the mineral; essential components are: H_2O, CO_2, N_2, CO, CH_4* and NH_3; other gases <1 molar %, molecular H_2 <0.07 molar %. Pressure during ore stage was evaluated as ~280 bars. Hydrogen isotopes from water of fluid inclusions are characterized by the followiong values (δD, ‰, SMOW standard): barite-polymetal association, inclusions in pyrite -77 ± 8(2); inclusions in chalcopyrite -67 ± 18(3); copper sulfide association, inclusions in quartz -65 ± 5(2), in pyrite -82 ± 8(1), in chalcopyrite -110 ± 20?(1); disseminated copper sulfides, inclusions in quartz - 74 ± 8(1), in pyrite -83 ± 20(2); barite-polymetal association, inclusions in sphalerite -63 ± 15(2), in galena -67 ± 7(2) and in barite -78 ± 7(1);

*Russian text gives here "NH_4" what seems to be a misprint for "CH_4." (A.K.)

barite association, inclusions in barite -70 ± 10(2); (numbers of samples in parentheses). Values of $\delta^{18}O$ of H_2O in mineral-forming solutions were calculated from $\delta^{18}O$ of barite and quartz and Th values; $\delta^{18}O$ for solutions ranges from -11.0 ± 1.5 to +3.9 ± 0.8‰ (SMOW). The initial fluid was diluted during formation of the deposit by meteoric waters. The paper presents also $\delta^{34}S$ variations in sulfides of the deposit. (Abstract by A.K.)

ARKHANGEL'SKAYA, V.V., 1983, Geological structure and lead-zinc ore mineralization of the Podolia-Pridnestrov'ye ore region: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 6, p. 90-103 (in Russian). Author at IGEM, Moscow, USSR.

Metasomatic fluorite, Pb-Zn and pyrite-chalcopyrite ores yielded Th about 240°C. (A.K.)

ARMBRUSTER, Th. and IROUSCHEK, A., 1983, Cordierites from the Lepontine Alps: Na + Be → Al substitution, gas content, cell parameters, and optics: Contrib. Mineral. Petrol., v. 82, p. 389-396.

ARMBRUSTMACHER, T.J., 1983, Fenitization of host rocks in the contact aureole of the complex of alkaline rocks at Iron Hill, Powderhorn district, Gunnison county, Colorado (abst.): Abstracts Volume, '83 MSA Symposium on Alkaline Complexes, Wausau, Wisconsin, Sept. 16-18, 1983 (unpaginated). Author at U.S. Geol. Survey, P.O. Box 25046, Denver Federal Center, Denver, CO 80225.

Granitic host rocks of the alkaline intrusive complex at Iron Hill, Colorado, show evidence of fenitization (contact alkali metasomatism) of the type generally associated with carbonatitic complexes. The Precambrian Powderhorn Granite undergoes progressive petrographic, mineralogic, and chemical changes to fenitized granite and then to rheomorphic fenite as the contact with alkaline rocks is approached. Nepheline syenites, previously interpreted as part of the alkaline intrusive complex, may instead represent the final end product of fenitization. These products of fenitization are characterized by progressive replacement of original sodic and potassic feldspars by ferric iron oxide-bearing potassic feldspars, by replacement of biotite by aegirine-augite, by disequilibrium of quartz and magnetite, and possibly by development of nepheline. Major-element analyses show a large decrease in SiO_2, and a large increase in Na_2O and moderate increases in Al_2O_3, CaO, K_2O, MgO, and FeO_t from granite to fenite. These are the kinds of changes most often quoted in the literature for fenitization of granitic rocks. Changes that occur from fenite to nepheline syenite include a large decrease in SiO_2 and moderate to slight decreases in MgO, CaO, and Na_2O; Al_2O_3 and K_2O show relatively large increases.

Pyroxenites within the alkaline complex are altered to rocks rich in vermiculite in response to the fenitizing solutions. The distribution of this vermiculitization of the pyroxenites and of fenitization of the granitic rocks suggests that the crystallizing carbonatite of the central core and not the silicate rocks of the alkaline complex was the source of the fenitizing solutions. (Author's abstract)

ARNOLD, M., 1983, Growth mechanism of natural quartz at low temperature (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 10. Author at Centre de Rech. Pétrogr. et Geochim., B.P. 20, 54501 Vandoeuvre Cedex, France.

In Limouzat as in other low temperature quartz veins involving an anhydrite stage (Arnold-Guillou, 1980) automorphic quartz crystals are systematically fibrous. This structure is diagenetic. Indeed, quartz growth is attained by a close packed assemblage of nuclei. These are spherical nuclei or optical diffusion features which are induced by smaller particles. Nuclei give quartz fibers by coalescence process. The average diameter of fibers is 1000 A. The length is 5 to 10 µm approximately. By successive coalescences, fibers give ribbons, bidimensional sheets and tridimensional quartz ultimately. In the quartz paracrystal resulting from repeated attachment of nuclei, the tridimensional continuity is attained by aging of the first precipitate. In the intermediate stage of this evolution, the quartz paracrystal is crossed by very numerous infra-microscopic channels, so the paracrystal is porous. Identical structures occur in Oligocene quartz veins connected with Rhenan Rifting. In these, quartz grew in a cold fluid ($T < 43$°C) as it is attested by an association of quartz, anhydrite and primary gypsum (Arnold-Guillou, 1983). In contrast, in the evolved quartz paracrystals, fluid inclusions are a dominantly biphase aqueous fluid. The average diameter is 5 µm. As indicated by the filling ratios, ($V_G/V_G + V_L < 10\%$) a filling temperature as high as 150-180°C (depending upon fluid salinity) is expected. This inconsistency is explained by mixing of a brine with a fresh water. Aqueous silica and dissolved gas species in the fresh water are salted out. Quartz paracrystals grew from an heterogeneous gas liquid mixture at very low temperature. (Author's abstract)

ARNOLD, Michel and GUILLOU, J.-J., 1983a Natural growth of quartz paracrystals in brines with dissolved anhydrite at low temperature: Bull. Minéral., v. 106, p. 417-442 (in French; English abstract). First author at C.R.P.G., B.P. 20, 54501 Vandoeuvre Cedex, France.

In brines with dissolved Ca-sulphates, the growth of quartz is attained by a close packed assemblage of nuclei. These are depicted as sharp spots of 250 A in size by SEM mode imaging. These are either spherical nuclei or electron optical diffusion features which are induced by smaller particles. Nuclei give quartz fibers by a coalescence process. The average diameter of fibers is 1000 A. Their length is 5 to 10 µm. By successive coalescences, fibers give ribbons, bidimensional sheets and tridimensional quartz ultimately. In the quartz paracrystal resulting from repeated attachment of nuclei, the tridimensional continuity is attained by aging of the first precipitate. At intermediate stages of this evolution, the quartz paracrystal is crossed by very numerous inframicroscopic channels, leaving a high internal porosity in each paracrystal. The primary structure, characterized by a close packed assemblage of nuclei, is very similar to the organization of spherical amorphous silica particles in precious opal. The ordered precipitation of both quartz nuclei in a paracristalline structure and amorphous silica particles in a precious opal are the products of the colloidal ordered precipitation due to the second potential well of the interaction energy between two particles. Quartz nucleation appears by the salting out of dissolved monomere silica. All this results from mixing of a brine and of a silica saturated solution. Quartz nucleation may be improved by impurities (Al^{+++}, hydrocarbons) in the growth medium. (Authors' abstract)

ARNOLD, Michel and GUILLOU, J.-J., 1983b Salting out misinterpreted in terms of a hot hydrothermal event from fluid inclusions: C.R. Acad. Sci. Paris, v. 296, Series II, p. 1259-1262 (in French).

In the Badenweiller-Sehringen vein, primary gypsum ($T \leqslant 43$°C) is intimately associated with quartz crystals. In the latter, degree of filling in fluid inclusions indicates temperatures higher than 150°C. This inconsistency is explained by mixing of a brine with a fresh water.

Aqueous silica and dissolved gas species are salted out. Quartz crystals grow from an heterogeneous gas-liquid system. (Authors' abstract)

ARNÓRSSON, Stefán, GUNNLAUGSSON, Einar and SVAVARSSON, Hördur, 1983a The chemistry of geothermal waters in Iceland. II. Mineral equilibria and independent variables controlling water compositions: Geochimica Cosmo. Acta, v. 47, p. 547-566. First author at Sci. Inst., Univ. Iceland, Dunhagi 3, Reykjavik, Iceland.

The major element chemistry of Icelandic geothermal waters is predictable provided two parameters are known. This follows from an attainment of, or a close approach to, an overall chemical equilibrium in the geothermal systems at temperatures as low as 50°C. It is considered that the geothermal system composition, temperature and kinetic factors determine which alteration minerals form. The system composition is not so much fixed by rock composition as by the rate of leaching of the various constituents from the fresh rock and the composition of inflowing water. The water chemistry is determined by the system composition and the external variables acting on the system. They include temperature and the mobility of chloride. Pressure, which theoretically should be regarded as an external variable, has insignificant effect on water compositions in the range (1-200 bars) occurring in the geothermal systems. (Authors' abstract)

ARNÓRSSON, Stefán, GUNNLAUGSSON, Einar and SVAVARSSON, Hördur, 1983b The chemistry of geothermal waters in Iceland. III. Chemical geothermometry in geothermal investigations: Geochimica Cosmo. Acta, v. 47, p. 567-577. First author at Sci. Inst., Univ. Iceland, Dunhagi 3, Reykjavik, Iceland.

New data from geothermal wells in Iceland have permitted empirical calibration of the chalcedony and Na/K geothermometers in the range of 25-180°C and 25-250°C respectively. The temperature functions are expressed algebraically, using concentrations in ppm. These temperature functions correspond well with the chalcedony solubility data of Fournier (1973) and the thermodynamic data for low-albite/microcline/solution equilibria of Helgeson (1969).

A new CO_2 geothermometer is also proposed which is considered to be useful in estimating underground temperatures in fumarolic geothermal fields. Its application involves analysis of CO_2 concentrations in the fumarole steam. (From the authors' abstract)

ARROYO P., G., 1983, Occurrence of uraniferous minerals in the Colquijirca deposit (central Peru): Bol. Sociedad Geologica del Peru, no. 72, Sept. 1983, p. 75-88 (in Spanish).

The Colquijirca Cu-Pb-Zn-As-Bi-U deposit is situated in the Andean mountains of central Peru. The enclosing rocks are limestones of lower Tertiary (Eocene) age, that have been intruded by a quartz monzonite stock. The mineralization is stratiform.

With mineralogic and fluid inclusion information, it is shown that the lowest temperature of formation of primary mineralization is higher than that of recrystallization of pitchblende into uraninite. This recrystallization is related to the emplacement of the monzonite stock. A new uranium mineral, zipeita[sic] is described. (Translation courtesy G.P. Landis)

ARTHUR, M.A., et al. (organizers), 1983, Stable isotopes in sedimentary geology: SEPM Short Course No. 10.

Includes discussions of O, C, N and S isotopes, and trace elements in carbonates. (E.R.)

ASHWAL, L.D., COLUCCI, M.T., LAMBERT, P., HENRY, D.J. and GIBSON, E.K., Jr., 1983, Fluid inclusions in meteorites: direct samples of extraterrestrial volatiles, in Conference on Planetary Volatiles, R.O. Pepin and R. O'Connell, eds., p. 18-19, L.P.I. Tech. Rpt. 83-01, LPI, Houston, TX.
See Warner et al., this volume. (E.R.)

ASHWORTH, K.K., 1983, Genesis of gold deposits at the Little Squaw mines, Chandalar mining district, Alaska: M.S. thesis, Western Washington Univ., Bellingham, WA, 98pp.
Indexed under Fluid Inclusions. (E.R.)

ATHERTON, M.P. and GRIBBLE, C.D., eds., 1983, Migmatites, melting and metamorphism: Shiva Series, 326 p.

A collection of papers stemming from a 1982 meeting at the University of Glascow on high-grade metamorphism, migmatite and melting. The most pertinent are abstracted in this volume. (E.R.)

ATKINSON, P., 1983a Fluorite deposition in the southern Pennines orefield: (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 3. Author at Univ. of Leicester.

A fluid inclusion study on Derbyshire fluorite has revealed five hydrothermal events involving deposition of remobilization. Each fluid is characterized by restricted chemical compositions and Th ranges. High Ca/Na and Ca/Mg ratios in the brines indicate compositions atypical of present-day formation waters resident in deep sedimentary basins. The homogeneity of the inclusion fluids, the uniform REE content of the fluorite and equilibrium mineral textures suggest a non-mixing mechanism of mineralization. Modelling of fluorite solubility places further constraints on the efficacy of depositional process such as cooling, dilution, dolomitization and metasomatism. (Author's abstract)

ATKINSON, P., 1983b Fluorite mineralization in the Southern Pennine Orefield (abst.): J. Geol. Soc. [G.B.], v. 140, part 6, p. 980. Author at Univ. Leicester.

Fluorite deposits in the Southern Pennine Orefield occur in vein fillings and metasomatic wallrock replacements in Dinantian limestones and dolomites. Fluid inclusion studies indicate 4 phases of fluorite mineralization, 2 of which dominate the major fluorite bodies of the district. Homogenization temperatures show that lateral, vertical and transverse thermal gradients were low. Salinities varied little during each event indicating that little fluid mixing took place. Ca and Na chlorides dominate the fluid chemistry. Two important genetic processes may have been (1) dolomitization of the wallrocks, and (2) the introduction of a descending fluoride-rich brine from the Namurian or Triassic cover. (Author's abstract)

AYORA, C. and CASAS, J.M., 1983, Microthermometric study of quartz veins of the Esquerdes de Roja, Canigo Massif, eastern Pyrenees: Acta. Geol. Hisp., v. 18, no. 1, p. 35-46 (in Catalan). Authors at Fac. Geol., Univ. Barcelona, Barcelona, Spain.

The Esquerades de Roja quartz vein system extends for ~15 km, cutting both the Late Hercynian, Costabona granites and their Cambrian-Ordovician, metasedimentary host rocks. Locally, the quartz veins show deformation by 2 events, producing early mylonite bands and a set of late fractures. Fluid inclusion studies indicate formation of massive microcryst. quartz at ~280° and of vug-filling quartz at ~250°; the mineralizing fluids had salinity ≤20 wt. % equiv. NaCl. The dominant metals in the mineralizing brines were Na, Ca, and K. (CA 101: 233616z)

BAKUMENKO, I.T., KOSUKHIN, O.N., KOSALS, Ya.A. and LHAMSUREN, J., 1981, Genesis of rhythmically banded textures in granitoid rocks: Dokl. Akad. Nauk SSSR, v. 260, p. 444-448 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 260, p. 131-134, 1983). First author at Inst. Geol. & Geophys., Siberian Dept. USSR Acad. Sci., Novosibirsk, USSR.

Inclusions in the minerals of these banded rocks range from aqueous, with Th $\sim$240°C to 1000°C (for silicate melt inclusions?). Some show salt phases plus gas, with no visible liquid, and Th = 350°(sic). (E.R.)

BALASHOV, V.N., ZARAISKII, G.P., TIKHOMIROVA, V.I. and POSTNOVA, L.Ye., 1983, Diffusion of rock-forming components in pore solutions at 200°C and 100 MPa: Geokhimiya, no. 1, p. 30-42 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 1, p. 28-40, 1983). Authors at Inst. Exper. Mineral., USSR Acad. Sci., Chernogolovka, USSR.

The effective diffusion coefficients for Na, K, Ca, Mg, Fe, Al, and Si have been determined at 250°C and 100 MPa for aqueous solutions (mainly chloride ones) under the conditions of diffusion through porous membranes of granite and consolidated TiO_2 powder. The available data on electrical conductivity have been used in theoretical calculations on the diffusion coefficients for the chlorides of rock-forming components in free solution at temperatures up to 350°C. Comparison with experiment indicates that the diffusion coefficients are reduced in the pore space in granite due to chemical interaction, which is particularly strong for $MgCl_2$, $FeCl_2$, $AlCl_3$, and $NaAlO_2$. (Authors' abstract)

BALASHOVA, S.P., 1983, Model of ore formation connected with waters of non-magmatic sources: Geol. Rudn. Mestorozhd., v. 25, no. 2, p. 44-56 (in Russian). Author at TsNIGRI, Moscow, USSR.

Stratiform Pb-Zn ore mineralization in carbonate beds of the May-Kyllakh zone (SE Yakutia) formed in several stages. Diagenetic ores yielded Th 150-220°C, ores recrystallized under high-T solutions 250-360°C. (A.K.)

BALDIN, M.N., KARPOV, G.A., KODENYEV, G.G., KUZNETSOV, V.V., PAVLOV, A.L. and SUTKIN, V.V., 1983 Iron pentacarbonyl $Fe(CO)_5$ in gas-hydrotherms of Volcano Uzon (Kamchatka): Dokl. Akad. Nauk SSSR, v. 269, no. 2, p. 458-460 (in Russian). Authors at Inst. Geol. and Geophysics, Novosibirsk, USSR.

Iron carbonyl $Fe(CO)_5$ was found in the emanations of the Uzon caldera. Identification was performed by gas chromatography with detection by condensation of molecular nuclei[sic]; detection limit of metal carbonyls 10^{-17} g/cm^3; concentration of $Fe(CO)_5$ was not determined. (A.K.)

BALL, T.T., 1983, Geology and fluid inclusion investigation of the Crown King breccia pipe, Yavapai County, Arizona: M.S. thesis, Colorado Sch. Mines, Golden, CO.

BALL, T.T. and CLOSS, L.G., 1983, Geology and fluid inclusion investigation of the Crown King breccia pipe complex, Yavapai County, Arizona (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 276-277. First author at 531 E. 4080 S. #3E Murray, UT 84107.

The Crown King breccia pipe complex at Porphyry Mt., lies within the Tertiary-Cretaceous Crown King granodiorite stock, southern Bradshaw Mts., Arizona. Rhyolite porphyry and dacite porphyry dikes older than the breccias, and dacite porphyry that is younger are also present.

The breccia pipe complex consists of three breccia types, the largest, oldest and weakly mineralized pipe, a magnetite-bearing pipe and three molybdenum-bearing pipes within the oldest pipe. The metal bearing breccias contain molybdenite and magnetite within their matrices.

Type I fluid inclusions in vug-filling quartz from the upper portions of the molybdenite-bearing breccia pipes homogenize between 370°C and 150°C. Type II inclusions homogenize near 325°C and 200°C. Salinities vary from 45 to 0.1 wt. percent NaCl equivalent. Boiling is not indicated. Minimum pressure of trapping is 200 bars.

The upper portion of the molybdenum-bearing pipe contained angular rock fragments, little rock flour and abundant open space containing vug-filling quartz, pyrite and calcite. The lower portion consisted of angular to rounded clasts, abundant rock flour, no open space and a matrix with flow structures. These features indicate that the upper portion of the pipe formed by collapse while the lower portion formed by fluidization.

The pipes probably formed explosively by molybdenum-bearing fluids exsolved from a shallow magma body. (Authors' abstract)

BALYKIN, P.A., YURKOVSKIY, S.A. and PROSKURYAKOV, A.A., 1983, Problem of evaluation of gas component of intrusive rocks of basite composition: Geol. i Geofiz., no. 12, p. 36-42 (in Russian; English abstract). First author at Inst. Geol. and Geophysics, Novosibirsk, USSR.

Specimens for studies were collected in five ultrabasite-basite and basite massifs of Transbaikalia and Upper Priamur'ye: Dovyren, Lukinda, Angashan, Vitimkon and Oshurka. Crushed rock or plagioclase was decrepitated (T 400-1000°C) for gas release followed by gas chromatographic analysis. This method was accepted as most appropriate for determination of gas composition. Rocks in all studied samples bear more CO, CO_2 and H_2O than plagioclase of this rock; rocks of the Vitimkon massif are also richer in H_2, and rocks of the Oshurka massif are especially rich in H_2 and H_2O. Differences in contents of gases between various samples of plagioclase are smaller than between rocks. Rocks contained OH-bearing minerals. (Abstract by A.K.)

BARNES, H.L., 1983, Ore-depositing reactions in Mississippi Valley-type deposits: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 77-85. Author at Ore Deposits Res. Sec., The Pennsylvania State Univ., University Park, PA 16802, USA.

The characteristics of the depositional environment are best evaluated by evidence from epigenetic, rather than syngenetic, Mississippi Valley-type deposits. Textures of the ores, especially sphalerite stratigraphy, prove that the metals and sulfide are transported together and that deposition is not caused by mixing of these components from separate solutions. Organic complexes of the metals are dominant during transport, possibly also including some thiols, because of the low stability of potential inorganic complexes, the observed solubilities in oil-field brines, and the presence of Ni and V porphyrins. Microcline + 2M illite alteration shows the solution to be weakly alkaline before ore deposition begins.

After dolomitization, sulfide deposition is accompanied by solution brecciation of carbonates, possible only by simultaneous generation of acidity. Barite distribution with, and above, the sulfides indicates also that oxidation of sulfide to sulfate is associated with deposition. Typical confining of most ores dominantly within a 15 meter-thick, horizontal section over large areas implies that localization of these processes was provided by an interface between a rising hydrothermal fluid and circulating groundwater. The broad uniformity of fluid inclusion filling temperatures of each paragenetic stage shows that neither boiling nor temperature decrease caused deposition. Oxidation of a metal complex containing an organic ligand is compatible with these criteria:

$$MeL(HS)_2(aq) + 2\ O_2 \rightarrow MeS(s) + 2\ H^+ + SO_4^{2-} + L\ (aq)$$

Sufficient O_2 to cause deposition can be supplied to the very slow flow of hydrothermal solutions by mixing or diffusion from much more rapidly circulating, air-saturated groundwater. Hydrothermal flow at about 3 m/yr provides sufficient reaction to form large ore bodies by depositing sphalerite at about 1 μm/yr during the requisite 0.25 m.y. indicated by dispersion analysis and supported by organic maturation. (Author's abstract)

BARNES, H.L. and BOURCIER, W.L., 1983, Role of organic and inorganic complexes in ore metal transport at low temperatures (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 521. First author at Ore Deposits Res. Sec., The Pennsylvania State Univ., University Park, PA 16802.

Organic chelates appear to be dominant during ore transport. Present data are insufficient to identify probable chelates from among thiols, porphyrins, and many other species, especially when stabilities are unknown at reducing, high pressure conditions. The probability of organic complexing is supported by the epigenetic organics found dissolved in the inclusions of sphalerite, and abundant in bitumen and in shales near orebodies in Mississippi Valley-type deposits. (From the authors' abstract)

BARNES, H.L., DOWNS, W.F. and RIMSTIDT, J.D., 1983, Experimental determination of rates of hydrothermal reactions, *in* Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 217-239.

BARNOLA, J.M., RAYNAUD, D., NEFTEL, A. and OESCHGER, H., 1983, Comparison of CO_2 measurements by two laboratories on air from bubbles in polar ice: Nature, v. 303, p. 410-413.

BARRIGA, F., 1983, Hydrothermal metamorphism and ore genesis at Aljustrel, Portugal: Ph.D. dissertation, Univ. of Western Ontario, Canada.

BARSUKOV, V.L. and BORISOV, M.V., 1982, Simulating the geochemical consequences of hyudrothermal solution automixing. Part 2. Mass transfer in areas of contraction of hydrothermal flow: Geokhimiya, 1982, no. 9, p. 1244-1256 (in Russian; translated in Geochem. Int'l., v. 19, no. 5, p. 26-36, 1983).

BARSUKOV, V.L., DURASOVA, N.A., RYABCHIKOV, I.D., KHRAMOV, D.A. and KRAVTSOVA, R.P., 1983, Peculiarities of tin behavior during liquation of alumosilicate melts: Geokhimiya, no. 2, p. 189-192 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 1, p. 127-130, 1983). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

Immiscibility was studied in K_2O-Al_2O_3-SiO_2-FeO at 1180 ± 10°C. (A.K.)

BARSUKOV, V.L., KOGARKO, L.N., POLYAKOV, A.I. and ROMANCHEV, B.P., 1983, Differentiation series of volcanic rocks on oceanic islands, *in* Magmatic and Metamorphic Rocks of the Ocean Bottom and their Genesis, Bogatikov. O.A., Dmitriyev, Y.I. and Tsvetkov, A.A., eds.: Moscow, Izdat. Nauka,

p. 38-46 (in Russian).

Includes Th determinations on melt inclusions in sodalite, olivine, pyroxene, apatite, kaersutite, plagioclase, nosean, and K-spar from various rocks, ranging from 920 to 1330°C. CO_2 inclusion densities are also listed. (E.R.)

BARTLETT, R.D., 1983, Geology and hydrothermal alteration of the Sugarloaf Prospect, San Luis Hills, Conejos and Costilla counties, Colorado (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 326. Author at Dept. Earth Res., Colorado State Univ., Ft. Collins, CO 80523.

Advanced argillic alteration characterized by quartz-alunite veins occurs in a 4 km^2 area 15 km east of Manassa, Colorado, within the Rio Grande Rift. Flows of intermediate composition, flow breccias, explosion breccias, and volcaniclastic deposits crop out in the area and are intruded by dikes and stocks of latite-andesite and quartz-latite. Fracture controlled quartz-alunite alteration is overlain by argillic alteration and subsinter silica-flooded zones characteristic of near-surface, hot springs activity. Preliminary alunite fluid inclusion analyses indicate a temperature of homogenization of approximately 250°C. The alunite fluid inclusions are liquid dominated with no evidence of boiling. Hydrothermal breccia and pebble dikes occur stratigraphically above the outcrops of quartz-alunite veins. A single K-Ar analysis of vein alunite indicates an age of 23.8 ± 1 m.y. for the hydrothermal alteration. Vent facies volcanic rock, located 5 km to the northeast of the altered area, is thought to define the site of an Oligocene composite volcanic cone. Although barren of known base and precious metal mineralization, the Sugarloaf Prospect is thought to be analogous to hydrothermal alteration found at Summitville, Colorado, 50 km to the west. The alteration is the result of solfataric hot springs activity which deposited a silica cap periodically brecciated along fractures and faults cutting the system. (Author's abstract)

BARTON, M.D., 1983, Calculation of C-O-H-S equilibria at constant bulk composition: some petrologic implications: Carnegie Inst. of Washington Year Book 82, p. 381-386.

BASTOUL et al., 1983, A study of the carbon/nitrogen-rich fluids associated with metamorphism of black shales (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 11 (in French; translation courtesy M.J. Logsdon). First author at CREGU, BP 23, 54501 Vandoeuvre les Nancy, Cedex, France.

Several generations of carbon- and nitrogen-rich fluids are displayed in three environments: Jebilet Central (Morocco); Les Bondons (Massif Central, France) and Pen Ar Ran (Brittany). All three environments are characterized by thermal metamorphism of black shales near the contact with granitoids, preceded by regional low-grade metamorphism. Microthermometry and fluid characteristics are summarized in the table.

The principal results of the study are: 1) observation of fluids very high in nitrogen; 2) absence of CO_2 when graphite is abundant; 3) absence of visible water in most C/N-rich inclusions; 5) the late introduction of brines. The origin of these fluids is discussed in terms of the prograde and retrograde metamorphism of organic-rich black shales. (Abstract courtesy M.J. Logsdon)

Continued next page.

		Quartz in rod				Quartz in geode*				Quartz pegmatitic				Quartz veins			
Sample No.		Jeb. E 100		M.C.By		Jeb Q G_2		Jeb E 48 b		Jeb Eg		M.C.B.$_{III}$		Jeb E 130		Br. P. 82-8	
Micro-thermo-metry T(°C)	Type I	Th_L=-133				Th_V=-125		Th_L=-100		Th_L=-126		Th_V=-120				Th_V=-125	
	Type II	Tf_{CO_2}=-65 Th_L=-145		Tf_{CO_2}=-59 Th_V=0		Tf_{H_2O}=-7 Th_L=400		Tf_{H_2O}=-2 Th_L=300		Tf_{CO_2}=-60 Th_L=-12		Tf_{CO_2}=-60 Th_V=-10		Tf_{CO_2}=-58 Th_L=+2		Tf_{CO_2}=-59 Th_V=+15	
Type		I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Raman Anal-ysis mole %	N_2	89	-	-	23	80	66	38	31	67	27	75	68	-	12	50	6
	CO_2	0	-	-	75	0	0	0	0	16	71	25	18	-	87	42	92
	CH_4	11	-	-	2	20	34	61	69	17	2	0	14	-	0,15	7	1,5
	H_2S	0	-	-	0	0	0	0,66	0	0	0	0	0	-	0	0	0
Vol. %	H_2O	n.f	n.f	n.f	20	n.f	80	n.f	n.f	n.f	n.f	n.f	n.f	n.f	n.f	n.f	20

n.f = not found. Tf = Temperature average melting point. Th = Average homogenization temperature (V = vapor phase, L = liquid phase). *Sample from near graphite.

BATTINO, Rubin, RETTICH, T.R. and TOMINAGA, Toshihiro, 1983, The solubility of oxygen and ozone in liquids: J. Phys. Chem. Ref. Data, v. 12, no. 2, p. 163-178. First author at Dept. Chem., Wright State Univ., Dayton, OH.

This review covers the solubility of oxygen and ozone in liquids as a function of temperature and pressure. Solubility data for individual systems were critically evaluated and recommended or tentative values presented in many cases. The trend of solubilities in homologous series or related solvents is discussed. Liquids include water; seawater; aqueous salt solutions; mixed solvents; hydrocarbons; organic compounds containing oxygen, halogen, sulfur, nitrogen, or silicon; olive oil; and human blood. For ozone, only its solubility in water is presented. (Authors' abstract)

BAZAROVA, T.Yu., 1983, Problem of natural sodium leucite: Geol. i Geofiz., no. 5, p. 130-134 (in Russian; English abstract). Author at Inst. Geol. and Geoph., Novosibirsk, USSR.

The studied basalts of the Bol'shoy Anyuy area bear phenocrysts of multiply zoned clinopyroxene and analcite. Pyroxene contains in its growth zones large amounts of crystal inclusions: leucite and Na-bearing [leucite] (determined by electron microprobe). Glass inclusions bear the same dms. Analcite phenocrysts bear frequently crystal inclusions of grossular (2% of spessartite, 27.3% of andradite, 70.3% of grossular), distributed uniformly throughout the host mineral. Glass inclusions in pyroxene also bear similar garnet (plus leucite, or analcite), Th 1240°. The author supposes either coeval crystallization of K- and Na-leucite or high-T ionic exchange in dry salt melts, but evaluates the second possibility as less probable. (Abstract by A.K.)

BEANE, R.E., 1983, The magmatic-meteoric transition: Geother. Resources Council, Special Rept. No. 13, p. 245-253. Author at AMAX Exploration, Inc.

Circulation of fluids derived from both magmatic and meteoric sources in the shallow intrusive environment is documented by several empirical factors in porphyry copper deposits of western North America. Early in the cooling history of the shallow plutons, fluids circulating in rocks were endogenous. Following consolidation and pervasive fracturing of the central intrusion, the igneous rock was cooled by broad-scale convective circulation of meteoric waters. The transition from magmatic- to meteoric-derived fluid flow in the porphyritic intrusion is monitored by a shift in the hydrogen isotope ratios of silicate minerals, by a sharp decrease in fluid salinity as recorded by fluid inclusions, and by chloritization of earlier-formed biotite. (Author's abstract)

BEDDOE-STEPHENS, B., ASPDEN, J.A. and SHEPHERD, T.J., 1983, Glass inclusions and melt compositions of the Toba Tuffs, northern Sumatra: Contrib. Mineral. Petrol., v. 83, p. 278-287. First author at Inst. Geol. Sci., Geochem. Div., 64-78 Gray's Inn Road, London WC1X 8NG, England.

Glass (melt) inclusions in quartz, plagioclase and K-feldspar phenocrysts in Toba Tuff ignimbrites all exhibit highly evolved, rhyolitic compositions, identical to glass forming the matrix of the rocks. About 4% H_2O is present, dissolved in the glass, suggesting a water saturation pressure (PH_2O) of about 1 kbar. Melt compositions are consistent with phase relations for the condition $PH_2O = P(total) = 1$ kbar.

The residual rhyolitic melt formed as the result of fractional crystallization from a more basic, possibly rhyodacitic melt, leading to the development of zoned feldspars. Water saturation in the melt probably arose as a result of this process.

Melt temperatures prior to eruption and quenching were probably less than 800°C. However, hot-state homogenization experiments yield entrapment temperatures significantly higher (>900°C). This discrepancy is not clearly understood but indicates care must be taken in the interpretation of such experiments.

Ignimbritic magmas at Toba, from pressure estimates, appear to have been erupted from about 3-4 kms depth and represent the silicic cap to a batholithic body consolidating beneath the Toba caldera. (Authors' abstract)

BEEUNAS, M.A. and KNAUTH, L.P., 1983, Isotopic composition of fluid inclusions in Permian halite; implications for the isotopic history of sea water (abst.): Geol. Soc. Am., 96th annual meeting, Indianapolis, Indiana, Oct. 31-Nov.3, 1983, Abstracts with Programs, v. 15, p. 524. Authors at Dept. Geol., Arizona State Univ., Tempe, AZ 85287.

Fluid inclusions in halite from the Permian bedded salts of the Palo Duro Basin of Texas have been isotopically examined to determine their origin and possible relationship to Permian sea water. The data lie below and to the right of the meteoric water line and range from $\delta^{18}O$ = -6.8 to +4.3‰, δD = -55 to -5‰ (SMOW). ^{18}O and D-enriched fluid inclusions are generally associated with detrital-free halite having primary growth textures. ^{18}O and D-depleted fluid inclusions are found in recrystallized halite and halite associated with red clastics.

These fluid inclusions are interpreted as trapped evaporite brines. The data reflect the mixing of ^{18}O and D-enriched marine evaporite brines and ^{18}O and D-depleted meteoric waters. Maximum $\delta^{18}O$ of the fluid inclusions of +4.3‰ are typical of brines evaporating at "normal" humidity. Low-^{18}O and low-D brines occur when rainfall and meteoric water runoff from continental highlands mix with the evaporating marine brines. This mixing displaces the typical $\delta^{18}O$-D evaporation trajectories toward the meteoric recharge isotopic composition. These fluid inclusions are isotopically similar to brines in a modern marine evaporite pan where meteoric influx is observed.

These data appear to be a record of evaporation, meteoric influx and early diagenesis during the Permian and have not been significantly influenced by modern meteoric dissolution or saline brines from underlying formations. The isotopic similarity of these fluid inclusions to modern salt pan brines suggests that Permian sea water was isotopically similar to modern sea water. (Authors' abstract)

BEHR, H.-J., HORN, E.E. and PORADA, H., 1983, Fluid inclusions and genetic aspects of the Damara Orogen: Intracontinental Fold Belts, H. Martin and F.W. Eder, eds.: Berlin, Springer-Verlag, p. 611-654. Authors at Geol.-

Paläon. Inst., GoldschmidtstraBe 3, 3400 Göttingen, FRG.

The relationships of fluid systems and orogenetic processes have been investigated in metasediments from the Khomas Trough of the southern Damara Orogen and from the margin of the southern platform. Fluid inclusion measurements revealed the existence of a high-saline system originating from playa sequences of the initial graben and rifting stage, and a low-saline system derived from metapelites of the geosynclinal fill.

The high-saline system [fluids] had been stored since diagenesis in sparite horizons and were liberated when hot crystalline nappes from the Khomas Trough were thrust onto the playa sequence of the Duruchaus Formation. Excess pore pressure built up by aquathermal pressuring caused a mechanical mobilization of the carbonate (sparite) horizons and strongly influenced the nappe tectonics along the southern margin of the Damara Orogen.

Profound hydrothermal metasomatic alterations of the country rock, crystallization of voluminous quartz-carbonate masses, locally with giant crystals, and the formation of stratiform copper mineralization are further consequences of the high-saline fluid circulation.

Dewatering and dehydration processes resulting in specific structures characterize the geosynclinal meta-pelites and their low-saline fluid system. Still preserved fluids allow a reconstruction of the P/T history and the process of uplift after the peak of metamorphism. (Authors' abstract)

BEIN, Amos and LAND, L.S., 1983, Carbonate sedimentation and diagenesis associated with Mg-Ca-chloride brines: the Permian San Andres formation in the Texas Panhandle: J. Sedimentary Petrol., v. 53, no. 1, p. 0243-0260. First author at The Geol. Survey of Israel, 30 Malkhe-Ysrael St., Jerusalem 95501, Israel.

The San Andres evaporitic sequence in the Palo Duro Basin includes several thick carbonate units in its lower part and many thin units in its upper part. Evaporites are concentrated in the northen part of the Northern Shelf of the Midland Basin, and carbonates predominate to the south. Within the Palo Duro Basin the carbonates in the lower part of the sequence differ from those in the upper part in containing skeletal lithofacies and in having lower Mn, Fe, and terrestrial organic content. The Br content in halite in the lower part of the sequence is consistently high, whereas halite in the upper part is commonly Br depleted. The Sr content in dolomite, calcite, and anhydrite and $\delta^{18}O$ values are about the same in the entire San Andres sequence in the Palo Duro Basin. Depleted $\delta^{13}C$ values in dolomite and low pristane/phytane ratios occur toward the south. Na/Cl and K/Cl ratios attributed to liquid inclusions in almost all carbonates are characteristic of marine brines evaporated beyond halite saturation. Na in the dolomite lattice is generally low and increases from north to south at the same stratigraphic levels.

The lower part of the formation was deposited in a broad shelf basin or lagoon sufficiently deep to maintain long periods of steady-state circulation, during which little halite dissolution and no potash-magnesia mineral precipitation occurred. The upper part of the formation was deposited in smaller water bodies sensitive to fluctuations in inflow of marine water as well as meteoric water.

Diagenesis of the carbonates occurred in contact with saline Mg-Ca-chloride brines evolved through anhydrite and halite precipitation. Skeletal mold formation, anhydrite cementation, dolomitization, and high Sr calcite cementation associated with celestite are all cogenetic products of such a brine-rock interaction. $\delta^{18}O$ of dolomite, calcite, and chert indicates apparent equilibrium relationships with the same solution. Tempertures have never exceeded 40 to 45°C, and imply the $\delta^{18}O$ of such a solution to be about 3‰. The somewhat depleted $\delta^{18}O$ composition of the proposed halite-saturated brine resulted from the reversal in the dependence of $\delta^{18}O$ on increased evaporation in highly saline brines. The proposed diagenetic model implies that, following early diagenetic processes, the rock sequence remained as a closed, but compacting, system unchanged by later fluid introduction. Low Sr values in dolomite are indicative of recrystallization and not fresh-water diagenesis. (Authors' abstract)

BELKIN, H., DE VIVO, B., GIANELLI, G. and LATTANZI, P., 1983, Fluid inclusion reconnaissance study of hydrothermal minerals from geothermal fields of Tuscany (Italy): 4th Int'l. Symp. on Water-Rock Interaction, Misasa, Japan, p. 43-47. First author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092, USA.

The purpose of this study is 1) to ascertain whether the physicochemical characteristics of fluids trapped as fluid inclusions in hydrothermal minerals from the geothermal fields of Larderello and Piancastagnaio (southern Tuscany) are comparable to those observed in their respective reservoir fluids; and 2) to obtain information on the deep fluid (brine?) from which the steam-gas mixture in the vapor-dominated system of Larderello is presumed to have been derived.

Three Larderello samples, from Larderello Profondo, Val Pavone, and Lago Puntone, were studied in detail; reconnaissance data were obtained on two additional Larderello samples from Sasso 22 and Serrazzano and one from Piancastagnaio. The fluid inclusions occur either in hydrothermal quartz and K-feldspar or in healed fractures in detrital quartz. Four types of inclusions were recognized: A) two-phase (liquid + vapor) liquid-rich; these occasionally contain cubic crystals (NaCl?) or anisotropic flakes which do not dissolve upon heating, and probably represent accidental trapping; salinity ranges from very dilute to very high (>22 wt% NaCl eq.); B) two-phase (vapor + liquid) vapor-rich, extremely dilute to moderate (10 wt% NaCl eq.) salinity; C) polyphase hypersaline (liquid + vapor + NaCl ± an elongate highly birefringent mineral ($CaSO_4$?)); D) three-phase (liquid brine + liquid CO_2 + CO_2-rich gas), very low salinity. Type D is especially abundant at Piancastagnaio, consistent with the high CO_2 content in the geothermal fluids.

Microthermometric determinations show that type A and some type B inclusions homogenize in the liquid phase; most type B inclusions homogenize in the gas phase. Type B have, on average, homogenization temperatures (Th) distinctly higher than those of type A and type C; this is due, in part, to heterogeneous trapping or widespread necking down resulting in erroneously high Th for type B. In polyphase type C inclusions, most NaCl crystals dissolve before Th. First melting temperatures (Te) as low as -52°C suggest that Ca (and/or Mg) is a major brine component along with Na and Cl. Temperatures of the triple point in type D inclusions are very close to that of pure CO_2 (-56.6°C). CO_2 homogenization occurs in the liquid phase at Piancastagnaio, and in the gas phase at Lago Puntone. In addition to optical evidence in type D inclusions, the presence of some gas under pressure, probably CO_2, is revealed by crushing-stage tests. Widespread coexistence of liquid- and gas-rich inclusions was taken as evidence of boiling; thus, Th was assumed to represent trapping temperature, and no pressure correction was applied.

The hydrothermal minerals in the Larderello and Piancastagnaio geothermal fields were formed by brines which were, at least in part, boiling. The wide range of compositions observed in the fluid inclusions can be interpreted as the result of boiling and condensation of an initially homogeneous, moderately saline, CO_2-bearing brine (type A), from which a vapor- and CO_2-rich low-salinity fluid (types B and D) and a slighly cooler hypersaline brine (type C) were produced. The average Th (types A and C) and present-day measured field or calculated (from mineral assemblages(s)) temperatures are generally similar, except for those of Val Pavone that are somewhat higher. Similarly, this correspondence between inclusion Th and present field temperature suggests that there was no major change in the thermal regime as they evolved from the water-rich hydrothermal mineral stage to the present vapor-dominated stage. The discrepancy observed at Val Pavone might suggest a decrease in temperature near the peripheral zone of the field. (From the authors' abstract)

BELKIN, Harvey, DE VIVO, Benedetto, LATTANZI, Pierfranco, 1983, Fluid inclusion studies in Maremma Toscana ore deposit minerals: Societa Geol. Italiana - Comune di Massa Marittima, Program (unpaginated) (in Italian).

BENDER, M., MARIS, C., HESS, J. and WAGGONER, G., 1983, Geochemical studies of ridge flank convection systems (abst.): IUGG, XVIII General Assembly, Program and Abstracts, v. 2, p. 813. Authors at Graduate Sch. Oceanography, Univ. Rhode Island, Kingston, RI 02881, USA.

We have studied the composition of discharging geothermal solutions from three ridge flank hydrothermal systems (Galapagos Mounds Field, EPR at 20°S, and Mariana Trough at 18°N), by sampling and analyzing interstitial waters at sites where geothermal solutions are upwelling through sediments. The results suggest that there is little chemical exchange between seawater and basalt associated wtih convection of seawater through the oceanic crust on ridge flanks. (From the authors' abstract)

BERDICHEVSKIY, V.L., 1983, Nuclei of melt in solid substance: Doklady Akad. Nauk SSSR, v. 273, no. 1, p. 80-84 (in Russian). Author at State Univ., Moscow, USSR.

The paper discusses theoretically nucleation of melt in an infinite elastic body submitted to uniform stress, especially the relation between the shape of the nucleus and stress state and appearance of axially symmetric nucleus. (A.K.)

BERDNIKOV, N.V. and PRIKHOD'KO, V.S., 1981, Loss of carbon dioxide from alkalic basalt magmas: Dokl. Akad. Nauk SSSR, v. 259, p. 708-710 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 259, p. 180-188, 1983).

Abstracted in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 18, 1981. (E.R.)

BERDNIKOV, N.V. and TOMILENKO, A.A., 1983, Carbon dioxide-methane inclusions in quartz from granites of the Agusa massif (Northern Sikhote Alin'): Dokl. Akad. Nauk SSSR, v. 268, no. 3, p. 656-659 (in Russian). First author at Inst. of Tectonics and Geophysics, Khabarovsk, USSR.

Xenoliths of granite-biotite migmatitized gneisses with quartz and quartz-feldspar veinlets were found in two-mica granites of the Agusa massif. Quartz from granites and gneisses bears P and PS inclusions of G or L methane. At T <-82.5°C in G inclusions L phase appears and in L ones - G bubble forms. Inclusions in quartz of granites yield Th -87 to -82.5°C (in L) and in quartz of gneisses - -86 to -94.2°C. Several times critical phenomena were observed in PS inclusions at -82.7°C, close to critical T of methane (-82.5°C). Freezing of L in inclusions occurs at -182.5°C, but many inclusions were not frozen even in L nitrogen (-196°C). Quartz of granites and gneisses also bears numerous PS inclusions filled by CO_2 + CH_4 mixture in various proportions. Essentially CO_2-filled inclusions have Tm of solid CO_2 -62.5°C due to CH_4 admixture, Th at -31.5 to -38.5°C in L phase. When CO_2:CH_4 ratio is close to 1, at -54°C G bubble appears and about -100°C L splits into two immiscible liquids: CO_2-rich and CH_4-rich, homogenizing at about -94°C. At -102°C LCO_2 freezes, but for the LCH_4 freezing was not achieved. Solid CO_2 completes melting at -65, but without formation of separate LCO_2 (solid CO_2 dissolves in LCH_4). In CH_4-rich inclusions at low T CO_2 crystallizes without preceding separation of LCO_2. In practically all CO_2-CH_4 inclusions water is present in trace amounts.

Quartz from granites and gneisses bears crystallized melt inclusions with Th 675-740°C (in granites) and 680-835°C (in gneisses). The wide range of Th for gneisses may be explained by the supposition that melt inclusions formed during migmatitization and interaction with granite magma. S G inclusions bear H_2O with admixture of methane and CO_2; total salt concentration does not exceed 1-2% of NaCl equivalent; Th from +130 to +407°C (Russian text gives value "-407°C," presumably a misprint, A.K.).

Specific volume of CH_4 in P inclusions in granite and PS in gneiss equals 4.710-3.600 cm^3/g, that yields at 675-730°C a pressure $1.5\text{-}3.0 \times 10^8$ Pa. (Abstract by A.K.)

BERGER, V.I., SHUMSKAYA, N.I. and SHLEYKIN, P.D., 1983, Mackinawite from antimony mineralization in Eastern Yakutia: Geol. Rudn. Mestorozhd., v. 25, no. 6, p. 110-113 (in Russian). Authors at VSEGEI, Leningrad, USSR.

Quartz paragenetic with mackinawite and native antimony from the deposit Markovskoe yielded Th 350-380°C. (A.K.)

BERLYAND, L.V. and OKHOTSIMSKIY, A.D., 1983, Averaged description of elastic medium with large number of small absolutely rigid inclusions: Dokl. Akad. Nauk SSSR, v. 268, no. 2, p. 317-320 (in Russian). First author at State Univ., Khar'kov, Ukraine.

The mathematical model is presented for material consisting of elastic isotropic medium with significantly more rigid inclusions; pertinent to minerals bearing solid inclusions. (A.K.)

BETHKE, C.M., 1983, Fluid flow and heat transfer in compacting sedimentary basins (abst.): Geol. Soc. Am., 96th annual meeting, Indianapolis, Indiana, Oct. 31-Nov.3, 1983, Abstracts with Programs, v. 15, p. 526. Author at Dept. Geol., Univ. Illinois, 1301 West Green Street, Urbana, IL 61801.

The nature of compaction-driven fluid flow and heat transfer in subsiding intracratonic sedimentary basins is important to the understanding of secondary petroleum migration, some sediment-hosted ore deposits, anomalous geothermal gradients, and some diagenetic processes.

A numerical model has been developed to simultaneously consider sediment compaction, fluid flow, and heat transfer over geologic time periods. The model solves equations describing these processes in deforming coordinates and with a moving boundary condition. The solution provides for geological unconformities and hiatuses in sedimentation.

The hydrologic and thermal effects of sedimentation along a cross-section of the Illinois basin, beginning in Cambrian time, were predicted by a model calculation. The model results show large-scale pore fluid redistributions and thermal anomalies. The resultant flow fields and temperature distributions compare well with known patterns of petroleum migration an fluid inclusion measurements within the basin. (Author's abstract)

BEUS, A.A. and KHETCHIKOV, L.N., 1983, Contribution to the problem of determination of concentration and composition of mineral-forming solutions from gas-liquid inclusions in minerals: Geol. Rudn. Mestorozhd., v. 25, no. 6, p. 88-90 (in Russian).
See Translations.

BEZMEN, N.I. and SUK, N.I., 1983, Basic-ultrabasic immiscibility (an experiment): Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 6, p. 43-51 (in Russian). Authors at Inst. Exper. Mineralogy, Chernogolovka near Moscow, USSR.

Experiments were performed with H_2-H_2O atmosphere at T 900-1500°C, P 100-500 MPa, yielding immiscibility in picrite and basalt melts. (A.K.)

BIGGAR, G.M., A re-assessment of phase equilibria involving two liquids in the system K_2O-Al_2O_3-FeO-SiO_2: Contrib. Mineral. Petrol., v. 82, p. 274-283. Author at Dept. Geol., Univ. Edinburgh, West Mains Road, Edinburgh, Great Britain.

According to Biggar, Roedder (1978) misinterpreted his own data. Note, however, replies by Roedder (1983a; this volume) and by Freestone (1983 ; this volume). (E.R.)

BILENKO, Yu.M., 1983, The nitrogen contents in diamonds from placers in the northeastern part of the Siberian platform: Geol.iGeofizika, v. 24, no. 3, p. 146-147 (in Russian; translated in Sov. Geol. & Geohys., v. 24, no. 3, p. 140-142).

On the basis of a study of more than 3000 diamonds from placer deposits in the northeasten part of the Siberian platform, the differences and similarities between these crystals in their nitrogen contents are shown. Diamonds from the kimberlite bodies known in this region make up a small part of the total number of crystals. Diamonds that may have originated from old and no longer existing sources are distinguished. (Author's abstract)

BISCHOFF, J.L. and ROSENBAUER, R.J., 1983a A note on the chemistry of seawater in the range 350°-500°C: Geochimica Cosmo. Acta, v. 47, p. 139-144. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

The chemistry of seawater at conditions of 350° to 500°C, 220 to 1000 bars (22 to 100 MPa) is controlled by reactions involving magnesium hydroxide sulfate (MHSH) and anhydrite. During progressive heating from 350° to 500°C at 1000 bars (100 MPa), MHSH with a Mg/SO_4 ratio of 1.25 is formed via precipitation from solution and via reaction of solution with preexisting anhydrite. During adiabatic expansion the MHSH extracts additional SO_4 from seawater and converts to a stoichiometry in which Mg/SO_4 = 1.16. These reactions control and greatly change the concentrations of Ca, Mg, SO_4 in solution and produce significant ionizable hydrogen, attaining 11.7 mmoles kg^{-1} at maximum conditions. (Authors' abstract)

BISCHOFF, J.L. and ROSENBAUER, R.J., 1983b The two phase boundary of seawater, 350° to 500°C: implications for submarine geothermal systems (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 50. Authors at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

The location of the two-phase boundary of sea water was determined by isothermal decompression of fully condensed sea water in the range of 350° to 500°C. The pressure at which phase-separation occurred for each isotherm was determined by a comparison of the refractive index of fluid removed from the top and bottom of the reaction vessel. The critical point was determined to be between 404° and 409°C, 290 to 304 bars and was located by noting the inflection in relative volume of fluid and vapor along the two-phase boundary. Because the salt composition of sea water varies somewhat as a function of water/rock ratio in the natural geothermal systems the exact position of the critical point probably cannot be more closely defined than this.

The two-phase boundary of 3.2% NaCl was found to coincide exactly with that of sea water over the range of the study. The boundary for both is described by the equation,

$$P = 2366 - 19.9t + 0.054t^2 = 4.3 \times 10^5 t^3$$

where P is in bars and t is in degrees Celsius from 350° to 500°. The curve shows no apparent inflection at the critical point and is virtually linear from 390°C to 500°C.

Thus, the boundary puts temperature limits of about 390°C for fluids circulating near the sea floor at active ridge segments, (250 bars) and about 470°C at the top of a magma chamber (450 bars) if they occur as shallow as 2 km beneath the sea floor. At present there is uncertainty concerning the nature of the magma chamber beneath the axial zone; in particular whether the magma chamber is steady state or episodic. If the system is steady state, then penetration of sea water at the axis is limited in depth to the top of the magma chamber. Deeper penetration and higher temperatures would occur only after the chamber has solidified during its lateral translation out of the axial zone. This off axis penetration, however, would be relatively passive and not part of a discharging axial system. Alternatively, if magma chambers are episodic, and cool completely in place then the geothermal systems may ultimately penetrate to the bottom of the original magma chamber to depths of 4.5 to 5 km, or to pressures in the range of 700-750 bars and fluid temperatures well above 500°C are possible. (Authors' abstract)

BIZOUARD, H., METRICH, N. and CLOCCHIATTI, R., 1983, Halogens and sulfur in glassy inclusions, groundmass, and certain minerals (biotite and apatite) of eruptive materials (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 12 (in French; translation courtesy M.J. Logsdon). Authors at ER 45 du CNRS Lab. de Pétrographie et Volcanol., Bat 504 Univ. Paris-Sud, 91405 Orsay, France.

Estimation of the fluid content of magmas has been approached using several methods: 1) direct sampling of gas that escapes from lavas or through fumaroles, with in-situ or laboratory analysis (Tazieff et al., 1972); 2) mass spectrometry of gases extracted by melting or by progressive degassing of samples (Chaigneau, 1975); 3) electron microprobe point analyses of certain volatile elements (S, Cl, F) dissolved in silicate liquids trapped in intramineral crystal defects (Rose, 1982; Bizouard, 1981).

This last approach, although posing certain problems of methodology and interpretation (Watson, 1982), seems to be the only one capable of providing an estimate of the fluid content of a magma at an instant in its eruptive history.

A rigorous technique must always be used with this approach, because a part of the original fluids may escape analysis or even unmix in a vapor phase (see Clocchiatti et al., this volume). Preliminary results show, at least in the case of glassy inclusions, that the concentration of F, Cl and S can be considered homogeneous - within the limits of the analytical precision - from one inclusion to another in the same crystal and from one mineral to another in the same rock. On the other hand, in the case of biotites and especially apatites, even if the concentrations of Cl and F are homogeneous in a single crystal, they may vary from one crystal to another in the same sample. A set of results from samples derived from active and ancient volcanoes representing major geochemical and geodynamic assemblages is presented and discussed. (Author's abstract)

BLANKENBURG, H.-J., 1980, The complex mineralogical-geochemical characterization of quartz and its significance for genetic interpretation and for the raw-material industry: Dissertation B, Bergakademie Freiberg, Part I: Contribution to the mineralogical-geochemical characterization of quartz of various origins and some remarks on their formation (155 p., 27 figures, 46 tables and 346 references, in German; abstract courtesy R. Thomas).

This paper also discusses different trace element-temperature correlations, the Li/Ge-temperature and the Ba/B-temperature relation as examples, as well as the consequence of the trace element ratios and contents in quartz and quartz raw material for genetic and (raw) material specific statements.

The geothermometer of Rösler et al. (1978), which is based on the dependence of crystal growth on the formation temperature, was corroborated for the postmagmatic stages and was expanded to magmatic and metamorphic quartzes. The range of temperature for formation of quartz of various origins was estimated and given in tabular form according to a complex interpretation of the trace element data, by the correlation between the formation temperature and by the quotient of the (X-ray) primary crystallite particle size at 25.11° and 10.44° as well as by fluid inclusion data.

BLANKENBURG, H.-J., SCHRÖN, W., STARKE, R. and KLEMM, W., 1983, Relations between agate, jasper, and the rock matrix in acid vulcanites: Chem. Erde, v. 42, p. 157-172 (in German; English abstract).

See Thomas and Blankenburg, 1981, this volume. (E.R.)

BLOOM, M.S., 1983, Geochemistry of fluid inclusions and hydrothermal alteration in vein- and fracture-controlled mineralization: Ph.D. dissertation, Univ. of British Columbia.

BODNAR, R.J., 1983, A method of calculating fluid inclusion volumes based on vapor bubble diameters and P-V-T-X properties of inclusion fluids: Econ. Geol., v. 78, p. 535-542. Author at U.S. Geol. Survey, Mail Stop 959, National Center, Reston, VA 22092.

The volume of a fluid inclusion (as is needed in various chemical and isotopic analytical techniques) can be calculated with surprising accuracy by this procedure. (Note - an erratum supplied by the author indicates that the third from the last term of equation A1 (p. 542) should be $1.2843 \times 10^{-3} B^3$.) (E.R.)

BODNAR, R.J. and BETHKE, P.M., 1983, Data on stretching of fluid inclusions in fluorite and sphalerite: U.S. Geol. Survey Open File Report 83-790, 20 pp. Authors at U.S. Geol. Survey, Reston, VA 22092.

Essentially the paper equivalent to an abstract presented in 1980 (Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 26, 1980).(E.R.)

BODNAR, R.J. and CONNOLLY, J.A.D., 1983, Fluid pressure as an independent variable in metamorphism obtained from integrated fluid inclusion-mineral phase equilibria studies (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 529. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Fluid inclusion data combined with mineral-volatile phase equilibria calculations provide a method of determining P-T conditions of metamorphism. In previous studies in which thermobarometry has been accomplished independently of fluid inclusions, pressures calculated from mineralogical barometers have been greater than those obtained from coeval fluid inclusions. A probable source of this discrepancy may be in the common assumption that fluid pressure (P_f) is <u>not</u> independent of lithostatic pressure (P_s). Specifically, it is <u>usually</u> assumed that $P_f = P_s$.

Integrated fluid inclusion-petrologic-mineral phase equilibria studies can provide the constraints necessary to evaluate P_f, P_s and T as independent variables. Relationships between P_f, P_s, and T are determined from volatile-dependent mineral phase equilibria calculations; isochores obtained from fluid inclusion studies define a unique relationship between P_f and T. For a given fluid composition and density, these data may be combined to determine <u>both</u> P_f and P_s, as well as T, of a metamorphic environment. As an example, the assemblage plagioclase+zoisite+calcite+quartz+garnet defines a univariant curve in P_f-P_s-T space at a fixed fluid composition; the intersection of this curve with the divariant plane defined by the inclusion isochore uniquely determines all three variables. Thus, an H_2O-CO_2 fluid inclusion in this assemblage with a composition of 10 mole percent CO_2 and a density of 0.7 g/cm^3 gives $P_f = 1.5$ kb, $P_s = 3.0$ kb and T = 5.0°C; an inclusion of this same composition but with a density of 0.9 g/cm^3 indicates $P_f = P_s = 8.9$ kb and T - 8.10°C for this same assemblage. In these calculations the effects of nonhydrostatic stress on mineral phases are ignored and inferred P_f-T conditions are therefore maximum values. (Authors' abstract)

BOETTCHER, Art, 1983, CO_2 and H_2O in silicate liquids: SiO_2-H_2O-CO_2 (abst.): EOS, v. 64, p. 339.

BOGARD, D.D. and JOHNSON, P., 1983, Martian gases in an Antarctic meteorite?: Science, v. 221, p. 651-654. Authors at Planetary & Earth Sci. Div., NASA Johnson Space Center, Houston, TX 77058.

Significant abundances of trapped argon, krypton, and xenon have been measured in shock-altered phases of the achondritic meteorite Elephant Moraine 79001 from Antarctica. The relative elemental abundances, the high ratios of argon-40 to argon-36 (⩾2000), and the high ratios of xenon-129 to xenon-132 (⩾2.0) of the trapped gas more closely resemble Viking data for the martian atmosphere than data for noble gas components typically found in meteorites. These findings support earlier suggestions, made on the basis of geochemical evidence, that shergottites and related rare meteorites may have originated from the planet Mars. (Authors' abstract)

BOGASHOVA, L.G., 1983, Metalliferous interstitial water in evaporites: Dokl. Akad. Nauk SSSR, v. 269, no. 4, p. 932-933 (in Russian).

BOGATIKOV, O.A., DMITRIYEV, R.V., ERSHOVA, Z.P., PILOYAN, G.O. and FRIKH-KHAR, D.I., 1983, Hydrogen in regolith "automatic station Luna-24:" Doklady Akad. Nauk SSSR, v. 270, no. 2, p. 421-423 (in Russian). First author at Inst. Geol. of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow, USSR.

Lunar regolith sample of grain class >10 μm, consisting mostly of glass, bears 0.96-0.93 ml of hydrogen per gram, by mass spectrometry. (A.K.)

BOGOCH, R. and MAGARITZ, M., 1983, Immiscible silicate-carbonate liquids as evidenced from ocellar diabase dykes, southeast Sinai: Contrib. Mineral. Petrol., v. 83, no. 3-4, p. 227-230.

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

Indexed under Fluid Inclusions. (E.R.)

BOGUSH, I.A. and TRUFANOV, V.N., 1983, Temperature regime and zoning of ore formation in polygenic sulfide ore bodies (northern Caucasus): Geol. Rudn. Mestorozhd., v. 25, no. 4, p. 71-79 (in Russian). First author at Polytechnical Inst., Novocherkassk, Ukraine.

On the basis of generalizations from over 300 decrepitation analyses of the genetically fixed minerals from ores of the N. Caucasus, a T model is proposed for vertical zoning of polygenic copper sulfide ore bodies (Khudess, Bykovskoe, Urup, Beskess, Vlasenchikha). (Authors' abstract translated by A.K.)

BOHLEN, S.R., 1983, Retrograde P-T paths for granulites (abst): EOS, Transactions, Am. Geophy. Union, v. 64, no. 45, p. 878.

BONE, Y., 1983, Interpretation of magnesites at Rum Jungle, N.T., using fluid inclusions: J. Geol. Soc. Australia, v. 30, p. 375-381. Author at Dept. Econ. Geol., Univ. Adelaide, S.A. 5000.

Fluid inclusion Th from the magnesites of the Celia Dolomite and the Coomalie Dolomite of the Rum Jungle area of the Pine Crek Geosyncline, N.T., indicate that temperature is a major control of the two distinctive morphological forms. The rhombohedral form recrystallized in association with fluids that homogenized mainly at temperatures less than 150°C, whereas the bladed (tabular) form developed by recrystallization at a higher temperature. Previously the two forms have been interpreted as pseudomorphs after halite and gypsum, respectively. (Author's abstract)

BONEV, I.K., 1983, Quartz-calcite epitaxic overgrowths and origin of some specific morphological quartz varieties: Rev. of the Bulgarian Geol. Soc., v. 44, pt. 1, p. 41-50 (in Russian; English abstract).

Proposes that the fluid-inclusion-rich "white stripe" ("Fäden" or "Streifen") quartz crystals from Alpine veins formed by filling a cavity from dissolution of a calcite seed plate. (E.R.)

BONHAM, H.F., Jr. and GILES, D.L., 1983, Epithermal gold/silver deposits: the geothermal connection: Geothermal Resources Council, Special Rept. No. 13, p. 257-262.

BÖTTGER, T., STIEHL, G. and MUHLE, K., 1983, D-variations in granite and mica schsist of contact zones of intrusives in the middle Erzegebirge (abst.): ZfI-Mitteilungen (papers of the Central Inst. of Isotope and Radiation Research of the Acad. Sci. GDR), v. 80, p. 95 (in German).

BOWERS, T.S. and HELGESON, H.C., 1983a, Calculation of the thermodynamic and geochemical consequences of nonideal mixing in the system H_2O-CO_2-NaCl on phase relations in geologic systems: equation of state for H_2O-

CO_2-NaCl fluids at high pressures and temperatures: Geochimica Cosmo. Acta, v. 47, p. 1247-1275. First author at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125.

Fluid inclusion analyses leave little doubt that solutions containing large concentrations of H_2O, CO_2, and electrolytes are involved in a wide range of geologic processes. Although the miscibility gap in the system H_2O-CO_2 occurs only at low temperatures, experimental data reported by Takenouchi and Kennedy (1965) and Gehrig (1980) indicate that the addition of 6 weight percent NaCl relative to H_2O + NaCl extends the region of immiscibility in the system H_2O-CO_2-NaCl to $\geqslant 700°C$ at 500 bars and mole fractions of CO_2 (XCO_2)$\leqslant 0.1$. In contrast, addition of 20 weight percent NaCl relative to H_2O + NaCl at 700°C and 500 bars expands the miscibility gap to $XCO_2 \leqslant 0.2$. At 2000 bars, addition of 20 and 35 weight percent NaCl relative to H_2O + NaCl causes the miscibility gap to extend to ~500° and ~700°C, respectively, at $XCO_2 \approx 0.3$. The existence of the immiscible region in this high-pressure/temperature environment has a profound effect on temperatures of equilibration for metamorphic mineral assemblages (Bowers and Helgeson, 1983). To determine the extent to which nonideality in the ternary system affects these equilibria, the modified Redlich-Kwong (MRK) equation of state was fit to pressure-volume-temperature data taken from Gehrig (1980) along pseudobinaries for which $XNaCl/XH_2O$ is constant. Fugacity coefficients of the components were then generatred from the fugacity coefficient analog of the MRK equation of state and these coefficients were used together with solubility data to determine the compositions of the coexisting immiscible phases. The tie lines connecting the coexisting phases shift in orientation from nearly parallel to the H_2O-CO_2 binary at low temperatures to almost perpendicular to this binary at high temperatures. (Authors' abstract)

BOWERS, T.S. and HELGESON, H.C., 1983b, Calculation of the thermodynamic and geochemical consequences of nonideal mixing in the system H_2O-CO_2-NaCl on phase relations in geologic systems: metamorphic equilibria at high pressures and temperatures: Am. Mineral., v. 68, p. 1059-1075. First author at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125.

Fluid inclusion analyses reported in the literature, together with experimental data and thermodynamic calculations indicate that nonideality in the system H_2O-CO_2-NaCl may have a profound effect on phase relations in metamorphic processes. High concentrations of NaCl in the system H_2O-CO_2-NaCl increase substantially the size of the two-phase (liquid + vapor) region by raising the consolute temperature for a given pressure and ratio of the mole fractions of H_2O and NaCl to more than double that in the binary system H_2O-CO_2. As a consequence, fluid immiscibility may occur at considerable depth during progressive metamorphism of siliceous carbonates. The effect of nonideal mixing of H_2O, CO_2, and NaCl on equilibrium constraints in metamorphic systems can be assessed quantitatively on phase diagrams generated with the aid of a modified Redlich-Kwong equation of state (Bowers and Helgeson, 1983). Diagrams of this kind indicate that increasing NaCl concentration results in higher temperatures and/or lower predicted values of XCO_2 for equilibrium mineral assemblages than would be true for the binary system H_2O-CO_2. Transection of various mineral stability fields by saturation lines representing equilibrium between the aqueous phase and calcite, dolomite, or magnesite on logarithmic activity diagrams is also highly sensitive to the NaCl concentration in the aqueous phase. For example, the assemblage tremolite + dolomite + talc coexists with an H_2O-rich fluid at 450°C, 2 kbar, and NaCl concentrations $\leqslant 1$ m.

However, as the concentration of NaCl increases to ~4 m, tremolite is no longer stable in the presence of the fluid phase. The slopes of isochores for given bulk compositions in the ternary system H_2O-CO_2-NaCl decrease substantially with increasing CO_2 concentration. The isochores generated from the equation of state for the ternary system can be used to calculate pressure corrections for fluid inclusion homogenization temperatures. Stability fields for certain mineral assemblages in temperature-composition diagrams for the two-phase (liquid + vapor) region of the system H_2O-CO_2-NaCl are much smaller than their counterparts in the one-phase region. Furthermore, all univariant curves which cross the consolute composition curve on such diagrams exhibit temperature minima. These curves terminate in invariant points which are replicated on both sides of the miscibility gap. Subtle changes in NaCl concentration at low to intermediate values of XCO_2 may result in the appearance of mineral assemblages commonly thought to occur only in the presence of CO_2-rich fluids. Failure to account for the possible effects of fluid immiscibility on equilibrium mineral asemblages may lead to serious errors in interpretation of phase relations in metamorphic rocks. (Authors' abstract)

BOWERS, T.S. and HELGESON, H.C., 1983c, Metamorphic equilibria in the liquid + vapor region of the ternary system H_2O-CO_2-NaCl at high pressures and temperatures (abst.): EOS, v. 64, p. 347.

See previous abstract. (E.R.)

BOWMAN, J.R., COVERT, J. and CLARK, A.H., 1983, Hydrogen, carbon, and oxygen isotope studies of the Cantung scheelite skarn, Tungsten, N.W.T., Canada (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A7. First author at Dept. Geol., Univ. Utah, Salt Lake City, UT 84112.

Hydrogen, carbon and oxygen isotopic analyses have been made on this large scheelite deposit, associated igneous and contact metamorphic rocks, and modern local meteoric water. Both "anhydrous" (garnet + pyroxene (Px) + quartz (Qz) + scheelite + pyrrhotite) and "hydrous" (amphibole (Amp) and/or biotite (Bi) + Qz + scheelite + pyrrhotite) skarns replaced calcitic marble ($\delta^{18}O$ = 19.7 to 20.5; $\delta^{13}C$ = -0.5 to 1.7) adjacent to a quartz monzonite stock ($\delta^{18}O$(w.r.) = 10.9 to 11.1; δD(Bio) = -78 to -100). The isotopic compositions of skarn minerals from both skarn types are similar:

	$\delta^{18}O$	δD
Anhyd. skarn	7.8 to 8.8(Px); 12.9 to 13.4(Qz)	-108 to -114 (Amp)
Hyd. skarn	7.3 to 8.0(Bi, Amp); 13.0 to 13.3(Qz)	-105 to -118 (Bi, Amp)

Mass-balance calculations indicate that the isotopic compositions of the skarn calcites ($\delta^{18}O$ = 11.7 to 14.2; $\delta^{13}C$ = -7.2 to -5.6) are not reproduced by simple isothermal decarbonation of the marble wallrock. Oxygen isotope thermometry results (465-520°C) are in good agreement with results of previous fluid inclusion studies (475 + 30°C). Calculated $\delta^{18}O$ and δD values of water in equilibrium at 475°C with the quartz monzonite (8.4 to 9.0; -35 to -50), skarn (8.7 to 10.4, -70 to -80), marble wall rock (18.0 to 18.9, -47 to -55), and meteoric water (-23.1, -190) indicate that the skarn fluids contained a detectable, but not dominant component of meteoric water. The isotopic data are consistent with derivation of the skarn fluids largely from fluids equilibrated with the Cantung stock (magmatic fluids?). However participation of certain types of formation water cannot be totally ruled out. The ^{18}O enrichment of $\leqslant$1.0‰ in the skarns relative to the igneous intrusion is consistent with either limited isotopic exchange between skarn fluids and the marble at high water:rock ratios or mixing with CO_2 evolved during skarn reaction. For the latter case, mass-balance calculations indicate an upper limit to $X(CO_2)$ of

<0.07, a value in agreement with limits inferred from phase equilibria and fluid inclusion studies. (Authors' abstract)

BOYD, J.W., IV, 1983, The geology and alteration of the Slate Creek breccia pipe, Whatcom County, Washington: M.S. thesis, The Univ. of Arizona, Tucson, AZ, 89 pp.

The Slate Creek breccia is a 200- by 260-meter oval, nearly vertical pipe formed by late-Miocene igneous activity. Genetic association with an S-type granite, the intrusive quartz-eye porphyry, is evident from the presence of quartz-eye porphyry as matrix, clasts, and dikes in the breccia. The breccia has both intrusion and explosion features. Venting is possible, but erosion prevents verification of the pipe's upper features.

Crenulated quartz, quartz-eye rhyolite, barren quartz veins, quartz-magnetite veins, and quartz-molybdenite veins within 300 meters of the breccia pipe are similar to rocks and textures found near the Henderson orebody, a Climax-type molybdenum deposit. Within the breccia, base-metal sulfide mineralization, phyllic alteration, and granitic intrusive associations all bear resemblances to the Redwell Basin prospect, also a Climax-type deposit. Fluid inclusion data also support comparison of the Slate Creek breccia and host rocks with Climax-type deposits. (Author's abstract)

BRENNINKMEIJER, C.A.M., KRAFT, P. and MOOK, W.G., 1983, Oxygen isotope fractionation between CO_2 and H_2O: Isot. Geosci., v. 1, p. 181-190.

BRIGHAM, R.H. and O'NEIL, J.R., 1983, Behavior of water during crystallization of a two-mica pluton: a hydrogen isotope study (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 533.

BRIL, Hubert, 1983, Fluid inclusion evidence from the Brioude-Massiac polymetallic district (Massif Central, France); Concerning the deposition of antimony minerals (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 13 (in French; translation courtesy M.J. Logsdon). Author at BRGM-CNRS, 1A, Rue de la Ferollerie 45045 Orleans, Cedex, France.

Fluid inclusions in gangue minerals from some thirty veins in the district were studied by microthermometry and Raman microprobe analysis. The principal results (summarized on Figure 1) outline 3 major mineralizing processes:

1) Type A: High temperature fluids which formed Sn-W-Au-As-bearing veins. These early fluids, enriched in CO_2, CH_4 and N_2, were progressively diluted by lower temperature, aqueous fluids (7-9% NaCl eq.); and Type B: high temperature fluids which formed As-Zn-Fe-Sb (stibnite)-rich veins. In these fluids the only volatile was CO_2.

2) Epithermal Pb-Zn-Cu (Type D) and sulfosalt (Type C) mineralization, characterized by very high salinities. In these fluids, both temperature and salinity declined together and progressively.

3) Fluorite-barite mineralization resulting from mixing at 170-100 degrees C of fluids of different salinities.

There are two types of antimony-bearing viens: mesothermal veins with stibnite associated with arsenopyrite, sphalerite and pyrite (Type B), and epithermal veins with Pb/Sb sulfosalts (Type C). Based on spatial, paragenetic, and geochemical arguments and comparison with other cases of antimony mineralization, one may conclude:

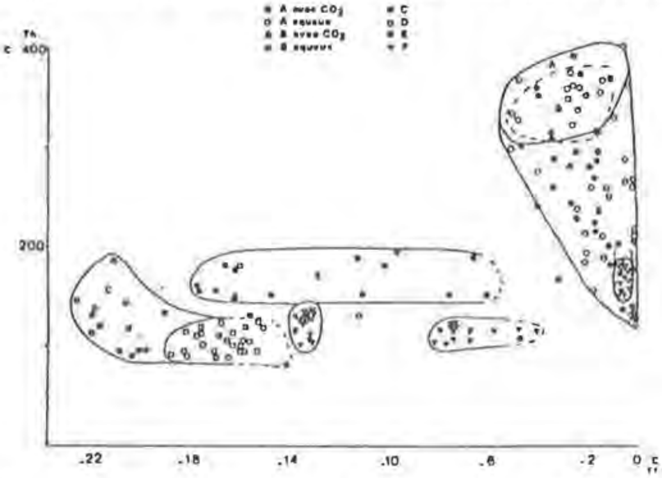
1) The temperature of deposition of the vein-stibnite approached 400 degrees C. However, emplacement of stibnite is possible at lower temperature over a wide range of $f(S_2)$, limited by the $T - f(S_2)$ values over the

stibnite - native antimony boundary. This may explain the epithermal characteristics frequently attributed to this type of mineralization.

2) The presence of CO_2 in all the early fluids poses a problem, in the absence of a carbonate environment, of a deep origin for the antimony. An isotopic study is underway.

3) The stibnite-depositing fluids were sometimes mixed with the second-phase, lead-bearing fluids, which then deposited Pb-rich Pb/Sb-sulfosalts in a much cooler environment. (Author's abstract)

Figure: Th vs Tf [Tm ice?] diagram of fluid inclusions recognized in the principal parageneses of the Brioude-Massiac district.



BRIMHALL, G.H., GILZEAN, M. and BURNHAM, C.W., 1983, Magmatic source region protoliths and controls on metallogenesis: mica halogen geochemistry (abst): EOS, Transactions, Am. Geophy. Union, v. 64, no. 45, p. 884. First author at Dept. Geol. & Geophy., Univ. California, Berkeley, CA 94720.

A model for halogen-bearing host minerals in granitic magma source regions is offered that accounts for the subdivision of magma types into two well-known groups, each with distinct metallogenic characteristics. Copper-rich systems are related to "I"-type (Chapell and White, 1974) or Magnetite-series (high fO_2) granitoids (Ishihara, 1977) arising from partial melting of a mafic amphibolite source rock with a low fluorine content. In constrast, a metasedimentary source containing various fluorine-rich phyllosilicates is proposed for the relatively high F/Cl biotites related to the "S"-type or Ilmenite-series (low fO_2) granitoids. Associated hydrothermal mineralization ranges from tin-tungsten to molybdenum deposits depending upon the relative amounts of muscovite (Fe-Al) and biotite (Mg) respectively in the metasedimentary source rock. (Authors' abstract)

BROMAN, Curt, 1983a, Fluid inclusions in apatite from the Kirunavaara orebody, Sweden: ORG 83, Annual Report Ore Research Corp., Stockholm Univ., p. 25-39.

Apatite from the Kirunavaara Precambrian iron ore contains two types of inclusions: primary solid inclusions and secondary fluid inclusions. The second type was formed during the rehealing of micro-cracks in the apatite crystals.

Temperature measurements of the fluid inclusions indicated that the apatite recrystallized in part at an average temperature of 170°C. The precipitating solution was a brine with a salinity of about 19 eq. wt% NaCl. (Author's abstract)

BROMAN, Curt, 1983b, Fluid inclusions in sphalerite from the Vassbo lead-zinc deposit, Sweden: ORG 83, Annual Report Ore Research Corp., Stockholm Univ., p. 103-116.

Fluid inclusions in sphalerite from the Vassbo lead-zinc deposit were of two types: (1) two-phase, possibly hydrocarbon inclusions containing a dark phase and a transparent fluid. Melting temperatures of -75°C were obtained for the fluid. (2) Two-phase aqueous inclusions sometimes containing a dark daughter mineral. Th of the latter inclusions demonstrated that the sphalerite was precipitated at around 140°C from NaCl brines. Two groups of salinities were distinguished. One stronger brine with 19.5 eq. wt% NaCl and a weaker composed of 5.6 eq. wt% NaCl.

Melting temperatures for calcite indicated a salinity of around 25-26 eq. wt% sodium chloride. (Author's abstract)

BROVKOV, G.N., MIROSHNIKOV, A.Ye. and OKHAPKIN, N.A., 1983, Genetic models of formation of polymetal deposits of the Enisey belt, in Genetic models of endogeneous ore formations: "Nauka" Pub. House, Siberian Branch, v. 2, p. 121-126 (in Russian).

Ore prospecting in the deposit Lineynoe used the decrepitation method in Td range 400-550°C, taking into account the variations of number of impulses. (A.K.)

BROWN, Michael, 1983, Fluids in metamorphism: J. Geol. Soc. London, v. 140, p. 529-532. Author at Dept. Geol. & Phys. Sci., Oxford Polytechnic.

An introduction to a series of papers stemming from a meeting, held 23 Sept., 1982, at Univ. Glasgow, on Fluids in Metamorphism. The individual papers are abstracted in this volume. (E.R.)

BROWN, P.E., 1983a, Gold mineralization in central Idaho--fluid inclusion and stable isotopic constraints (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 534. Author at Dept. Geol. & Geophy., Univ. Wisconsin, Madison, WI 53706.

Numerous examples of gold mineralization occur in central Idaho and NE Oregon. Few modern studies have been undertaken addressing the distribution and origin of these deposits.

Mineralization in the Buffalo Hump District is confined to 6 major (and several minor), N10E trending, steeply dipping quartz veins. The veins cut granodiorites associated with the Idaho Batholith but are usually found with Belt series schists and gneisses as wall rocks. Several episodes of quartz and sulfide deposition are evident separated by periods of shearing and granulation; shears are often marked by the development of sericite. High grade ore shoots rake steeply down the veins. Sulfide paragenesis is pyrite (Py)-galena (Ga)-chalcopyrite-sphalerite (Sl)-tetrahedrite with later covellite and iron oxides. Gold (820-880 fine) appears as both free grains and as inclusions in most of the rest of the sulfides. Tetrahedrite, spatially associated with the gold, exhibits similar variations in silver content.

Silicification is the major wall rock alteration observed and is concentrated in the hanging wall which may also carry good gold values. Fluid inclusions in the quartz contain no daughter salts, have salinities <10% and are either simple 2-phase or 3-phase (liq water, liq CO_2, CO_2 vap). Sulfur isotope values for Py (14.8-16), Sl (10.6-14.7) and Ga (12.7-13) are heavy and consistent with the sulfur being scavanged from the Belt series rocks. Sulfide pairs give temperatures in the range 3-400°C but equilibrium between the sulfides is unsure. The role of unmixing of the fluid phase in ore deposition is considered. (Author's abstract)

BROWN, P.E., 1983b, Ore genesis; the contributions and confusions of stable isotope investigations, *in* Revolution in the Earth Sciences: Advances in the Past Half-Century, Boardman, S.J., ed.: Northfield, Minn., Kendall/Hunt Pub. Co., p. 256-267.

Indexed under Fluid Inclusions. (E.R.)

BROWN, W.M., 1983, The genesis of a F-Sn-W skarn at Mt. Garnet, Queensland - an example of a granite-skarn hydrothermal system: M.S. thesis, La Trobe Univ., Bundoora, Victoria 3083, Australia.

The Hole-16 deposit is a small unexposed F-Sn-W ('wrigglite') skarn 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 a pure calcite marble. Assemblages representing successive stages of skarn genesis are 1) massive andradite, 2) massive Sn-rich garnet and magnetite, 3) 'wrigglite,' which refers to a characteristic fine-grained contorted rhythmically layered texture, consisting of alternating layers fluoro-vesuvianite and fluorite, 4) massive to coarsely layered fluoro-vesuvianite and fluorite, 5) iron-rich amphibole, biotite and phyllosilicates, calcite and scheelite, and 6) chlorite, hematite and clay minerals. Minerals corresponding to stages 5 and 6 are found in minor amounts throughout other assemblages. The increase in the Fe^{2+}/Fe^{3+} ratio of assemblages 1-4 is interpreted to reflect progressive 'swamping' of a high fO_2 environment (hematite-bearing marble) by low fO_2 granite-derived fluids.

The compositions of fluid inclusions were estimated by the phase volume method with liquid compositions inferred from freezing experiments and the presence of daughter minerals. Fluid inclusions in the granite contain highly saline fluids, (averaging 70 wt% dissolved salts in the quartz and 62 wt% in the fluorite). S.E.M. analyses indicate that a daughter mineral assemblage of KCl, NaCl, $CaCl_2$[sic], Ca-silicate, $FeCl_2$[sic], FeS_2 and ZnS, is common to both minerals. In addition to these, granite quartz-hosted fluid inclusions contain CaF_2, and fluorite-hosted fluid inclusions in the granite and the skarn contain $CaCO_3$ daughter minerals. Quartz and fluorite in the granite, and clinopyroxene, garnet and vesuvianite in the skarn contain fluid inclusions of two types: gas-poor moderate salinity inclusions, and gas-rich low salinity ones. This suggests that intermittent boiling of solutions occurred. The daughter mineral assemblage $CaCl_2$, KCl and NaCl is common to all skarn minerals except calcite. No $FeCl_2$ daughter minerals were observed in skarn minerals.

Homogenization experiments for fluid inclusions in the granite indicated temperatures of crystallization from 600°C to greater than 700°C. In the skarn, homogenization temperatures ranged from 300°C to greater than 600°C for early skarn minerals, to 100°C to 250°C for skarn calcite.

A model is proposed for the genesis of the skarn in which a convection cell of relatively small volume was initiated late in the paragenesis of the granite. A two-stage process is envisaged in which 1) the breakdown of F-annite in the granite by $CaCl_2$-rich skarn-derived solutions produced greisen (and endoskarn) and $FeCl_2$, and 2) the reaction of $FeCl_2$-rich solutions with marble produced skarn and $CaCl_2$-rich solutions which were recirculated back to the granite. (Author's abstract)

BRUHA, D.J. and NOBLE, D.C., 1983, Hypogene quartz-alunite±pyrite alteration formed by moderately saline, ascendant hydrothermal solutions (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 325. Authors at Dept. Geol. Sci., Mackay Sch. Mines, Univ. Nevada, Reno, NV 89557.

Certain near-surface, high-sulfur, high-fO_2 hydrothermal systems are characterized by intense, relatively coarse-grained quartz + alunite ± pyrite alteration with associated Ag + Cu ± Pb ± Zn mineralization containing enargite and/or tetrahedrite or with enargite plus gold. Secondary fluid inclusions in quartz phenocrysts provide samples of the solutions that formed the alteration. Th ranges, NaCl-equivalent salinities, and eutectic temperature of specimens from the following districts are:

Julcani, Peru	161-275°C	5-24, median 12 wt.%	?
Colquijirca, Peru	225-256°C	4-11, median 9 wt.%	-24°C
Summitville, CO	231-276°C	7-21, median 10 wt.%	-35°C
Goldfield, NV	230-475+°C	5-18, median 7 wt.%	-39°C
Ccarhluaraso, Peru	329-384°C	7-18, median 11 wt.%	-22°C

The presence of vapor-dominated inclusions at Ccarhuaraso shows that Tt was ≈330°C. Necking was important at Goldfield, but no vapor-dominated inclusions were seen; true Th is probably 250-290°C. The high eutectic temperatures of two specimens show that the salts are not entirely NaCl or KCl, but rather a complex mixture containing $CaCl_2$, $MgCl_2$ and/or $FeCl_2$. As many as five daughter minerals are present in samples from Summitville, Goldfield, and Ccarhuaraso. One with rhombohedral form, high birefringence and Tm ≈ 200°C is probably a sulfate or carbonate.

Field relations show that the alteration was formed within a few hundred meters of the surface by ascending solutions. The dissolved salts, and, in some districts, sealing allowed the solutions to exist at higher-than-expected levels. The apparently high Cl contents of the inclusions argue that the acid and sulfate-rich solutions were derived from depth, and were not formed at higher levels by condensation of upwardly-streaming SO_2-bearing vapors. The salinity variations probably in part reflect mixing of the original solutions with meteoric waters. (Authors' abstract)

BRYNDZIA, L.T., SCOTT, S.D. and FARR, J.E., 1983, Mineralogy, geochemistry, and mineral chemistry of siliceous ore and altered footwall rocks in the Uwamuki 2 and 4 deposits, Kosaka mine, Hokuroku district, Japan: Econ. Geol. Monograph 5, p. 507-522. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

Stockwork siliceous ores in the Uwamuki 2 and 4 deposits are developed as anastomozing quartz veins in autobrecciated white rhyolite lava domes and adjacent tuff breccias. At Uwamuki 2, two concentrically zoned stockworks have yellow siliceous ore (chalcopyrite + pyrite) in the center surrounded by black siliceous ore (sphalerite + pyrite + galena). At Uwamuki 4, stockworks of black and yellow siliceous ores and barite form discrete zones adjacent to one another. Alteration trends of footwall rocks from both deposits appear to be the product of two superimposed events: MgO enrichment followed by relative increase in Al_2O_3 and decrease in CaO and Na_2O; K_2O was only slightly depleted. At Uwamuki 2, the highest ore grades are found in the most intensely altered rocks.

Pressure-corrected Th of primary fluid inclusions in quartz euhedra intergrown with sulfides in yellow siliceous ore on the -10-m level from Uwamuki 2 range from 268° to 376°C and salinities from 3.9 to 6.7 equiv. wt.% NaCl. Corresponding data from Uwamuki 4 are 270° to 345°C and 2 to 5 equiv. wt.% NaCl (Marutani and Takenouchi, 1978). Sulfur isotopic temperatures estimated for sulfide-sulfate pairs are uniformly higher than fluid inclusion Th by about 108°C at Uwamuki 2 and 155°C at Uwamuki 4. These discrepancies are attributed to disequilibrium isotopic processes during deposition of sulfides and sulfate.

On the -100-m level at Uwamuki 4, $\delta^{34}S$ of pyrite decreases across the stockworks from 8 per mil in yellow siliceous ore to 5.5 per mil in black siliceous ore. Barite from both stockwork deposits has a mean $\delta^{34}S$

of 22.6 ± 0.6 per mil (1 σ, n = 4) and is identical to the mean $\delta^{34}S$ of syngenetic bedded sulfates (barite, anhydrite, and gypsum) from five other Kuroko deposits (22.5 ± 0.8‰; 1 σ, n = 21) from which we conclude that contemporaneous seawater was the probable source of sulfate sulfur.

Mole percent FeS in sphalerite coexisting with pyrite from the black siliceous ore at Uwamuki 4 decreases from 0.62 ± 0.10 on the -100-m level to 0.22 ± 0.02 on the -55-m level, paralleling a decrease of fluid inclusion Th in sphalerite from 287° ± 18°C to 255° ± 13°C. The vertical decrease of FeS in sphalerite was in response to declining temperature under conditions of nearly constant sulfur fugacity. The area of highest fS_2 in black siliceous ore coincides with the locus of maximum Zn + Pb deposition.

The important variations in the ore-forming fluid with time as deduced for Uwamuki 4 are simultaneous decrease in temperature, increase in total dissolved sulfur, increase in fO_2, and decrease in pH. Mineralization appears to have involved progressive domination of the ore fluid by seawater, giving rise to the decrease in $\delta^{34}S$ of pyrite as well as seawater characteristics for $\delta^{34}S$ of barite in the stockworks. Mass balance calculations demonstrate that the observed enhanced salinity of the ore fluid over seawater is not the result of normal seawater participating in rock-water hydration reactions. An admixture to seawater of a more saline fluid is required, possibly a magmatic fluid on the basis of existing H and O isotope data. (Authors' abstract)

BRYZGALIN, O.V., 1983, An electrostatic model for the instability constants of tungsten hydroxy complexes at elevated temperatures: Geokhimiya, no. 2, p. 228-235 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 1, p. 150-157, 1983).

BUCHINSKAYA, K.M., 1983, Substantial composition and formation conditions of lead-zinc ore mineralization of the Ust'-Parninskoe deposit: Mineralog. Sbornik, v. 37, no. 1, p. 53-62 (in Russian; English abstract). Author at Inst. Geochem. and Physics of Minerals, Kiev, Ukraine.

The polymetal deposit Ust'-Parninskoe (Krasnoyarsk country) occurs in the Lower Devonian sedimentary-volcanic beds; inclusions in sphalerite yielded T [Th? - A.K.] 220-240°C. (A.K.)

BUL'ENKOV, N.A., BELYANIN, A.F. and TSINOBER, L.I., 1983, Orientation and shape of inclusions in transparent quartz and fluorite crystals: Nov. Dannye Mineral., v. 31, p. 146-153 (in Russian).

A method was devised for plotting the orientation and form of inclusions by measuring the angles formed by projection of the edges and planes of inclusions to the sides of the crystal in which the inclusions occur. Based on the angles the position of the inclusion edges and faces is determined in stereog. projection of the crystal; the spherical coordinates are then found and used to calculate indexes of the inclusion edges and faces in the crystallography coordinates of the crystal. Study of the morphology of bounded gas-liquid inclusions in transparent fluorite crystals showed that the inclusions developed in relation to a regularly oriented set of secondary internal fissures. Filling of these fissures by water occurred by a mechanism different from that usual for formation of gas-liquid inclusions. The orientation of dislocations and regular aggregations of them (glide planes, dislocation loops, helicoids, etc.) were studied in α-quartz crystals. The position and interrelations of screw and other dislocations is described. The orientation of dislocations in configuration loops were compared by theoretical calculations of the angular dependence of the K energetic factor (Heinish, H.L. et al., 1975) in quartz. (C.A. 100: 24531h)

BURCH, C.R. and HINTON-CLIFTON, E., 1983, Use of the Zeiss HD (brightfield-darkfield) transilluminator for stereomicroscopes in conjunction with the photomicroscope for the examination and photography of gemstone inclusions: Zeiss Inform., v. 27, p. 18-19 (1982/83).

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 pre-mineralization 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)

Includes 15 Raman analyses of gases from inclusions (Fig. 5), for CO_2, N_2, CH_4 and H_2S (the highest H_2S was 0.6 mole %). (E.R.)

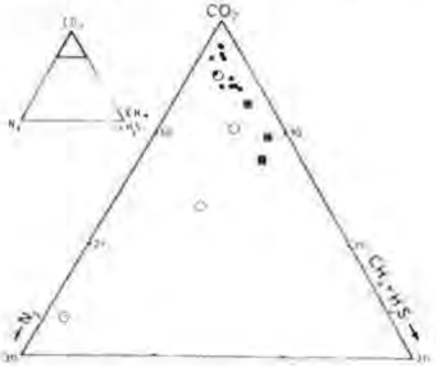


Fig. 5. Raman microprobe gas analyses (in mole %) of "CO_2-rich" fluid inclusions in Aberfoyle district quartz veins.

BURNHAM, C.W., 1983, Deep submarine pyroclastic eruptions: Econ. Geol. Monograph 5, p. 142-148. Author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Published experimental, thermodynamic, and other geochemical data on

H_2O-bearing silicic melts are used to obtain relationships which show that: (1) the rate of exsolution of H_2O (vesiculation) from silicic magmas that contain more than a few tenths of 1 wt percent H_2O is sufficiently rapid to contribute to the explosivity of pyroclastic eruptions; (2) the exsolution of ony a few tenths of 1 percent H_2O from a typical rhyolitic magma by the second boiling reaction--H_2O-saturated melt $\rightarrow$ crystals + H_2O vapor releases sufficient mechanical energy ($P\Delta V$ work of expansion)--to cause tensional fracture failure of wall rocks at pressures corresponding to ocean depths of at least 10 km; (3) the $P\Delta V$ energy released by the exsolution of additional H_2O, as a result of decompression following wall-rock failure, is fully adequate to produce pyroclastic eruptions, even at these great ocean depths; (4) the crystallinity and vesicularity of the juvenile pyroclasts of the tuff units that host and underlie the Kuroko ores in the Hokuroku district of Japan are consistent with their having been erupted onto the sea floor at an ocean depth of 3.5 ± 0.5 km, from a magma chamber situated 1.1 ± 0.3 km beneath the sea floor; and (5) the submarine caldera model of Ohmoto (1978) for the formation of volcanogenic massive sulfide deposits appears, therefore, to be viable, at least for the deposits in the Hokuroku district. Application of these same relationships to the 1980 eruption of Mount St. Helens suggests that the March through May 18, 1980, eruptive sequence, including the intrusion of magma into the northern bulge and the landslide-triggering earthquake, was initiated by the second boiling reaction at a substantial depth beneath the summit. Furthermore, the devastating blast could have been, but probably was not, caused entirely by the virtually instantaneous exsolution of H_2O from a higher level magma upon sudden decompression that accompanied the landslide. (Author's abstract)

BURRUSS, R.C., CERCONE, K.R. and HARRIS, P.M., 1983a, Fluid inclusion petrography and tectonic-burial history of the Al Ali No. 2 well: evidence for the timing of diagenesis and oil migration, northern Oman foredeep: Geology, v. 11, p. 567-570. First author at Gulf Res. & Dev. Co., P.O. Drawer 2038, Pittsburgh, PA 15230.

Cores cut in shallow-marine Lower and middle Cretaceous carbonates in the Al Ali No. 2 well, Umm al Qaiwain, United Arab Emirates, display a five-stage sequence of calcite cementation, fracturing, and stylolitization. These stages are correlated with the tectonic history of the northern Oman orogeny. Occurrence of fluorescent hydrocarbon fluid inclusions is restricted to stage 2 and stage 3 fracture-filling calcites that are crosscut by stylolites. Stylolite formation during rapid burial beneath abyssal Campanian foredeep sediments restricts hydrocarbon migration to post-mid-Cenomanian and pre-mid-Campanian time. (Authors' abstract)

BURRUSS, R.C., CERCONE, K.R. and HARRIS, P.M., 1983b, Regional distribution of hydrocarbon fluid inclusions in carbonate fracture filling cements: geohistory analysis and timing of oil migration, Oman foredeep (abst.): AAPG Bull., v. 67, no. 3, p. 434. First author at Gulf Sci. & Tech. Co., Pittsburgh, PA.

Fractured, reservoir limestones in Oman and the Unitd Arab Emirates include the Shuaiba (lower Aptian) and Mauddud (upper Aptian-lower Cenomanian). Deposition of these bioturbated, argillaceous foraminiferal-peloidal wackestones and packstones ceased in the Early Cretaceous as the Oman foredeep subsided and filled with pelagic sediment. Petrography and geohistory analysis of four wells and one outcrop suite reveals five stages of diagenesis, fracturing, and fluid migration. (1) Shelf emergence: early cementation associated with regional unconformities overlying both limestones; (2) pre-orogenic shelf emergence, late Cenomanian to Turonian: fractures cutting Stage 1 cements are healed by very cloudy, cleaved, and twinned calcite containing microfractures with yellow-white fluorescent, hydrocarbon fluid inclusions; (3) initial foredeep downwarp of 0 to 800 m (0 to 2626 ft), Coniacian to early Campanian: fractures crosscutting Stage 2 fractures are healed with cloudy, cleaved, and sometimes twinned calcite containing dull-blue flurorescent, hydrocarbon fluid inclusions; (4) rapid subsidence and filling with 600 to 3400 m (1970 to 11,155 ft) of flysch, exotic blocks, and thrust toes, Campanian to Maestrichtian: burial and tectonic stylolites crosscut Stage 2 and 3 fractures; and (5) uplift of the Oman Mountains after 3900+ m (12,795+ ft) burial by early Tertiary: fractures crosscutting all diagenetic features are filled with clear untwinned and uncleaved calcite containing only nonfluorescent, aqueous fluid inclusions. If we can correlate earliest stylolite formation with a minimum burial load of ~800 m (~2625 ft), then the hydrocarbon inclusions in Stage 2 fractures must predate all of Stage 4 and most of Stage 3. In the deepest portions of the foredeep, close to the Oman Mountain front, this limits the presence of oil in fracture porosity to late Turonian-early Campanian time. Farther to the west, in the shallower parts of the foredeep, this constraint relaxes, and oil migration occurred as late as early Tertiary. (Authors' abstract)

BURSILL, L.A., 1983, Small and extended defect structures in gem-quality Type I diamonds: Endeavour, New Series, v. 7, no. 2, p. 70-77. Author at Univ. Melbourne, Melbourne, Australia.

Gem quality diamonds may have up to one atom of carbon out of one thousand replaced by nitrogen. This article reviews the structures formed by the nitrogen in various states of aggregation, ranging from a few atomic diameters up to platelet shapes several microns in extent. The understanding of such defect structures now emerging gives new impetus to studies of the geological origin and evolution of various diamond species. The ability to control, by synthetic means, the defect structure of diamond has important implications for the future use of diamond, both as a gemstone and for more practical applications. (Author's abstract)

BURYAK, V.A. and FROLOV, N.M., 1983, Lateral zoning of distribution of magmatism and ore mineralization in volcanic-tectonic structures (on the example of the south-west part of Okhotsk-Chukotka volcanic belt): Doklady Akad. Nauk SSSR, v. 270, no. 2, p. 387-390 (in Russian). First author at Producing-Geol. Trust "Dal'geologiya," Khabarovsk, USSR.

Gold ores associated with dikes of andesite and consisting of quartz-carbonate veins yielding Td 140-380°C, rarer 400-420°C from the marginal parts of volcanic-tectonic depressions. Au-Ag and Ag deposits occur in the intermediate zone between margins and center of volcanic-tectonic structures, Td of ore-bearing quartz 140-420°C. Central parts of the structures bear copper-porphyry deposits with Au and Au-Ag ores, Td of ore quartz 160-420°C; in the same area Mo-quartz ores may form, Td 180-460°C. (Abstract by A.K.)

BUSHEVA, N.L., 1983, Genetic peculiarities of deposit of corundum in North Karelia: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 12, p. 90 (in Russian). Author at Moscow Geol.-Prosp. Inst., USSR.

The deposit (name not given; figure shows decrepigraphs of "pegmatite from Chupa, corundum and plagioclase," but it is not sure if this corundum occurs at Chupa) formed in connection with plagioclasite bodies cutting garnet-biotite and kyanite-garnet-biotite gneisses and schists. Td of corundum fall in two intervals: 300-500°C believed to be connected with S inclusions and 660-900°C - with P inclusions. Similar Td were found for garnet, kyanite and plagioclase. Gas analysis proved that volatiles in inclusions are essentially water and do not contain CO_2. (Abstract by A.K.)

BUSSINK, R.W., 1983, Fluid inclusions and stable isotopes of the Panasqueira tungsten-tin deposit (Portugal) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 14. Author at Inst. Earth Sci., P.O. Box 80.021, 3508 TA Utrecht, The Netherlands.

The horizontal tungsten-tin veins at Panasqueira occur around a greisenized granite cupola. The cupola is coverd by a quartz-cap from which the veins penetrate into the surrounding schists.

A pressure drop from about 1500 to about 150 bar at a depth of about 1400 m caused ore fluids, with 6-10 wt% NaCl, to boil at temperatures between 290 and 330°C. During the boiling stage arsenopyrite, wolframite, cassiterite, topaz and fluorite were deposited. At later stages, without boiling, arsenopyrite, sphalerite, chalcopyrite, apatite and siderite were deposited from fluids with decreasing salinity at temperatures between 250 and 290°C.

The $\delta^{13}C$ of CO_2 from fluid inclusions is -4 to -12 per mil. The $\delta^{13}C$ of total carbon (CO_2+CH_4) in the fluids is rather constant with values between -11 and -14 per mil, indicating a contribution of organic matter from the surrounding schists.

The $\delta^{18}O$ values of the fluids are between 5 and 7 per mil and indicate isotopic equilibrium with the granites. $\delta^{18}O$ values of the fluid, high internal pressures of fluid inclusions in the early stage of $\delta^{13}C$ values of the CO_2 favor a magmatic origin for the wolframite forming fluids. Meteoric water with $\delta^{18}O$ values of +2 to -4 per mil occurred in the later stages. (Author's abstract)

BYERS, C.D., MUENOW, D.W. and GARCIA, M.O., 1983, Volatiles in basalts and andesites from the Galapagos Spreading Center, 85° to 86°W: Geochim. Cosmo. Acta, v. 47, p. 1551-1558. First author at Chem. Dept. & Hawaii Inst. Geophys., Univ. Hawaii, Honolulu, Hawaii 96822 USA.

Glasses from submarine lavas recovered by the ALVIN submersible from the Galapagos Spreading Center (GSC) near 86°W have been analyzed by electron microprobe for major elements and by high-temperature mass spectrometry for volatiles. The samples studied range in composition from basalt to andesite and are more evolved than typical MORBs. Previous studies indicate that they are related to normal MORB by extensive crystal fractionation in small, isolated magma chambers. The H_2O, Cl and F contents of these lavas are substantially higher than any previously reported for MORBs. H_2O, Cl and F abundances increase linearly with P_2O_5 content, which is used as an indicator of the extent of crystal fractionation. The $Fe_2O_3/(FeO + Fe_2O_3)$ ratios measured in the andesite glasses progressively decrease with increasing P_2O_5 content and are probably related to fractionation of Fe-Ti oxides. Reduced carbon gas species, principally CH_4 and CO, were discovered in these glasses. The presence of reduced carbon species in GSC glasses may be indicative of a more reduced oxidation state of the upper mantle than is commonly assumed. (Authors' abstract)

CADY, G.H., 1983, Composition of gas hydrates - new answers to an old problem: J. Chem. Educa., v. 60, no. 11, p. 915-198. Author at Univ. Washington, Seattle, WA 98195.

A review. (E.R.)

CALESS, J.R., CRAIG, J.R. and RIMSTIDT, J.D., 1983, Geochemistry and paragenesis of sphalerite mineralization in the east Tennessee zinc district (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 538. Authors at Dept. Geol. Sci., Virginia Polytech. Inst. & State Univ., Blacksburg, VA 24061.

The Mascot-Jefferson City zinc district of East Tennessee is the major source of zinc in the United States. Sphalerite mineralization which occurs as a breccia infilling in the Lower Ordovician Knox Group carbonates has been studied in detail at the Young mine, located in the central part of the district. The sphalerite occurs as fracture fillings and as rosettes between carbonate breccia blocks and displays well developed growth zoning characterized by variations in color, opacity, hydrocarbon inclusions, and composition.

Ore emplacement was preceded by two periods of solution brecciation. The first episode occurred in the early Middle Ordovician as a result of subaerial development of a paleokarst system which left strong relief on the Knox surface and created an extensive paleoaquifer network. The second episode occurred after significant burial and was probably related to tectonic activity and expulsion of fluids from a sedimentary basin to the southeast. Episodic dolomitization in the vicinity of the ore bodies both predated and accompanied sphalerite deposition. Gangue dolomite and minor pyrite and marcasite deposited concurrently with sphalerite. Lesser amounts of fluorite, calcite and quartz grew as post-ore, vug-filling phases.

Sphalerite fluid inclusions reveal wide ranges in homogenization and freezing temperatures (81° to 199°C; -11.2° to -37.0°) and thus are indicative of a changing environment of deposition and fluid composition. This wide range may represent the mixing of two fluids--a hypersaline metal-rich brine with a less saline fluid resident in the host rocks. Inclusions in post-ore gangue phases display an overall decrease in homogenization temperatures, are less saline, and show a narrower range of salinities. (Authors' abstract)

CALLIER, L., ESCANDE, B. and VACHER, A., 1983, A molybdenum-rich intrusive porphyry complex at Beauvain, Normandy (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 14 (in French; translation courtesy M.J. Logsdon). Authors at BRGM, Div. Miniere Massif Armoricain 45045 Orleans, Cedex, France.

The Brioverian sequence, thermally metamorphosed by a Cadomian granodiorite, is intruded by a porphyritic microgranite. The microgranite is responsible for the major hydrothermal activity in the area, including potassic metasomatism and phyllic alteration. This initial magmatic episode was followed closely by an explosive rhyodacite episode, then by a second rhyodacite, both of which are porphyritic.

Microthermometry of inclusions in quartz reveals four fluids, each characterized by Th and salinity, although one cannot assign each to a particular phase of alteration or even lithology. One of these fluids, with a high salinity and Th between 200 and 350°C, shows many of the characteristics found in porphyry molybdenum deposits. Spatial relations between temperatures, salinities and the presence of mineralization indicates that the mineralization was localized in zones where the temperature did not exceed 400°C and where the salinities are >40% (eq. NaCl).

Based on this data, a sequence of mineralization is hypothesized:

1) "A" Fluids - Th = 350-450°C and intermediate salinities (0-25% eq. NaCl), which may correspond to the emplacement of the intrusives.

2) "B" Fluids - Th = 200-350°C and high salinities (30-50% eq.

NaCl), which seem to correspond to the major phases of brecciation (under hydraulic pressure) and of hydrothermal alteration.

3) "C" and "D" Fluids - Th = 200 and 100°C (respectively) and low salinity (0-10% eq. NaCl), representing late-stage fluids that circulated at the time of cooling of the intrusive complex. (Authors' abstract)

CAMPBELL, A.R., 1983, Genesis of the tungsten-base metal ores at San Cristobal, Peru: Ph.D. dissertation, Harvard Univ., Cambridge, Massachusetts.

San Cristobal is a tungsten base-metal vein deposit in central Peru. Mineralization consists of augelite, pyrite, wolframite, quartz, chalcopyrite, sphalerite, galena and carbonate. Metal distribution studies indicate that the mineralization was deposited in an undulating band from 25 to 400 meters in width and at least 2.5 km long. Metal distribution maps for five metals yield high grade bands that are essentially coincident even though the metals were deposited during different stages of mineralization.

The sulfur isotopic composition of the sulfide minerals is more positive than that of several other wolframite deposits. This may be explained by the input of heavy sulfur from sedimentary sulfates. Oxygen and hydrogen isotope ratios were measured in vein minerals and in extracted fluid inclusion waters. Oxygen isotope values for quartz range from 9.8 to 14.4 permil, and for wolframite from 0.6 to 4.6 permil. Hydrogen isotope values show an overall variation of δD from -58 to -148 permil, 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 composition 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 can be generated. The isotopic composition of minerals from San Cristobal can be interpreted as the result of deposition from meteoric water which has undergone isotopic exchange with granitic rock at 400°C with a water to rock ratio ranging from 0.01 to 0.003. Isotopic data from two other wolframite deposits, Pasto Bueno (Landis, 1972) and Panasqueira (Kelly and Rye, 1979) are reinterpreted using the model developed for San Cristobal. Both are consistent with the hypothesis that wolframite deposits are formed by meteoric 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. (Author's abstract)

CAMPBELL, A.R., RYE, D.M. and PETERSEN, Ulrich, 1983, The role of temperature and water to rock ratio in the isotopic composition of ore solutions (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 538. First author at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

Oxygen and hydrogen isotope ratios were measured from vein minerals and extracted fluid inclusion waters from the San Cristobal tungsten-base metal mine in Peru. $\delta^{18}O$ values for quartz and wolframite ranged from 9.8-14.4‰ and 0.6-4.6‰ respectively. The equilibrium water values calculated at 300°C are $\delta^{18}O = 2.8\text{-}7.3‰$ for quartz and $\delta^{18}O = 1.4\text{-}5.4‰$ for wolframite. Hydrogen isotope values show an overall range of dD = -58 to -148‰ 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 composition of meteoric waters exchanging with a 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 are generated. The isotopic composition of waters which have exchanged under conditions of low but varying water to rock ratio are characterized by a constant $\delta^{18}O$ value with a range of δD.

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 0.001 to 0.03. 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 are consistent with the hypothesis that wolframite deposits are formed by meteoric waters exchanged at low w/r (<0.05). (Authors' abstract)

CANDELA, P.A., 1983, Halogen trends in apatite as an indicator of magmatic vapor evolution (abst.): EOS, v. 64, p. 343. Author at Dept. Geol., Univ. Maryland, College Park, MD 20742.

Trace element systematics have been derived which yield trends in the concentration of Cl, F and water in apatite during the crystallization of a magma. These trends have been calculated using the following methods: 1) A simple Nernst partition coefficient for Cl and F, and 2) Exchange constants for the two independent exchange reactions involved (e.g., the Cl-F and Cl-OH exchanges). The results of the two methods are quite different and illustrate an extreme example of the failure of a simple Nernst partition coefficient. This failure occurs because Cl and F are not phase components of apatite. The following results were obtained assuming that Cl, F and water behave as incompatible substances in the vapor-undersaturated magma. Case 1 yields a Cl concentration in apatite which increases as crystallization of the magma proceeds. The absence of such trends in natural apatites has been cited as evidence against the accumulation of Cl during the crystallization of the intrusions associated with porphyry Cu ores. Case 2 predicts that the concentration of Cl, F and water in apatite remain approximately constant before the occurrence of vapor evolution (even though their concentration in the magma is increasing). However, when a vapor phase is evolved the Cl/F ratio in the apatite decreases sharply because Cl is partitioned strongly into the aqueous fluid while F is not. Such trends in the chemistry of apatite have been reported in the literature. When coupled with textural data, these heretofore unexplained trends in apatite chemistry can be used as indicators of vapor evolution in felsic igneous systems. (Author's abstract)

CANN, R.M. and GODWIN, C.I., 1983, Genesis of magmatic magnetite-apatite lodes, Iron Mask batholith, south-central British Columbia, in Geological Fieldwork 1982, a summary of field activities of the Geological Branch, Min. Resources Div., Paper 1983-1: Ministry of Energy, Mines & Petrol. Resources, British Columbia, p. 267-284. First author at 3, 313 Highland Way, Port Moody.

Immiscibility of a volatile-rich oxide-apatite melt formed layers and pools of such melt in a diorite magma chamber. (E.R.)

CARLISLE, T.R., 1983, The influence of surfaces on natural gas hydrate formation in the rock-sediment environment (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 72-

74. Author at The Arctic Inst. of North America, The Univ. Calgary, 2500 University Dr. N.W., Calgary, Alberta, Canada T2N 1N4.

In sediment pores, surfaces for hydrate formation may be provided by gas/water or oil/water interfaces, or by the solid surfaces of mineral grains and kerogen particles since these may adsorb gas in water-saturated strata, or water in hydrocarbon-saturated strata. The availability of phase-boundaries between fluids and the adsorptive properties of solid surfaces, however, will depend on whether the sediment is water- or hydrocarbon-saturated. (From the author's abstract)

CARRON, J.P., CLOCCHIATTI, R. and LE GUEN de KERNEIZON, M., 1983, Relict magmatic samples in minerals of the dacitic pumice of the Soufriere region, Ste. Lucie (Lesser Antilles) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 16 (in French; translation courtesy M.J. Logsdon). First author at Lab. Pétrol., Univ. Bretagne Occidentale, 6, avenue Le Gorgeu, 29283 Brest Cedex, France.

In the Soufriere region, large volumes of Quaternary to Recent dacite lavas have been erupted, forming numerous domes and vast pumice blankets. In these deposits, phenocrysts represent about half the volume, comprising strongly zoned plagioclase (An 90-45) and automorphic quartz, with minor orthopyroxene, biotite, and cummingtonite in variable proportions. The groundmass of the domes is highly recrystallized[sic], but that of the pumice entirely glassy. Similarly, relict samples of magma are highly altered in the massive rocks, but have been rapidly quenched in the pumice. In the latter case, it is possible to obtain significant analyses of glasses included in crystals of quartz, biotite and in the external zones of plagioclase phenocrysts. The great similarity of the analyses shows that these magmatic samples have not been modified near the boundaries of the minerals. Also, the composition is very close to that of the glassy groundmass and close to that for a typical rhyolite (Qz40-Or22-Ab30-An8). The K_2O value is at least double that in the whole rock, which corresponds well to a crystallization rate of 50%. In the whole set of samples, the fluid value of the relict samples is about 3-4%, and Th in the quartz phenocrysts is always close to 850°C.

Based on these data, it is possible to trace the evolution of temperature and chemical composition (including the proportion of water) from the fully melted stage to a stage just before the emplacement of the pumice blankets, and to evaluate with good precision the essential physical parameters (density, viscosity), not only for the successive liquids, but also for the magma caught in the assemblage. (Authors' abstract)

CARTER, N.L. and HANSEN, F.D., 1983, Creep of rocksalt: Tectonophysics, v. 92, p. 275-333. First author at RE/SPEC Inc., P.O. Box 725, Rapid City, SD 57709, USA.

A review is presented of the fundamental flow properties and processes in experimentally deformed natural and synthetic halite single crystals and polycrystalline aggregates. Included in the summary are discussions of: (a) microstructures induced during steady-state creep; (b) creep-rupture of rocksalt; (c) experiments associated with "Project Salt Vault" and more recent field studies; and (d) brine migration. A representative steady-state flow law determined for natural aggregates and maximum natural deviatoric stresses deduced from subgrain sizes are applied briefly to considerations of creep in waste repositories and of salt dome dynamics. While the mechanical behavior of rocksalt is probably better understood than for all other rock types, further investigations, especially on load path, stress history and creep-rupture are clearly mandated. Furthermore, additional investigations of brine migration and of bench and field-scale deformations are needed, the latter incorporating realistic rocksalt flow properties into numerical simulations of natural rock-mass response. (Authors' abstract)

CARUSO, L. and SIMMONS, G., 1983, Mechanism and geophysical implications of the chemical sealing of microcracks in granites (abst.): Geol. Soc. Newsletter, v. 12, no. 5, p. 42-43.

CATHLES, L.M. and SMITH, A.T., 1983a, Thermal constraints on the formation of Mississippi Valley-type lead-zinc deposits and their implications for episodic basin dewatering and deposit genesis: Econ. Geol., v. 78, p. 983-1002. First author at Chevron Oil Field Res. Co., P.O. Box 446, La Habra, CA 90631.

The hypothesis that the Mississippi Valley-type lead-zinc deposits largely associated with basin margins formed as the result of compactive expulsion of basin brines is examined in light of two simple constraints: that the deposits formed within 1 km of the surface, and that the temperature of the ore fluids at the time of mineral deposition was 100° to 150°C. It is shown that for these near-surface temperatures to be attained the rate of fluid migration up the margins of the basin must have been more than 1,000 times greater than could be produced by the steady subsidence, sedimentation, and compaction of most basins. For base metal deposits to form as the result of the compactive expulsion of basin brines, brine expulsion must be episodic, occurring cumulatively over a period of time representing only a few thousandths of the pertinent history of basin growth. (From the authors' abstract) See next item.

CATHLES, L.M. and SMITH, A.T., 1983b, Thermal constraints on the formation of Mississippi Valley-type lead-zinc deposits and implications for episodic basin dewatering and deposit genesis (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 540. First author at Chevron Oil Field Res. Co., P.O. Box 446, La Habra, CA 90631.

If Mississippi Valley-type lead-zinc deposits formed within 1 km of the surface as the result of expulsion of 70-150°C basin brines, thermal constraints require the dewatering of the basin to be episodic rather than steady. Energy balance considerations indicate the number of dewatering pulses was about 50 over the pertinent portion of basin development. Episodic basin dewatering can account for the observed gross color banding in sphalerite in the Upper Mississippi District, cycles of sulfide deposition and dissolution, and the close association of vein brecciation and sulfide deposition. The thermal modeling suggests abundant shale with a complex deposition pattern, stable basin margins, a permeable, but thin, basal aquifer, and basin structures that focus outflow to restricted portions of the basin margin will favor the development of Mississippi Valley deposits. Interior basins in the mid-continent region are surveyed with these criteria in mind and it is shown the criteria appear to be valid. (Authors' abstract) See previous item.

CHAINEY, D., 1983, Petrographic and geochemical parameters of the gold ores of the Camflo mine, Quebec: M.S. thesis, Univ. Montreal, Montreal, PQ, Canada, 215 pp. (in French; English summary).

Indexed under Fluid Inclusions. (E.R.)

CHAMPIGNY, Normand, 1983, Geology and geochemistry of the Cinola gold deposit, Queen Charlotte Islands, British Columbia (abst.): Geol. Assoc.

Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A11. Author at Int'l. Geosystems Corp., 304-1200 West Pender Street, Vancouver, British Columbia V6E 2S9, Canada.

Cinola (Specogna) gold deposit in the northern Queen Charlotte Islands, British Columbia, was first discoverd in 1970. The deposit is in a clastic sequence consisting of a lower shale unit (Haida Formation, Late Cretaceous) and an overlying conglomerate-sandstone sequence (Skonun Formation, Miocene). Both sedimentary units are cut by a stock and dykes of rhyolite-porphyry. Two K-Ar model ages indicate mineralization and probably rhyolite-porphyry intrusion at about 14 Ma late(sic) (Early Miocene). The model ages, together with plant microfossil and fauna examination, revealed a 17-15 Ma age for the fluviatile Skonun sequence, in which the Cinola deposit occurs. Gold mineralization is widespread, and occurs as micron-size particles disseminated in the sedimentary host rocks and in quartz veins. Pyrite and marcasite are the main sulphides, and alteration type is dominantly argillic. The Cinola deposit resulted from the development of a large geothermal system, the energy of which derived from the rhyolitic intrusion. Ore fluids originated from pore water in the fluviatile host rock, as indicated by fluid inclusion studies. Two temperature regimes centered on 160°C and 270°C existed during circulation of the ore fluids. Depth of mineralization is estimated between 1.1 and 1.8 km. A geostatistical evaluation of geochemical data from Cinola shows that Au, Ag, Hg, As, Sb, and W have systematic distribution patterns in either primary or secondary environments, and could be useful pathfinders for exploration for similar types of gold deposits. (Author's abstract)

CHAO, I.-M., 1983, Migration rates of brine inclusions in single crystals of NaCl (abst.): U.S. Geol. Survey Prof. Paper 1375, p. 138.

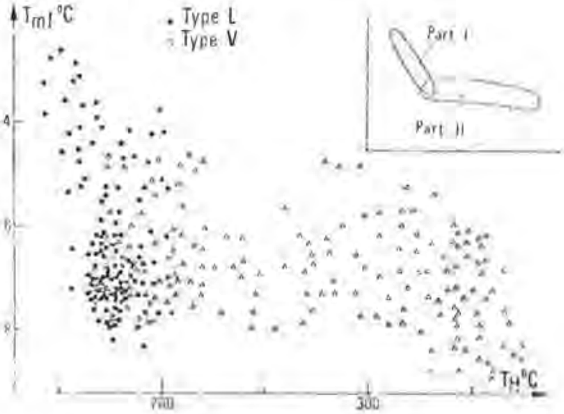
Rock-salt deposits have been considered as a possible medium for the permanent storage of high-level radioactive wastes and spent fuel. Brine inclusions present in natural salt can migrate if the temperature gradients in the vicinity of the radioactive waste are large enough. The migration rates of these brine inclusions under various repository conditions have been estimated. Among the existing models of the migration process, the one presented by Anthony and Cline (1971) is considered as being the most complete because it accounts for most of the phenomena known to occur in the migration process. However, application of their model is difficult because of an insufficient data base. By utilizing recent data for halite saturated brines and the model of Anthony and Cline, the author evaluated the effect of brine composition on the migration rate of inclusions at 50° and 100°C. Because Soret coefficients (sigma) of salt in brines are not known, the Soret coefficient must be treated as a variable. To simplify the calculation, the interface kinetics are neglected. Then the isothermal maximum migration rate predicted by Anthony and Cline's model reduces to a simple linear function of sigma for each brine composition. Although the estimated maximum migration rates for WIPP-A, NBT-6, and 2.41 molality $MgCl_2$ brines are of the same order of magnitude, they differ markedly from those of pure NaCl solution (except in a narrow region of sigma values). At 100°C, these calculated migration rates are considerably higher than those measured experimentally. This discrepancy indicates either that the neglected interface kinetics might be an important retarding factor for the migration rates of inclusions or that the model used is deficient. (Author's abstract)

CHAREF, A. and RAMBOZ, C., 1983, Evidence from fluid inclusions of fluid immiscibility during the deposition of late drusy barite in the Pb-Zn district of Les Malines (abst.): Symposium, European Current Research on

Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 17. Authors at Centre de Rech. Petrogr. et Geochim., B.P. 20, 54501 Vandoeuvre Cedex, France.

In the Pb-Zn deposit of Les Malines, late post-Eocene fissures crosscut the Mesozoic sediments and barite-filled drusy cavities are developed at their base. Both aqueous and yellow oil inclusions are found in the barite. Two-phase aqueous inclusions occur scattered in the crystals, some being vapor-dominant (type V; 0.6<vol % liquid<0.9), some being liquid-dominant (type L; 0.1<vol % liquid<0.5). The melting points of ice (T_{mI}) and the homogenization temperatures to the vapor (T_{HV}) or to the liquid (T_{HL}) in aqueous inclusions are scattered. This results in a large and continuous microthermometric trend in the T_{mI}-T_H plane, with two parts characterized by different slopes (Part I and II, see Figure).

The only process which can account for such continuous and correlative microthermometric variations is immiscibility in the H_2O-CO_2-NaCl system. Part II of the trend, in particular, results from heterogeneous trapping. A temperature of 165°C ± 5°C may be inferred for the process. Part I of the microthermometric trend represents a preliminary stage where the V-X of the fluid reequilibrate to new P-T conditions by vapor loss. It is geologically likely that an abrupt drop of the fluid pressure induced boiling of the low-salinity liquid and favored the precipitation of late barite in the Malines. (Authors' abstract)



CHAREF, A. and SHEPPARD, S.M.F., 1983, Sources of aqueous fluids and sulphur in the Les Malines, France, carbonate-hosted Pb-Zn deposits (abst.): Terra cognita, v. 3, p. 171-172. Authors at CRPG (CNRS) B.P. 2, 54501 Vandoeuvre Cedex, France.

A part (50%) of the post-Hercynian Les Malines Pb-Zn deposits on the SE side of the Massif Central are located in karsts and fissures within Cambrian dolomitic limestone. Three major stages in the formation and evolution of these deposits have been characterized by isotopic studies (D/H, $^{13}C/^{12}C$, $^{18}O/^{16}O$, $^{34}S/^{32}S$) of minerals and fluid inclusions and petrography. (1) Dolomitic limestone ($\delta^{18}O_d$ ~26‰ SMOW; $\delta^{13}C_d$ ~0.5‰ PDB) was accompanied locally by quasi-syngenetic pyrite masses ($\delta^{34}S_{py}$ ~-23‰ CDT) with quartz ($\delta^{18}O_q$ ~26) and dolomite ($\delta^{18}O_d$ ~25; $\delta^{13}C_d$ ~-5.5). Local recrystallization occurred during low-grade Hercynian metamorphism (T ~200°C). (2) Fracturing of limestone and minerals, karst formation followed by intra-karstic sedimentation including sphalerite($\delta^{34}S_{sl}$ ~-23) [Mineralization K]. Local dissolution and crystallization occurred with modification of $\delta^{18}O_{carb}$ (~22 ± 2). Later K mineralization was associated with $\delta^{34}S_{sl}$ ~-18 and $\delta^{34}S_{barite}$ ~+17. (3) Fracturing of limestone, local alteration of karst fillings ($\delta^{18}O_q$ ~23; $\delta^{18}O_d$ ~24; $\delta^{13}C_d$ ~-2), crystallization of dolomite and quartz in geodes ($\delta^{18}O_{d \text{ and } q}$ ~21), sulphides in fissures ($\delta^{34}S_{sl}$ ~-10) and barite ($\delta^{34}S_b$ ~17) at T ~150°C. Liassic mineralization F[sic].

For main K mineralization no direct temperature information nor δD_{fluid} is available. Temperatures could have been low with aqueous fluids of meteoric or formation water origin and sulphur from reworking of Cambrian sulphides. Late K mineralization occurred at T ~150°C from saline formation waters (δD_w ~-15‰ SMOW) and mixed sulphur sources.

F mineralization occurred at T ~150°C from saline formation waters (δD_w ~-35) with part of sulphur coming from reduction of Triassic sulphate which was also source of barite sulphur.

Later Bathonian ores have not been studied. However the deposits experienced a post-Eocene reheating (T ~165°C) with precipitation of minor barite.

Isotopic and fluid inclusion studies combined with detailed petrography emphasize the polyphase nature of mineralization and multiple sources at Les Malines. (Authors' abstract)

CHAUDHURI, S., CLAUER, N. and O'NEIL, J.R., 1983, Hydrogeochemical evolution of some oilfield waters from central Kansas, U.S.A. (abst.): Terra Cognita, v. 3, p. 177.

CHEANG, K.K., 1982, Oxygen isotope, fluid inclusion, microprobe and petrographic studies of the Precambrian granites from the southern Wind River range and the Granite Mountains, central Wyoming, U.S.A.: Constraints on origin, hydrothermal alteration and uranium genesis: Ph.D. dissertation, Univ. Georgia, Athens, GA, 150 pp.

The Granite Mountain is comprised of the granite of Long Creek Mountain and the volumetrically dominant granite of Lankin Dome. Average $\delta^{18}O$ values in per mil (‰) of the granite of Long Creek Mountain is 8.2 ± 0.3‰ (N = 4) and average $\delta^{18}O$ values of the two phases from the granite of Lankin Dome are: biotite granites = 8.5 ± 0.5‰ (N = 37), leucocratic granite = 8.4 ± 0.3‰ (N - 12). The averge $\delta^{18}O$ values for the Louis Lake Batholith are: hornblende-biotite granodiorite = 7.3 ± 0.3‰ (N = 13) and leucocratic biotite granite = 7.7 ± 0.1‰ (N = 6).

It is concluded from the whole-rock oxygen isotopic, mineralogical, chemical and strontium isotopic data that the unaltered granites in the Granite Mountains were probably derived from a uranium-enriched source with some peraluminous metasedimentary component which favored the preconcentration of uranium and thorium, whereas the Louis Lake Batholith was formed by partial melting of igneous source materials that are not strongly enriched in uranium.

Progressively altered rocks of the Granite Mountains, along with their mean $\delta^{18}O$ values, include: sericitized-chloritized-saussuritized granites (whole rock = 7.1, N = 17, quartz = 8.9, N = 6, feldspar = 6.4, N = 6); albitized granites (whole-rock = 6.3, N = 6, quartz = 8.1, N = 3, and feldspar = 5.6, N = 3); silicified-epidotized granites (whole rock = 4.7, N = 26, quartz = 5.6, N = 4, feldspar = 3.2, N = 4). The ^{18}O depletion of these altered granites indicates interaction with a low ^{18}O fluid (probably meteoric water), thus preconditioning the rock for leaching of uranium from the granites during later events.

ΔQuartz-feldspar values of unaltered granites from both the Granite

Mountains (2.1; N = 7) and the Louis Lake Batholith (2.1; N = 5) gave average reequilibration isotopic temperatures of ≈423°C. These results are similar to temperatures of 385-430°C from the Granite Mountains (N = 3) and 430-450°C for the Louis Lake Batholith (N = 1) derived by two-feldspar geothermometric studies. ΔQuartz-feldspar isotopic fractionations in altered granites reveal that the hydrothermal alteration took place at approximately 363 ± 50°C.

Fluid inclusion studies show that late stage fluid formed at approximately 144 ± 22°C (107 measurements, 8 samples) and of moderate salinity of about 23 equivalent weight % NaCl (40 measurements, 8 samples) occurs within the altered units. These fluids may have been partly responsible for the uranium loss (up to 80%) in the Granite Mountains during the Cenozoic. (Author's abstract)

CHEILLETZ, A., 1983, Fluid inclusion study in scheelite and quartz from the tungsten mineralization of Jbel Aouam (Morocco) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 18 (in French; translation courtesy M.J. Logsdon). Authors at CRPG-CNRS, 15, rue Notre Dame des Pauvres, BP 20 - 54501 Vandoeuvre-les-Nancy Cedex, France.

The tungsten mineralization of Jbel Aouam presents a morphology of several types of veins, characterized by the juxtaposition of bundles of quartz veinlets in parallel networks and more rarely in stockwork. All the tungsten shows are associated with biotite-rich, metamorphosed Silurian schists and sandstones. Two generations of mineralized fractures have been recognized. The first, and volumetrically the most important in terms of mineralization, is characterized by the deposition of scheelite-wolframite associated with quartz-biotite-muscovite-K-feldspar-chlorite-apatite. The second, containing traces of scheelite, is transitional to the sulfide mineralization (Cu-Zn-Pb-Ag-Sb).

Fluid inclusions in quartz and scheelite were studied to determine the composition of the mineralizing hydrothermal fluids. Techniques of the study included microthermometry and Raman spectroscopy. The fluids trapped in quartz and scheelite are very similar and quite homogeneous; average compositions (mole %) are: H_2O = 85-90; NaCl = 1.5; CO_2 = 5-10; and CH_4 + N_2 = 1. Microthermometric properties, morphologic characteristics and phase relations in the system H_2O-CO_2-NaCl indicate a subcritical evolution during the trapping of fluids. Comparison with the experimental results from the ternary system allows one to fix the conditions at the time of entrapment as P = 800-850 bars and T = 350-400°C. Using a lithostatic-loading model, these data indicate that the deposit was formed at a depth of about 5 km in an elevated geothermal gradient (80-100°/km). (Author's abstract)

CHEILLETZ, A., DUBESSY, J., KOSZTOLANYI, J.C., MASSON, N., RAMBOZ, C. and ZIMMERMANN, J.L., 1983, Molecular fluid phases in crystals: comparison of four analytical techniques on the example of an hydrothermal quartz vein (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 19. First author at C.R.P.G., B.P. 20, 54501 Vandoeuvre, France.

Four techniques have been selected to analyze molecular fluid phases in crystals: (a) microthermometry (M.) and Raman spectrometry (R.S.): non destructive punctual techniques for transparent minerals; (b) mass spectrometry (M.S.) and gas chromatography (G.C.) 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 studied by the four techniques because it contains a homogeneous generation of fluids. The following results are obtained. (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) Heavy carbonaceous species are systematically identified by G.C. and M.S., whereas only CO_2 and CH_4 are detected by R.S. (4) Small and constant amounts of H_2 is detected only by M.S. These results might suggest that two types of cavities are present in the studied quartz: (1) fluid inclusions visible under the microscope containing H_2O, CO_2, CH_4, N_2. (2) Fissures containing carbonaceous solid species. These particles could yield the heavy hydrocarbons by cracking during the heating stage prior to M.S. or G.C. analysis. A higher degree of cracking in the source of mass spectrometer would result in the excess of CH_4 and H_2 measured by this technique. A more accurate interpretation of the various analytical techniques could be made on synthetic fluid inclusions in pure quartz crystals. (Authors' abstract)

CHEKALIN, V.M., 1983, Geological-genetic model of polymetal deposits of the ore field Talovskoe (Rudnyi Altai), in Genetic models of endogeneous ore formations: "Nauka" Pub. House, Siberian Branch, v. 2, p. 87-95 (in Russian).

Non-recrystallized massive polymetal ores have low decrepitation activity (up to 100 impulses), recrystallized ores-higher (1200-1500 imp.); disseminated ores display activity 1000-1300 imp. and veinlet-type ores 2000-3000 imp. (A.K.)

CHERSKIY, N.V., GROYSMAN, A.G., TSAREV, V.P. and NIKITINA, L.M., 1983, Thermophysical properties of natural gas hydrates: Dokl. Akad. Nauk SSSR, v. 270, no. 4, p. 949-952 (in Russian).

CHOU, I.-M., 1983a, Remarks on "Migration of brine inclusions in salt": Nuclear Tech., v. 63, p. 507-509. Author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

A critique of a 1982 paper by Pigford. See Pigford's response (this volume). (E.R.)

CHOU, I.-M., 1983b, The liquidii of the system NaCl-KCl-H_2O at elevated pressures (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 543. Author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

Knowledge of the phase relations in the system NaCl-KCl-H_2O is essential for interpretation of many fluid-inclusion data, but little is known of this system at elevated pressures. In this study, the liquidii of the system were determined by differential thermal analysis (DTA) at pressures $\leqslant 2$ kb.

The experimental technique used in this study was described in detail by Chou and Eugster (1981, EOS, 62, p. 410) and Chou (1982, Geochim. Cosmochim. Acta (GCA), 46, p. 1957-1962). The liquidii of the three binary subsystems at elevated pressures have been reported previously: NaCl-KCl system (Chou, 1982, GCA, 46, p. 1957-1962); NaCl-H_2O system (Gunter et al., 1983, GCA, 47, p. 863-873); and KCl-H_2O system (Chou, 1982, GSA Abs. with Programs, p. 463).

The liquid/(liquid + solid) boundaries were determined at elevated pressures for 17 ternary compositions (open circles in Fig. 1) and are summarized in Fig. 1. The isotherms are given for the isobaric liquidii at 2 and 0.5 kb. At temperatures above the isobaric critical solution temperatures of the system NaCl-KCl, liquids that lie on the solid and dashed curves DE coexist with single solids; at lower temperatures they coexist with two solids. However, the compositions of the solids which are in equlibrium with the liquids of specific compositions at fixed P and T remain unknown. Also, the isotherms below 420°C cannot be located because the DTA signals in dilute samples are too small to be detected. (Author's abstract)

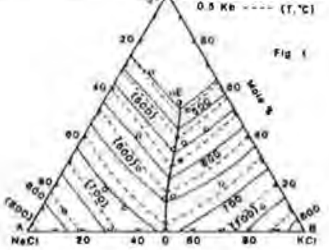


Fig 1

CHOWN, E.H., GUHA, J., KOUASSI, F., CHAGNON, A. and HEROUX, Y., 1983, Preliminary model for the origin of Cu and Pb-Zn mineralization in the Mistassini basin, Quebec (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A11. First author at Sci. de la Terre, Univ. Québec à Chicoutimi, Chicoutimi, Québec, G7H 2B1, Canada.

The Aphebian Mistassini Group lies unconformably on crystalline Archean basement along the Grenville Front. Most known mineralized showings are contained within the Lower Albanel Formation, the basal 1000 m sequence of alternating dolomite and shale. Diagenesis of the formation commenced shortly after deposition and has resulted in complete dolomitization of all carbonate members. Diagenesis of the shales, as indicated by clay mineral crystallinity and reflectivity of organic material reached the level of incipient burial metamorphism near the start of the anchizone.

Two disparate mineralization types occur. Chalcopyrite-pyrite-quartz ± carbonate veins (Icon) occur within shale units near the base of the formation, and galena-sphalerite-pyrite-quartz-carbonate-anthraxolite fracture fillings and vugs are contained in carbonate units in the middle of the formation. Both types of mineralization, while respecting a general stratigraphic control, clearly postdate the diagenesis and are localized in deformational structures. The similar gangue mineralogy of barren and mineralized veins, fracture fillings and vugs suggests a common origin. Study of the fluid phases associated with the unmineralized and mineralized veins, vugs and fracture fillings indicate the presence of at least two generations of fluid with different salinities and homomogenization temperatures. A certain amount of overlap in fluid types occurs in the sites so far investigated and a preliminary model must consider the merits of a single versus multiple mineralizing episodes. (Authors' abstract)

CHRISTIE, A.B., 1983, Fluid inclusions, stable isotopes and geochemistry of porphyry copper and epithermal vein deposits of the Hauraki gold-silver province, New Zealand: Ph.D. dissertation, Victoria Univ. of Wellington, 796 pp.

Extensive Tertiary epithermal Au-Ag-Pb-Zn-Cu vein deposits with Te and Se, in quartz-calcite gangue, and porphyry copper deposits occur in the Hauraki Province.

Near neutral or slightly alkaline fluid pH is indicated for the epithermal fluids by the occurrence of sericite and/or adularia in wall rock alteration mineral assemblages. Acidic fluids, forming kaolinite, are characteristic of late stages or near surface environments.

Fluid inclusion filling temperature, and sulphur isotope temperatures from sphalerite-galena pairs, indicate that base metal deposition occurred mainly between 320 and 280°C, precious metal assemblages predominantly in the range of 280-200°C and late stage barite, in some deposits, generally below 200°C. There is fluid inclusion evidence for boiling during mineralization in some deposits.

Apparent salinities of the epithermal fluids, determined from fluid inclusion freezing temperatures, range from 0-6.1 eq. wt. % NaCl. No consistent difference in average apparent salinity was recognized between the different types of epithermal deposits, although the highest recorded values were from the base metal deposits. The absence of liquid CO_2 in fluid inclusions limits the maximum possible concentration of CO_2 to approximately 3 mole %. Extraction and measurement of CO_2 from some samples indicates an average concentration of approximately 1 mole %. Corrections for dissolved CO_2 required to transform apparent salinities to true salinities indicate that CO_2 is the major solute in low salinity inclusions and that its concentration varied widely during mineral deposition in most deposits.

Deuterium/hydrogen ratios of water extracted from fluid inclusions indicate that most hydrothermal fluids were originally meteoric water.

Sulphur isotope ratios of sulphide and sulphate minerals, in association with the thermodynamic relations of the mineral assemblages, indicate that the sulphur was derived from at least two different sources; sedimentary sulphate and magmatic SO_2, the relative importance of each varying from one deposit to another.

Two types of hydrothermal systems are postulated for the formation of the epithermal deposits. During andesitic volcanism in the Miocene-early Pliocene, hydrothermal fluid convective cells were generated by heat from near surface small intrusive bodies of magma, whereas during rhyolitic volcanism in the late Miocene-Pleistocene the heat sources were larger plutons at greater depth.

Porphyry copper deposits are associated with quartz diorite stocks intruded into Jurassic greywacke suite rocks and Miocene andesites. They are "diorite" model hypabyssal and volcanic types. The major minerals are quartz, pyrite, chalcopyrite and sphalerite. Additional minerals differ between the different deposits and define two contrasting geochemical environments of deposition, one characterized by low fS_2, fO_2, and ΣS, indicated by the presence of pyrrhotite, and the other of moderate to high fS_2, fO_2 and ΣS, indicated by the occurrence of bornite, magnetite or hematite. Associated hydrothermal alteration is generally propylitic although limited phyllic and "potassic" (defined by secondary biotite) types also occur in some deposits.

Fluid inclusion and sulphur isotope studies of the Miners Head porphyry copper deposit suggest that copper mineralization occurred at a temperature of approximately 425°C from fluids with apparent salinities up to 15.5 eq. wt. % NaCl and containing sulphur of magmatic origin, predominantly as H_2S. (Author's abstract)

CHRYSSOULIS, S.L., 1983a, Study of the effects of feldspar and mica contamination upon the analysis of fluid inclusions by the decrepitation-ICP method: Chem. Geol., v. 40, p. 323-335. Author at Dept. Geol., Imperial College, London SW7 2BP, Great Britain.

The effects of feldspar and mica contamination on the analyses of fluid inclusion contents, in quartz from granitic rocks, are evaluated when the fluid inclusions are analyzed by the decrepitation-inductively coupled plasma emission spectroscopy (D-ICP) method. (Author's abstract)

A few percent of alkali feldspar contamination is of minor consequence, but biotite has more severe effects. (E.R.)

CHRYSSOULIS, S., 1983, Composition of the hydrothermal fluids in the Guadalcazar granite, San Luis Postosi, Mexico (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 20. Author at Imperial College, Prince Consort Rd., London SW7 2BP, Great Britain.

The relative proportions of the major cations (Na, K, Ca, Mn, Fe and Zn) in the fluids that travelled through the Guadalcazar granite, San Luis Postosi, Mexico, during its hydrothermal evolution, were estimated from electron-probe analyses of the precipitates formed upon the decrepitation of individual fluid inclusions in magmatic quartz. Only the nonvolatile constituents of moderately saline to saline fluid inclusions (salinities greater than 15 wt% equivalent NaCl) can be analyzed by this technique because only these are likely to produce a precipitate upon decrepitation.

Iron, manganese and zinc, in addition to the alkalies and calcium, are important constituents of the hydrothermal fluids. A limited number of craters carried copper, barium, silver, magnesium and aluminum. Only the cations present in the precipitates are considered in this paper, but it should be mentioned that chlorine is the major anion, except in the case of Ba-bearing craters where sulphur is the major anion.

The craters were statistically discriminated into several groups on the basis of the relative proportions of Na, K, Ca, Mn and Fe. Tentatively, it is suggested that each of these groups corresponds to an aqueous fluid formed during the hydrothermal evolution of the Guadalcazar granite.

Coupling of electron-probe data of the precipitates with the data on salinities and temperatures of homogenization enables discrimination of the fluid inclusions into several groups, possibly representing hydrothermal fluids on the basis of their physico-chemical characteristics.

Finally, the sources of error in the technique are discussed. (Author's abstract)

CHRYSSOULIS, Stephen and WILKINSON, Neil, 1983, High silver content of fluid inclusions in quartz from Guadalcazar granite, San Luis Potosi, Mexico: a contribution to ore-genesis theory: Econ. Geol., v. 78, p. 302-318. First author at Dept. Geol., Royal Sch. Mines, Imperial College of Sci. & Tech., Prince Consort Rd., London SW7 2BP, England.

During a detailed study by electron probe of the composition of fluid inclusions in granitic quartz (Guadalcazar granite, San Luis Postosi, Mexico), silver could be detected in a limited number of samples. Silver-bearing fluid inclusions have been detected in one area (Sangre del Cristo) close to the largest silver mine in the region. Besides sodium and potassium, manganese and iron were found in significant amounts. These results confirm that the base metal and silver transporting capability of some early magmatic fluids is considerable.

Chloride complexes were the most favorable species for transporting silver and base metals in the early magmatic fluids of the Guadalcazar granite. An electron probe in the energy dispersive mode has been used in order to analyze the precipitates formed upon the decrepitation of fluid inclusions. The precipitates represent the nonvolatile constituents of the fluid inclusions. (Authors' abstract)

CHUVASHEV, G.I., KIRILLOVA, G.I. and RZHECHITSKIY, E.P., 1983, Solubility in the system HF-NaF-Na_2SiF_6-H_2O at 20 and 50°C: Zhurn. Neorg. Khimii, v. 28, no. 3, p. 809-811 (in Russian). Continued next page.

The paper presents conditions of existence of crystals of Na_2SiF_6 and $NaHF_2$ in equilibrium with solution. (A.K.)

CLIFTON, C.G., 1983a, An improved method for locating blind or buried sulphide mineralization (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A13. Author at Exploration Res. Labs., Salt Lake City, UT 84108.

Detection of blind or buried mineralization is a difficult problem facing the exploration industry. As the amount of terrane possessing both high mineral potential and good exposure decreases, the requirement for techniques capable of 'seeing through' post-mineral cover becomes more acute. In many situations standard geochemical methods are not applicable and geophysical methods too costly to be applied in a reconnaissance fashion.

It is well known that certain gases are produced by oxidizing sulphides and that these gases migrate to the surface. Recent research has determined that COS and CS are the primary gaseous products of sulphide oxidation, not H, S and SO, as formerly thought. These gases have been found to be abundant in the soil horizon and atmosphere above sulphide-bearing mineralization in Nevada. Gas adsorbent materials readily collect COS, CS, and other gases. These materials are buried for a short time at shallow depth in the target area and are analyzed for adsorbed gases by gas chromatography/mass spectrometry. Successful detection and delineation of sulphide mineralization has been achieved through tens of feet of colluvial cover and hundreds of feet of unmineralized wallrock in preliminary tests. Parallel research on adsorption of gases on soil particles is discussed and the two mechanisms of gas adsorption compared. Analysis of gases present in regular soil geochemical samples provides complimentary data to trace element analysis and, in areas of post-mineral cover, may provide the only geochemical signature developed by mineralization at depth. (Author's abstract)

CLIFTON, C.G., 1983b, Gas analysis of rocks and minerals: applications in ore deposit research (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A13. Author at Exploration Res. Labs., Salt Lake City, UT 84108.

Ore and wallrock material from hydrothermal ore deposits commonly contain in excess of 10,000 ppm gaseous compounds adsorbed or trapped during the hydrothermal event. Typical primary (hypogene) species include: CH_4, CO_2, H_2S, SO_2, CS, He, O_2, N_2, and traces of C-hydrocarbons. The gases are liberated from mineral surfaces, crystal lattices, and fluid inclusions by heating and are analyzed by gas chromatography/mass spectrometry. Gases contained in rocks and minerals are as fundamental to the total geochemical signature as are elements and oxides.

Recent research in gas geochemistry has shown that gases can be used to classify ore deposits of different genetic type and to identify and quantify subtle chemical changes in solution chemistry. Because the chemistry of hydrothermal solutions is often controlled by a small number of volatile species, gas analysis offers major advantages over more detailed chemical studies of ore-forming solutions. Ideally, the gas signature present in ore and wallrock materials should reflect the vapor-phase dynamics of the original hydrothermal solution. Progress toward relating these signatures to solution chemistry, ore deposit type, and depth of boiling will be discussed. (Author's abstract)

CLOCCHIATTI, R., DHAMELINCOURT, P., MASSARE, D., TANGUY, J.C. and WEISS, J., 1983, Pyroclastics of the 1669 eruption of Etna: Physical-chemical results from a study of intramineral inclusions (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 21 (in French; translation courtesy M.J. Logsdon). First author at ER 45 du CNRS, Inst. des Sci. de la Terre, 91405 Orsay, France.

The eruption of 1669 was one of the most disastrous if not the most important modern eruption of Etna, destroying numerous villages and spreading cinders over virtually all of Sicily. Scoria has a trachybasalt composition and contains millimeter-sized crystals of olivine, plagioclase, clinopyroxene and magnetite. Three parageneses can be recognized based on mineralogy and the nature of intracrystalline inclusions:

1. An early paragenesis with olivine (Fo 82-79) and diopside (Wo 48.7-47.8; Fs 7.7-9.6; En 43.6-42.6) which crystallized in a basic liquid with high fluid content (5-6%).

2. A cotectic paragenesis with olivine (Fo 75-69), plagioclase (An 92-70), salite (Wo 47-47.1; Fs 12.2-16.2; En 40.8-36.7) and magnetite (Usp 35-33) which crystallized near 1100°C in a trachybasalt liquid in which the fluid content did not exceed 3%.

3. A "pneumatolytic" paragenesis represented by plagioclase (An 63-67) which has rare inclusions of orthopyroxene (En 80.3; Fs 18.5; Wo 1.2) and magnetite (Usp 15-16). The plagioclases terminate their growth with a magmatic stage (An 79-72), probably representing a deep reservoir. Fluid inclusions in minerals from this phase include $CO_2 + SO_2$ (10%) + S_8 and $CO_2 + S_8$.

The chemical evolution of the glassy inclusions can be explained by a simple process of fractional crystallization which entrained, early in the process, a gas phase dissolved in the magma. The phenocrysts of plagioclase containing gas inclusions were formed in the gas pockets that first separated during this early stage in the crystallization process. (Authors' abstract)

COCHRAN, Ann, 1982, Fluid inclusion populations in quartz-rich gold ores from the Barberton greenstone belt, eastern Transvaal, South Africa: M.S. thesis, The Univ. Arizona, Tucson, AZ, 208 pp.

Fluid inclusions in gold-bearing quartz-rich ores from five mines in the Barberton Greenstone Belt were studied to detect differences and similarities in inclusion character according to sample locality and sulfide mineralogy. Through freezing-heating studies, many of the Barberton inclusions encountered were found to have formed at restricted amphibolite-grade conditions of 4.5 kilobars pressure and 610°C-655°C temperature regardless of the locality or the sulfide mineralogy. Inclusion population counts and bulk fluid analyses reveal differences in fluid content, chemistry, and inclusion type according to the major sulfide phase present in the sample.

Fluid inclusion populations in Witwatersrand Basin quartz-vein pebbles may provide useful provenance indicators for the Witwatersrand sediments. Inclusions from the Barberton quartz vein samples were compared with those reported from the Witwatersrand quartz-vein pebbles. The comparison provided no correlation between the Barberton and Witwatersrand quartz based on fluid inclusion populations. (Author's abstract)

COLE, D.R., 1983, Time estimates for oxygen isotopic exchange during mineral-fluid interaction in hydrothermal systems: Geother. Resources Council, Transactions, v. 7, p. 283-287.

COLE, D.R., OHMOTO, Hiroshi and LASAGA, A.C., 1983, Isotopic exchange in mineral-fluid systems. I. Theoretical evaluation of oxygen isotopic exchange accompanying surface reactions and diffusion: Geochimica Cosmo. Acts, v. 47, p. 1681-1693.

CONNELLY, M.P., BOWMAN, J.R. and WHELAN, J.A., 1983, Petrologic and fluid inclusion studies of the Bwana and Maria copper skarns, Rocky Range, SW Utah (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 299. Authors at Geol. Dept., Univ. Utah, Salt Lake City, UT 84112.

The Bwana and Maria copper skarns replace calcitic marble at the intrusive contact of Miocene quartz monzonite in the Rocky Range, SW Utah. The formation of these skarns involved: (1) initial isochemical metamorphism of calcitic limestones and calc-pelite units yielding assemblages such as diopsidic pyroxene (Px) + calcite (Cc) and Px + grossular-rich garnet (Gn) + Cc + quartz (Qz) + plagioclase (Pg), respectively; (2) initial replacement of calcitic marble by massive Gn (grandite) + Px (diopside-hedenbergite) skarn; (3) subsequent deposition of Qz + Cc + magnetite (Mt) + pyrite (Py) + chalcopyrite (Cpy). Electron microprobe analyses of coexisting garnet and pyroxene yield garnet compositions of X (andradite) = .60 - .73 X, (grossular) = .26 - .39, and pyroxene compositions of X (diopside) = .48 - .85, X (hedenbergite) = .15 - .52. Progressive Fe enrichment occurs in both Gn and Px away from the intrusive contact. Both early stage garnets and later quartz contain fluid dominated (<50% vapor), multiphase fluid inclusions with halite daughter salts. The fluid inclusions in quartz are marked by the occasional presence of liquid CO_2. Liquid homogenization temperatures range from 570°C to excess of 600°C (the limit of the heating apparatus), while halite dissolution temperatures give NaCl salinities in excess of 55 wt%. Liquid homogenization temperature for inclusions in quartz range from 350 to 400°C with halite still present after L-V homogenization. Estimates of minimum lithostatic load indicate Pt of approximately 400 bars. Application of phase equilibria to observed skarn assemblages, temperature results from fluid inclusion data, and Fe partitioning between coexisting Gn and Px restrict early skarn formation to $T = 600 - 650°C$, $X(CO_2) < 0.3$, $-18.5 < \log f(O_2) < -17.0$, and $\log f(S_2) < -2.0$. (Authors' abstract)

CONNOLLY, J.A.D. and BODNAR, R.J., 1983, A modified Redlich-Kwong equation of state for H_2O-CO_2 mixtures: application to fluid inclusion studies (abst.): EOS, v. 64, p. 350. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

A modified Redlich-Kwong (MRK) equation of state has been used to calculate molar volumes of H_2O-CO_2 mixtures from 100 to 1000°C and 0 to 10 kb. This equation predicts the volumetric properties of H_2O-CO_2 fluids on the solvus and also shows better overall agreement with experimental measurements at hypersolvus conditions than has been obtained with other equations of state. The solvus calculated using fugacities generated by the MRK closely matches the experimentally determined solvus, except for extremely H_2O-rich compositions. The MRK a terms for H_2O and CO_2 were calculated from available empirical equations of state for the end-member compositions and are functions of both P and T. The a cross term was found to be independent of pressure within experimental error over the range 0.1 to 5 kb. Densities of fluids along the solvus obtained from the MRK were combined with experimental phase equilibria data for the system H_2O-CO_2 at low temperatures to predict the room temperature properties of H_2O-CO_2 fluid inclusions. The relative volumes of liquid H_2O, liquid CO_2, and CO_2 vapor at 25°C, as well as the internal pressure, the density and homogenization temperature of the CO_2 phases and the dissociation temperature of the CO_2 clathrate hydrate compound, $CO_2 \cdot 5\ 3/4 H_2O$, have been determined for inclusions trapped over a wide range of P-T-X conditions. In addition, pressure corrections for inclusions trapped in the one-phase field, and the low temperature properties of inclusions resulting from heterogeneous fluid entrapment in the two-phase field, have been calculated. Comparison of these predicted values with data obtained from heating/freezing/crushing studies of H_2O-CO_2 fluid inclusions makes it easier to recognize spurious inclusions, and provides a simple means of verifying internal consistency between the measured inclusion data and interpreted trapping conditions. (Authors' abstract)

CORTECCI, G., LATTANZI, P. and TANELLI, G., 1983, Fluid inclusion and isotopic studies on hydrothermal calcites from pyrite and polymetallic mineralizations, southern Tuscany, Italy (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 22. First author at Dipartimento di Sci. della Terra, Univ. di Pisa via S. Maria, 22 - I-56100 PISA, Italy.

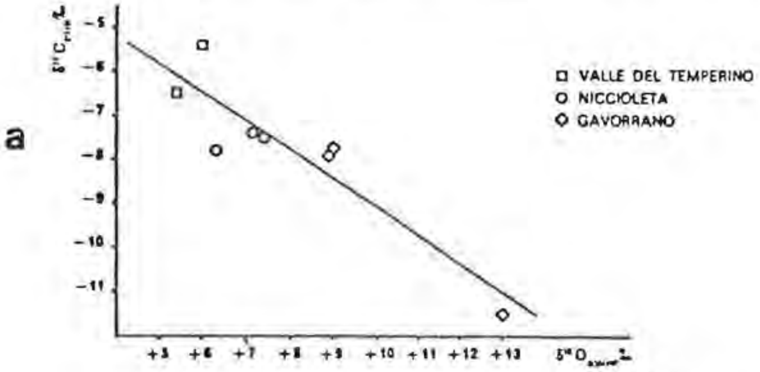
In pyrite and polymetallic deposits of southern Tuscany, spatially associated with Mio-Pliocene granitoids, calcite occurs widely as hydrothermal post-ore gangue mineral.

Samples from the pyrite deposits of Niccioleta A and Gavorrano-Massa Boccheggiano, and from the skarn-Cu-Pb-Zn deposit of Valle del Temperino group into distinct isotopic populations (Niccioleta: δ^{13}C(PDB) per mil: -7.4 to -7.8; δ^{18}O(SMOW) per mil: +6.3 to -7.4; Gavorrano: δ^{13}C: -7.7 to -11.5; δ^{18}O: +8.9 to +13.0; Valle del Temperino: δ^{13}C: -5.4 to -6.5; δ^{18}O: +5.4 to +6.0). An appreciable negative correlation exists between δ^{13}C and δ^{18}O values (Fig. 1a).

Homogenization temperatures (°C) of fluid inclusions are roughly similar for all deposits (Niccioleta: 199 to 371; Gavorrano: 226 to 305; Valle del Temperino: 205 to 264). Preliminary data on salinities (wt% NaCl eq.) show a more systematic variation, from higher salinities at Gavorrano (5.8 to 15.9) to intermediate at Niccioleta (1.2 to 7.9) to near pure water at Valle del Temperino. Average salinity of each sample positively correlates to δ^{18}O calculated for water in isotopic equilibrium with calcite (Fig. 1b).

It is suggested that two major components contributed to calcite-forming hydrothermal fluids: the one (dominant at Gavorrano) had high salinity, water in isotopic equilibrium with granitoids, and non-marine carbon of magmatic-metamorphic (?) origin; the other (prevailing at Valle del Temperino) was nearly pure dominantly meteoric water, with carbon largely derived from marine country rocks. (Authors' abstract)

Fig. 1 - a) Relationship between C- and O-isotopic compositions of calcites.
b) Relationship between average salinity of fluid inclusions in calcites and calculated isotopic composition of water.



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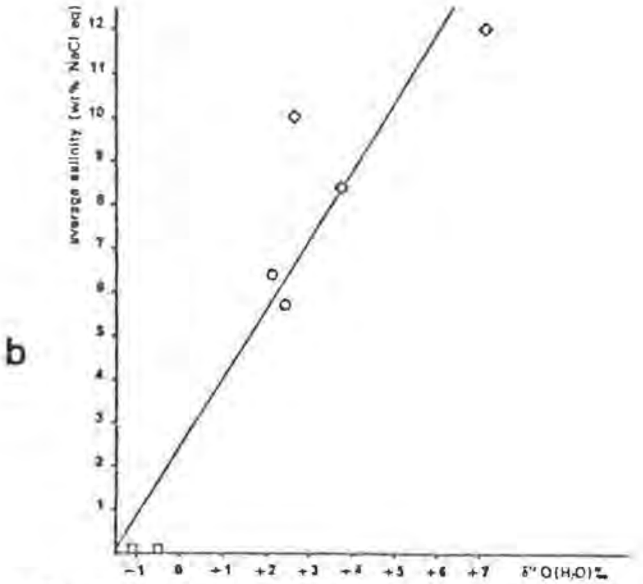

COSTA, U.R., BARNETT, R.L. and KERRICH, R., 1983, The Mattagami Lake mine Archean Zn-Cu sulfide deposit, Quebec: hydrothermal coprecipitation of talc and sulfides in a sea-floor brine pool - evidence from geochemistry, $^{18}O/^{16}O$, and mineral chemistry: Econ. Geol., v. 78, p. 1144-1203. First author at Programa Pesquisa Pos-Graduacao & Geopfisica, Inst. Geosci. da Univ. Federal Bahia, Federacao, Salvador, Bahia 40.000, Brazil.

Quartz in the orebody has a $\delta^{18}O$ of 10 to 11.9 per mil or ~2 per mil heavier than footwall quartz, signifying precipitation temperatures of 250° to 280°C; this is corroborated by filling temperatures of primary fluid inclusions within gangue quartz (Tf = 240°-270°C). Both isotopic and fluid inclusion temperatures signify a broad thermal zonation from ~270°C at the base to ~240°C at the top of the orebody. Minimum water depths of 300 m are indicated from nonboiling hydrothermal fluids of 3 to 5 weight percent NaCl equivalent at ~250°C. A ~50°C cooling of fluids during passge from the footwall to a suggested sea-floor brine pool above the ore zone may have been induced by turbulent mixing of ~20 percent pristine Archean marine bottom water at ~70°C downward into the brine pool. (From the authors' abstract)

COUTURE, R.Z., SEITZ, M.G. and STEINDLER, M.J., 1983, Sampling of brine in cores of Precambrian granite from northern Illinois: J. Geophys. Research, v. 88, no. B9, p. 7331-7334. Authors at Argonne Nat'l. Lab., Chem. Tech. Div., Argonne, IL 60439.

The composition of groundwater in deep-seated rocks is of great interest, both geochemically and in connection with the disposal of radioactive waste. However, sampling of deep-seated groundwater is expensive and often difficult. We describe here a simple technique for the elution of pore fluid (groundwater) from cores of igneous rocks, and we describe brine eluted from a core fo Precambrian granite from Northern Illinois drill hole UPH-3. The brine is predominantly NaCl and $CaCl_2$, with a Ca/Na mole ratio of about 0.05 to 0.1. From analysis of soluble chloride in a crushed sample the chloride concentration in the pore water is estimated as 2.3 M. The brine is similar to brine in the Illinois Basin, and it was probably derived from the overlying sediments. (Authors' abstract)

COVENEY, R.M., Jr. and GOEBEL, E.D., 1983, New fluid-inclusion homogenization temperatures for sphalerite from minor occurrences in the Mid-Continent area: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc

Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 234-242. Authors at Dept. Geosci., Univ. Missouri at Kansas City, Kansas City, MO 64110, USA.

Summarizing the progress of research on Mississippi Valley-type (MVT) ores, Ohle (1980) suggested that, if such deposits resulted from leaching of source beds by a wave of heated brine, one ought to see some trace of its passage within the surrounding midcontinent country rocks. Here we report on efforts to find such evidence through the use of fluid-inclusion techniques. We find that filling temperatures for sphalerite-hosted, briny (ca. 22 wt % equiv. NaCl) fluid inclusions normally exceed 80°C and in some cases reach 120°C even in areas located hundreds of kilometers from known ore deposits. Such filling temperatures and fluid compositions are comparable to those previously established by other workers for MVT deposits (e.g. Leach, 1973). Possibly, then, fluid inclusions in our trace occurrences of sphalerite are samples of regionally circulating, ore-forming brines -- the evidence sought by Ohle (1980). Their filling temperatures may be representative of deep circulating formation waters. Without more detailed analysis, however, the possibilities remain that, in some cases, the comparatively high filling temperatures for sphalerite-hosted inclusions may stem from abnormally high regional geothermal gradients during sphalerite deposition. It is also possible that elevated fluid-inclusion temperatures may be caused by post-entrapment generation of methane as proposed by Hanor (1980). Erratic, but generally high (100-260°C) filling temperatures for sphalerite from oven-dried drill cuttings of western Kansas are most likely artifacts. Such results support the need for caution in using such samples for fluid-inclusion work; and possibly for conodont-color geothermometry as well. A few of our filling temperatures are for calcite from Pennsylvania-age algal mounds of southeastern Kansas. Comparatively high filling temperatures (ca. 80-135°C) for some calcite occurrences may be evidence of hot circulating formational waters in that area. (Authors' abstract)

COX, G.F.N., 1983, Thermal expansion of saline ice: J. Glaciology, v. 29, no. 103, p. 425-432. Author at U.S. Army Cold Regions Res. & Engrg. Lab., Hanover, NH 03755, USA.

The coefficient of thermal expansion of NaCl ice and natural sea ice is theoretically shown to be equal to the coefficient of thermal expansion of pure ice. (Author's abstract)

COX, J.L. (ed.), 1983, Natural gas hydrates: properties, occurrence and recovery: Boston, Butterworth Publishers, 125 pp.

CRAIG, H. and RISON, W., 1983, Helium isotopes and mantle heterogeneity (abst.): EOS, v. 64, p. 348.

CRAIG, J.R., SOLBERG, T.N. and VAUGHAN, D.J., 1983, Growth characteristics of sphalerites in Appalachian zinc deposits: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 317-327. First author at Dept. Geol. Sci., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

Carbonate hosted zinc (-lead) deposits (Mississippi Valley Type) occur in the Cambrian and Ordovician beds of the folded Appalachians from Pennsylvania to Tennessee. The ore mineralization which occurs as breccia infillings and as bedded and disseminated replacements is dominated by pale yellow to light brown sphalerite; galena and pyrite are locally significant and marcasite and chalcopyrite occur in trace amounts. Samples have been examined and analyzed from 13 occurrences; they are uniformly low in iron (usually less than 2 wt %) and commonly contain significant amounts of cadmium (up to about 1 wt %). These sphalerites often appear homogeneous megascopically and are a nearly featureless gray when viewed in reflected light. However, examination by means of doubly polished thin sections reveals that subtle to pronounced growth banding is usually present. The banding varies from micron to centimeter scale in thickness and was commonly initiated at multiple growth centers on a breccia fragment or along an open fracture. Subsequent growth occurred as concentric hemispherical bands about the individual centers until they coalesced to form continuous layers. The colors of bands range from pale yellow to reddish brown to black and may correlate with chemical composition and/or with the abundance and nature of solid and liquid inclusions. The pattern of growth banding is characteristic of each individual deposit and may sometimes be correlated over distances of more than a kilometer. The banding may thus provide a valuable aid in deciphering and correlating ore mineral paragenesis and in suggesting directions of fluid flow. (Authors' abstract)

CRAMER, R.S. and TAYLOR, B.E., 1983, Oxygen, hydrogen and sulfur isotope geochemistry of the Gray Eagle Cu-Zn-Au deposit, Siskiyou Co., CA: location of the elusive vent area (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 297. Authors at Dept. Geol., Univ. California, Davis, CA 95616.

The Gray Eagle volcanogenic massive sulfide (py+cpy+po+sphal) deposit is hosted by greenschist metamorphosed Jurassic calc-alkaline volcaniclastic and sedimentary rocks of the Galice formation. Isotopic analysis of samples from drill core throughout the deposit permitted construction of a three dimensional model of fluid-rock interaction above and below the sulfide horizon. Although a mineralogically distinct stockwork zone is not present in the Gray Eagle host rocks, patterns of ^{18}O depletion indicate the presence of a hydrothermal vent area. ^{18}O depletion is more extensive and localized in the <u>overlying</u> host rocks, where $\delta^{18}O$ varies from +15.9 to +5.8‰. This pattern of ^{18}O exchange is concentric about the east-central portion of the deposit, recording locally higher water/rock ratios expected in the vent area. These data indicate that (1) the deposit has been overturned, and (2) some hydrothermal activity persisted after sulfide deposition.

δD (whole rock) values from the host rock have a narrow range of -38 to -43‰, essentially reflecting the isotopic composition of chlorite. No gradients in δD were identified, although a slight increase in water content characterizes samples nearer the delineated vent area. The oxygen and hydrogen isotope data indicate that evolved sea water constituted the hydrothermal fluid ($\delta^{18}O \simeq 0$ to +5‰ and $\delta D \simeq -10$ to +10‰, calculated from quartz and chlorite data). Fluid inclusion studies indicate that the hydrothermal fluid reached temperatures of 176 to 358°C during sulfide deposition.

The $\delta^{34}S$ values of pyrite from the sulfide horizon vary from 0 to +3.4‰, and are compatible with a reduced (i.e. H_2S dominant) hydrothermal fluid and a dominantly magmatic (leached?) source of sulfur. (Authors' abstract)

CRAWFORD, M.J. and BEALES, F.W., 1983, The Shawangunk mine: a possible sandstone-hosted Mississippi Valley-type ore deposit in New York: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 436-446. First author at Phelps Dodge Exploration East, Inc., 404-11484 Washington

Plaza West, Reston, VA 22090.

The Shawangunk Mine is one of several small lead-zinc deposits occurring in a slightly deformed sequence of Silurian sandstone and shale in southeastern New York. The geology in the area represents a transitional sequence between fluvial and marine sedimentation along the edge of the Siluro-Devonian basin. Mineralization consists of sphalerite-galena-chalcopyrite--pyrite-quartz veins filling a strike/slip fault in sandstone of the Shawangunk Formation. Subsidence, compaction, and tectonism in the marine basin are thought to have generated low temperature metal- and sulfur-bearing brines which migrated into structural traps in the Shawangunk Formation and precipitated sulfides.

The Shawangunk deposit is very similar in many respects to sandstone-hosted Mississippi Valley-type deposits. The differences between these deposits and the Shawangunk Mine are attributed to the tectonism that affected the Shawangunk area. It is concluded that the Shawangunk deposit represents a heretofore unrecognized end-member of the group of sandstone-hosted lead-zinc deposits. It is also suggested that, based on the degree of tectonic deformation of the host basin, sandstone-hosted deposits can be divided into three subgroups. (Authors' abstract)

Th for quartz and sphalerite ranged from 75 to 275°C (mostly ~115°C for primary inclusions); Tm(ice?) ranged from -7.5 to -15°. (E.R.)

CUNNINGHAM, C.G., RYE, R.O., STEVEN, T.A. and MEHNERT, H.H., 1983, The genesis of epithermal alunite deposits and implications for exploration, in Proceedings of the Denver Region Exploration Geologists Society Symp.; the Genesis of Rocky Mountain Ore Deposits; Changes with Time and Tectonics, Nov. 1982, p. 163-164.

See same authors, Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 49. (E.R.)

DARIMONT, A., 1983a, Fluid inclusions in calcite associated with the Pb-Zn mineralization of Poppelsberg, eastern Belgium: Mineral. Deposita, v. 18, p. 379-386 (in French). Author at Chercheur IRSIA, Lab. Géol. Appli., Liège, Belgium.

Fluid inclusions in calcites sampled in a Pb-Zn mineralized vein in East Belgium are characterized by a large dispersion of filling temperatures Th (30°C to more than 360°C) and by two groups of Tm (-14°C and -21°C). Boiling has not been proved. According to the still unexplained dispersion of the filling temperatures, this study does not permit an estimation of the depth of the ore formation. Nevertheless, fluid inclusion thermometric properties make possible the distinction between calcites associated with a mineralization (from the fertile locality of Poppelsberg) and calcites from sterile area (Belle Roche, Th = 150°C, Tm variable around a mode of -8°C). (Author's abstract)

DARIMONT, Anne, 1983b, Fluid inclusion study of the F-Ba-(Zn, Pb) mineralization from southern Belgium (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 23 (in French; translation courtesy M.J. Logsdon). Author at Lab. Geol. Appli., 45, avenue des Tilleuls, D-4000 Liege, Belgium.

Vein-type F-Ba-(Zn, Pb) mineralization in the metallogenic district of southern Belgium is localized in a band of east-west oriented, Devonian carbonate terrain bounded on the south by the Dinant Synclinorium. The study sites (Ave et Auffe, Beauraing, Foisches, Dancennes, Poly et Vierves) can be distinguished by the abundance of barite relative to fluorite and/or by the abundance of galena relative to sphalerite. Thermometric analyses of fluid inclusions observed in sphalerite, fluorite, calcite and barite indicate that Th values are all below 140°C and the melting temperatures [Tm ice?] are all above -32°C. Based on these data, the author proposes a chronology of mineralization and compares the physico-chemical conditions of the various sites. (Author's 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).

DEICHA, Georges, 1983, Some aspects of the present discussion on phase transitions in the genesis of mineral deposits: Bull. Soc. Geol. France, Series 7, v. 25, no. 1, p. 129-139 (in French).

Study of fluid inclusions is a good thing. (E.R.)

DELANEY, J.R. and KELLEY, D.S., 1983, Indirect evidence of hydrothermal temperatures in excess of 400°C from the Mid-Atlantic Ridge (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A17. First author at Sch. Oceanography, Univ. Washington, Seattle, WA 98195, USA.

High salinity fluids trapped within secondary mineral assemblages from submarine ridges and seamounts may develop from seawater by enrichment of salts resulting from: 1) progressive dehydration of the fluid (formation of hydrous alteration), or 2) fluid phase separation in a rising fluid. Production of such high salinities by dehydration requires a small water-to-rock ratio (<.3); generation by fluid phase separation requires high enthalpy (temperatures >400°C). Detailed textural analysis of 'open space' filling pebble breccias in quartz veins from the Mid-Atlantic Ridge-Kane Fracture Zone Intersection indicates fluid flow rates on the order of 1.3 to 1.6 m/sec, implying a dynamic flow system with a high water/rock ratio.

A seawater analogue (3.5 wt% NaCl in H_2O) will exhibit normal boiling if the decompressional fluid path intersects the two phase region at temperatures and pressures lower than the intersection of the compositional plane and the critical curve (icpcc). Very high enthalpy conditions are required to simply double the salinity by this mechanism. If the fluid path encounters the two fluid phase region at conditions greater than the icpcc, droplets of chloride-rich brine will separate and may be incorporated into fluid inclusions in secondary minerals. The icpcc for the seawater analogue is ~410°C.

We therefore conclude that fluids hotter than 410°C circulated through presently exposed crust near the Kane Fracture Zone within the past million years. (Authors' abstract)

DE ROSA, Rosanna and SHERIDAN, M.F., 1983, Evidence for magma mixing in the surge deposits of the Monte Guardia Sequence, Lipari, in M.F. Sheridan and F. Barberi (eds.), Explosive Volcanism: J. Volcanol. Geotherm. Res., v. 17, p. 313-328. First author at Dept. Geol., Univ. Calabria, Cosenza, Italy.

Includes an analysis of a glass inclusion in plagioclase. (E.R.)

DESYATNIK, V.N., KATYSHEV, S.F., TRIFONOV, K.I. and NIKULINA, M.M., 1983, Studies of reaction of calcium chloride with cryolite in water solutions at temperatures 60 and 80°C: Zhurn. Neorg. Khimii, v. 28, no. 1, p. 224-227 (in Russian).

The reaction $3CaCl_3 + 2Na_3AlF_6 = Ca_3(AlF_6)_2 + 6NaCl$ is characterized, including formation of the compound $CaNaAlF_6$. (A.K.)

DEVINA, O.A., YEFIMOV, M.Ye., MEDVEDEV, V.A. and KHODAKOVSKIY, I.L., 1982a Thermodynamic properties of the uranyl ion in aqueous solution at elevated temperatures: Geokhimiya, 1982, no. 10, p. 1454-1463 (in Russian; translated in Geochem. Int'l., v. 19, no. 5, p. 161-172, 1983).

DEVINA, O.A., YEFIMOV, M.Ye., MEDVEDEV, V.A. and KHODAKOVSKIY, I.L., 1982b Thermodynamic parameters of $B(OH)_3^0$ and $B(OH)_4^-$ in aqueous solution at 298-573 K: Geokhimiya, 1982, no. 4, p. 550-564 (in Russian; translated in Geochem. Int'l., v. 19, no. 2, p. 147-164, 1983).

DICKHAUT, L.A., 1983, The strontium isotope and rare-earth element systematics of nonsulfide minerals from the Illinois-Kentucky fluorspar district: M.S. thesis, Miami Univ., Oxford, OH, 64 pp.

Indexed under Fluid Inclusions. (E.R.)

DICKSON, J.A.D., 1980, Artificial coloration of fluorite by electron bombardment: Min. Mag., v. 43, p. 820-822. Author at Dept. Geol., Univ. Park, Nottingham NG7 2RD.

Irradiation (for hours) of uncovered sections in a diffractometer X-ray unit induces transient color outlining growth bands, but is not satisfactory, but 1 hour in a cathodoluminescence chamber worked beautifully. This coloration helps to decide upon the origin and mode of formation of fluid inclusions. (E.R.)

DIMOV, Virgil, BRESKOVSKA, Veselina and MALEEV, Mihail, 1983, A microdiffraction study of the phase composition of precipitates from fluid inclusions in minerals from the Madjarovo ore deposit: Geokhim. Mineral. Petrol., Bulgarian Acad. Sci., no. 13, p. 44-58 (in Russian; English abstract).

The mineral precipitates crystallized after the evaporation of aqueous extracts on a formvar substrate have been identified for quartz, galena and sphalerite from the hypogene stage and for pyromorphite in the Madjarovo ore deposit. A number of crystalline phases, corresponding structurally to the minerals villiaumite, sylvine, halite, fluorite, calcite, vaterite, bradleyite, ewaldite, huanhite [juanite?], anhydrite, fairchildite, cryptohalite, baraite, hieratite and marshite, have been identified by electron microdiffraction. Part of the crystalline phases could not be identified. The morphological features of the precipitates, the formulae of the natural equivalents of the respective phases, the cross-section of the reverse [reciprocal?] lattice, the measured and calculated interplanar distances and the indices of reflection are given in tables. For part of the minerals studied, the only phase identified by X-ray was gypsum. Compared to the results from chemical analyses, the electron microdiffraction identifies additional silicofluoride and ammonium-bearing phases. Taking sphalerite, galena and pyromorphite as examples, it is demonstrated that the main elements forming the composition of the host mineral (in this case zinc, lead and phosphorus) are not to be found in the mineral precipitates, while ammonium and potassium silicofluorides have been identified in individual quartz samples.

The minerals studied from the main hypogene stage - quartz, sphalerite and galena, and the "supergene" pyromorphite have anionic and cationic compositions similar to those of the mineral precipitates. (Authors' abstract)

DINGWELL, D.B. and SCARFE, C.M., 1983, Major element partitioning in the system haplogranite-HF-H_2O: implications for leucogranites and high-silica rhyolites (abst.): EOS, v. 64, p. 342. Authors at Experimental Petrol. Lab., Dept. Geol., Univ. Alberta, Edmonton, Alberta, T6G 2E3, Canada.

Experiments were conducted a 1 kbar and 750-850°C on selected melt compositions in the system haplogranite-HF-H_2O. Run durations were 10^6 sec using a rock-water ratio of 1:1. The charges were quenched and frozen in liquid nitrogen, opened and immersed in 2N HNO_3 to recover the fluid phase. Glass run products were analyzed by microprobe and the fluid phase by AA (Na, K, Al, Si) and specific ion electrode (F).

The fluid phase coexisting with F-bearing haplogranite is enriched in alkalis and Na/(Na+K) relative to the melt. The Na/(Na+K) of the fluid depends strongly on Na/(Na+K) of the melt. The effect of F on the content of dissolved metals is intermediate between that of pure water and dilute HCl. Melt/fluid partitioning of F averages 3:1 and the total of dissolved metals (Na+K+Al+Si) increases linearly with added F.

These results, combined with work by others on B-bearing and Cl-bearing systems, are particularly applicable to studies of late stage fluids present prior to eruption of high-silica rhyolites and during emplacement of leucogranitic melts at low pressures. These fluids will have Na/K ratios controlled by the melt composition and (Si+Al)/(Na+K) ratios controlled by the major complexing anions present (B, Cl, F, etc.). (Authors' abstract)

DOBROVOL'SKIY, Ye.V. and LYAL'KO, V.I., 1983, Dynamics of groundwater fluoride: A model for the effects of kinetic and infiltration factors: Geokhimiya, no. 7, p. 1050-1064 (in Russian).

DOLGOV, Yu.A. and BAKUMENKO, I.T., eds., 1981, Thermobarogeochemical Investigations: Novosibirsk, Acad. Sci. USSR, Sib. Div., Inst. Geol. & Geophys., 79 pp.

Contains seven papers, by various authors, abstracted in this volume. (E.R.)

DONNELLY, T.H., et al., 1983, Ore genesis investigations: Baas Becking Geobiological Lab., Ann. Rept. 1982, p. 4-13.

A variety of current ore genesis investigations at the Baas Becking laboratory are described including fluid inclusion studies as follows:

1) NaCl-rich inclusions (Tt ~300°C, 4 km depth) in dolomite at the Copper Claim sulfide deposit.

2) Granite in the Mt. Gunson area (indicating it is not intrusive and hence not the source of the hydrothermal fluids). A variety of other samples from the area were also studied for inclusions, $\delta^{13}C$, $\delta^{18}O$, and $\delta^{34}S$.

3) Pillara prospect area sphalerite shows Th = 55-110°C and Tm -14 to -31°C.

4) Wagon Pass prospect area dolomite Th 65-110°C; Tm complicated by metastability and organic phases. (E.R.)

DORONIN, A.Ya. and BAL'TER, B.L., 1983, Evolution of ore-forming processes in polymetal deposits of the Rubtsovskiy and Zmeinogorskiy ore regions: Geol. i Geofiz., no. 4, p. 70-76 (in Russian; English abstract). Authors at PGO "Zapsibgeologiya," Novokuznetsk, USSR.

The paper presents an equation for determining pH of ore-forming hydrotherms and calculations of Pb:Zn ratio in solution. (A.K.)

DOROSHENKO, Yu.P. and PAVLUN', N.N., 1983, Thermobarogeochemical conditions of formation of molybdenum-tungsten deposits of the Central Kazakhstan: Doklady Akad. Nauk SSSR, v. 273, no. 4, p. 969-972 (in Russian). Authors at State Univ., L'vov, Ukraine.

Ore (Mo-W) parageneses were studied in the following deposits of the Central Kazakhstan: Akchatau, E. and N. Kounrad, Karaoba, Dzhanet, Nura-Taldy, Upper Kayrakty, Koktenkol', Baynazar, Skorpion and Akmaya. Parameters of mineral-forming solutions were different for various stages of mineralization (Th, °C; P, bar; wt.% of NaCl+KCl): a) molybdenite-quartz stage 495-280; 1200-700; 42-20, b) complex rare metal stage 480-230; 1600-400; 65-8, c) wolframite (scheelite)-quartz stage 385-190; 1200-650; concentrations not given, d) sulfide-quartz stage 320-120; 550-250; 10-4, e) calcite-fluorite-quartz stage 205-55 (only Th). Na/K ratio ranges in inclusion fluids from 3 to 10, Cl/F ratio - from 2 to 10. Main gas component (CO_2) increases from the early to the late stages up to 97 vol. % of total gases, N_2 + rare gases varies from 2 to 12 vol. %, CH_4 content decreases from early to late stages. (Abstract by A.K.)

DUBA, Daria and WILLIAMS-JONES, A.E., 1983, The application of illite crystallinity, organic matter reflectance, and isotopic techniques to mineral exploration: a case study in southwestern Gaspé, Quebec: Econ. Geol., v. 78, p. 1350-1363. Authors at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec H3A 2A7, Canada.

A comparison is made with Th of fluid inclusions; these suggest that the hydrothermal metamorphism at several copper deposits occurred at 300°C. The study suggests that illite crystallinity and organic matter reflectance are tools that could usefully supplement existing methodologies in the exploration for sedimentary-hosted mineralization which was deposited in association with low-temperature heating. (From the authors' abstract)

DUBESSY, J., 1983, Chemical equilibria in the C-O-H system and methodological consequences on fluid inclusion studies (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 24. Author at Centre de Rech. sur la Geol. de l'Uranium, 3, rue du Bois de la Champelle, 54501 Vandoeuvre-les-Nancy Cedex, France.

The C-O-H system forms the basis for the study of many geological fluid inclusions. There are however three main problems concerning the usage of this system with respect to the calculation of the composition, the pressure, and the oxygen fugacity of the inclusion fluid at the time of trapping.

1. Equilibrium constants of chemical reactions between the different species are temperature dependent. One must ask if the composition measured at room temperature, $X_i(25°C)$, is exactly the same as the true composition of the fluid, $X_i(P,T)$, in the P-T conditions of trapping. If not,

a) What is the order of magnitude of $(X_i(P,T) - X_i(25°C))/X_i(P,T)$?

b) What is the order of magnitude of the error involved on pressure estimation?

2. Some geochemists explain the composition of some fluid inclusions as the result of a loss of molecular H_2 from the fluid after trapping. What exactly are the consequences of such a H_2 loss on composition and pressure estimation? Might not H_2 loss be connected with the kinetics of diffusion processes occurring during the history of the fluid inclusion, subsequent to its formation, which take into account time, temperature, and H_2 concentration gradient?

3. In some graphite-rich environments, graphite is sometimes found

trapped inside fluid inclusions. What is the evolution of, composition, and volumetric properties of such inclusion fluids if equilibrium is achieved between the graphite and the fluid phase during cooling?

We have developed computer models to attempt to solve these chemical and physical problems. (Author's abstract)

DUBESSY, J., GEISLER, D., KOSZTOLANYI, C. and VERNET, M., 1983, The determination of sulphate in fluid inclusions using the M.O.L.E. Raman microprobe. Application to a Keuper halite and geochemical consequences: Geochimica Cosmo. Acta, v. 47, p. 1-10. First author at Centre Recherches Géol. de l'Uranium, BP 23, 54401 Vandoeuvre Les Nancy Cedex, France.

Sulphate concentrations have been determined in fluid inclusions by Raman spectroscopy using the M.O.L.E. microprobe after verifying that the sulphate determination is proportional to the total sulphate in the aqueous phase. Comparison of m-tSO_4 values in primary fluid inclusions with associated mother brine from actual solar salt works demonstrates their chemical equivalence.

Keuper halite of marine origin has also been studied. The inclusions contain solid phases: anhydrite and possibly gypsum and glauberite as well. The molality of the total dissolved sulphate in the aqueous phase is lower than that obtained during present sea-water evaporation at the halite stage of precipitation. Some geochemical hypotheses are proposed to account for this anomaly. (Authors' abstract)

DUDAS, F.O., 1983, The effect of volatile content on the vesiculation of submarine basalts: Econ. Geol. Monograph 5, p. 134-141. Author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

A shallow environment of formation has been inferred for Kuroko ores in northern Japan at least in part because of their association with vesicular basalt flows. Consideration of the PTX conditions which affect vesiculation demonstrates that reliable depth inferences can be made only if the volatile content of the melt can be independently determined. Vesicle volume and calculated water solubilities are used to estimate the initial water content of the Kuroko basalts. The calculated H_2O values indicate that most of the vesiculated Kuroko basalts could have been generated at seawater depths up to 4,000 m at total H_2O contents near 2 wt percent. Analytical data on volatiles in island-arc related lavas, and on the distribution of vesicles in some abyssal basalts, suggest that such volatile concentrations are realistic in environments similar to that of the Kuroko deposits. The vesicular basalts associated with the ores are thus not reliable indicators of the depth of ore formation and do not restrict the Kuroko deposits to depths of less than 1,000 m. (Author's abstract)

DUJON, S.C. and LAGACHE, M., 1983, Determination of the deviation from ideality of plagioclases and equilibrium constants with chloride solutions, between 500 and 700°C, 1 and 2 kilobars: Fortschritte der Mineral., v. 61, pt. 1, p. 51-52 (in French).

We studied, at constant pressure and temperature, equilibrium between plagioclase and aqueous chloride solutions, which follows the reaction:

$$2NaAlSi_3O_8 + CaCl_2 \rightleftharpoons CaAl_2Si_2O_8 + 4SiO_2 + 2NaCl$$

for which, in the presence of excess quartz, the law of mass action may be written:

$$RT \log K(T,P) = RT \log \frac{X(An)}{X^2(Ab)} \frac{X^2(NaCl)}{X(CaCl_2)} + \mu^{ex}_{(An)} - 2\,\mu^{ex}_{(Ab)}$$

where K(T,P) is the equilibrium constant of the reaction, X are the mole fractions, μ^{ex} are the excess chemical potentials. Knowing experimentally the compositions of the phases present allows K, the μ^{ex}, and G^{ex}, the excess molar free energy of the plagioclase mixture, to be calculated.

We have redone and expanded the experiments of Orville (1972) at various temperature between 500 and 700°C, pressures between 1 and 2 kbars, using solutions of different molalities.

- The solid phases produced are high temperature plagioclases. From the albite end-member to a composition X(An) = 55%, the solid solution behaves quasi-ideally. Beyond this, G^{ex} passes through a maximum for X(An) = 75%. This maximum deviation from ideality was inferred at 500°C by the appearance of a metastable phase, hexagonal $CaAl_2Si_2O_8$.
- Outside of the zone of unmixing of the fluid phase, we verified that the equilibrium constant varies little with pressure but much with temperature.

We have shown that the Ca/Na ratio in a solution in equilibium with a plagioclase depends on the molality of that solution, contrary to the case of exchange between alkalic feldspars and solution. Finally, we compare the equilibrium constants obtained here with those that have been published for much lower temperatures (Helgeson, 1969).

Helgeson, H.C., 1969, Am. Jour. Sci., 267, 729-804.
Orville, P.M., 1972, Am. Jour. Sci., 272, 234-272.
(Abstract translated courtesy R. Bodnar)

DUKE, E.F. and RUMBLE, Douglas, III, 1983, Graphite textural and isotopic variations: a record of fluid evolution in plutonic rocks, New Hampshire (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 562.

DUNHAM, Kingsley, 1983, Ore genesis in the English Pennines: a fluoritic subtype: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 86-112. Author at Univ. Durham, Durham DH1 3DY, England.

In the three separate orefields (Alston and Askrigg in the north, Peak District in the south) mineralization of fracture-controlled aquifers in thin, brittle host rocks (limestone, siliceous sandstone, dolerite) confined by shale and argillized volcanics produced ribbon-shaped oreshoots (e.g. 1500 m x 15 x 2.5). The Carboniferous host rocks belong mainly to the Asbian, Brigantian, and Pendleian stages, approximately equivalent to Upper Mississippian. The three fields were positive areas relative to adjacent contemporary basins and were gently domed after 296 my, with strain displayed as NNW, ENE, and E-W/ESE fractures. Tension and wrench faulting mainly opened up ENE and E-W sets and from about 280 my brines were entering from the basins, encountering in the northern fields two hot spots apparently related to reheating of granites orignally intruded into basement slates and turbidities at 405-410 my. The hot spots had attained about 200°C at the level of mineralization prior to its inception. Convective systems were set up as the temperature of the rocks decayed, and minerals were deposited at temperatures ranging from over 200°C to 90° (fluorine zone), 120° to under 50° (barium zone) in outward and upward succession, highest Pb and Zn values being where these zones overlapped. The deduced minimum temperature gradient during mineralization (75°C/km) if continued in depth would pass the fusion temperature of granite within the upper crust, 9-14 km deep. By Late Permian time, say 240 my, rock temperature had returned to normal. For the Peak orefield, no comparable heat source has yet been found; here the maximum mineralization temperature was 154°C and K/Na ratios in inclusions are below 0.034 (sea water), compared with ratios up to 0.18 in the northern fields. In the Peak district, sulfide $\delta^{34}S$‰ varies from +9.5 to -23.2, generally in accordance with F-Ba-Ca zonation from east to west; the ratios for Alston are +15 to -5.9, zonally outward. Barite $\delta^{34}S$‰ for Alston has a small range around +20 correlated with Carboniferous, not Permian sulfate: Derbyshire barite ranging +4.4 to +22.9 offers great latitude. Mean Ag in PbS is 150 ppm (Alston), 40 (Askrigg), 25 (Peak); Y in CaF_2 varies from 1200 ppm near northern feeding centers outward and southward to 20. Data for possible sources of metals and fluorine in basement, Carboniferous and Permian are summarized. Genetic models by Wallace, Dunham, Sawkins, Davidson, Ford, Ineson, Russell, Moore and others are reviewed. (Author's abstract)

DUNLOP, H.M. and FOUILLAC, A.-M., 1983, Isotopic studies of fluid inclusions in chrome-spinels: implications concerning the genesis of ophiolitic chromitite deposits in Oman (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 25. First author at Centre de Rech. sur la Synthese et la Chimie des Mineraux, G.I.S., C.N.R.S.-B.R.G.M., 1A, rue de la Férollerie, 45045 Orleans Cedex, France.

Small (5-40 µm), aqueous, biphase fluid inclusions are ubiquitous in spinels from Oman chromitite deposits at all levels of the mantle sequence and in the lowermost part of the cumulate sequence. Similar inclusions have also been observed in nodular chromite and in fresh silicates (forsteritic olivine, diopside, and plagioclase) within massive chromitite. D/H ratios in unaltered spinels separated from massive chromitite range from -56‰ to -79‰ and are typical of primordial mantle waters. This data represents the isotopic composition of the fluid inclusions since an unreasonably high concentration of hydrous silicate inclusions (>>1%) would otherwise have to be present to account for the very low H_2O contents observed (0.03-0.06 wt. %). These D/H ratios are independent of depth in the mantle sequence. Spinels containing nonremovable serpentinized silicates were also analyzed and have more elevated ratios (-35‰ to -42‰) and correspondingly higher H_2O contents (0.08 to 0.15 wt. %). $^{18}O/^{16}O$ ratios in fresh mineral separates from massive chromitite, the enclosing dunite envelope, harzburgite and the overlying basal cumulates reflect mantle isotopic fractionation processes (high temperature >800°C, subsolidus reequilibration) and have not been disturbed by hydrothermal exchange with seawater. The magmatic nature of these deposits is also demonstrated by the similarity of $^{143}Nd/^{144}Nd$ ratios of chromite (Nd = 10.4) and diopside (∈ND - 9.9) to the depleted MORB type ratios of overlying cumulates and basalts. (Authors' abstract)

DURAK, B., PAGEL, M. and POTY, B., 1983, Temperatures and salinities of fluids related to diagenetic silicification of a Sandstone Formation overlying a uranium deposit located in the Basement: Examples from the Kombolgie Sandstone (Australia): C.R. Acad. Sci. Paris, Series II, v. 296, p. 571-574 (in French; translation by Lisa M. Bithell; U.S. Geol. Survey Open-File Report 85-155; call no. (200) R29o, 84-155).

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 to +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 spatially associated with Proterozoic unconformities. (Authors' abstract)

DYMKIN, A.M., 1983, State of studies of the skarn- and ore-formation problem, in Skarns and ores, Transactions of Inst. Geol. and Geoph. of Sib. Branch of Acad. Sci. USSR: "Nauka" Siberian Branch, Novosibirsk, v. 546, p. 20-23 (in Russian). [The book presents materials of All-Union Symp. "Skarns and Ores," held in Novosibirsk, 18-19, May, 1981, A.K.]

A review of data (also Th) that were submitted in the abstracts for symposium. (A.K.)

EADINGTON, P.J., 1983a, Applications of calculated solubilities of cassiterite to mineralization in granitic rocks and skarns: CSIRO Div. of Mineral. Res. Review 1983, p. 128-131.

Calculated solubilities of cassiterite indicate solubility-temperature-oxygen fugacity relationships for tin (II) halogen complexes that enable the accumulation of cassiterite by reactions with circulating hydrothermal solutions in ilmenite-bearing granites. At the oxygen fugacity of magnetite-bearing granites the solubility of cassiterite is too low for comparable concentration of dispersed tin.

In carbonate-magnetite-bearing rocks cassiterite has a high solubility as tin (IV) hydroxy complexes. On the other hand, there is a field of low cassiterite solubility in the presence of carbonates and pyrrhotite or pyrite at temperatures near 250°C (Eadington 1982). (Author's abstract)

EADINGTON, P.J., 1983b, A fluid inclusion investigation of ore formation in a tin-mineralized granite, New England, New South Wales: Econ. Geol., v. 78, p. 1204-1221. Author at CSIRO Div. Mineral., P.O. Box 136, North Rhyde, New South Wales 2113, Australia.

A variety of tin, tungsten, and minor base metal deposits occurs in the Mole Granite pluton within the New England batholith, eastern Australia. Fluid inclusion studies of late magmatic rocks and hydrothermal ore deposits trace the changes in temperature, pressure, and composition of the hydrothermal solutions, and their relation to silicate and ore mineralogy, during the dispersion of the heat and brine concentrations produced by the granite.

Primary fluid inclusions were not observed in granite or granite pegmatite. Primary (nonsilicate) fluid inclusions and silicate melt inclusions were observed in magmatic quartz-topaz rock. These fluid inclusions are considered to represent unmixing of an aqueous phase in residual magma. Primary fluid inclusions have filling temperatures from 550° to more than 620°C and salt contents of 54 to 65 wt percent. Primary vapor-rich inclusions are common but were not measured owing to problems with visibility.

After crystallization of the magmatic rocks the following hydrothermal mineral assemblages were produced. They are listed with the main ranges of filling temperature [Tf] and salt content of multiphase and liquid-rich fluid inclusions: (1) complex pegmatite consisting of coarse-grained orthoclase-biotite-beryl-topaz-fluorite-quartz-muscovite (sometimes gem bearing), depending on position in the sequence of crystallization: Tf 510° to 580°C, salinity 67 to 74 wt percent, to Tf 300°C, salinity 35 to 40 wt percent; (2) disseminated wolframite mineralization in sericitized quartz-topaz rock: Tf 250° to 360°C, salinity 30 to 35 wt percent; (3) cassiterite-quartz veins in relatively unaltered granite: Tf 350° to 420°C, salinity 20 to 40 wt percent; (4) disseminated cassiterite mineralization in sericitized and chloritized granite bordering joints and shears: Tf 250° to 290°C, salinity 25 to 35 wt percent; (5) base metal sulfide-quartz veins bordered by argillized granite: Tf 240° to 280°C, salinity 3 to 5 wt percent; and (6) narrow crosscutting veins of adularia-quartz in the earlier hydrothermal ores: Tf 290° to 350°C, salinity 2 to 3 wt percent.

Daughter crystals in multiphase inclusions were mostly halite and other chlorides.* Inclusions in the late-stage quartz-adularia assemblages contained dawsonite, indicating an increase in the relative importance of carbonate in the solutions.

Above a temperature of 400°C the hydrothermal solutions were two-phase. Evidence for this (interspersed multiphase and gas-rich inclusions) was seen in the quartz-topaz rock and hydrothermal assemblages 1, 2, and 3. Solutions in hydrothermal assemblages 4, 5, and 6 were a single phase (liquid). PH_2O deduced from the vapor pressure in the water-sodium chloride system, for the two-phase solutions was 700 bars for the quartz-topaz rocks, 300 bars for the complex pegmatite, 200 bars for the quartz-cassiterite veins, and 80 to 90 bars for the disseminated sericite-wolframite mineralization. The decrease in pressure is attributed to the transition from lithostatic pressure in the quartz-topaz magma to hydrostatic pressure in the solid, fractured rocks.

The fluid inclusion measurements and chemical analyses indicate two stages of hydrothermal activity. In stage one, in which heat was dispersed but not dissolved salts, the temperature decreased by 200°C while the salt content increased and chemical composition of multiphase inclusions (entrapped brine) was conserved. There is evidence for coexisting brine and vapor in the hydrothermal system. In stage two, dissolved salts were dispersed more rapidly than heat, and fluid inclusion evidence indicates a decreasing incidence of vapor in the hydrothermal system.

These fluid inclusion data could be accounted for if each fluid phase (vapor and brine) interfered with the flow of the other in an analogous way to water-oil or other immiscible fluids in porous media. Large amounts of vapor in the hydrothermal system would impede the flow of brine and minimize the amount of mixing with ground water, thus conserving the salt content and chemical composition of the brine, now observed as multiphase inclusions. Upon condensation of the vapor phase, mixing of the brine and ground waters should occur; this is observed in stage two of hydrothermal actiity.

The formation of major fractures occurred at the transition from stage one to stage two of hydrothermal activity. Fracturing was initiated by differential stress and is believed to have accelerated condensation of vapor and the mixing of magmatic brine and ground water. Most of the tin and tungsten ores were precipitated during the decrease in salt content of the concentrated brine. (Author's abstract)

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*Including also possible amarantite ($Fe(SO_4)(OH) \cdot 3H_2O$)(Tm 280°C); $FeCl_2 \cdot 2H_2O$ (Tm ~270°C), and several unknowns. (E.R.)

EADINGTON, P.J., 1983, Calculated solubilities of cassiterite in high temperature hydrothermal brines, and some applications to mineralization in granitic rocks and skarns, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 335-345. Author at CSIRO Div. Mineral., P.O. Box 136, North Ryde, Australia, 2113.

The stabilities of 36 tin complexes containing chloro, fluoro, hydroxy, and hydroxyhalogen ligands have been calculated for the following conditions. Temperature 250°C to 500°C, aCl^- 1m, aF^- 1.6×10^{-3} m. These conditions were chosen to represent those in hydrothermal systems that deposited cassiterite ores.

Under acid conditions, such as those of the microcline-muscovite hydrolysis reaction in granitic rocks, and at fO_2 values slightly under the Ni/NiO buffer the Sn(II) complexes $SnCl_2^0$ and SnF^+ predominate. These complexes markedly increase the solubility of cassiterite, which varies from about 180 ppm at 400°C to less than 0.1 ppm at 250°C. A decrease in either the temperature or activity of chloride would thus precipitate cassiterite.

Under alkaline conditions, such as those determined by the dissolution of calcite in skarns, and at similar fO_2 values to those stated above, the Sn(IV) complexes $Sn(OH)_5^-$ and $Sn(OH)_6^{2-}$ predominate. The solubility of cassiterite under these conditions may be as high as several thousand ppm. Only in exceptional geological situations will hydrothermal solutions in skarns become saturated with cassiterite. Accordingly tin is usually observed in these rocks as tin silicates such as malayaite ($CaSnSiO_5$) or in cation substitution in calc-silicate minerals such as hornblende and andradite. (Author's abstract)

EADINGTON, P.J. and KINEALY, K., 1983, Some aspects of the hydrothermal reactions of tin during skarn formation: J. Geol. Soc. Australia, v. 30, p. 461-471.

EADINGTON, P.J. and PATERSON, R.G., 1983, Internal deformation and fluid inclusions in relation to mineralized breccia columns in the Ardlethan tin mine, central New South Wales, Australia, in Abstracts Volume, Conf. on Brecciation and Mineralization: Geologic Occurrence and Genesis, Colorado Springs, Colorado, Sept. 18-22, 1983: MacKay Sch. Mines, Univ. Nevada, Reno, Nevada (no editors given; unpaginated). First author at CSIRO Div. Mineral., North Ryde, 2113 Australia.

The Ardlethan tin deposit contains disseminated cassiterite ores in a large number of breccia columns within an area of about 0.5 km^2 and a vertical range of at least 700 m. The total resource was about 10 m.t. at 0.45% tin. The breccia columns are in adamellite in close proximity to quartz-feldspar porphyry dykes. The mine is in the western part of the Lachlan orogenic belt where predominantly 'S'-type Silurian granitic rocks intrude Ordovician slates and phyllites.

The breccia columns are of three main types.

(1) Highly comminuted breccia containing angular mineral and granite fragments of 0.1-5 mm diameter. There are occasional fragments of porphyry to 0.5 m. These occur alongside, and also crosscutting, porphyry dykes. This breccia is intensely altered and recrystallized to hydrothermal rocks. The breccia characteristics are only seen in thin section as a disrupted quartz fabric and relic fragment shapes.

(2) Mixed lithic breccias consisting of fragments of altered granite and porphyry, and minimally altered metasediment, 1 to 30 cm in diameter in a clay-sericite-chlorite matrix. Blocks of metasediment to 10 mm diameter also occur in this breccia.

(3) A breccia of angular fragments of altered granite 3-4 cm in diameter in a high proportion of matrix of quartz-tourmaline-sericite. In the upper levels this breccia is bounded by a marginal zone of large misoriented blocks 1-2 m diameter with little matrix and numerous vughs, 10 cm in diameter, lined with quartz crystals.

Intense comminution and upwards translation of porphyry fragments in type (1) breccia suggest it is intrusive breccia. Large misoriented blocks in type (3) breccia and metasediment blocks in type (2) mixed lithic breccias are a collapse feature.

Internal deformation in quartz, especially in large blocks bordering type (3) breccia, results from incremental strain due to repeated microfracturing. The microfractures are often confined to single grains. This is interpreted as a dilational phase of deformation occurring beyond the limits of elastic strain but before failure by macroscopic fracture and brecciation.

Fluid inclusions in the rocks are saline and CO_2-rich. Inclusions formed synchronously with the microfracturing trapped a single liquid phase, those formed after the brecciation trapped immiscible CO_2-rich vapor and aqueous liquid at pressures of about 500b. Unmixing of the CO_2-rich phase enabled prolonged flow of escaping gas and may have contributed to the intense comminution in breccia type (1) and translation of fragments in breccia types (1) and (2). (Authors' abstract)

EADINGTON, P.J. and SUN, S.-S., 1983, Fluid mixing and the precipitation of tin ores in a hydrothermal circulation system in granite: CSIRO, Div. of Mineralogy, Res. Review, 1983, p. 125-127.

Fluid inclusion and oxygen isotope measurements show that hydrothermal solutions in the tin-mineralized Mole Granite, northern N.S.W., were initially enriched in ^{18}O and dissolved salts and probably were of direct magmatic origin. These solutions were progressively depleted in ^{18}O and salts, resulting from an influx of surface-derived water of meteoric origin. The cassiterite ores were deposited during initial dilution of the magmatic solutions. Base-metal ores were deposited from hydrothermal solutions that were dominantly of meteoric origin (Eadington and Sun 1982). (Authors' abstract)

EASTOE, C.J., 1983, Sulfur isotope data and the nature of the hydrothermal systems at the Panguna and Frieda porphyry copper deposits, Papua New Guinea: Econ. Geol., v. 78, no. 2, p. 201. Author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

Values of $\delta^{34}S$ have been determined for 58 anhydrite and sulfide specimens from Panguna and Frieda. Individual minerals have the following ranges: at Panguna, pyrite 0.5 to 3.1 per mil, galena; -1.5 per mil, sphalerite; -1.0 to +1.6 per mil, anhydrite; 7.6 to 1.6 per mil; at Frieda, sulfides coexisting with anhydrite, -3.5 to +1.9 per mil; pyrites without anhydrite, -1.6 to +2.1 per mil; anhydrite, 10.0 to 18.3 per mil. Isotopic zonation in time and space was not observed in either deposit. Temperature ranges of copper mineralization based on ^{34}S fractionations between coprecipitated anhydrite and sulfides are 416° to 877°C at Panguna and 356° to 677°C at Frieda, provided there was isotopic equilibrium. Isotopic equilibrium seems likely on the basis of high temperatures indicated by fluid inclusions. Fluid inclusions data indicate that copper mineralization at Frieda was associated with boiling salt-rich liquid at temperatures of 420° to >580°C, and pressures of 150 to 250 bars. Brines of lower salinity were present at another stage and may have invaded the deposit after copper mineralization. Anhydrite-sulfide isotopic data indicate $\delta^{34}S(\Sigma S)$ values of 1.0 per mil in the ore-forming fluid at Panguna, and $m(SO_2):m(H_2S) \approx 1:9$. At Frieda, the fluid $\delta^{34}S(\Sigma S)$ values may have been 1 and 2 per mil, and $m(SO_2):m(H_2S)$ is 1:4 and 1:1, respectively, for two subdeposits. These $SO_2:H_2S$ ratios contrast with much larger values determined for the vapor in the case of Panguna. The fluid $\delta^{34}S(\Sigma S)$ values do not correspond directly to the $\delta^{34}S$ of the magma, which may have been between 0 and >4.1 per mil in the case of Panguna. (Author's abstract)

EBY, G.N., 1983, The identification of silicate-liquid immiscibility processes using minor and trace element distributions, <u>in</u> The Significance of Trace Elements in Solving Petrogenetic Problems & Controversies: Theophrastus Publications S.A., Athens 622, Greece, p. 27-38.

EDMUNDS, W.M., DAY, R.L.F. and McCARTNEY, R., 1983, Origin of saline groundwaters in the Carnmenellis granite: natural process and reaction during hot dry rock reservoir circulation: Proc. Fourth Water-Rock Interaction Symp., Japan, p. 127-131.

EFIMOVA, E.S., SOBOLEV, N.V. and POSPELOVA, L.N., 1983, Inclusions of sulfides in diamonds and peculiarities of their paragenesis: Zapiski Vses. Mineralog. Obshch., v. 112, no. 3, p. 300-310 (in Russian). Authors at Inst. Geol. and Geophys. of Sib. Branch of Acad. Sci. USSR, Novosibirsk.

The paper presents the possible chemical composition of sulfide melt trapped as inclusions in diamonds: S 36-41%, Fe 28-61%, Co 0.1-0.7%, Ni 0.5-30%, Cu 0.1-6.5%. (A.K.)

EFREMOVA, E.P. and KUZNETSOV, V.A., 1983, Solubility and crystallization of cinnabar under hydrothermal conditions, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 317-331.

ELDERS, W.A. and COHEN, L.H., 1983, The Salton Sea geothermal field, California, as a near-field natural analog of a radioactive waste repository in salt: Technical Rept BMI/ONWI-513, 146 pp.

ELDERS, W.A., BIRD, D.K. and WILLIAMS, A.E., 1983, Models of hydrothermal systems in the Salton Trough: active ore formation in a sedimentary basin (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 566. First author at IGPP, Univ. California, Riverside, CA 92521.

The Salton Trough, a site of rifting and deposition of deltaic and lacustrine sediments today, contains several geothermal fields, with temperatures of ≤370°C at <2 km depth. In the Cerro Prieto field, which with >100 deep wells is the best studied, a prograde series of calc-silicate minerals including wairakite, epidote, prehnite and clinopyroxene is forming. However ore minerals are present in only trace amounts. The fluid is primarily a Na+K+Ca chloride brine of ≤18,000 ppm TDS with $pH_2O < 200$ bars, $pCO_2 < 10$ bars, and $fO_2 \approx 10^{-35}$ at 350°C. Oxygen isotope exchange data indicate a water/rock volume ratio of 3:1. According to quantitative models of heat transfer and magnetic and gravity data, the heat source for this field is probably a funnel-shaped gabbroic intrusion, 4 km across, intruded at a depth of 5 to 6 km, 50,000 years ago.

In contrast, in the geologically similar Salton Sea field ore mineralization is very abundant and at ≥350°C an assemblage of garnet + actinolite + biotite + epidote is developed. The chief difference is that the fluid is a highly concentrated brine formed by solution of non-marine evaporites. It contains ≤280,000 ppm TDS, including Mn ≤1,700 ppm, Zn ≤800 ppm, Pb ≤100 ppm, Cu ≤8 ppm, Ag ≤1.5 ppm, and Pt ≤50 ppb. The source of sulfur is diagenetic pyrite and >80% of the Pb and Sr isotopes in solution come from the sediments. The Salton Sea system is an incipient stratabound sulfide deposit transforming into a hydrothermal ore body. In this environment to form ore grade Cu-Pb-Zn sulfides and Fe oxides requires the juxtaposition of a heat source, dissolved evaporites, metal-bearing sediments and diagenetic sulfur. (Authors' abstract)

ELOY, J.F., LELEU, M. and UNSOLD, E., 1983, Geological applications of the laser probe mass spectrometer (L.P.M.S. II): Int'l. J. Mass Spectrometry & Ion Physics, v. 47, p. 39-42. First author at Comm. l'Energie Atomique -

Centre d'Etudes Nucleaires de Grenoble, SEAPC, P.O.B. 85 x, F-38041 Grenoble, France.

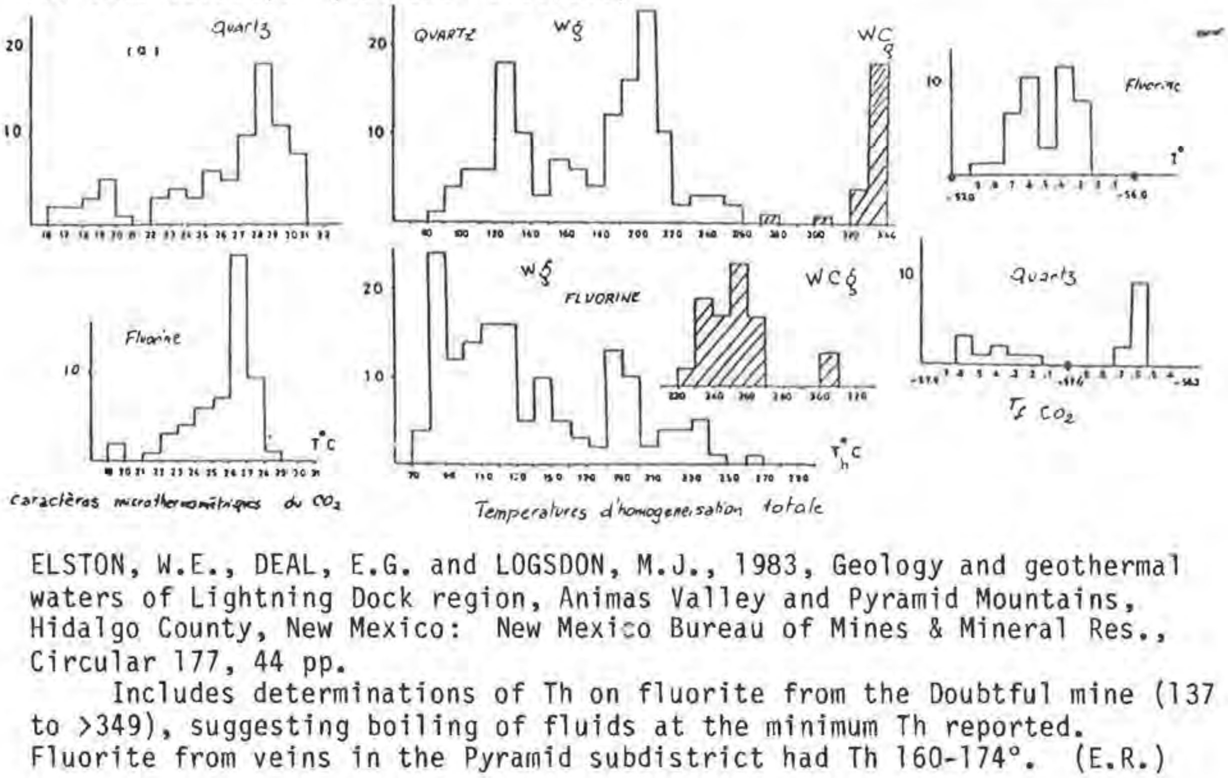
A brief review of the use of the method to obtain Na and K in inclusions in quartz. (E.R.)

EL SAMANI, Y., de BRETIZEL, P., PICOT, P. and TOURAY, J.-C., 1983, Parageneses and fluid inclusions of the Eyob tungsten deposit (Sudan) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 26 (in French; translation courtesy M.J. Logsdon).

The Eyob tungsten deposit (Alikalaib Plain, Red Sea Hills, Sudan) is located in a post-tectonic, leucocratic "younger granite," characterized by muscovite-microcline-(fluorite), which is intruded into Archean catazonal gneiss. The gneiss locally includes scheelite-rich greisen. The country rock is cut by stockwork veins including late-stage quartz-wolframite-scheelite-fluorite. A variety of sulfide and oxide phases are accessory to this paragenesis.

Fluid inclusion data are summarized on the figures. Secondary inclusions in quartz and fluorite belong to the Wg and Wcg types indicated. Temperatures of melting of ice are >-4°C; a CO_2 clathrate is observed.

The deposit belongs to the "greisen" type of Naumov, and the fluid evolution is similar to the Xivashen deposit (Jang Si, China; Giuliani et al, this volume). (Authors' abstract)



caractères microthermométriques du CO_2

Temperatures d'homogeneisation totale

ELSTON, W.E., DEAL, E.G. and LOGSDON, M.J., 1983, Geology and geothermal waters of Lightning Dock region, Animas Valley and Pyramid Mountains, Hidalgo County, New Mexico: New Mexico Bureau of Mines & Mineral Res., Circular 177, 44 pp.

Includes determinations of Th on fluorite from the Doubtful mine (137 to >349), suggesting boiling of fluids at the minimum Th reported. Fluorite from veins in the Pyramid subdistrict had Th 160-174°. (E.R.)

ENIKEEVA, L.N., AKKERMANTSEV, S.M. and SKACHKOVA, L.A., 1983, Tourmalines from pegmatites of the Kulam deposit (Afghanistan): Uzb. Geol. Zh., v. 5, p. 69-73 (in Russian). Authors at Inst. Geol. Geofiz. im. Abdullaeva, Tashkent, USSR.

The albitized microcline pegmatites of the area consist of microcline, clevelandite, lepidolite, spodumene, tourmaline (TL), pollucite, cassiterite, microlite, petalite, etc. Varicolored grains of TL occur as short-tabular or acicular crystals with well-developed prismatic faces. Chem., the TL are elbaite, schorl, and dravite. The total content of chromophore-element oxides ranges 0.99-16.68%, with d. 3.06-3.21 g/cm^3; the ns are ω = 1.643-1.668 and ε = 1.620-16.39. The Th of gas-liq. inclusions in the various TL was determined (140-280°). The TL formed as a pneumatolytic phase in an alk. medium. (C.A. 100: 54696h)

EREMIN, N.I., 1983, Differentiation of volcanogenic sulfide ore mineralization (on the example of the Phanerozoic sulfide deposits), ed., V.I. Smirnov, Moscow Univ. Pub. House, 256 pp., 660 copies printed, price 3.50 rbls (in Russian).

In chapters 8 and 9, p. 183-237, the following aspects of the use of fluid inclusion data (mostly from literature) are discussed: T, P, pH, f(O_2), total sulfur activity and f(S_2), construction of f(O_2)-pH plots and conditions of formation of sulfide ores. (A.K.)

EROKHIN, V.Ye. and TITKOV, G.A., 1983, First results of studies of isotope composition of hydrogen in methane of mud volcano gases in Azerbaydzhan and Turkmenia: Doklady Akad. Nauk SSSR, v. 271, no. 3, p. 715-717 (in Russian). Authors at Geol. Inst. of Acad. Sci., Moscow, USSR.

Composition of gases is as follows (in vol. %): CH_4 93.75-99.13, heavy hydrocarbons 0.027-3.96, N_2 nil-2.56, CO_2 0.30-6.14, He not detected, H_2 nil-0.007; δD of CH_4 (in ‰) from -159 to -236 indicates the connection with gases of oil and gas deposits, but not with gases of magmatic volcanoes. (A.K.)

EUGSTER, H.P., 1983, Granites and hydrothermal ore deposits (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 2. Author at Johns Hopkins Univ., Baltimore, MD, USA.

Solubility determinations on magnetite and cassiterite in supercritical chloride solutions shed light on Sn-W deposits associated with granitic rocks. Principal solutes are $SnCl_2$ and $FeCl_2$ and their dissociation products. For a given fH_2, solubilities are governed by HCl concentrations, with Sn levels about 100 times lower than Fe values (Wilson and Eugster). In contrast, NaCl solutions are ineffective carriers. HCl produced during boiling by hydrolysis of NaCl (melt) is essential for mineralized batholiths. Early acid and reducing fluids accomplish transport and deposition of minerals such as cassiterite, wolframite, arsenopyrite, in contrast to later oxidizing fluids. (Author's abstract)

EWALD, A.H. and HLADKY, G., 1983, Solubility measurements on sphalerite (abst.): CSIRO Div. of Mineralogy Res. Review, 1983, p. 42-43.

New measurements have been made on the solubility of sphalerite in 1 to 3 molal NaCl at temperatures between 100 and 250°C. The results are lower than published values by a factor of 2 to 3 (Ewald and Hladky 1980). (Authors' abstract)

EWERS, G.R., FERGUSON, John and DONNELLY, T.H., 1983, The Nabarlek uranium deposit, Northern Territory, Australia: some petrologic and geochemical constraints on genesis: Econ. Geol., v. 78, p. 823-837. First author at Bureau of Min. Res., P.O. Box 378, Canberra City, A.C.T. 2601, Australia.

The very negative $\delta^{13}C$ values of the Nabarlek carbonates suggest very little (or no) CH_4 was present in the hydrothermal fluids from which they formed. Ypma and Fuzikawa (1980) suggest as well that the ore fluid was of ground-water (pristine or slightly modified) origin having $\delta^{18}O$ values between -5 and +1 per mil--values incompatible with the $\delta^{18}O$ values found for the Nabarlek hydrothermal carbonates (Friedman and O'Neil, 1977).

Clearly, the fluids giving rise to the Nabarlek ore-zone carbonates and those examined by Ypma and Fuzikawa (1980) are different. Ypma and Fuzikawa have recognized the limitation of their work in looking at fluid inclusions in quartz from late-stage veins. Some of these veins can contain remobilized uraninite. However, it is clear from the present study that this quartz is unrelated to the earliest mineralization, and therefore the relevance of Ypma and Fuzikawa's data to the genesis of the Nabarlek deposit must be in some doubt. A possible explanation is that their data may reflect the presence of CO_2-rich ground waters and CH_4 in the ore zone in the recent past. (From the authors' text, p. 835)

FABRICIUS, J., 1983, Formation temperature and chemistry of brine inclusions in authigenic quartz from Permian salt in the Danish Trough (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 27. Author at Geol. Survey of Denmark, 31 Thoravej, DK 2400 Copenhagen, NV.

Microthermometric studies have been carried out on inclusions in euhedral quartz from salt domes in the area of N. Jutland, which is a part of the Norwegian-Danish Basin. The investigated salt is of Zechstein age.

Euhedral quartz crystals have been extracted from selected core material from wells in different domes at various depths from 200 m to 3485 m. The homogenization temperature and the melting temperature of the ice and the different hydrates have been measured on fluid inclusions in the quartz crystals. The salinity and the Ca:Mg ratio have been determined from the various phase diagrams of the system $CaCl_2$-$MgCl_2$-$NaCl$-H_2O. Salinity: 30-45 weight % brine. Ca:Mg ratio: 3:1-1:4. NaCl: 1-10 weight %.

In some cases both the trapping and the homogenization temperature were measured and the pressure during the crystallization of the quartz was determined.

The maximum P and T values indicate thermal convection in the salt early in the diapiric penetration phase. (Author's abstract)

FARFEL', L.S., SAVEL'YEVA, N.I. and MIRONOVA, O.F., 1983, Hydrothermal solutions of gold ore deposit Aksu: Geokhimiya, no. 12, p. 1781-1786 (in Russian). First author at Central Complex Geol. Exped. of Ministry of Colored Metals of the USSR.

Hydrothermal solutions that formed the deposit Aksu were concentrated Na-Ca fluids with a high content of CO_2 and Cl. Their composition is similar to solutions from metamorphosed sediments, typical of Paleozoic complexes. The composition is as follows (in g/kg of H_2O): Na 4.6-28.5, K 0.5-6.7, Ca 21.6-28.2, Mg 2.8-7.0, Cl 40.0-68.4, CO_2 (total) 66-143, CH_4 traces 2.0, total ion and gas content 87-190 (ore-bearing quartz and calcite). Solutions in gas-liquid inclusions in ore and barren quartz differ significantly. The latter are essentially of Cl-Na type with subordinate alkaline earths (mainly Mg) and HCO_3. In inclusions in ore-bearing quartz the role of alkaline earths significantly increases. Presence of CH_4 and CO_2, and positive relations between distribution of gold and organic carbon proves the active participation of organic matter in hydrothermal gold-ore forming process. Th of inclusions in ore quartz were in ranges 302-350°C, in calcite 308-350°C, Td also were measured. (Authors' conclusions translated and extended by A.K.)

FARRELL, C.W. and HOLLAND, H.D., 1983, Strontium isotope geochemistry of the Kuroko deposits: Econ. Geol. Monograph 5, p. 302-319. First author at In-Situ Inc., 209 Grand Ave., Laramie, WY 82070.

The isotopic composition of strontium in sulfate minerals from the Fukazawa and Kosaka ore deposits has been measured in order to evaluate the importance of seawater in the development of the Kuroko deposits. The $^{87}Sr/^{86}Sr$ values in samples of anhydrite and gypsum from the sekkoko (gypsum) units in both deposits fall in a narrow range (0.7082-0.7087) whose upper limit approaches that estimated for Miocene seawater. The $^{87}Sr/^{86}Sr$ values of the analyzed barites are generally slightly lower than those of the anhydrite and gypsum from the sekkoko and cover a wider range (0.7069-0.7079). None of the ratios are higher than the estimated for Micoene seawater. Closely crystalline barite specimens from the siliceous ore zones have $^{87}Sr/^{86}Sr$ values which are indistinguishable from those of fine-grained barites in the stratabound sulfide ores. (From the authors' abstract)

FAYZIYEV, A.R. and ISKANDAROV, F.Sh., 1983, Trace elements in fluorites from the Pamirs: Geokhimiya, no. 2, p. 263-274 (in Russian; English abstract). Authors at Tadzhik State Univ., Dushanbe, Tadzhikistan.

The relation between trace element contents (Si, Al, Mg, Fe, Ti, Cu, Pb, RE, Y, Mn, Ni, V, Mo, Ag, Ga, Bi) and Th is revealed: the higher Th, the higher total content of trace elements. The Th values for 3 deposits were as follows: Sasyk 380-390°C, Kara Dzhilga 130-170°C, Dzhaambay 80-110°C. (A.K.)

FEOKTISTOV, G.D., 1983, Physico-chemical calculations of process of equilibrium crystallization of silicate melt by use of a computer: Doklady Akad. Nauk SSSR, v. 271, no. 3, p. 720-724 (in Russian). Author at Inst. of Earth's Crust, Irkutsk, USSR.

The proposed model of melt phase may be used for calculation of crystallization of magmatic melt under various pressures and in the presence of H_2O. (A.K.)

FERRER, H.P., 1983, Hydrothermal petrology, fluid inclusion geothermometry and stable isotope geochemistry of the Tongonan geothermal field, Leyte, Philippines (abst.): Proc. 5th N.Z. Geothermal Workshop, p. 114. Author at PNOC-EDC, Philippines.

A comprehensive study of samples from seven wells in the Tongonan geothermal field shows a regular distribution of alteration mineral assemblages. It also reveals the thermal history and pattern of fluid flow in this water-dominated geothermal system.

The studies recognized two phases of geothermal activities and suggested that the upwelling thermal plume is located in the Upper Mahiao area. (Author's abstract)

FERRY, J.M., 1983a, Mineral reactions and element migration during metamorphism of calcareous sediments from the Vassalboro Formation, south-central Maine: Am. Mineral., v. 68, p. 334-354. Author at Dept. Geol., Ariz. State Univ., Tempe, AZ 85287.

Whole-rock chemical data for a suite of metamorphosed carbonate rocks from a single stratigraphic unit indicate that K, Na, and CO_2 were progressively lost from the rocks during the metamorphic event. Average rocks collected at the highest grades contain only 18% as much K and only 31% as much Na as do average rocks collected at the lowest grades. Extraction of Na and K occurred over a wide range of metamorphic grades, but extraction of Na began at lower grade conditions than did extraction of K. The chemical data and petrological arguments are consistent with no mass transfer of Fe, Mg, T, Si, or Ca relative to a constant aluminum reference frame. Consideration of the compositions and proportions of minerals in the metamorphic rocks, and of whole-rock chemistry leads to the inferred mechanisms by which K and Na were lost. Sodium was probably lost through a mineral-fluid hydrolysis reaction that destroyed the albite component of plagioclase and produced quartz, anorthite, and a soluble Na-bearing fluid species. Potassium was probably lost independently through a mineral-fluid hydrolysis reaction that destroyed biotite and formed calcic amphibole, sphene, anorthite, and a soluble K-bearing fluid species. The reactions indicate that H_2O was progressively lost during metamorphism, as well as K, Na, and CO_2. The observed amount of mass transport of K and Na requires that 1-10 rock volumes of fluid interacted with the carbonate rocks during metamorphism. The large fluid volumes and the observed hydrolysis reactions lead to a model that considers regional metamorphism in the area as possible large-scale acid metasomatism. (Author's abstract)

FERRY, J.M., 1983b, Regional metamorphism of the Vassalboro Formation, south-central Maine, USA: a case study of the role of fluid in metamorphic petrogenesis: J. Geol. Soc. London, v. 140, p. 4551-576.

Progressively metamorphosed carbonate rocks of the Vasslboro Formation serve as a natural laboratory for the investigation of fluid/rock interactions during metamorphism. An integrated study of their whole-rock chemistry, mineralogy, mineral chemistry and mineral abundances has led to the following results. (a) Prograde mineral reactions involved hydrolysis as well as dehydration and decarbonation. The hydrolysis reactions have resulted in an almost quantitative extraction of K and Na from high-grade metacarbonates. (b) Prograde mineral reactions buffered the XCO_2 of coexisting metamorphic fluid during almost all the rocks' metamorphic history. (c) The carbonate rocks were infiltrated by large volumes of H_2O-rich fluid while the buffering reactions progressed during the metamorphic event. Some high-grade metacarbonates were infiltrated by at least 3 rock volumes of fluid. Combined buffering and infiltration appears to be a general metamorphic phenomenon in carbonate-bearing rocks to depths of ~30 km in the crust. (d) There is an excellent positive correlation between the heat budget of individual metacarbonate rock samples and calculated fluid/rock ratios. Convective heat transfer by metamorphic fluids is therefore likely to be an important item in the heat budget of metamorphic terrains.

Consideration of these results leads to a model of regional metamorphism which involves infiltration of rock by large volumes of acid, H_2O-rich fluid (large-scale acid infiltration metasomatism?). In this model, the infiltrating fluid exerts enormous control over the mineralogical evolution of the carbonate rocks during the metamorphic event: it drives mineral reactions, it changes whole-rock chemistry and it supplies heat. (Author's abstract)

FERRY, J.M., 1983c Reaction progress: a probe of fluid-rock interaction during metamorphism and hydrothermal alteration (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 571.

FILIPISHIN, F.L., GROMOV, A.V. and BUTLER, A.S., 1983, Xonotlite from Tsvetkovskoe phlogopite deposit (South Yakutia): Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 12, p. 38-42 (in Russian). Authors at Moscow Geol.-Prospecting Inst., USSR.

Xonotlite at Tsvetkovskoe phlogopite deposit (Aldan Shield) formed during calcite-fluorite-silicate stage; inclusions in calcite and fluorite yielded Th 320-150°C. (A.K.)

FILIPPOV, V.K. and FEDOROV, Yu.A., 1983, Use of the Pitzer equations for calculations of solubility plots for systems following Zdanovskiy's rule: Doklady Akad. Nauk SSSR, v. 273, no. 2, p. 393-396 (in Russian). Authors at State Univ., Leningrad, USSR.

The paper bears data on the $NaCl-Na_2CO_3-H_2O$ system (solubility isotherm and water activity of saturated solutions) at 25°C. (A.K.)

FINE, G. and STOPLER, E., 1983, The speciation of carbon dioxide in silicate glasses (abst.): EOS, Transactions, Am. Geophy. Union, v. 64, no. 45, p. 875.

FIRSOV, A.P. and REYF, F.G., 1983, Effect of presence of relatively insoluble gases in inclusions in connection with interpretation of thermometric data: Geol. i Geofiz., no. 7, p. 89-96 (in Russian; English abstract; translated in Soviet Geol. & Geophys., v. 24, p. 81-87). Authors at Geol. Inst., Ulan-Ude, USSR.

During interpretation of thermometric data usually only the presence of CO_2 is taken into account, although generalized data show the presence in inclusions also of other volatiles, sometimes in significant amount. The volatiles may be divided into two groups: easily soluble in water (SO_2, H_2S, Cl_2, CO_2, etc.) and relatively insoluble (N_2, H_2, O_2, C_nH_m, etc.).

On the basis of experimental data a preliminary PVT plot for the system H_2O-N_2 is proposed, reflecting the main peculiarities of this system and the difference of the course of homogenization of N_2-H_2O inclusions in comparison with pure H_2O inclusions. Analysis proves that interpretation of homogenization results of H_2O-N_2 inclusions using "pure water" model causes a too low estimate of $\bar{P}$ at Th, and under conditions of distillation of magmatic melt the error may exceed 1-2 kbar and the relative error in water determination in melt inclusions may achieve 60% or possibly more.

Due to the fact that frequently the effect of relatively insoluble gases in inclusions is significant, their identification should be performed with appropriate care. A method is proposed for recognizing inclusions rich in relatively insoluble gases without analysis. Such inclusions were found in hydrothermal quartz of the studied deposits and with their use the interpretation of thermometric data with relatively insoluble gases is shown.

Conclusions made during analysis of water-nitrogen system may be extended to fluid inclusions bearing any relatively insoluble gases, due to the similarity of their properties. The authors suppose that they also should concern $G-H_2O$-salt inclusions. (Authors' conclusions translated by A.K.)

FISHER, D.E., 1983, Rare gases from the undepleted mantle?: Nature, v. 305, p. 298-300. Author at Rosenstiel Sch. Marine & Atmospheric Sci., Univ. Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, USA.

If the concept of a depleted/undepleted mantle system is valid, rare gas isotopic composition and abundances should be different in continental and plume areas fed from the undepleted mantle than in oceanic glasses fed from a depleted mantle. Ultramafic inclusions in basalt have been studied in attempts to find examples of undepleted mantle trapped gases. In particular, Kaneoka and Takaoka measured the helium and argon isotopic abundances in olivine nodules and phenocrysts from Hawaiian basalt. The nodules are characterized by mid-ocean ridge basalt (MORB)-type $^{40}Ar/^{36}Ar$ and $^{3}He/^{4}He$ ratios, while the phenocryst data show lower $^{40}Ar/^{36}Ar$ and higher $^{3}He/^{4}He$; these latter data were interpreted to indicate an undepleted mantle source relative to that for the nodules and oceanic tholeiites. I have measured ^{4}He, ^{40}Ar and ^{36}Ar abundances in two Hawaiian ultramafic nodules, and find clear evidence of incomplete retention of mantle gases plus significant atmospheric contamination. Comparison with the previously measured phenocrysts indicates the prevalence of these complications in all such ultramafic samples. Conclusions concerning the nature of the rare gases in the undepleted mantle based on such samples are invalid. (Author's abstract)

FISHER, S.R. and HOVORKA, S.D., 1983, Textural and geochemical evidence of primary and altered halite, Permian San Andres Formation, Texas (abst.): Geol. Soc. Am., 96th annual meeting, Indianapolis, Indiana, Oct. 31-Nov.3, 1983, Abstracts with Programs, v. 15, p. 574. Authors at Bureau Econ. Geol., The Univ. Texas at Austin, Austin, TX 78712.

Cyclic evaporite sequences of the Permian San Andres Formation, Palo Duro Basin, contain halite units as thick as 100 m. Textural and geochemical evidence indicates that halite precipitation occurred in shallow but regionally extensive brine pools that were episodically flooded and subaerially exposed. Within the halite units, previously unrecognized 0.5- to 2-m-thick subcycles resulted from frequent interruption of halite precipitation. Halite subcycles contain primary textures at the base, altered and disrupted textures near the top, and a thin mudstone cap. Halite having primary chevron-shaped growth bands defined by fluid inclusions has Br concentrations ranging from 56 to 82 ppm (average 70 ppm), indicating that concentration did not proceed much beyond initial halite saturation because of continual communication with the marine environment. Cessation of influx of marine-derived brine resulted in concentration of brines and partial dissolution and recrystallization of halite in contact with fresh water, resulting in variable Br concentrations (28 to 163 ppm) in the upper part of the subcycle. Interruption of halite deposition increased the effectiveness of sheetwash and eolian transport of terrigenous clastics, resulting in thin mudstone beds at the top of the subcycle. Halite that fills shrinkage cracks in these mudstone layers has Br concentrations as high as 342 ppm, reflecting precipitation from the most highly concentrated brine. (Authors' abstract)

FLOWERS, G.C., 1983, Thermodynamic properties of water at elevated pressures and temperatues: revision of the SUPCRT thermochemical code (abst.): EOS, Transactions, Am. Geophy. Union, v. 64, no. 45, p. 875. Author at Dept. Geol., Tulane Univ., New Orleans, LA 70118).

The equation of state developed by Haar et al. (1980) to represent the thermodynamic surface of water has been incorporated into the SUPCRT code. For liquid or supercritical water in the range of conditions $25°C \leqslant t \leqslant 850°C$ and $0.1\ MPa \leqslant P \leqslant 1000\ MPa$, the maximum, absolute differences between revised properties and those presented by Helgeson and Kirkham (1974) are approximately 0.5 cc/mole for $V°$, 17 J/mole for $C°_p$, 4 J/(mole °K) for $S°$, 1 KJ/mole for $H°$, and 0.5 KJ/mole for $G°$.

In addition to the above modification of SUPCRT, a revision of Delany and Helgeson's (1978) fit for $P > 1$ GPa was made. Volumes reported by Jüza (1966) for the pressure range $1\ GPa \leqslant P \leqslant 10$ Gpa were used to obtain regression parameters for the reference function (P_0) of the Haar et al. (1980) equation. In the regression process volumes for $P < 1$ GPa were included for continuity across the 1 GPa fit boundary. The 8 regression parameter fit represents the volumetric data in this region to within ±1%, with an average deviation of 0.4%.

The reported modifications of SUPCRT result in: 1) elimination of discontinuities in the volumetric fit of Helgeson and Kirkham (1974); 2) a significant reduction of the 1 Gpa discontinuity between the fits of Helgeson and Kirkham (1974) and Delany and Helgeson (1979); 3) an overall improvement in the calculated thermodynamic properties of water; and 4) a dramatic reduction in the CPU time required for calculations involving water. (Author's abstract)

FOURNIER, R.O., 1983a, Active hydrothermal systems as analogues of fossil systems: Geothermal Res. Council, Special Rept. No. 13, p. 263-284. Author at U.S. Geol. Survey, Menlo Park, CA.

The physical and chemical characteristics of many diverse active hydrothermal systems have been determined from exploratory drilling and commerical production of geothermal resources. Fluid pressures and temperatures vary widely, depending on the distribution of permeable rocks and their specific permeability, the position of the water table, the source of recharge water, the salinity and gas content of the hydrothermal fluids, and the nature of the heat source. In convecting hot-water systems, the maximum temperatures attainable at given depths are given by boiling-point curves that are appropriate for hydrostatic conditions. In vapor-dominated systems, liquid water is present in pore spaces within the rock, but vapor (steam and gas) fills open fractures throughout much of the system. Temperatures and pressures vary little within vapor-dominated zones, and these systems are underpressured with respect to normal hydrostatic systems. Lithostatic fluid pressures have been encountered in deep sedimentary basins. There is reason to believe that exceptionally high fluid pressures might be encountered in other environments with temperatures higher than about 350°C. Increases in fluid pressure from hyrdostatic to lithostatic can occur only where a permeability barrier prevents free movement of liquid from the high- to low-pressure region. With increasing fluid pressures, boiling temperatures increase, or supercritical conditions might be attained. In either event, a relatively steep temperature gradient may develop across a thin impermeable barrier. Sudden rupturing of such a barrier, and the accompanying drop in confining pressure, could result in violent boiling, brecciation of the overlying rock, and simultaneous deposition of minerals. (Author's abstract)

FOURNIER, R.O., 1983b, A method of calculating quartz solubilities in aqueous sodium chloride solutions: Geochimica Cosmo. Acta, v. 47, p. 579-586.

FOURNIER, R.O., 1983c A method of calculating quartz solubilities in aqueous sodium chloride solutions above 100°C, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 332. See previous item.

FOURNIER, R.O., 1983d Self-sealing and brecciation resulting from quartz deposition within hydrothermal systems (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 137-140. Author at U.S. Geol. Survey, Menlo Park, CA 94025.

Self-sealing of hot-spring systems by deposition of amorphous silica from waters discharging at and near the surface is well documented. Self-sealing may also occur deep in hydrothermal systems as a result of deposition of quartz and other minerals. Permeability changes due to solution and deposition of quartz are of particular interest because quartz commonly is found to be the main mineral that fills veins in hydrothermal systems. Fig. 1 plots the calculated solubilities of quartz in water over a wide range of temperatures and pressures, using the empirical equation of Fournier and Potter (1982), which correlates the experimental results of numerous investigators. In Fig. 1 a solubility maximum (first reported by Kennedy, 1950) extends from about 340°C at the vapor pressure of solution to 520°C close to 900 bars.

The effects of dissolved salts on the solubility of quartz can be modeled by using information about the behavior of quartz in NaCl solutions. At temperatures above about 300°C and at pressures likely to be encountered in hydrothermal-convection systems, dissolved NaCl considerably increases the solubility of quartz. However, solubility maxima are still present, though displaced to higher temperatures. Thus, as recharge water of any salinity is heated at any constant pressure less than about 900 bars, it will dissolve silica until either the solubility maximum is reached or the solution starts to boil. With further heating, that solution will precipitate quartz.

When saline solutions boil, the salinities of the residual solutions increase as steam separates. Although the solubility of quartz increases in the more highly saline solutions, this effect is counteracted by the relatively low solubility of quartz in the escaping steam. The net effects are precipitation of quartz where solutions boil at high temperatures and, because of kinetic effects, the formation of solutions supersaturated with respect to quartz where solutions boil at low temperatures.

Hydrothermal-explosion activity is a possible consequence of the formation of an impermeable zone of quartz-sealed rock. A sudden decrease in pressure when initial temperatures are above about 350°C will lead to massive deposition of quartz and other minerals, particularly K-rich feldspar and sulfides. This mineral deposition may reestablish the impermeable seal and set the stage for repeated cycles of brecciation and additional mineral deposition. (From the author's abstract)

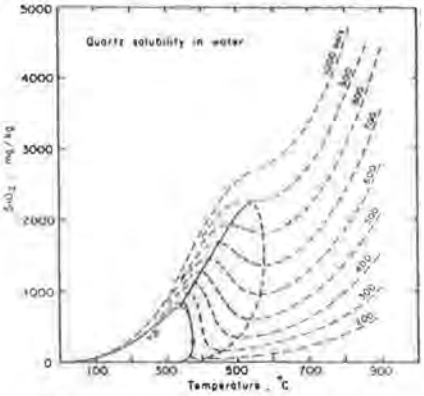


Figure 1. Calculated solubilities of quartz in water as a function of temperature at various pressures. Shaded area denotes a region of retrograde solubility.

FOURNIER, R.O. and MARSHALL, W.L., 1983a Calculation of amorphous silica solubilities and cation hydration numbers in aqueous salt solutions using the concept of effective density of water, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 333. See next item.

FOURNIER, R.O. and MARSHALL, W.L., 1983b, Calculation of amorphous silica solubilities at 25° to 300°C and apparent cation hydration numbers in aqueous solutions using the concept of effective density of water: Geochimica Cosmo. Acta., v. 47, p. 587-596.

FOURNIER, R.O. and POTTER, R.W., II, 1983, An equation correlating the solubility of quartz in water from 25° to 900°C at pressures up to 10,000 bars, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 334.

FOWLER, L.L., 1982, Brecciation, alteration, and mineralization at the Copper Flat porphyry copper deposit, Hillsboro, New Mexico: M.S. thesis, The Univ. Arizona, Tucson, AZ, 133 pp.

The Copper Flat porphyry copper deposit is located in the Hillsboro mining district 48 kilometers from Truth or Consequences, New Mexico. Geologically, the district consists of a circular outcrop of Late Cretaceous andesite in fault contact with Paleozoic sediments, a central quartz monzonite with a breccia pipe, and a series of latite dikes which cut and radiate outward from the quartz monzonite. The breccia pipe is an oval body in plan and is generally characterized by gradational contacts with the quartz monzonite. Quartz monzonite fragments in the breccia are angular to subangular and the matrix is composed of biotite, orthoclase, quartz, apatite, chalcopyrite, pyrite, and molybdenite. Fluid inclusion data indicate that temperatures between 320° and 360°C prevailed during alteration and mineralization at a pressure between 100 and 200 bars and a depth of 1 to 2 kilometers. Brecciation was the result of retrograde boiling of a H_2O-rich volatile phase which exsolved from the magma. (Author's abstract)

FRANCK, E.U., 1983, Water and aqueous solutions at high temperatures, pressures and concentrations, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 1-23. Author at Inst. Phys. Chem., Univ. Karlsruhe 12 KaiserstraBe, D7500 Karlsruhe, West Germany.

Selected thermophysical properties of pure water and aqueous mixtures and solutions are presented and discussed to temperatures of about 400°C and pressures to about 4 kbar. Data of the viscosity, static dielectric constant and thermal conductivity are given as functions of temperature and density. Critical curves of binary aqueous systems are demonstrated, the phase diagram of water hydrogen and functions of dense supercritical mixtures of water-benzene are discussed in some detail. New data on the solubility of anthracene as a model compound in hot, high pressure water are given. Raman and visible spectra are used to give structural information about aqueous solutions to 500°C. Recent results on PVT-data of concentrated sodium chloride solutions to 400°C and 4 kbar are presented, which include apparent and partial molar volumes of the sodium chloride. The high electrolytic conductivity of supercritical dilute alkali chloride and concentrated calcium chloride solutions is discussed. An equation for the ionic dissociation of pure water, applicable to temperatures to 1000°C and densities to 1 $g \cdot cm^{-3}$ for use in applied geochemistry is given. (Author's abstract)

FRANKS, Felix (ed.), 1982, Water, a comprehensive treatise, Vol. 7, Water and aqueous soltuions at subzero temperatures: New York, Plenum Press, 484 pp.

Includes chapters on supercooled water, amorphous solid water, properties of aqueous solutions at subzero temperatures (including nucleation and growth of ice and metastable systems), and dynamics of water in heterogeneous systems. (E.R.)

FRANTZ, J.D. and MARSHALL, W.L., 1983a Association constants for magnesium chloride and calcium chloride in aqueous solutions at temperatures from 25° to 600°C and pressures to 4,000 bars, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 129-134. First author at Geophys. Lab., Carnegie Inst. Washington, 2801 Upton St., NW, Washington, DC 20008.

Ionization constants for magnesium chloride and calcium chloride in supercritical aqueous solutions are given as functions of inverse temperature and the logarithm of the density of pure water. The results cover a temperature range between 25° and 600°C and a pressure range from 1 to 4,000 bars. Comparisons are made with the ionization constants of 1-1 electrolytes. (Authors' abstract)

FRANTZ, J.D. and MARSHALL, W.L., 1983b Electrical conductances and ionization constants of acids and basis in supercritical aqueous fluids: Hydrochloric acid from 100° to 700°C and at pressures to 4000 bars: Carnegie Inst. Washington Year Book 82, p. 372-377.

FREESTONE, I.C. and POWELL, R., 1983, The low temperature field of liquid immiscibility in the system K_2O-Al_2O_3-FeO-SiO_2 with special reference to the join fayalite-leucite-silica: Contrib. Mineral. Petrol., v. 82, p. 291-299. First author at British Museum Res. Lab., Great Russell St., London WC1B 3DG, Great Britain.

The extent of the low temperature field of liquid immiscibility in the system K_2O-FeO-Al_2O_3-SiO_2 in the vicinity of the plane fayalite-leucite-silica has been experimentally determined. (From the authors' abstract)

FREUND, Friedemann, WENGELER, Heinz, KATHREIN, Hendrik, KNOBEL, Rolf, OBERHEUSER, Gert, MAITI, G.C., REIL, Dieter, KNIPPING Uwe and KOTZ, Jürgen, 1983, Hydrogen and carbon derived from dissolved H_2O and CO_2 in minerals and melts: Bull. Minéral., v. 106, p. 185-200. Authors at Mineral. Inst., Univ. zu Köln, D-5000, Köln - 41, FRG.

A detailed evaluation of the dissolution mechanism of water and carbon dioxide in nominally anhydrous and carbonate-free minerals leads to a number of consequences which appear important for the petrology of mantle-derived rocks and their melting behavior in the presence of fluids.

(1) The dissolution of water leads to the formation of OH^- which may react to form molecular H_2, O^- and eventually peroxy anions, O_2^{2-}.

(2) The molecular hydrogen (see pt. 1) may escape, resulting in a system stoichiometrically enriched in oxygen, which may exsolve at certain well-defined temperatures as molecular O_2.

(3) Dissolved carbon dioxide may form carbonate ions, CO_3^{2-}, but - more important - it dissociates to form very mobile "atomic" C and O^-. The C atoms are bonded to either two or one O^- as CO_2^{2-} or CO^-.

(4) Strains induced by the dipolar species CO_2^{2-} and CO^- (see pt. 3) may lead to defect ordering which causes otherwise non-ferroelectric minerals to become ferroelectric.

(5) Applied non-uniform stress will cause a diffusion flux of the dissolved carbon (see pt. 3), which may be fast, carrying carbon over geologically significant distances.

(6) The experimentally observable CO_2 evolution from heated silicate

minerals is not a proof of an initial presence of CO_3^{2-}, because CO_2 also evolves from CO_2^{2-}, the atomically dissolved carbon.

(7) The dissolution of CO_2 in solid silicates proceeds via chemisorption even at P = 1 bar and room temperature. Hence, the solid rock reservoir of the Earth may contribute to buffering the CO_2 partial pressure of the atmosphere.

(8) Reaction of dissolved "atomic" C with cations, hydrogen and lattice oxygen may lead to metallo-organic compounds.

(9) Hydrocarbons, considerably more complex than methane, are formed at fractured crystal surfaces as a result of the reactions of dissolved "atomic" C with H_2 (see pt. 1).

(10) Nitrogen may also be dissolved in silicate minerals. Upon heating it exsolves as N_2 or reacts with "atomic" C, H_2 and O^- to give amino compounds.

A quantitative assessment of the local strains associated with dissolved carbon species, with molecular hydrogen and the peroxy anions will allow us to calculate the solubility difference for CO_2 and H_2O in solids and melts. (Authors' abstract)

FRIEDRICH, Marc and CUNEY, Michel, 1983, Uraninite crystallization and polygenism in the granite complex of Saint-Jouvent-Brame-Saint Sylvestre (Limousin): C.R. Acad. Sc. Paris, Ser. II, v. 296, p. 1249-1252 (in French).

In the Saint-Jouvent and Brame granites, as well as in the transition zone leading to the Saint-Sylvestre massif, uraninite is heterogeneously distributed. Its crystallization occurs simultaneously with an association of accessory minerals during a late magmatic phase. Observed textures imply that uraninite grows in equilibrium with a silicate melt, crystals and a fluid phase. (Authors' abstract)

GAFFEY, S.J., 1983, Spectral reflectance of carbonate rocks and minerals (abst.): Am. Assoc. Petrol. Geol., Ann. Convention, Abstracts, p. 77. Author at Univ. Hawaii, Honolulu, HI.

Fluid inclusions appear to be nearly ubiquitous in carbonate rocks and are particularly abundant in skeletal material. Diagenesis of skeletal material results in loss of large percentage of these inclusions, and spectral studies can be used to monitor these changes.

Reflectance spectra may be obtained from powders, sands, rock surfaces, and thin sections. (From the author's abstract)

GALABURDA, Yu.A., 1983, Inclusion in quartz from undifferentiated pegmatites of the northwestern part of the Ukrainian Shield: Mineral. Zh., v. 5, no. 6, p. 38-45 (in Russian; English abstract). Author at Inst. Geokhim. Fiz. Mineral., Kiev, USSR.

Objective data on the evolution of physicochemical parameters of mineral-forming solutions of the last stage of quartz formation in two types of pegmatites are obtained on the basis of studies of inclusions.

Korostyshev pegmatites exhibiting rare-metal mineralization are characterized by complex evolution of mineral-forming solutions. The earliest solutions were of carbonate-water-salt composition and were highly concentrated and, probably, homogeneous. The temperature was ±400°C, pressure exceeded $2300 \cdot 10^5$ Pa. With a decrease in temperature and pressure the solutions got homogenized[sic], the mineral-forming environment included gaseous nitrogen and methane mixing with CO_2. The concentration of the solutions and CO_2 content in them gradually reduced.

Novograd-Volyn pegmatites, devoid of rare-metal mineralization, are featured by a relatively simple evolution of mineral-forming solutions. The earliest of them were in a homogeneous liquid state and had a minimum temperature of 270-240°C, lower concentrations and small content of CO_2. (Author's summary)

GAMBLE, R.P. and CANNON, R.P., 1983, Brine migration in nuclear-waste repositories in salt: an overview (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 3. Authors at Ebasco Services Inc., Earth Sci. Office, 2211 W. Meadowview Road, Greensboro, NC 27407.

A potential problem considered in licensing of a high-level nuclear-waste repository constructed in salt is the migration of brine-filled inclusions toward the waste packages due to the imposed thermal gradient. The general concern is that a large amount of brine could accumulate near the waste packages, which would accelerate the rates of canister corrosion and waste leaching, and compromise the repository's containment capabilities.

The effect of brine migration on repository safety must be assessed by using a credible methodology to estimate the expected rate and volume of brine in-flow. The methodology must use realistically conservative assumptions and must be able to demonstrate that the expected in-flow is negligible or that any potential adverse effects can be mitigated by proper selection and design of backfill and canister materials. The approach most commonly used to estimate expected in-flow volume relies on theoretical equations and empirical data for intergranular transport. A more recently applied and more technically defensible approach considers coupled short-range intragranular and long-range intergranular transport. The estimated expected in-flow volume for coupled transport is about 2000 liters per canister during the repository lifetime, or about 2 orders of magnitude greater than that generally estimated for intragranular transport alone and an order of magitude greater than the published upper-bound estimate for intragranular transport. Effects on repository safety of this greater in-flow volume will need to be considered during repository design. (Authors' abstract)

GAMYANIN, G.N., GORYACHEV, N.A., ZHDANOV, Yu.Ya. and SUPLETSOV, V.M., 1983, Significance of studies of mineral typomorphism during regional-mineralogical investigations (on the example of the gold-ore deposits of the North-East USSR): Mineralog. Sbornik, v. 37, no. 2, p. 17-25 (in Russian; English abstract). Authors at Inst. Geol. of Yakutian Division of Siberian Branch of Acad. Sci. USSR, Yakutsk, USSR.

Gold-bearing quartz releases a large amount of CO_2 during decrepitation, and it yields two decrepitation peaks in the T interval 150-300°C. (A.K.)

GARCIA IGLESIAS, Jesus and LOREDO PEREZ, Jorge, 1983, Study of fluid inclusions in fluorite veins related to Paleozoic terrains in northern Spain: Rev. Minas, v. 3, p. 55-62 (in Spanish; English abstract). Authors at Dept. Metal., Esc. Ing. Minas, Oviedo, Spain.

The present work is a study of the genetic conditions of four fluorite deposits, situated in Asturias and Leon, and related to Paleozoic terrains, from physico-chemical data of mineralizing solutions obtained by the application of several techniques to primary fluid inclusions in the mineral: optical microscopy, microthermometry, infrared spectrometry, Raman spectrometry and crushing stage.

The "Caleao" and "Oseja" deposits show similar characteristics of Th and salinities of the solutions. These deposits show a singular type of secondary inclusions, which are comparable to similar inclusions in the fluorite of "Sierra de Lujar" (Granada).

In the other deposits, "La Felguerina" and "Pena Tene," the mixing of solutions of different nature is evident. In the "Pena Tena" deposit, the characteristics and behavior of its inclusions show that they are not assignable to the simple system $NaCl-H_2O$, and have significant amounts of other ions: Ca^{++}, Mg^{++}... (Authors' abstract)

GARDNER, H.D., 1983, Petrologic and geochemical constraints on genesis of the Jason Pb-Zn deposits, Yukon Territory: M.S. thesis, Univ. Calgary, Calgary, Alberta, Canada, 212 pp.

Indexed under Fluid Inclusions. (E.R.)

GATTER, Istvan, 1983, Fluid inclusion studies on the Pb-Zn-Cu ore deposit at Gyöngyösoroszi, north Hungary (I. Outcrops): Anuarul Inst. de Geol. si Geofizica, v. 62, p. 103-112 (in English). Author at Dept. Mineral., Eötvös Univ. Sci. Museum krt. 4/a, 1088, Budapest, Hungary.

Th quartz ranges 120-260, barite 105-210°C; Te ranged from -1 to -6° (alkaline sulfate-carbonate systems) to -17 to -50 (Ca-Mg-Cl systems); composition changed with paragenesis; "T_2" [= Tm ice?] -15 to 0°C. Some bitumen droplets noted. Density calculated to range 0.88-0.98 g/cm^3. (E.R.)

GELDRON, A. and LE BEL, L., 1983, Fluid characteristics of the stockwork molybdenum mineralization of Breittenbach (Vosge) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 28 (in French; translation courtesy M.J. Logsdon). Authors at Centre de Recherches sur la Synthese et la Chimie des Mineraux G.I.S., C.N.R.S.-B.R.G.M., 1A, rue de la Férollerie 45045 Orleans Cedex, France.

Molybdenum mineralization of Breittenbach, found in the Kreuzweg granite, is located at the southern end of the Champ du Feu granitic massif. The stockwork is characterized by intense alteration of the granite. The alteration paragenesis includes quartz, albite, sericite, orthoclase, carbonates (about 3%), with local transitions to nearly 100% albite.

The alteration includes microveinlets (<1 mm) with carbonates and phengites. In the magmatic quartz, these veins are recognized by trains of very small (<4 μm) fluid inclusions. These inclusions are sometimes single-phase (pure CO_2), sometimes three-phase ($H_2O + CO_2$), dominated by CO_2. They homogenize in both liquid and vapor phase.

MEB analyses [i.e., SEM] of inclusions shows the presence of KCl precipitates and Si-Al-K-Fe solids, probably sericites. Isotopic analyses of carbonates indicates a magmatic origin for the CO_2 ($\delta^{13}C_{PDB}$:-6.5‰; $\delta^{18}O_{SMOW}$:+12.2‰). The mineralization is tied to quartz or quartz-carbonate veins, in which the quartz shows only rare and very small (<2 μm) fluid inclusions which cannot be studied by optical microscopy. (Authors' abstract)

GENKIN, A.D., DOBROVOL'SKAYA, M.G., KOVALENKER, V.A. and SHADLUN, T.N., 1983, Relations between paragenetic mineral associations and mineralization stages in hydrothermal deposits, p. 36-42, in Problems of petrology, mineralogy and ore genesis: "Nauka," Moscow, 224 pp., 900 copies printed, price 3 rbls. 70 kopecks (in Russian).

Skarns of the Pb-Zn deposits of the Dalnegorsk region bear hedenbergite with inclusions of Th 450-550°C; diopside, quartz and sphalerite 300-360°C; arsenopyrite, pyrite, calcite and quartz 250-100°C. Ore parageneses of the Kochbulak deposit (gold-telluride-tetrahedrite stage) formed at T (Th) 270-240 and 190-170°C, parageneses with tellurides of silver, lead, copper and other elements 150-130°C. (A.K.)

GERLA, P.J., 1983, Hydrothermal alteration of the Diamond Joe stock, Mohave county, western Arizona (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 580. Author at Dept. Geol., Muskingum College, New Concord, OH 43762.

Fluid inclusion and mineral equilibria data indicate the T-X control of hydrothermal alteration and mineralization in the 70 m.y.-old Diamond Joe stock. Outward from the center of the 8 km diameter stock are zones of K-feldspar, Kf + muscovite ± albite, mus + chlorite ± epidote ± ab fracture selvage alteration that are overpinted by later sericite + Kf, argillic, or carbonate alteration. Most assemblages include pyrite, hematite, or magnetite, and quartz. Abundant coarse muscovite (0.8 mus, 0.16 celadonite, 0.04 pyrophyllite), often in equilibrium with Kf + q, indicates that log activity K^+/H^+ of the hydrothermal fluid was about 4 in most areas. Albite occasionally occurs as either an additional phase or a replacement of K-feldspar suggesting a log activity Na^+/H^+ of 6 or less. Homogenization temperatures of the predominantly low salinity, high density fluid inclusions in quartz veins near the margins of the stock are higher (250-400°C) than in veins near the center (<150°). The variation of pyrophyllite activity in muscovite solid solution coexisting with Kf + q predicts similar temperatures. Primary fluid inclusions have not been found in late magmatic quartz veins.

Apparently, opening and filling of fractures continued within the center of the stock as cooling proceeded, whereas fluid circulation near the margins ceased at higher temperatures. Mineral equilibria data of assemblages containing calcite + epid + hem suggest transfer of Ca^{2+}, Fe^{3+}, CO_2, and O_2 into the stock from surrounding Precambrian gneisses. Copper, Ag, and Mo in mineralized veins within the stock may similarly have been derived. (Author's abstract) See next item.

GERLA, P.J., 1983, Structural and hydrothermal alteration of the Diamond Joe stock, Mohave County, Arizona: Ph.D. dissertation, Univ. Arizona, Tucson, AZ, 120 pp.

The origin of fractures in plutons has been ascribed to differential stress resulting from regional tectonics, magmatic emplacement, crystallization, and cooling. The evolution of stress, and hence the evolution of fractures in plutons, controls the timing and spatial distribution of fluid flow and alteration. Quantitative data on fracture orientation, density, vein width, and alteration systematically obtained from the 70-m.y.-old Diamond Joe stock, west-central Arizona, were used to determine the evolution of stress and fractures within the stock during its crystallization. The dome-shaped chamber of the predominantly quartz monzonite stock is 8 km in diameter.

Regional east-northeast compression produced the north-northwest crustal dilation necessary for the ascent and emplacement of the stock. Two-dimensional models using analytic solutions for stress in elastic media indicate that the prominent radial fractures within the stock developed in response to magma pressure, contraction, and regional stress. Most fractures formed by tensile failure during cooling, although magma pressure led to shear failure near the center. Deflection of radial fractures away from the east-northeast axis of the pluton at increasing distances from the center indicates north-northwest and east-northeast orientation of regional maximum and minimum principal stress, respectively, during crystallization. Apparently, north-northwest-trending uplift in the vicinity of the pluton led to a shallow local reversal of principal stress after magma emplacement.

Theoretical strain estimates show a correlation with high fracture densities and abundant alteration along the north-northwest axis and the pluton margins. Zones of fracture selvage K-feldspar, quartz, muscovite+

K-feldspar+quartz, and muscovite+chlorite+quartz alteration are concentric about the center of the stock and extend a short distance into the surrounding host rocks. Younger sericite+K-feldspar, argillic, and carbonate alteration occurs locally. Mineral equilibria and fluid inclusion data indicate low hydrothermal temperatures (<150°C) near the center of the stock and higher temperatures (200°C-400°C) near the margins. Apparently, fractures continued to open and fill as cooling proceeded within the center of the stock, whereas fluid circulation ceased at higher temperatures near the margins. (Author's abstract) See previous item.

GIARDINI, A.A. and MELTON, C.E., 1983, A scientific explanation for the origin and location of petroleum accumulations: J. Petrol. Geol., v. 6, no. 2, p. 117-138. First author at Dept. Geol., Univ. Georgia, Athens, GA 30602, USA.

The authors use the analytical data they have obtained earlier on gases, alcohols and hydrocarbons from mass spectrometry of gases released on crushing or carbonizing diamonds to propose an abiogenic, deep-mantle source for oil. (E.R.)

GIBSHER, N.A., MIROSHNIKOV, A.E. and SHKLYARIK, G.K., 1983, New data on formation conditions of the Tychany stratiform lead deposit (Siberian Platform): Geol. i Geofizika, v. 24, no. 10, p. 73-79 (in Russian; translated in Soviet Geol. & Geophys., v. 24, p. 68-73.

Based on study of ore-forming fluids of gas-liquid inclusions and sulfide isotopes $\delta^{34}S$ we have proposed a model of the formation of the Tychany deposit. It is shown that two types of solutions participated in its formation: the first had a temperature of 150°C, less than 15 wt% salinity, Na/K < 1, and high CO_2 concentrations; the second had a temperature below 120°C, more than 20 wt% salinity, Na/K > 2, and the gas phase of inclusions except for CO_2 contains CH_4 and H_2S. The latter approaches connate water in terms of parameters. (Authors' abstract)

GIBSHER, N.A. and PROKOPENKO, A.I., 1983, Temperature conditions of formation of pyrite-polymetal deposit Chekmar' (Rudnyi Altai): Geol. i Geofiz., no. 12, p. 52-59 (in Russian; English abstract). First author at Inst. Geol. i Geophysics, Novosibirsk, USSR.

The studied deposit is in volcanic-sedimentary beds of basalt-liparite formation (Upper Eifelian-Lower Givetian) covered by Givetian-Frasnian black shales. Temperature conditions were studied by Th method. Inclusions in quartz yielded Th 120-380°C (1112 determinations), in sphalerite 300-340°C (6 det.), in calcite 150-200°C (45 det.). Vertical gradient of solution cooling was about 140°C per 100 m to 15°C per 100 m. Stages of ore mineralization were distinguished. (Abstract by A.K.)

GIGGENBACH, W.F., 1981, Geothermal mineral equilibria: Geochimica Cosmo. Acta, v. 45, p. 393-410. Author at Chem. Div., Dept. Sci. & Industrail Research, Private Bag, Petone, New Zealand.

The dominant reaction determining the chemistry of fluids in a geothermal system of the New Zealand type consists of the conversion of primary plagioclase by CO_2 to calcite and clays with $\log P(CO_2) = 15.26 - 7850/(t + 273.2)$, temperature t in °C. Subsequent reactions involving secondary minerals control relative CO_2-H_2S-contents. The distribution of mineral phases throughout a geothermal system reflects the stepwise conversion of thermodynamically unstable primary phases through a series of intermediate, metastable phases to a thermodynamically stable, secondary assemblage. The relative stabilities of these phases was evaluated on the basis of their solubilities, the least soluble aluminum-silicate representing the thermodynamically most stable phase under a given set of conditions. Observed assemblages of secondary minerals in geothermal systems represent indicators allowing mineral/fluid-interaction conditions to be evaluated on the basis of multi-component mineral stability diagrams. (Author's abstract)

See also Grant, M.A. (1982) and Giggenbach (1982). (E.R.)

GIGGENBACH, W.F., 1982, "Geothermal mineral equilibria." Reply to a comment by M.A. Grant: Geochimica Cosmo. Acta, v. 46, p. 2681-2683. Author at Chem. Div., DSIR, Private Bag, Petone, New Zealand.

The dominant process limiting CO_2-contents of fluids in high temperature (>240°), liquid-dominated systems consists of the conversion of primary plagioclase by CO_2 to calcite and clay according to $\log P(CO_2) = 15.26 - 7850/(t + 273.2)$, temperature t in °C, with a likely error in $\log P(CO_2)$ due to variations in the activities of the anorthite and kaolinite components of the mineral phases involved of around ±1 log unit. Secondary processes such as adiabatic expansion, conductive cooling and mixing with cooler groundwaters are largely responsible for subsequent variations in $P(CO_2)$ at lower temperatures (<240°C). (Author's abstract)

GILLETTE, R.S., 1983, Geology and mineralization of the east-central and southeastern Swisshelm Mountains, Cochise County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 94 pp.

The Swisshelm Mountains, located in southeastern Cochise County, Arizona, are an uplifted fault block containing Precambrian granite, Paleozoic carbonate and Cretaceous clastic rocks, and Tertiary felsic and intermediate intrusive rocks and rhyolite tuff flows. The area has had a complex structural history involving at least four faulting and two folding events. Hydrothermal silica was introduced into the structurally disturbed rocks as quartz veins and jasperoids. Fluid inclusion data defined a homogenization temperature zoning pattern in which temperatures increase northwestward. Two zones displayed homogenization temperatures between 190°C-270°C and 270°C-300°C. A pressure correction range of 0°C-38°C was calculated. Trapping temperatures therefore occurred at and above the upper end of the epithermal range. Low-grade precious- and base-metal mineralization associated with the quartz veins and jasperoids was probably derived from a granodiorite stock that crops out in the west-central part of the range. (Author's abstract)

GIRET, P., DEBBAH, B. and TOURAY, J.-C., 1983, Fluids associated with the extrusive structures of the Taourirt region (eastern Morocco) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 29 (in French; translation courtesy M.J. Logsdon). First author at Dept. des Sci.. de la Terre, Univ. d'Orleans, France.

Three Liassic limestone domes emerge from the Bajocian plain in the Taourirt region; these structures are mineralized with fluorite. Two types of explanations for these deposits have been put forward: a magmatic hypothesis based on the presence of nepheline lamprophyre dikes and sills and an hypothesis involving circulation of halogen-rich brines. The brine theory rests on the presence of collapse structures and red marls attributable to Triassic activity, in association with some of the intrusives. The recent discovery of bipyramidal quartz with hypersaline inclusions, identical to those observed in the Triassic sediments of the region confirms this theory. The fluid inclusion results, supplementing the 1969 work of Touray, are comparable to those obtained on newly formed minerals of Tunisian diapirs, indicate the circulation of CO_2-rich brines. (Authors' abstract, modified)

GIULIANI, G., 1983, Fluid inclusion study of the Xihuashan tungsten-bearing quartz veins (south Jiangxi, China) (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 30. Author at Centre de Rech. sur la Synthese et la Chimie des Mineraux, G.I.S., C.N.R.S.-B.R.G.M., 1A, rue de la Férollerie, 45045 Orleans Cedex, France.

The Xihuashan tungsten deposit is closely related to a small, highly evolved granitic intrusion. The fluid phases associated with the wolframite-bearing quartz veins from different levels of the mine were investigated using microthermometric analyses. Raman microprobe analysis permitted calculation of the bulk composition and density of the different fluid phases. Fluid inclusions in the quartz veins are highly variable in density and composition:

1. The earlier fluids seem to be: a) a CO_2-rich fluid trapped in vapor-rich inclusions. Evidence of immiscibility of the carbonic complex fluids (CO_2, CH_4, N_2, NaCl, H_2O) occurs in the 300-340°C temperature range: separation of a vapor-rich fluid (25 mole % CO_2; 0.1 mole % N_2; 0.1 mole % CH_4; 0.50 mole % NaCl) and a liquid-rich fluid (6.8 mole % CO_2; 0.7 mole % N_2; 0.6 mole % CH_4; 1.5 mole % NaCl); b) apparently pure CO_2 with 3 mole % N_2, CH_4; and c) a low density, low salinity (2 to 3 wt %, eq. NaCl) aqueous solution without traces of CO_2 circulating at high temperature until 420°C and probably corresponding to a specific hydrothermal fracturing event.

2. The late fluids characterize the sulfide-carbonate stage; they are the evidence of the succession of opening fissures and fluid circulations. These fluids are aqueous fluid inclusions with variable salinities, homogenizing in liquid phase between 100° and 275°C.

Fluid inclusion study of Xihuashan tungsten deposit indicate that CO_2 is an important component of the hydrothermal fluid. It is met in the earliest fluids and probably the carbonates complexes may play a role in the transport of tungsten? (Author's abstract)

GIULIANI, G., LE BEL, L., LI, YK.D. and SHENG, J.F., 1983, Geochemistry and fluid inclusion studies of the Xihuashan tungsten-bearing system (abst.): Terra Cognita, v. 3, p. 173. Authors at G.I.S. B.R.G.M.-C.N.R.S., 1A, Rue de la Férollerie, 45045 Orléans Cedex, France.

The Xihuashan W deposit and other associated deposits of the Dayu district (south Jiangxi, China) are wolframite type veins associated with Jurassic granitic stocks. The granites are highly evolved adamellites with high silica and alkali contents. They form a multi-phase intrusion at Xihuashan over a rather short period at circa 155 M.A. Detailed R.E.E. analyses permit one to follow the ultimate evolution of the body characterized by an important fluid activity which controls the typical "seagull" shape of the patterns. Investigation of the Rb/Sr isotopic system excludes: (1) long-life duration of the magmatic-hydrothermal activity; (2) direct anatexis of Cambrian and/or Sinian materials; (3) implication of fluids of supercrustal origin.

The fluid phases associated with wolframite-bearing quartz veins have been investigated using microthermometry and the Raman microprobe. They are highly variable in density and composition. In the earliest fluid, evidence of immiscibility at 300-340°C and under $P \simeq 1$ Kb into the CO_2, CH_4, N_2, NaCl, H_2O complex system is advocated by the coexistence of a CO_2-rich fluid ($H_2O : CO_2 = 2.6$ with .5 mol. % NaCl) and a H_2O-rich one

(H_2O : CO_2 = 12 with 1.5 mol. % NaCl). The late fluids belong to the H_2O-NaCl system with variable salinities trapped at lower P.T conditions and characterize the sulphide-carbonate stage.

The abundance of CO_2 in the early fluid phase probably in equilibrium with an evolving residual granitic system emphasizes its role controlling the behavior of W during crustal phenomena. (Authors' abstract)

GLADKIKH, V.S. and ROMANCHEV, B.P., 1983, Crystallization temperatures of clinopyroxenes from basaltoids of the Maymecha-Kotuy province: Dokl. Akad. Nauk SSSR, v. 268, no. 4, p. 964-966 (in Russian). First author at Inst. Mineralogy, Geochemistry and Crystallochemistry of Rare Elements, Moscow, USSR.

Pyroxenes from olivine nephelinites, picrite porphyrites, olivine-melilite nephelinites, trachytes, basanites, etc. of composition ~50% of Ca, ~40% of Mg and ~10% of Fe components, yielded Th in ranges 1160-1320 ± 10°C. Th are connected with the Mg/Mg+Fe index of clinopyroxenes and liquidus temperature of the studied basaltoids. (Abstract by A.K.)

GLASSLEY, W.E., 1983a, The role of CO_2 in the chemical modification of deep continental crust: Geochimica Cosmo. Acta, v. 47, p. 597-616. Author at Dept. Geol., Middlebury College, Middlebury, VT 05753.

Compositional differences between granulite facies rocks and equivalent amphibolite facies rocks and the observation of CO_2-rich fluid inclusions in granulites, have led to the suggestion that CO_2 must play a role in modifying the composition of deep continental crust. How CO_2 effects this change has remained unclear. Using the thermodynamic properties of aqueous ions in a fluid of evolving CO_2/H_2O ratio, it is possible to model the incongruent dissolution of feldspars under conditions appropriate for granulite facies metamorphism. The results demonstrate that dissolution will be strongly enhanced at high CO_2/H_2O ratios, with ion solubilities being $Na^+>K^+>>Ca^{++}$. This enhancement is compatible with the reported compositional contrasts between granulite and amphibolite facies rock, but requires large fluid volumes.

To test the dissolution model, a detailed field and petrologic study was conducted in a well exposed granulite facies terrane in West Greenland. Strong correlation between fluid composition and bulk rock chemistry can be documented; CO_2-rich regions contain rocks which consistently have low $a(Na_2O)/a(CaO)$ ratios, while H_2O-rich regions consistently have high $a(Na_2O)/a(CaO)$ ratios. Magnetite rims on sulfide grains are ubiquitous in high $f(CO_2)$ regions and are absent in high $f(H_2O)$ regions, and they provide evidence that CO_2 was introduced into the region. These correlations and observations are predictable from the properties of the dissolution process. These considerations, along with observations regarding graphite petrogenesis, provide strong arguments that the total fluid volume interacting with the rock during metamorphism was very large, in some cases equaling or exceeding total rock volume. Such large fluid volumes can lead to significant compositional modification of the crust, and will mask the original protolith chemistry. Such processes should lead to Ca- and Al-enriched, Na-, K-, S- and Si-depleted residues in the deep crust. (Author's abstract)

GLASSLEY, W.E., 1983b, Deep crustal carbonates as CO_2 fluid sources: evidence from metasomatic reaction zones: Contrib. Mineral. Petrol., v. 84, p. 15-24.

GOLDFARB, M.S., CONVERSE, D.R., HOLLAND, H.D. and EDMOND, J.M., 1983, The genesis of hot spring deposits on the East Pacific Rise, 21°N: Econ.

Geol. Monograph 5, p. 184-197.

GOLDING, S.D. and WILSON, A.F., 1983, Geochemical and stable isotope studies of the No. 4 lode, Kalgoorlie, western Australia: Econ. Geol., v. 78, p. 438-450. Authors at Dept. Geol. & Mineral., The Univ. Queensland, St. Lucia, Queensland 4067, Australia.

Wall-rock alteration and $\delta^{18}O$, $\delta^{34}S$, and $\delta^{13}C$ data on minerals suggest a moderately reduced ($a\text{-}O_2 \sim 10^{-37}$), near-neutral (pH ~6) fluid which has incorporated magmatic sulfur and carbon. Gold, probably transported as thio complexes, was precipitated by a decrease in the activity of reduced sulfur by formation of pyritic wall-rock assemblages. (From the authors' abstract)

GONCHAROV, V.I., VORTSEPNEV, V.V. and AL'SHEVSKIY, A.V., 1983, Water in inclusions of melts in quartz from the magmatic rocks of the Okhotsk-Chukotka volcanic belt: Geokhimiya, no. 8, p. 1208-1211 (in Russian). Authors at North-East Complex Sci.-Research Inst. of Far-East Sci. Center of Acad. Sci. USSR, Magadan, USSR.

Inclusions in quartz were studied from leucogranites of the Neorchanskiy intrusive, and from granite-porphyry from Ugrlyuma and Kolkhida volcanic structures. Melt inclusions are filled by an aggregate of highly birefringent mineral(s), gas and glass (the latter not in all inclusions). Solids start to melt at 530-800°C, Th 760-940°C. During quenching runs, after melting of dms but before homogenization, at room temperature volatiles separate to G + 5 to 40 vol. % of L H_2O; Th of G + L ranges from 370 to 400°C. Content of H_2O in melt, calculated by the Naumov's method, was 0.3 to 3.5 wt. %. The detection of water was possible due to use of quenching method; homogenization by continuous heating in a heating stage provides unfavorable conditions for detection of water. The studied inclusions occurred in rocks of late stages of formation of the magmatic complex. Early-stage rocks bear inclusions of "dry" melts. (Abstract by A.K.)

GOODELL, P.C., 1983, Geochemical characteristics of the Pena Blanca uranium district, Chihuahua, Mexico, in Geol. & Min. Resources of North-Central Chihuahua: El Paso Geol. Soc., Guidebook for 1983 Field Conf., p. 345-350. Author at Dept. Geol. Sci., Univ. Texas at El Paso, El Paso, TX 79968.

Epithermal to mesothermal conditions of deposition are generally attributable to the Pena Blanca mineralization. Twenty fluid inclusions from quartz in geodes 6 km SSW of Margaritas give temperatures that range from 220° to 280°C, but an exact relationship of this silicification with the uranium mineralization has not been established. Geochemical data provided above are suggestive of and compatible with an epithermal environment. The source of such an epithermal system whether rift or caldera or otherwise related, is not established. (From the author's text)

GORZHEVSKIY, D.I. and MEL'NIKOV, F.P., 1983, New methods of prognosis of post-magmatic ore mineralization: Geol. Rudn. Mestorozhd., v. 25, no. 3, p. 103-105 (in Russian). Authors at TsNIGRI, Moscow, USSR.

A review of the book "Physico-chemical principles of prognosis of post-magmatic ore mineralization," Moscow, "Nedra" 1981, written by Laz'ko, Ye.M., Lyakhov, Yu.V. and Piznyur, A.V., and presenting use of fluid inclusion studies for ore prospecting. (A.K.)

GOSS, B., 1983, An analysis of fluid-rock interactions at the Ely porphyry copper deposit by utilization of fluid inclusions: M.S. thesis, Pennsylvania State Univ. University Park, PA.

GOSS, B.G. and CATHLES, L.M., 1983, Fluid inclusion study of the porphyry copper deposit at Ely, Nevada (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 583. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Porphyry copper mineralization at Ely occurs within a number of pits trending in an EW direction. The Cretaceous intrusive and Paleozoic wall-rock hosting the mineralization were transported to their present configuration by Tertiary normal faulting.

Heating and freezing studies of fluid inclusions within quartz from various alteration assemblages provided estimates of the temperature and salinity of alteration fluids and the load pressure.

Alteration assemblage	Homogenization temperatures	Salinities (eq. wt. % NaCl)	Pressures from "boiling" inclusions
#1 Potassic	250->550°C	0-24; 29-38	60-155 bars
#2 Sericitic	225->550°C	0-11; 29-34	100-280 bars
#3 Sericitic	400->550°C	34-50	Possible condensation
#4 Argillic	290- 330°C	10-15	No boiling indicated
#5 Propylitic	105- 310°C	<26	No boiling indicated

Assemblage #2 denotes late quartz-sericite veins and a zone of sericitic alteration peripheral to the pluton. Assemblage #3 denotes a quartz-sericite alteration zone above and central to the intrusive. The fluid inclusion population within assemblage #3 is dominated by vapor-rich inclusions which suggests that a vapor-saturated zone once existed over the central portion of the pluton.

Chalcopyrite daughter crystals were more commonly observed in halite-bearing inclusions than in moderate salinity or vapor-rich inclusions. A chalcopyrite daughter crystal is contained in over 25% of the halite-bearing inclusions within early quartz veins (#1) and in less than 7.5% of those from late quartz veins (#2). High copper grades are associated with early quartz veins suggesting that the chalcopyrite-bearing inclusions are trapped remnants of ore fluid. (Authors' abstract)

GOSTYAJEVA, N.M., 1983, Apatite mineralization caused by calcium metasomatism in the central Ukrainian Shield: Dopovidi Akad. Nauk Ukrayins'koyi RSR, Ser. B, Geol. Khim. ta Biol. Nauki, 1983, no. 7, p. 13-15 (in Ukrainian; English abstract). Author at Akad. Nauk Ukr., RSR, Inst. Geokhim. i Fiz. Mineral., Kiev, Ukraine.

The paper deals with investigation of apatite-feldspar rocks through gas-liquid inclusions using the inclusion methods. The starting minimum temperature of calcium metasomatism, character of metasomatic solution have been determined. The concentration of calcium and phosphorus in solution is suggested to be a result of these elements leaching from enclosing rocks of basic composition. (Author's summary)

GRAF, D.L., ANDERSON, D.E. and WOODHOUSE, J.B., 1983, Ionic diffusion in naturally-occurring aqueous solutions: transition-state models that use either empirical expressions or statistically-derived relationships to predict mutual diffusion coefficients in the concentrated-solution regions of 8 binary systems: Geochimica Cosmo. Acta, v. 47, p. 1985-1998.

GRAHAM, C.M., GREIG, K.M., SHEPPARD, S.M.F. and TURI, B., 1983, Genesis and mobility of the H_2O-CO_2 fluid phase during regional greenschist and epidote amphibolite facies metamorphism: a petrological and stable isotope study in the Scottish Dalradian: J. Geol. Soc. London, v. 140, p. 577-599.

During high-pressure, low-temperature greenschist and epidote-amphibolite facies metamorphism in Dalradian rocks of the SW Scottish Highlands, mineral assemblages in metabasites and calcareous metasediments were dominantly controlled by infiltration of hydrous fluids; consequently, mineral assemblages capable of buffering the fluid phase composition were rare. Equilibrium prograde H_2O-CO_2 fluids usually contained less or much less than about 1-2 mol% CO_2.

Three fluid infiltration events are recognized. During prograde greenschist facies metamorphism, metabasic sills were infiltrated by large volumes of CO_2-bearing hydrous fluid; carbon isotope studies indicate that the CO_2 was locally derived by widespread oxidation of graphite or other organic carbon in adjacent metasediments. This may have occurred under approximately lower greenschist facies conditions as a result of mixing of fluids of varying fO_2 initiated by thermal expansion of water during heating, decompression and consequent hydraulic fracturing. In the epidote-amphibole facies (garnet zone), dehydration reactions in metabasites generated large quantities of water, which removed carbonate from metabasites on a regional scale and infiltrated calcareous metasediments to produce assemblages containing grossular, diopside, K-feldspar, amphibole, clinozoisite and sphene. A late retrograde infiltration of CO_2-bearing hydrous fluid under lower greenschist facies conditions generated assemblages containing K-feldspar + chlorite + rutile ± dolomite in calcareous rocks and albite porphyroblast schists in zones of intense secondary deformation.

Large-scale infiltration of fluid into greenschist-facies metadolerite sills was intimately related to, and possibly controlled by, penetrative deformation and, in the absence of a penetrative deformation, grain-boundary diffusion by itself was an ineffectual mechanism of fluid transport. (Authors' abstract)

GRAHAM, J., BUTT, C.R.M. and VIGERS, R.B.W., 1983, Charging as a source of error in microprobe analysis: CSIRO Div. of Mineralogy Res. Review 1983, p. 237-238.

Over the last few years, the labile nature of sodium and other alkali metals under the electron beam has been ascribed more and more to mobility of their ions under the influence of electronic charge from the beam, rather than to loss by evaporation. Such charge build-up has profound consequences for all microprobe analyses, even where no mobile ions are present. Difficulties in analyzing silicates and non-conducting sulfides could be due to this cause. We have investigated some natural and synthetic phases in which the ionic migration is gross, and also some glass specimens, to determine the magnitude and incidence of charging effects. (Authors' abstract)

GRANOVSKIY, A.G., NEVSKIY, L.N., TRUFANOV, V.N., DAVYDOV, K.V., TIBILOV, S.M. and BRITAEV, Ts.Kh., 1983, Polymetal ore mineralization in metamorphic complexes of Central Caucasus: Sovetskaya Geologiya, no. 12, p. 45-54 (in Russian). First author at Rostov State Univ., USSR.

The studied polymetal mineralization occurs in crystalline schists, quartzites, gneisses and amphibolites (Donifar ore field with deposits Totors, Karidon, Buron ore field with deposits Buron, Sau-khokh, Starotseyskoe, Fiagdon ore field, East Dzhimidon deposit). The deposit E. Dzhimidon yielded Th and P as follows: pyrite-quartz stage 340-210°C, 90-60 MPa; quartz-pyrite-sphalerite stage 320-160°C, 70-40 MPa; galena-quartz stage 220-160°C, 60-30 MPa; carbonate stage, 160-100°C, 40-10 MPa. Td are in intervals 340-420°C, 200-300°C, 60-120°C. Part of PS inclusions bears LCO_2 (Th of $LCO_2 + GCO_2 \rightarrow LCO_2$ + 25 to +28°C). Water solution contains Na, K, Ca, Cl, HCO_3 (total salt concentration 8-16%). By G chromatography, gases in inclusions consist of CO_2, CO, N_2 and CH_4. (Abstract by A.K.)

GRANT, M.A., 1982, On the lack of a unique relation between CO_2 partial pressure and temperature in geothermal system. Comment on "Geothermal mineral equilibria" by W.F. Giggenbach: Geochimica Cosmo. Acta, v. 46, p. 2677-2680. Author at Applied Math. Div., Dept. Sci. & Industrial Res., Wellington, New Zealand.

Giggenbach (1981) has proposed a relation of van't Hoff form, $\log_{10}P(CO_2) = A - B/(t + 273)$, between temperature and CO_2 partial pressure in deep liquid in geothermal systems. The proposed values for the coefficients are $A = 15.26$, $B = 7850$.

The proposal is not supported by pressure-temperature data used by Giggenbach, and a survey of different fields indicates that the proposal is not valid. (Author's abstract)

See reply by Giggenbach, 1982, this issue. (E.R.)

GRANT, N.K. and BLISS, M.C., 1983, Strontium isotope and rare earth element variations in non-sulphide minerals from the Elmwood-Gordonsville mines, central Tennessee: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 206-210. Authors at Dept. Geol., Miami Univ., Oxford, OH 45056.

$^{87}Sr/^{86}Sr$ ratios of calcite, dolomite, fluorite and barite exceed the ratios of the host Kingswood and Macot Formations of the lower Ordovician Knox Group, and record the influx of radiogenic fluids immediately following the crystallization of the sulphides. The isotope data show the effect of the dissolution of the host carbonates during sulphide crystallization, and also the changes in the ore fluid system when the pulse of fluid with elevated $^{87}Sr/^{86}Sr$ ratios ended, and the remaining fluids evolved through local isotopic chemical exchanges with the host carbonates.

The rare earth element (REE) patterns in pre- and post-sulphide calcites are not similar to sedimentary patterns, and the increasing LREE depletion through the paragenesis, and the changes to the Eu anomalies, are not coupled to the isotopic changes. In consequence the evolution of the REE is thought to be largely determined by fractionations occurring during the dissolution, transport and crystallization processes of the mineralization. (Authors' abstract)

GRATIER, J.P. and JENATTON, L., 1983a Experimental deformation of quartz and calcite by solution-deposition with diffusion in fluid (abst.): Terra Cognita, v. 3, p. 256. Authors at IRIGM, Univ. 1 Grenoble, France.

Experimental solution-deposition is studied by observing the change of shape of fluid inclusions in crystals depending on temperature and pressure. Upon heating a crystal containing fluid inclusions (synthetic quartz and calcite obtained by hydrothermal synthesis), to a temperature (Ti) higher than the temperature of homogenization of the fluid phase, an internal pressure (Pi) appears in the cavity. After several weeks, or months, of heating, inclusions initially elongated, undergo shape changes and tend to become more rounded, with solution at the median part of the inclusion, diffusive mass transfer within the fluid phase, and crystallization at the extremities. The driving force for this change of shape is a surface energy effect, due to the difference of curvature along the solid-fluid surface.

The rate of change of length ($\Delta l/\Delta t$) is found to be limited by the rate of the process at the solid-fluid interface (rate of solution), and not by the rate of diffusion within the fluid phase. $\Delta l/\Delta t$ is activated by an increase in temperature (Ti = 250-400°C, with ΔE = 15 kcal/mole) and by an increase in internal pressure (Pi = 5-85 MPa, with an approximately linear relation). (Authors' abstract)

Change of shape of fluid inclusion in quartz

GRATIER, J.P. and JENATTON, L., 1983, Deformation and reequilibration of fluid inclusions depending on temperature, internal pressure and stress (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 31. Authors at Inst. Rech. Interdisciplinaires de Geol. et de Mecanique, Univ. Sci. et Medicale de Grenoble, BP 68, 38402 Saint Martin D'Heres Cedex, France.

Fluid inclusions are usually used as markers of the conditions of growth of crystals, under the hypothesis that these inclusions behave as a closed system. To estimate their behavior in nature, stability of fluid inclusions was experimentally tested when an internal overpressure (Pi) is imposed within these inclusions by heating, or when the crystal is subjected to a state of stress.

An instability of shape and density is observed when the crystal is heated above a temperature Ti equal or superior to the temperature of homogenization Th (Th = 250°C in synthetic quartz and 210°C in synthetic calcite), these conditions being maintained for several weeks or months under a microscope:

- Even without fracture of the inclusion, the density decreases slowly with time depending on temperature, pressure, nature of mineral, etc...

- The inclusion always changes shape by a dissolution-diffusion-deposition process if a fluid phase stays in the cavity during heating, even if this cavity is fractured:

With high internal pressure ($5 \leqslant Pi \leqslant 85$ MPa), an initially elongated inclusion becomes more round.

With low internal pressure ($Pi \leqslant 5$ MPa), an initially elongated inclusion becomes more round; an initially round inclusion tends to a negative crystal shape.

- The rate of change of length of an inclusion L increases with the increase of pressure, for the same temperature Ti.

- L increases with the increase of Ti, for the same Pi.

- L is proportional to L/w^2 (L = length of the inclusion, w = width), therefore L depends on the rate of dissolution, and not on the rate of diffusion.

- L also depends on the initial orientation of the inclusion in crystal.

No instability of shape appears during the application of a state of stress at temperature Th, and during the heating of natural minerals (but at low Th = 135°C then low Ti).

Rates of deformation and reequilibration of inclusions could be extrapolated for natural deformation. This shows that inclusions are not always closed systems in nature. (Authors' abstract)

GRAZIANI, G., 1983, Advances in the study of mineral inclusions: N. Jb. Miner. Mh., v. H. 11, p. 481-488. Author at Inst. Mineralog. e Petrografia, Univ. degli Studi, "La Sapienza", Piazzale Aldo Moro 5, 00185

Roma, Italy.

Mineral inclusions and individual daughter minerals have been extracted from fluid inclusions in the host crystal by using an original microtechnique called MEA: Microscopic Extracting Assemblage. The apparatus consists of four principal sections: overturned mineralogical microscope, microdrill, freezing system, and micromanipulator. This technique allows the operator to locate the inclusions, to define their optical properties, as well as those of their host crystal, and to extract them without ever moving the specimen, which is kept at constant temperature. The technical features of the assemblage were calibrated. The inclusions have been unequivocally identified by using both the Gandolfi X-ray camera and the electron microprobe. (Author's abstract)

GREEN, H.W., II, 1983, Coupled exsolution of fluid and spinel from olivine: evidence for O^- in the mantle? (abst.): EOS, v. 64, p. 340.

GREEN, H.W., II and GUEGUEN, Yves, 1983, Deformation of peridotite in the mantle and extraction by kimberlite: A case history documented by fluid and solid precipitates in olivine, in M. Etheridge and S. Cox (eds.), Deformation Processes in Tectonics: Tectonophysics, v. 92, p. 71-92. First author at Dept. Geol., Univ. California, Davis, CA 95616, USA.

During an extensive study of the microstructure of peridotite xenoliths from kimberlite pipes, coprecipitation of fluid and solid phases has been observed in olivine. One specimen which displays these precipitates particularly well contains three generations of olivine: (a) original, coarse-grained, highly deformed porphyroclasts, (b) dynamically recrystallized neoblasts, and (c) statically recrystallized tablets. All three generations display precipitates on virtually all dislocations, indicating that exsolution occurred during transport to the surface. Analysis by a variety of analytical techniques has determined that the solid phase is chrome-aluminum spinel and the fluid phase is probably CO_2. The deformation and the exsolution microstructure allow construction of a detailed model of the P-T path followed by the xenolith to the surface and further allow refinement of our earlier diapiric model of kimberlite genesis. (Authors' abstract)

GRICHUK, D.V. and BORISOV, M.V., 1983, Thermodynamic model of hydrothermal system in oceanic crust: Doklady Akad. Nauk SSSR, v. 270, no. 2, p. 424-427 (in Russian). Authors at Moscow State Univ., Moscow, USSR.

The model of convection hydrothermal system was calculated for 13 elements (H, O, Na, K, Ca, Mg, Fe, Al, Si, C, S, Cl, Pb), 48 ions and complexes in solution, 37 minerals, T 25-350°C, P of saturated vapor. (A.K.)

GRISHINA, S.N., 1983, Determination of carbon dioxide and methane in inclusions in halite from Dnepr-Donets depression: Doklady Akad. Nauk SSSR, v. 273, no. 6, p. 1475-1477 (in Russian; see Translations).

GROMOV, A.V. and FILIPISHIN, F.L., 1983, Thermobarogeochemistry of phlogopite-bearing diopside rocks of the Aldan metamorphic complex: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 10, p. 76-86 (in Russian). Authors at Moscow Geol.-Prospecting Inst., USSR.

Archean diopside rocks in Central Aldan bear commercial deposits of phlogopite and magnetite. Inclusions in diopside of schists and skarns of migmatic stage (usually few µm in size) are G/L, only sometimes with highly birefringent trapped minerals. Th was not measured because at 570-

610 to 650-720°C diopside cracks strongly and inclusions leak before homogenization. One-phase LCO_2 inclusions heterogenize at T >-20°C, Th range from -10 to +12°C, hence density of CO_2 was 0.968 to 0.837 g/cm^3; P at assumed T of formation (700-900°C) was 400-730 MPa. Diopside from skarns of post-magmatic stage bears inclusions of LH_2O + G, and LH_2O + LCO_2 + G, Th 300-520°C, but mostly 380-490°C; LCO_2, Th +1 to +14°C, CO_2 density 0.918 to 0.818 g/cm^3, P 270-380 MPa; the latter skarns bear phlogopite deposits. Water leachates contained always (17 samples) Ca 0.013-0.238, frequently Na to 0.047, K to 0.034, Mg to 0.038, always HCO_3 0.021 to 0.110, frequently Cl to 0.098, SO_4 to 0.244, rarer F to 0.015 (in mg-equiv. per sample)[sic, sample weight ranged from 29 to 71 g, A.K.]. In inclusions (by gas chromatography, in moles per 1 kg of H_2O) gases were present as follows: CO_2 always (17 samples) 0.05 to 0.55, CH_4 always 0.01 to 0.06, other gases in about half of total analyzed samples, O_2 to 0.01, N_2 to 0.02, H_2 to 0.21. (Abstract by A.K.)

GRUZDYEV, V.S., PRUSHINSKAYA, E.Ya., SPIRIDONOV, E.M., EVSTIGNEEVA, T.L. and CHVILEVA, T.N., 1982, Antimony-bearing pyrite: Akad. Nauk SSSR Doklady, v. 264, no. 2, p. 445-451 (in Russian). First author at Inst. Mineral., Geochem. and Crystallochem. of Rare Elements, Moscow, USSR.

Pyrite from E. Yakutia and Magadan area bears up to 21.7% of Sb. Th of inclusions in quartz from these deposits estimated T interval of ore formation for 320-125°C, with Sb mineralization at 250-160°C. (A.K.)

GÜBELIN, E., 1983, Distinctive marks in the new synthetic rubies: Rev. Gemm. A.F.G., no. 76, p. 9-16 (in French). Author at Benzeholzstrasse 11, CH-6045 Meggen, Switzerland.

Fingerprint-like inclusions are present. (E.R.)

GUEDDARI, Moncef, MONNIN, Christophe, PERRET, Dominique, FRITZ, Bertrand and TARDY, Yves, 1983, Geochemistry of brines of the chott El Jerid in southern Tunisia - Application of Pitzer's equations: Chem. Geol., v. 39, p. 165-178. First author at Centre Sédimen. & Géochimie de la Surface (C.N.R.S.) & Inst. Géol., 1 rue Blessig, 67084 Strasbourg Cedex, France.

In the chott El Jerid in southern Tunisia, waters are strongly concentrated by evaporation under an arid climate. The diluted waters are of the Ca-Mg-SO_4 type whereas the brines are of the Na-Cl type, relatively concentrated in K and Mg. In concentrated waters, Ca and silica concentrations remain at a very low level. The use of Pitzer's equations for calculating the ion activities has permitted accurate saturation tests and a fairly good evaluation of the mineral sequences controlling the geochemistry of the basin. (Authors' abstract)

GUHA, Jayanta, ARCHAMBAULT, Guy and LEROY, Jacques, 1983, A correlation between the evolution of mineralizing fluids and the geomechanical development of a shear zone as illustrated by the Henderson 2 mine, Quebec: Econ. Geol., v. 78, p. 1605-1618. First author at Sci. de la Terre, Univ. Québec à Chicoutimi, Chicoutimi, Quebec G7H 2B1, Canada.

The Henderson Cu-Au deposit is contained within the metaanorthosite of the Dore Lake Complex, located at the eastern end of the Chibougamau-Matagami greenstone belt. Two ore zones, one enclosed within a shear zone (zone B) and the other in a subsidiary structure (zone D) offer an ideal situation to study the correlation between the mechanical development of a shear zone and its subsidiary structure and the evolution of mineralizing fluids.

Mineralizing fluids introduced into this shear environment show a similar pattern of evolution, with a wider range of homogenization and halite disappearance temperatures in the more active zone B than within zone D. Systematic variations of Ca/Na and Ca/Mg ratios in the fluid between zones B and D indicate migration and accompanying chemical changes of the fluid from zones B to D, in keeping with the evolution of the main shear zone and its subsidiary structure. These correlations suggest strongly that fluid inclusion studies can be useful for documenting geomechanical processes. (From the authors' abstract)

GUIJARRO, J., HOYOS, M.A., CASAS, J. and MARTIN DE VIDALES, J.L., 1983, Study of fluid inclusions in stockwork tin ore deposits of Cerro de San Cristóbal (Logrosán, Spain): Boletin Geol. Minero., v. 94-96, p. 521-529 (in Spanish; English abstract). First author at Dept. Geol. y Geoquímica., Univ. Autónoma Madrid, Spain.

In the stockwork running across the adamellitic apex of Cerro de San Cristóbal (Logrosán, Spain) we have distinguished four generations of fractures which were refilled by mineralizing solutions. This process formed veins whose order of formation 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 mineralizated in sulphides and cassiterite; Type IV veins, E-W direction and unproductive.

Th 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. Thereafter temperature falls in Type IV veins (318-338°C).

Relative Th of the secondary fluid inclusions are quite similar in the diverse vein generations because they range between 236 to 245°C. (Authors' abstract)

GUILHAUMOU, N., KLOSTERMANN, M.J., BENY, C. and VELDE, B., 1983, Raman microprobe studies of gaseous inclusions from oolitic limestones (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 33. First author at E.N.S. Lab. Géol., 46 rue d'Ulm, 75239 Paris, France.

Raman microprobe analyses have been made on inclusions in calcite cement from two core samples of Smackover formation Jurassic, sampled from a depth of approximately 6.5 kilometers. Gaseous inclusions contain the following chemical assemblages H_2S-CH_4-CO_2-graphite, H_2S-CH_4-CO_2-H_2O-graphite and H_2S-CH_4-graphite. The solid phase appears to be a very poorly ordered form of graphite, similar to that found in the earliest stages of the kerogen-graphite transition. Aqueous inclusions found in association with the gaseous inclusions have uncorrected homogenization temperatures of 125-135°C.

Bottom hole temperature corrected for circulation and equilibration is 190°C (Boles and Francks, 1979). Densities actually measured in aqueous inclusions indicate conditions near those of present day bottom hole temperatures and pressures. Gas production from this and other nearly wells indicates phases similar to those found in the inclusions.

The above data suggest: 1) entrapment of fluids similar in composition to present pore fluid and 2) evolution of pore fluids to the upper stability range for methane and methane-carbon dioxide mixtures. (Authors' abstract)

GULIY, V.N., 1983, Pyroxenes of the lime-silicate rocks of the Aldan Shield with various ore specialization: Mineralog. Sbornik, v. 37, no. 2, p. 78-82 (in Russian; English abstract). Author at the University, Leningrad, USSR.

Various kinds of pyroxene-phlogopite skarns with apatite bear the following gases determined by Letnikov's method (see Letnikov 1980, Letnikov, Feoktistov et al. 1980, Letnikov, Glebovitskiy et al. 1980, Konev and Bekman 1980, all in Fluid Inclusion Research--Proceedings of COFFI, v. 13), in ml per kg of samples: H_2O 0.51-6.83, CO_2 0.14-4.65, CO traces 8.55, CH_4 nil-traces, H_2 nil-2.13, N_2 nil-0.1. (A.K.)

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. 179-198 (in Russian).

GUMENYUK, V.A. and GLYUK, D.S., 1983, Nature of ore-metasomatic zoning of gold-silver deposits: Dokl. Akad. Nauk SSSR, v. 269, no. 1, p. 179-184 (in Russian). First author at Far-Est Sci.-Research Inst. of Mineral Raw Materials, Khabarovsk, USSR.

Gold ores of most deposits precipitated from HCO_3^- solutions with small admixture of SO_4 and Cl. Only certain gold-polymetal and gold-bearing pyrite deposits formed from essentially Cl solutions. On the basis of inclusion data, experiments were performed on gold solubility at T 250°C, pressure 500 and 1000 kg/cm^3. The studies showed that H_2O-HCO_3 solutions are not transporting but precipitating ones. Transport of Au by molecular CO_2 also was not confirmed. Probably transporting solutions were of HS-Cl type and mixing with oxidized HCO_3-bearing waters caused precipitation of Au. The paper also characterizes metasomatite wall-rocks for gold ores (alunite-quartzites, kaolinite-quartzites, quartz-hydromica rocks, quartz-sericite rocks, quartz-adularia rocks and carbonate-propylites). (Abstract by A.K.)

GUNTER, W.D., CHOU, I.-M. and GIRSPERGER, Sven, 1983, Phase relations in the system NaCl-KCl-H_2O II: Differential thermal analysis of the halite liquidus in the NaCl-H_2O binary above 450°C: Geochimica Cosmo. Acta, v. 47, p. 863-873. First author at Oil Sands Res. Dept., Alberta Res. Council, 11315-87th Ave., Edmonton, Alberta, T6G 2C2, Canada.

Thermal analysis of the halite liquidus in the system NaCl-H_2O has been conducted for NaCl mole fractions (X(NaCl)) greater than 0.25 (i.e., >50 wt. % NaCl) at pressures between 0.3 and 4.1 kb and temperatures greater than 450°C. The dP/dT slope of the liquidus is positive and steep at high pressures, but at high X(NaCl) and pressures below 0.65 kb it appears to reverse slope and intersects the three-phase curve (liquid-halite-vapor) at a shallow angle. However, due to the complex nature of the DTA signal when $P \leq 0.5$ kb, there is considerable doubt about exactly what event has been recorded in the experiments conducted at these low pressures.

Concentrated solutions of NaCl show negative deviations from ideality which rapidly increase in magnitude with decreasing X(NaCl). (From the authors' abstract)

GUSEVA, Ye.V., MEL'NIKOV, F.P., ORLOV, R.Yu. and USPENSKAYA, M.Ye., 1983, Spectroscopy of combined light dispersion [Raman spectroscopy] in the investigation of mineral gas-liquid inclusions: Doklady Akad. Nauk SSSR, v. 272, no. 1, p. 197-200 (in Russian). Authors at State Univ., Moscow, USSR.

The paper presents investigations by Raman spectroscopy of the following inclusions: $LCO_2 + GCO_2$ (20% by vol.), Th 29°C in L; $LH_2O + GCO_2$ (80 vol. %); $LH_2O + GH_2O$ + dm(halite) + dm carbonate (smithsonite). Analytical lines used for phase identification are given. (A.K.)

Continued next page.

An argon laser and a novel 180° backscatter geometry were used. Phases analyzed included CO_2 liquid, CO_2 gas, CO_2 in water solution, H_2O, NaCl solutions, and daughter mineral smithsonite. (E.R.)

GUTSALO, L.K., 1983, Mechanism of formation of biogenic methane in natural gases: Dokl. Akad. Nauk SSSR, v. 267, no. 3, p. 729-732 (in Russian).

GUTSALO, L.K. and PLOTNIKOV, L.M., 1981, Isotopic composition of hydrogen in the CO_2-CH_4 system as a test of origin of methane and carbon dioxide in natural gases: Dokl. Akad. Nauk SSSR, v. 259, p. 470-473 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 259, p. 183-186, 1983).

HAGNI, R.D., 1983, Ore microscopy, paragenetic sequence, trace element content, and fluid inclusion studies of the copper-lead-zinc deposits of the southeast Missouri lead district: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 243-256. Author at Dept. Geol. & Geophys., Univ. Missouri-Rolla, Rolla, MO 65401.

The ore deposits in the Southeast Missouri Lead District occur in lower Paleozoic sedimentary rocks and are exploited for lead, zinc, copper, cadmium, and silver. These metals are contained primarily in galena, sphalerite, and chalcopyrite which were repetitively deposited by replacement of host rock dolomite and by crystallization into open spaces. The gangue constituents, dolomite, calcite, quartz, marcasite, and pyrite, also were crystallized abundantly and repetitively from the introduced ore fluids. Small quantities of potentially recoverable cobalt and nickel occur in the ubiquitous phases, siegenite and bravoite, and more locally as nickelean carrollite, millerite, polydymite, fletcherite, and vaesite. Additional opaque phases with restricted occurrence include bornite, gersdorffite, tennantite, digenite, djurleite, anilite, chalcocite, covellite, blaubleibender covellite, enargite, pyrrhotite, magnetite, and arsenopyrite.

Each stage of sulfide deposition has a characteristic mineral association. Although intensive microscopic studies of the ores reveal that the full detailed paragenetic sequence is exceedingly complex, the general sequence of deposition is: 1) dolomite, 2) disseminated iron-nickel sulfides, 3) bornite and associated chalcopyrite, fletcherite, nickelean carrollite, and gersdorffite, 4) chalcopyrite, 5) siegenite, 6) sphalerite, 7) colloform iron sulfides, 8) octahedral galena, 9) dolomite, 10) cubic galena, 11) quartz, 12) late minor chalcopyrite, siegenite, and pyrite crystals deposited in vugs, and 13) calcite. Several periods of dissolution have partially or completely removed galena, sphalerite, and barite from portions of the ore deposits.

Each period of deposition of a given sulfide mineral has a characteristic trace element content, may be restricted to certain crystal habits, and formed during a limited temperature range. For example, early yellow sphalerite is characterized by relatively low cadmium (3460 ppm) and moderate iron (7860 ppm) content and was deposited from 137° to 82°C. Subsequent brown sphalerite is characterized by higher cadmium (9780 ppm) and iron (10560 ppm) content and was deposited predominantly between 125°C and 110°C. Late yellow sphalerite has much lower cadmium (2775 ppm) and iron (2835 ppm) content and was formed mainly from 115°C to 80°C.

The repeated paragensis, dissolution, alteration, varying amounts of trace elements, and fluctuating temperatures have resulted from multiple introductions of ore fluids into structurally favorable areas and from varying degrees of mixing of diverse ore fluids. (Author's abstract)

HAJASH, Andrew, 1983, Experimental seawater/gabbro interactions: preliminary results of a kinetic study at 400°C, 1 kb (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 37.

HAŁAS, S., 1983, Isotope analysis on nano-mole gas samples (abst.): ZfI-Mitteilungen (papers of the Central Inst. of Isotope and Radiation Research of the Acad. Sci. GDR), v. 80, p. 70-71 (in German).

HALLBAUER, D.K., 1983, Geochemistry and fluid inclusions in detrital minerals as guides to their provenance and distribution: Spec. Publ. Geol. Soc. S. Afr., no. 7, p. 39-57. Author at Mining Tech. Lab., Chamber of Mines of South Africa Res. Org., Johannesburg, South Africa.

Information on the origin, transport and distribution of economically important minerals in Precambrian placers can be obtained from geochemical and fluid inclusion studies of some of their principal detrital components, i.e. pyrite, quartz and gold.

Examination and analysis of fluid inclusions and their daughter minerals in pyrite and trace element analyses of single grains not only allow a classification of pyrite types but also permit statements to be made about their origin. Such studies give information regarding ore forming processes and the distribution of different pyrite types in fossil placers.

Quartz pebbles, similarly, have characteristic daughter minerals and fluid compositions which in some cases can be used as pathfinders. Regional trends in the distribution of certain pebble types have been observed.

The silver content (fineness) of gold particles has shown occasionally a high degree of correlation with the distribution of sedimentological units. Reworking and sedimentary redistribution of gold from older sediments could be recognized. (Author's abstract)

HALLBAUER, D.K. and VON GEHLEN, K., 1983, The Witwatersrand pyrites and metamorphism: Min. Mag., v. 47, p. 473-479. First author at Chamber of Mines of South Africa, Res. Org., Johannesburg, Republic of South Africa.

Evidence obtained from morphological and extensive trace element studies, and from the examination of mineral and fluid inclusions in Witwatersrand pyrites, shows three major types of pyrite: (i) detrital pyrite (rounded pyrite crystals transported into the depositional environment); (ii) synsedimentary pyrite (round and rounded aggregates of fine-grained pyrite formed within the depositional environment); and (iii) authigenic pyrite (newly crystallized and/or recrystallized pyrite formed after deposition). The detrital grains contain mineral inclusions such as biotite, feldspar, apatite, zircon, sphene, and various ore minerals, and fluid inclusions with daughter minerals. Most of the inclusions are incompatible with an origin by sulphidization. Recrystallized authigenic pyrite occurs in large quantities but only in horizons or localities which have been subjected to higher temperatures during the intrusion of extrusion of younger volcanic rocks. Important additional findings are the often substantial amounts of pyrite and small amounts of particles of gold found in Archaean granites (Hallbauer, 1982) as possible source rocks for the Witwatersrand detritus. Large differences in Ag and Hg content between homogeneous single gold grains within a hand specimen indicate a lack of metamorphic homogenization. The influence of metamorphism on the Witwatersrand pyrites can therefore be described as only slight and generally negligible. (Authors' abstract)

HALSOR, S.P., CHESNER, C.A., ROSE, W.I. and BORNHORST, T.J., 1983, An introduction to fluid inclusions: a color videotape teaching aid for economic geology classes (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 590. Authors at Dept. Geol. & Geol. Engrg., Michigan Tech. Univ., Houghton, MI 49931.

We have produced a 50-minute color videotape which introduces the novice student to fluid inclusions and some basic functions which can be performed on them. Topics covered include: 1) What is a fluid inclusion, 2) How fluid inclusions are useful, 3) Types of fluid inclusions, 4) Sample preparation, 5) Heating and cooling stage demonstrations, and 6) Calibration and data reduction. The tape combines down-the-tube microscope shots of inclusions with lecture material, graphical illustrations, and superimposed terminology. The tape has been designed as a classroom and/or instructional tool to be used in undergraduate or graduate level courses in economic geology. Conceivably the tape could also be used by the individual in the mining industry who wants to learn the basics of fluid inclusions. Simple fluid inclusion studies are particularly well suited for this kind of teaching medium because: 1) A fluid inclusion microscope equipped with a TV camera permitted filming of changing conditions of inclusions during heating and cooling function, 2) Many people can watch a TV monitor at once while only one person at a time can view down a microscope, and 3) A videotape can be viewed over and over thus allowing a student to be certain that he understands particular concepts.

The presentation will include a 10-minute excerpt of the tape. (Authors' abstract)

HAMILTON, D.L., OXTOBY, S. and MANNING, D.A.C., 1983, The solubility of water in simplified rock-melts, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 280-289.

HAN, Fa and GE, Chaohua, 1983, Makeng iron deposit--a submarine volcanic hydrothermal-sedimentary ore: Scientia Sinica, Ser. B, v. 26, no. 10, p. 1075-1087 (in English). Authors at Inst. Min. Deposits, Chinese Acad. Geol. Sci., Beijing.

Based on the study of the geologic setting of the Makeng iron deposit, its mode of occurrence, types of the primary ore, and its texture and structure, this paper classifies the deposit as belonging to syngenetic sedimentary origin and suggests that the skarn there is but a postmineral hydrothemal superposition product. In consideration of its geothermometry, ore composition, the behavior of Mn and Fe in the ore-forming process and other geochemical features, the Makeng iron deposit is demonstrated to be a submarine volcanic hydrothermal-sedimentary-type ore. Study on stable isotopes proves that the ore-forming thermal fluid is a mixture of "magmatic water" and seawater. (Authors' abstract)

Th (and some Td) determined on various ore and gangue phases ranged from 180° to 590°C. (E.R.)

HANNAH, J.L., STEIN, H.J. and POSEY, H.H., 1983, Oxygen and carbon isotopic compositions of vein and vug carbonates from the Bonneterre Formation, Missouri: variations in ore fluid composition (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A30. First author at Dept. Geol., Univ. Vermont, Burlington, VT 05405.

The Bonneterre Formation hosts significant lead-zinc mineralization in a typical Mississippi Valley-type setting in the Viburnum Trend, southeast Missouri. Isotopic compositions of oxygen and carbon for vein and vug carbonates within mineralized and barren sections of the Bonneterre show remarkable consistency over 100 km distances.

$\delta^{18}O$ values for all calcites and dolomites are lower than fresh marine carbonates suggesting formation from an isotopically light fluid and/or equilibrium at somewhat elevated temperatures. Dolomite and calcite show little or no oxygen isotopic fractionation, indicating disequilibrium and suggesting that open space calcites formed at lower temperatures or later than vug-lining dolomites, as supported by paragenesis. The total range of $\delta^{18}O$ values for mineralization-related carbonates is 21.4 to 23.8‰ (12 samples including one of the Bonneterre Fm). Late scalenohedral calcite is heaviest with a core-transition-rim section from a large crystal yielding $\delta^{18}O$ values of 23.8, 22.4, and 23.5‰, respectively. Even at 100 km distances from the Viburnum area barren vein calcites continue to be isotopically light and a calcite from Bonneterre limestone yielded the lowest value, 18.6‰. In general, carbonates associated with mineralization have heavier $\delta^{18}O$ values. $\delta^{13}C$ values for calcites and dolomites, both within and distant from mineralization, range from +0.3 to -6.1‰. In general, mineralization-associated calcites are isotopically ligher suggesting introduction of organic carbon during ore forming processes. The late scalenohedral calcite, associated with chalcopyrite deposition, shows a decrease in $\delta^{13}C$ from core to rim (-2.8, -3.9, and -6.1‰).

Because carbon and oxygen isotope ratios vary independently, the variation cannot be attributed solely to changing temperature or water/rock ratio. A temporally changing ore fluid composition is suggested. (Authors' abstract)

HANNI, H.A., KLEIN, H.H. and TSCHULDIN, F., 1983, An emerald deposit in Madagascar: Revue de Gemmologie a.f.g., March 1983, no. 74 (in French).

Includes a tabulation of the inclusion types found in 5 different emerald localities. (E.R.)

HANOR, J.S., 1983a Fifty years of development of thought on the origin and evolution of subsurface sedimentary brines, in S.J. Boardman (ed.), Revolution in the earth sciences: advances in the past half-century: Kendall/Hunt, Dubuque, p. 99-111. Author at Dept. Geol, Louisiana State Univ., Baton Rouge, LA 70803.

A review of the processes affecting subsurface brines. (E.R.)

HANOR, J.S., 1983b Subsurface sedimentary brines: chemical evolution and role as ore-forming fluids (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 590. Authors at Dept. Geol., Louisiana State Univ., Baton Rouge, LA 70803.

Approximately 20% by volume of the sedimentary portion of the earth's crust is pore water, most of which is hot, salty, and under high pressure. Some pore waters contain enough dissolved metals to be classed as potential ore-forming fluids. Many questions remain concerning their origin. Why are basinal waters so salty? Why are the relative proportions of major dissolved species unlike those of ocean waters or surface brines? What processes control the distribution of ore-forming constituents?

The high salinities of most subsurface waters are thought to originate by: 1) membrane filtration; 2) infiltration and burial of surface brines produced by subaerial evaporation; and 3) subsurface dissolution of halite. While membrane filtration continues to have its adherents, no unambiguous, large-scale field example has yet been identified. The relative proportions of many dissolved species in subsurface brines are largely controlled by what may be termed thermohaline diagenesis: the maintenance of chemical equilibrium between pore fluid and solids with increasing burial temperature, and the introduction of dissolved sodium through brine migration and/or halite dissolution. The first process provides the basis for brine geothermometry, the second can cause pervasive albitization of other silicates.

Metals and the alkaline earth's Sr and Ba are most likely to be released into solution from sediments undergoing pervasive alteration of original detrital components. High temperatures and the introduction of Na both facilitate this. The resultant pore fluids are also characterized by enrichment in K and Ca. The sulfur geochemistry of brines is poorly known. However, the relative abundance of Fe may play an important role in controlling levels of reduced S. (Author's abstract)

HANOR, J.S. and BAILEY, J.E., 1983, Use of hydraulic head and hydraulic gradient to characterize geopressured sediments and the direction of fluid migration in the Louisiana Gulf Coast: Transactions-Gulf Coast Assoc. Geol. Soc., v. 33, p. 115-121.

HARDIE, L.A., 1983, Origin of $CaCl_2$ brines by basalt-seawater interaction: Insights provided by some simple mass balance calculations: Contrib. Mineral. Petrol., v. 82, p. 205-213. Author at Dept. Earth & Planet. Sci., The Johns Hopkins Univ. Baltimore, MD 21218, USA.

Modern rift zone hydrothermal brines are typically $CaCl_2$-bearing brines, an unusual chemical signature they share with certain oil field brines, fluid inclusions in ore minerals and a few uncommon saline lakes. Many origins have been suggested for such $CaCl_2$ brines but in the Reykjanes, Iceland, geothermal system a strong empirical case can be made for a basalt-seawater interaction origin. To examine this mechanism of $CaCl_2$ brine evolution some simple mass balance calculations were carried out. Average Reykjanes olivine tholeiite was "reacted" with average North Atlantic seawater to make an albite-chlorite-epidote-sphene rock using Al_2O_3 as the conservative rock component and Cl as the conservative fluid component. The excess components released by the basalt to the fluid were "precipitated" at 275°C as quartz, calcite, anhydrite, magnetite and pyrite to complete the conversion to greenstone. The resulting fluid was a $CaCl_2$ brine of seawater chlorinity with a composition remarkably similar to the actual Reykjanes brine at 1750 m depth. Thus, the calculations strongly support the idea that the Reykjanes $CaCl_2$ brines result from "closed system" oceanic basalt-seawater interaction (albitization - chloritization mechanism) at greenschist facies temperatures. The calculation gives a seawater:basalt mass ratio of 3:1 to 4:1 (vol. ratio of 9:1 to 12:1), in keeping with experimental results, submarine vent data and with ocean crust cooling calculations. The brine becomes anoxic because there is insufficient dissolved or combined oxygen to balance all the Fe released from the basalt during alteration. Large excesses of Ca are released to the fluid and precipitate out in the form of anhydrite which essentially sweeps the brine free of sulfate leaving an elevated Ca concentration. The calculated rock-water interaction basically involves $Na + Mg + SO_4 \rightarrow Ca + K$, simulating chemical differences observed between oceanic basalts and greenstones from many mid-ocean ridges. (Author's abstract)

HARMON, R.S. and ALDERTON, D.M.H., 1983, Stable isotope and fluid inclusion composition of granite-associated mineralization in SW England (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 591. First author at Southern Methodist Univ., Dallas, TX, USA.

The peninsula of SE England is a classic example of polymetallic mineralization associated with acid plutonism. The bedrock geology of the region is primarily Lower Palaeozoic geosynclinal sediments and mafic volcanics subjected to greenschist facies metamorphism during the Hercynian Orogeny. Subsequently these rocks were intruded at c.280 Ma by 2-mica, 'S'-type granites. The development of an intense alteration and development of high temperature (Th = 300-500°C) Sn-W veins trending parallel to the main axis of the granites occurred shortly after granite emplacement within or adjacent to the granite plutons. A suite of lower temperature (Th = 200-400°C) Pb-Zn veins occur in the same trend away from the granites in the metasediments. Of less economic importance is a later, very low temperature (Th = 100-200°C) Pb-Zn mineralization which occurs in mineralized faults which crosscut earlier veins at nearly right angles.

Examination of fluid inclusions in mineralized vein and gangue mineral samples indicates that, in most vein systems, boiling was rare and CO_2 contents of the fluid were low. Respective salinity, fluid inclusion δD, and quartz $\delta^{18}O$ values for the granites (i), the early Sn-W mineralization (ii), the main late Pb-Zn mineralization (iii), and the very last crosscourse Pb-Zn mineralization (iv) are: (i) 18 to 40%, -55 to -48‰, 11.5 to 12.1‰; (ii) 5 to 30% (most 8 to 15%), -39 to -30‰, 13.9 to 15.4‰; (iii) 0 to 15% (most <15%), -46 to -34‰, 14.5 to 20.8‰; and (iv) 20 to 25% (most 10%), -45 to -33‰, 17.5 to 20.7‰. These data suggest that hydrothermal mineralization associated with the Hercynian granites of SW England was formed from hybrid magmatic-exchanged meteoric fluids. (Authors' abstract)

HARRIS, D.M. and ANDERSON, A.T., Jr., 1983, Concentrations, sources, and losses of H_2O, CO_2, and S in Kilauean basalt: Geochimica Cosmo. Acta, v. 47, p. 1139-1150. First author at Dept. Geol., The Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

Basaltic glasses included in olivine phenocrysts from Kilauea volcano contain concentrations of H_2O, CO_2, and S similar to glassy Kilauean basalt dredged from the deep sea floor and greater than vesicular, subaerial Kilauean basalt. Our result contrasts with earlier reports that inclusions of basaltic glass in phenocrysts have little or no H_2O and large ratios of CO_2/H_2O. Our analyzed inclusions of glass are larger than 100 micrometers thick and similar in chemical composition to the host glass surrounding the olivine crystals indicating that the trapped melts are representative of the bulk liquid from which the crystals grew. Crystallization of about 2-8% of olivine from the melts after they were trapped is indicated by slight departures from the experimentally established equilibrium distribution of Mg and Fe between olivine and liquid. The measured concentrations of CO_2 correspond to phenocryst crystallization pressures of about 1.3 kbar for a subaerial basalt and about 5 kbar for a submarine basalt, consistent with geophysical models of Kilauea volcano. The compositions of volcanic gas predicted from our analyses are consistent with restored compositions of actual Kilauean gases. The rate of sulfur emission predicted from our analyses is greater than the sulfur dioxide emission rate observed during repose, but probably consistent with total degassing including eruptive episodes. The concentrations of H_2O, K_2O, Cl, and P in parental Kilauean basalt can be derived from upper mantle phlogopitic mica, pargasitic amphibole and apatite with compositions close to those of natural primary minerals in ultramafic xenoliths from continental kimberlites, or solely from apatite and phlogopitic mica with H_2O/K_2O near 0.47 ± 0.03, slightly higher than the range of values reported. The amounts of phlogopitic mica and pargasitic amphibole contributing volatiles to Kilauean tholeiite is about 10 percent by mass of the parental liquid, or about 5% if the source does not include amphibole. In view of an estimated 20% of partial melting of mantle source rock to produce Kilauean tholeiites, there may be about 2 weight percent of mica plus amphibole in part of the mantle beneath Kilauea, or about 1 weight percent of phlogopitic mica if amphibole is absent. (Authors' abstract)

HART, Roger, DYMOND, Jack, HOGAN, Lewis and SCHILLING, J.G., 1983, Mantle plume noble gas component in glassy basalts from Reykjanes Ridge: Nature, v. 305, p. 403-407. First author at Sch. Oceanography, Oregon State Univ., Corvallis, OR 97331, USA.

Basalts from the Reykjanes Ridge contain noble gases delivered from the non-degassed lower mantle by the Iceland plume. These lower mantle gases are thought to be a mixture of planetary and solar components, as would be expected if the Earth accreted from fine silicate particles. (Authors' abstract)

HART, Roger and HOGAN, Lewis, 1983, A counter offensive against "terrestrial xenology" by Allegre and Staudacher (abst): EOS, Transactions, Am. Geophy. Union, v. 64, no. 45, p. 881.

HARWOOD, Gill, 1983, The application of cathodoluminescence in relative dating of barite mineralization in the Lower Magnesian Limestone (Upper Permian), United Kingdom: Econ. Geol., v. 78, p. 1022-1027.

HASELTON, H.T., Jr., HEMLEY, J.J. and CYGAN, G.L., 1983, HF-KF buffers in the system K_2O-Al_2O_3-SiO_2-H_2O-F_2O_{-1} (abst.): EOS, v. 64, p. 350.

HASHIMOTO, Masayuki and WAKAHAMA, Gorow, 1983, Plastic deformation of ice single crystals containing inclusions: Low Temp. Sci., Ser. A, v. 42 (in Japanese; English summary).

The inclusions were solid glass beads; "voids" often developed around the beads. The deformation behavior is explained in terms of work-hardening and dislocation theory. (E.R., from the authors' summary)

HAYBA, D.O., 1983, A compilation of fluid inclusion and stable isotope data on selected precious- and base-metal epithermal deposits: U.S. Geol. Survey Open File Report 83-450, 26 pp. Author at U.S. Geol. Survey, Reston, VA 22092.

This report is a tabulation of the fluid inclusion temperature, salinity, and chemical analyses, and the oxygen, deuterium and sulfur isotope data from a compilation of the lithotectonic, mineralogical and geochemical traits of 15 epithermal, volcanic-hosted districts (Heald-Wetlaufer et al., 1983). Of the 15 districts, the following 14 have some or all of the above types of geochemical information: Colqui, Peru; Comstock, Nevada; Creede, Colorado; Goldfield, Nevada; Guanajuato, Mexico; Lake City, Colorado; Julcani, Peru; Oatman, Nevada; Pachuca-Real Del Monte, Mexico; Red Mountain, Colorado; Round Mountain, Nevada; Sunnyside mine, Eureka district, Colorado; Summitville, Colorado; and Tonopah, Nevada. No data were found for the Silver City - De Lamar, Idaho district.

The purpose of this report is to make this compilation of fluid inclusion and stable isotope data available. The interpretations and conclusions drawn from this data have been abstracted in Heald-Wetlaufer et al. (1983) and will be presented in a subsequent publication. (Author's introduction)

HAYNES, F.M., 1980, The evolution of fracture-related permeability within the Ruby Star Granodiorite Sierrita porphyry copper deposit, Pima County, Arizona: M.S. prepublication manuscript, The Univ. Arizona, Tucson, AZ, 48 pp.

Quantitative data from the margins of the Sierrita porphyry copper deposit were derived by direct measurements from fractures in the field and fluid temperatures in the laboratory. These data constrain interpretations of the nature and extent of fracture permeability at different stages of cooling of the quartz monzonite porphyry which invaded the Ruby Star Granodiorite batholith at Sierrita.

Fracturing coeval with formation of the ore body extends into the granodiorite some 4.5 km away from the center of the hydrothermal system. Integrated fracture densities decrease from values of 0.2 to 0.3 cm^{-1} near the system's center to a background value of 0.03 cm^{-1} or less outside the system. Four mineralogically distinct vein types with a distinct paragenetic sequence are present. Distribution of vein types in the granodiorite indicates that the areal extent of fracturing associated with each type diminishes with time.

Vein-filling temperatures determined from fluid inclusions at two localities reveal a general decrease in the homogenization temperature of vein quartz of each vein type as the system evolved. Sulfide-bearing quartz veins collected at sites 1.8 and 2.9 km from the system's center showed similar temperatures of formation; however, secondary inclusions representing later events, present at the 1.8 km site, were absent at the 2.9 km site, suggesting that the late lower temperature event related to their formation was less widespread. (Author's abstract)

HAYNES, F.M., KESLER, S.E. and TAYLOR, Mark, 1983, Analytical evidence for a wide range of fluid inclusion compositions, Mascot-Jefferson City zinc district, east Tennessee (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 593. First author at Dept. Geol., Univ. Michigan, Ann Arbor, MI 48109.

Fluid inclusions in sphalerite and dolomite from the Mascot-Jefferson City zinc district in east Tennessee show a wide range of major cation compositions. Individual inclusion compositions were determined by SEM/EDA analyses of chloride-rich evaporites produced by heating polished chips above the decrepitation temperature of the fluid inclusions, forcing the enclosed fluids to the surface. A majority of the evaporites yield Na>Ca>>K compositions, in reasonable agreement with leachate analyses reported from Mississippi Valley-type deposits and with present day, carbonate-hosted, subsurface brine analyses. However, a significant population of chloride-rich evaporites have Na>Ca=K with higher K content than most modern basinal brines. Mg and Fe are present in some evaporites in subordinate amounts.

Variable freezing point depression temperatures (-16 to -28°C) observed in primary fluid inclusions throughout the district may reflect major cation differences and not a variation in total salinity. At a nearly constant salinity of 22-24 wt % combined salts, the observed compositional data predict variations of freezing point depressions (disappearance of last ice) in close agreement with those observed microscopically. These data provide permissive evidence of the presence of two fluids, a Na-Ca dominated brine, and a Na-K-Ca brine, in the mineralizing system. (Authors' abstract)

HE, Zhili, 1983, Discovery of anomalous gas-liquid inclusions in gypsum from an antimony ore deposit in China and preliminary study of their genesis: Kuangchuang Dizhi, v. 2, no. 3, p. 88-95 (in Chinese). Author at Beijing Univ. Iron Steel Technol., Beijing, PRC.

Large (≤40 cm in length), CO_2-H_2O fluid inclusions (7.5% salinity) occurring in megacryst. (1-2.4 m) gypsum from the oxidn. zone of a Chinese

Sb ore yield erroneous homogenization and decrepitation temps. (84-128°). In fact, the gypsum crystd. from cold fluids. The large gas-liq. inclusions are genetically similar to inclusions occurring in stalactites and stalagmites and represent the chem. product of the reaction $H_2SO_4 + CaCO_3 + 2H_2O \rightarrow CaSO_4 2H_2O + H_2O + CO_2$. (C.A. 100: 24546s)

HEALD-WETLAUFER, P., HAYBA, D.O., FOLEY, N.K. and GOSS, J.A., 1983, Comparative anatomy of epithermal precious- and base-metal districts hosted by volcanic rocks: U.S. Geol. Survey Open-File Report 83-710, 16 pp. (abstract also in Geol. Assoc. Canada/Mineral. Assoc. Canada Program & Abstracts, v. 8, p. A31).

In order to distinguish dissimilar from similar features of epithermal districts, lithotectonic, mineralogical and geochemical traits are compiled for 15 such districts. The districts occur in structurally complex settings associated with silicic to intermediate volcanics. Affiliation with subduction environments on a continental scale and caldera settings on a regional scale is common but is not demonstrable for all districts. Most deposits formed near the end of major volcanism, but some formed considerably later. Paleodepth to the top of the ore is 300-600m for most districts, although Au-rich districts appear to be shallower. The lateral extent of the ore zone is highly variable and far exceeds the limited vertical range (300-800m). Most ore was deposited from dominantly meteoric fluids ranging in temperature from 220°-290°C. Salinities ranged from 0-13 wt % NaCl equiv., and typical values were 1-3 wt %. Although noted for eight deposits, boiling is clearly associated with precious-metal deposition in only two deposits. Four districts, typified by Goldfield, Nev., are characterized by a highly sulfidized mineral assemblage, advanced argillic alteration, and ore deposition closely following emplacement of the host rock. The remaining eleven districts highlight a second, discrete type of deposit. They contain adularia, exhibit sericitic ± argillic alteration, and were mineralized significantly after emplacement of the host rock. The latter category includes two subgroups: Ag- and base-metal-rich deposits (e.g., Creede, Colo.), and Au-rich, base-metal-poor deposits (e.g., Round Mtn., Nev.). (Authors' abstract)

HEDENQUIST, J.W., 1983a, Mineral-gas equilibria in the Waiotapu geothermal system, New Zealand (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 175-178. Author at Geothermal Res. Centre, Chem. Div., D.S.I.R., Wairakei, Private Bag, Taupo, New Zealand.

The deep system water at Waiotapu is slightly alkaline (pH 5.7 to 6.3 at 225°C) and of low salinity (0.05 m NaCl), with up to 0.05 m gases, largely CO_2, but with measurable H_2S, N_2, H_2, CH_4 and NH_3 (Table 1 gives 6 analyses for 19 constituents). Quartz and NaKCa geothermometer temperatures range mainly from 200 to 250°C, with quartz temperatures usually 10 to 20°C lower than those from the NaKCa geothermometer.

It is concluded that the pyrite-pyrrhotite reaction is effective in constraining the H_2/H_2S content in solution, even during periods of boiling. The Waiotapu system bears many similarities to epithermal precious metal deposits. Gold is probably being transported to the surface as a thiosulphide complex, and its absence at depth suggests that the boiling at depth is not oxidizing the fluid sufficiently to cause gold precipitation. This is consistent with buffering of the fluids by the pyrite-pyrrhotite reaction. Rather, mixing with shallow acid sulphate waters may be a controlling factor on gold deposition from the fluid once it approaches the surface. Adsorption of gold onto arsenic and antimony sols may also be important in gold deposition at the surface at Waiotapu.

With continued evolution and consumption of the pyrite-pyrrhotite buffer, boiling and gas loss may eventually be an effective oxidizing process at depth and result in deeper gold mineralization within the Waiotapu system. These conclusions may be applied to epithermal gold deposits for a better understanding of the physical and chemical processes which are possible (and their relative importance) in mineralization. (From the author's abstract)

HEDENQUIST, J.W., 1983b, Waiotapu, New Zealand: the geochemical evolution and mineralization of an active hyrdrothermal system: Ph.D. dissertation, Univ. Auckland, Auckland, Australia.

[See also previous abstract.] Fluid inclusion homogenization temperatures closely approximate a boiling point with depth profile, which is also the case for present measured well temperatures in the southern portion of the system. However, in wells to the north, present measured temperatures have an inversion 20° to 40°C lower than the inclusion trapping temperatures, indicating that some cooling has occurred since inclusion formation. Freezing temperature results are generally consistent with present fluid chemistry, except in the south, where at least a ten fold higher gas (mainly CO_2) content was present during inclusion formation than now (0.03 molal CO_2). This higher gas content contributed to hydraulic fracturing at depths of 100 to 250 m, resulting in hydrothermal eruption activity ~900 years ago.

Stable isotope values ($\delta^{18}O$, δD and $\delta^{13}C$) of minerals, coupled with whole rock $\delta^{18}O$ values and present fluid isotope concentrations, define a pattern of meteoric fluid flow; the fluid has evolved isotopically (and chemically) through interaction with the rock to produce variable fluid/rock ratios of ~1.0 (in the north) to ~0.1 (in the south).

Fluid chemistry of well discharges indicates that a deep upflow of neutral chloride fluid (~240°C but having boiled from at least 300°C) in the north is diverted southwards by a southerly flowing, cooler (~170°C), more dilute chloride fluid; this pattern, and near surface boiling, is consistent with the chemistry of the hot springs. Isotope concentrations in the fluid also support mixing and boiling at depth.

The $\delta^{13}C(CO_2)$ values of some calcite (~-7‰) coupled with an inverse correlation to $\delta^{18}O$ values, suggests that there was an intermittent, magmatic CO_2 input; δD values from some fluid inclusions are also anomalously light with respect to the dominantly meteoric fluid, though this does not appear to have been caused by a magmatic input.

The hydrothermal mineral assemblage and chemistry, in terms of thermodynamic component equilibria, are consistent with present fluid chemistry; where differences occur, reaction progress may be identified, with textural evidence indicating the path of chemical evolution.

At 225°C (a common well fluid discharge temperature), the pH of the present fluid varies from 5.7 to 6.3 (weakly alkaline). The PH_2 and PH_2S of well discharges allow fO_2 and fS_2 of the deep fluid to be calculated. These values are consistent with the observed pyrite and pyrrhotite (+ chlorite?) assemblage.

The composition of sphalerite and epidote (plus the presence of minor hematite) suggests that fO_2 and fS_2 have fluctuated at times, probably due to boiling episodes; however, the fluids have (almost) always remained sulfide dominant. Earlier in the system's history (prior to the high CO_2 level), CO_2 was an order of magnitude lower than now, and an albite-adularia assemblage was stable; the increase in CO_2 lowered the pH and resulted in a more recent formation of white mica alteration.

Hydrothermal fluids are presently depositing ore grade concentrations of precious metals within and beneath surface siliceous sinters (up to 80 mg/kg gold, 175 mg/kg silver, 2 wt % arsenic and antimony each, and anomalously high mercury and thallium). Base metal sulfides are disseminated in a zone beneath the precious metals between 200 and 800 meters depth.

Calculations of lead chloride, silver chloride and gold thio complex stability, compared with metal contents in the fluids, agree with the observed metal zonation and indicate that gold is extremely undersaturated in the deep fluid. Boiling (with a subsequent pH increase) and cooling dominate base metal sulfide precipitation, whereas silver may be precipitating due to dilution as well. The only way to precipitate gold is to mix the deep fluid with surficial acid, oxidized fluids. This probably occurs during boiling episodes and after hydrothermal eruptions, when depressurization serves to draw surficial fluids deeper into the system. As_2S_3 in Champagne Pool may be adsorbing gold prior to deposition.

The evolution of the gas and therefore fluid chemistry may be closely related to nearby rhyolite-basalt volcanism. This evolution also has an effect on the processes controlling mineralization in the system, and along with the lateral zonation of mineralization.

An understanding of the important processes operating in the Waiotapu system, particularly related to fluid flow and mineralization, assists in reconstructing the hydrology and chemistry of a fossil system. This provides exploration criteria for and helps in unraveling aspects of epithermal mineralization. (From the author's abstract)

HEDENQUIST, J.W. and HENLEY, R.W., 1983, Chemical controls on gold mineralization in an active geothermal system, Waiotapu, New Zealand (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 594. Authors at Geothermal Res. Center, D.S.I.R., Taupo, New Zealand.

The Waiotapu geothermal system, 25 km southeast of Rotorua, New Zealand, is actively depositing precious and base metals. Gold, accompanied by silver, arsenic, antimony and mercury, occurs at and near the surface, and locally greatly exceeds ore grade. Base metal sulfides occur from 150 to 800 m depth.

The chemistry of deep thermal fluids at Waiotapu has been calculated from analyses of fluids discharged from geothermal exploration wells. These near neutral pH chloride fluids are consistent with the observed 240°C alteration mineral assemblage (pyrite-pyrrhotite-qurtz-albite-epidote-calcite-wairakite). Distinctive 'steam-heated' hot spring waters characterized by relatively high sulfate and low chloride contents occur at the surface. Those are formed by condensation, oxidation and dilution of steam containing H_2S and CO_2 and are associated with advanced argillic alteration (alunite-kaolinite-pyrite-cristobalite) in the upper 50 m of the system. Chloride and hybrid chloride sulphate hot spring waters also occur.

The relatively reducing, deep Waiotapu fluids are several orders of magnitude undersaturated with respect to gold thio-complexing. The most likely mechanism for supersaturating these fluids with respect to gold is through near surface mixing with the relatively oxidized steam-heated sulfate fluids. At depth, adiabatic boiling appears to be the dominant mechanism controlling base metal sulfide deposition. Waiotapu geothermal system are illustrative of the importance of boiling and fluid mixing in the formation of this and analogous epithermal Au-Ag deposits. (Authors' abstract)

HEICHEL, K.S., 1981, Microveinlet alteration and mineralization at the Sierrita porphyry copper deposit, Pima County Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 104 pp.

A detailed study of microveins, those veinlets less than 1 mm wide, was conducted at the Sierrita porphyry copper deposit in an attempt to determine microvein contribution to both ore-grade mineralization and fracture-related permeability in the porphyry copper system. The microveins display a distinct paragenetic sequence, as demonstrated by crosscutting relationships which evolved contemporaneously with those of the larger veins and veinlets. An early barren orthoclase and biotite-chlorite microvein stage is followed by a quartz and plagioclase (albite) stage. An intermediate stage of sulfide microveining followed, which was in turn superseded by epidote and later phyllic microveins. Calcite-gypsum microveins crosscut all other microveins present. The stage of sulfide mineralization is characterized by fluids, the sulfide content of which increased with time as temperatures cooled from about 390 to 300°C during deposition in sulfide microveins. Microfracture density relationships indicate that the greatest amount of microfracturing occurred during sulfide microvein formation. Study of the distribution of ore mineralization between microveins and larger veins and veinlets indicates that, on the average, 48% of the ore mineralization is contained within microveins. It appears that mineralized microfractures may have contributed significantly to the fracture-related permeability of the porphyry copper system. (Author's abstract)

HEIDECKER, E.J., 1983, Influence of basement structures, pore fluids, and stress refraction on en echelon veins, Burdekin region, Queensland (abst.): Bermagui '84; Int'l. Conf. on Multiple Deformation and Foliation Development; Newsletter of the Specialist Group in Tectonics & Structural Geol., Geol. Soc. Australia, Dec. 1983, v. 9, p. 124.

Indexed under Fluid Inclusions. (E.R.)

HEINRICH, E.W., GIARDINI, A.A., MELTON, C.E. and GUPTA, S.K., 1978, Gases in the alkalic rocks from McClure Mountain, Colorado in Proc. of the First Int'l. Symp. on Carbonatites, Pocos de Caldas, MG, Brazil, June 1976, Brazilian Ministry Mines & Energy, p. 257-260.

Occluded hydrocarbons and other fluids are found in dikes of carbonatite, "red rock," and lamprophyre, and their immediate wall rocks, and in nepheline syenite, ijolite, syenite and gabbro of the McClure Mountain-Iron Mountain mafic-alkalic complex in the northern Wet Mountains of south-central Colorado. H_2O is the predominant fluid in all analyses of rocks from the central part of the complex. CH_4 is the principal hydrocarbon in the central part of the complex, but C_5 and C_6 hydrocarbons are found in younger radioactive dike rocks outside the complex. Relative to rock age, from older gabbro to younger nepheline syenite, former contains the greatest volume of occluded gas and hydrocarbon and hydrogen contents, and the least quantity of water. CO_2, CO and N_2 are absent in the gabbro and most abundant in the nepheline syenite. (Authors' abstract)

HENLEY, R.W. and ELLIS, A.J., 1983, Geothermal systems ancient and modern: a geochemical review: Earth-Sci. Rev., 19, p. 1-50.

A major review (~300 refs.) of the current knowledge of geothermal systems. (E.R.)

HENNESSY, J.A., 1981, Geology and hydrothermal alteration of the Glen Oaks porphyry copper occurrence, Yayapai County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 103 pp.

The Glen Oaks porphyry copper-molybdenum deposit is a subeconomic occurrence of disseminated, veinlet, and vein controlled pyrite, chalcopyrite, and molybdenite associated with a multiple-phase Laramide quartz latite porphyry stock. The porphyritic intrusives were emplaced along a contact between Precambrian amphibolite and Precambrian quartz diorite between 77 and 79 m.y. ago.

The hydrothermal alteration associated with this deposit consists of early potassic and propylitic alteration zones with a later structurally controlled phyllic alteration superimposed on the potassic zone. A post-mineral sericitic alteration is associated with a late hornblende quartz latite porphyry stock emplaced near the center of the deposit. The potassic and phyllic alteration show a loss of Ca, Mg, and Na and a gain of K and Si. The late sericitic alteration induces a loss of all major elements except Fe. The potassic alteration and main copper-molybdenum mineralization were formed from a high salinity fluid. The phyllic and late sericitic alteration assemblages were formed by a low salinity fluid.

The early Laramide age of the deposit, the great depth of erosion in the area, the low total sulfide content, and the profound potassic alteration all lead to the conclusion that this deposit represents a deeply eroded porphyry copper deposit. (Author's abstract)

HENRY, D.J., MACKINNON, I.D.R., CHAN, I. and NAVROTSKY, A., 1983, Subliquidus glass-glass immiscibility along the albite-diopside join: Geochim. Cosmochim. Acta, v. 47, no. 2, p. 277-282.

HESSE, Reinhard and LEBEL, Jean, 1983, Pore-water evolution in gas-hydrate bearing sections of modern terrigenous continental margins (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 183-186.

HEYL, A.V., 1983, Geologic characteristics of three major Mississippi Valley districts: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 27-60. Author at U.S. Geol. Survey, MS 905, Denver, CO 80225, USA.

Three of the most important Mississippi Valley districts are the Upper Mississippi Valley, the southern Illinois-western Kentucky, and the Southeast Missouri districts. In 1979 Southeast Missouri produced 88 percent of the lead in the United States and our largest quantity of zinc; Illinois-Kentucky district produced most of our domestic fluorite; and Upper Mississippi Valley may have very large reserves of zinc and lead.

The three districts are characterized by (1) very large areal extent; (2) very large individual deposits; (3) ore deposition in hard rock; (4) structural and stratigraphic control of most deposits; (5) open-space fillings by most ores, although replacements are important in southeast Missouri, as are veins in Illinois-Kentucky; (6) deposition in certain favorable strata, but ores are not stratabound, nor are they stratiform in detail; (7) subtly complex mineralogy of the ores, which can no longer be called "unusually simple;" (8) markedly radiogenic J-type lead in the galenas deposited epigenetically by heated concentrated brines; (9) presence of mantle-derived alkalic igneous rocks in southeast Missouri; similar mantle-derived alkalic plutons are genetically related to the ores of Illinois-Kentucky, but not to those in the Upper Mississippi Valley; (10) dissolution of large volumes of the carbonate country rock by active ore solutions. (Author's abstract)

HITZMAN, M.W., 1983, Geology of the Cosmos Hills and its relationship to the Ruby Creek copper-cobalt deposit: Ph.D. dissertation, Stanford Univ., Stanford, CA, 386 pp. Indexed under Fluid Inclusions.

HOCHELLA, M.F., Jr., KEEFER, Keith D. and DeJONG, B.H.W.S., 1983, The crystal chemistry of a naturally occurring magnesium hydroxide sulfate hydrate, a precipitate of heated seawater: Geochimica Cosmo. Acta, v. 47, p. 2053-2058. First author at SP-FR-18, Corning Glass Works, Corning, NY 14831, USA.

The crystal chemistry of a naturally occurring magnesium hydroxide sulfate hydrate, $MgSO_4 \cdot 1/3\ Mg(OH_2) \cdot 1/3\ H_2O$ (designated MHSH(2/3)), and a number of existing and predicted compounds which are structurally related to MHSH(2/3) are discussed. An X-ray diffraction powder pattern for MHSH(2/3) is calculated from single crystal data to aid in the identification of this phase, recently found associated with active hydrothermal vents along the East Pacific Rise. It is suggested that this MHSH-type crystal structure can have a variable composition due to a novel chemical substituion, $Mg^{2+} \rightleftarrows 2\ H^+$, which this particular structure may be able to accommodate. In relation to this, a method for determining the stoichiometry of MHSH crystals via density measurements is also proposed. Finally, the leaching properties of heated seawater, instrumental in the genesis of metalliferous deposits on the seafloor, may be due in part to the growth of MHSH-type phases in certain seawater-rock systems. (Authors' abstract)

HOCHSTEIN, M.P., CALDWELL, G. and KIFLE, K., 1983, Minimum age of the Aluto geothermal system (Ethiopia) from fossil temperatures beneath a deep lateral outflow: Proc. 5th New Zealand Geothermal Workshop, p. 209-212. Authors at Geothermal Inst., Univ. Auckland.

Fossil temperatures of about 260°C, obtained from a study of alteration minerals, are indicated for a deep layer of acidic rocks (1.05 km depth) in an exploratory well outside the Aluto geothermal system. The layer is underlain by impermeable, dense basalts. The present-day temperature of the layer is only 90°C. The fossil and present-day temperature profiles can be explained in terms of a heating-cooling cycle associated with the build-up and decay of a deep sheet flow of hot water. A model is presented which reproduces the ancient temperature profile and which shows that the heating-cooling cycle at the bottom of the well lasted about 140,000 yr. Since the thermal outflow originated from the Aluto geothermal system, this period indicates a minimum age for this system. (Authors' abstract)

HODGSON, N., 1983, Carbonatitic magmas and fluids (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 4. Author at Univ. of Leicester.

Carbonatite suites from the Cape Verde Islands have $\delta^{13}C$(pdb) from -5.9 to -1.3 and $\delta^{18}O$(SMOW) from 8.5 to 28.1. Within these carbonatites, trace and rare earth element distribution may be used to postulate magma evolution series. Some carbonatites contain U- and Na-rich accessory minerals, whilst the principal minerals (apatite and calcite) are depleted in these elements. This provides evidence for the separation of an H_2O-rich fluid, which fenitizes the country rocks. It is proposed that this separation event may be observed from the disturbed ^{18}O reservoir, whilst the ^{13}C and REE systems remain relatively undisturbed. (Author's abstract)

HOEFS, J. and TOURET, J., 1982, The sulfur and carbon isotope composition of the deep crust - deduced from scapolites in granulites (abst.): Terra Cognita, v. 2, p. 70. First author at Geochem. Inst. der Univ. Göttingen, FRG.

Goldsmith (1976) has pointed out the scapolite with its specific crystal structure may act like a sponge and thus absorbs the volatiles present during scapolite formation. The analysis of the isotopic composition of scapolite should therefore give us information about the sulfur and carbon isotopic composition of the environment in which scapolite is formed.

We have analyzed granulites of the Furua Complex (Tanzania), in which scapolite is a major rock-forming mineral (up to 30%). $\delta^{34}S$ values vary between 0.3 and 3.6‰ with a mean value of 1.9‰ being slightly heavier than normally found in deep-seated materials. In respect to the carbon isotope compositions, two different components with different isotopic compositions have to be distinguished: one liberated by phosphoric acid at room temperatures with $\delta^{13}C$ values between -3.8 and -11.2‰, with a mean value of -6.7‰. This carbon component seems to occur as very fine-dispersed, submicroscopic carbonate inclusions. The second carbon fraction is liberated by phosphoric acid treatment at high temperatures in the temperature interval 200-400°C and has lighter $\delta^{13}C$ values between -10‰ and -15‰ which seem to represent the CO_3 groups in the scapolite. These $^{13}C/^{12}C$ ratios do not agree with the generally accepted mantle value of around -7‰, but strengthen the earlier ideas by Hoefs and Touret (1976).

Goldsmith, J. (1976): Geol. Soc. Am., Bull. 87, 161.

Hoefs, J., Touret, J. (1976): Contr. Mineral. Petrol. 52, 165.
(Authors' abstract)

HOFSTRA, A.H., 1983, Geology and alteration of the NG alunite area, southern Wah Wah Range, southwesten Utah (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 326. Author at Dept. Geol., Colorado Sch. Mines, Golden, CO 80401.

Th NG Alunite Area is the largest deposit of alunite rock in the U.S. with reserves of 630 million tons of >30% alunite [>10% Al_2O_3].

Oligocene calc-alkaline ignimbrites are pervasively altered to dominantly quartz and alunite forming four large funnel shaped bodies zoned horizontally from silica at the center outward through quartz-alunite, kaolinite-hematite, and montmorillonite-chlorite-calcite-pyrite zones. The vertical pattern grades from silica at the top through quartz-alunite to quartz-alunite-sericite-pyrite at a depth of 250-300 meters. The altered areas are confined by a system of normal faults and are arranged concentrically about three small Miocene porphyritic rhyolite plugs. Monoclinal flexures and tilted fault blocks reflect the presence of a shallow level intrusion. A K-Ar age date of 22.5 m.y. on alunite is contemporaneous with dated rhyolites occurring in this part of the Greta Basin. The isotopic composition of S in alunite of +2.1 per mil is indicative of magmatically derived S. Fluid inclusions in early quartz have homogenization temperatures of 275-325°C and salinities of <2 eq. wt. % NaCl in areas of later intense alteration. Inclusions in alunite consist only of vapor dominant types that were too small to measure. Mineral stability relations indicate the fluids depositing alunite consisted of a solution of H_2SO_4.

These features suggest that H_2S-bearing fluids, evolved from a shallow level intrusion, rose and mixed with circulating meteoric waters that were later oxidized to H_2SO_4 as they crossed the boiling curve [approx. 700 meters below the present surface] on their trip towards the paleosurface. This resulted in the formation of vapor dominated hydrothermal systems in the areas presently altered to alunite. The deposits at NG reflect the action of only the near surface part of a larger hydrothermal system. (Author's abstract)

HOGAN, Lewis, HART, Roger, DYMOND, Jack and SCHILLING, J.-G., 1983, Mantle plume primordial noble gases component in glassy basalts from the Reykjanes Ridge (abst.): EOS, v. 64, p. 348.

HOLLAND, T.J.B., 1983a, Fluids in high pressure metamorphism (abst.): Terra Cognita, v. 3, p. 185.

HOLLAND, T.J.B., 1983b, Aqueous eclogite facies fluid inclusions (abst.): Geol. Soc. Newsletter, v. 12, no. 2, p. 13-14. Author at Univ. Cambridge.

Primary eclogite facies fluids are found entrapped in crystals of omphacite and zoisite from kyanite eclogites of the Hohe Tauern, Austria. Evidence from the field (veins and segregations) and from petrological investigations, both theoretical and experimental indicate that these eclogites were formed under high H_2O-potentials. Confirmatory evidence in the form of fluid inclusions was sought and found; early eclogite inclusions appear to be composed essentially of pure H_2O. The implications are that certain subduction zone eclogites can crystallize wet, and that the extraordinarily high pressures (>18 kb) necessary for their formation pose some uncomfortable tectonic problems. (Author's abstract)

HOLT, R.W. and WRIGHTMAN, R.T., 1983, The role of fluids in the development of a granulite facies transition zone in S India: J. Geol. Soc. London, v. 140, p. 651-656.

The Bodinayakkanur area of Tamil Nadu lies in the transition zone ($P \approx 5$ kbar, $T \approx 700°C$) from amphibolite to granulite facies metamorphism, in the Archaean high grade terrain of S India. Within the zone 3 closely associated rock units occur: (1) Precursor grey gneiss, (2) Pink migmatitic and metasomatic gneiss, (3) Green charnockitic granulites. Field observation shows that the complex interrelations between these 3 rock types can be related to influx of fabric- and layer-guided CO_2- and H_2O + K_2O-rich fluid phases, derived from a deep-seated source. (Authors' abstract)

HONNOREZ, J., HONNOREZ-GUERSTEIN, B.-M., ALT, J.C. and RUIZ, J., 1983, DSDP hole 504B: A 1.35 km long section through a sealed hydrothermal system (abst.): IUGG, XVIII General Assembly, Program and Abstracts, v. 2, p. 812. Authors at Rosenstiel Sch. Marine & Atmos. Sci., Univ. Miami, Miami, FL 33149, USA.

The most complete reference section to date through the upper ocean crust was drilled down to a total depth of 1350 m below sea floor on the southern flank of the Costa Rica Rift. Estimated age is 6.2 my. The simplified lithostratigraphic sequence is given. The parageneses of alteration minerals suggest that the transition zone and dikes were altered under greenschist followed by zeolite facies conditions probably close to the spreading axis. Pillows and flows accumulated as the lower crust cooled and moved away from the axis, and were altered at low temperature (150°C) in a shallow hydrothermal system. Based on the mineralized stockwork in the upper transition zone, the higher temperature alteration is interpreted to be the result of a relatively long term evolving and cooling hydrothermal system, with shorter term fluctuations in temperature and composition of solutions within each stage. Initially, actinolite, chlorite, albite, sphene, and pyrite formed in the rocks from Mg-rich seawater-derived hydrothermal fluids. Subsequently, quartz, epidote, pyrite, sphalerite, chalcopyrite, and minor galena formed in veins. Fluid inclusion data indicated that quartz formed at about 290°C; compositionally zoned sphalerite and sulfide mineral parageneses record fluctuations in temperature and composition of solutions. Stilbite and analcite associated with quartz suggest later formation from more evolved fluids at lower temperature, possibly <200°C. Analcite is partly replaced by later laumontite; fluid inclusions at this reaction front indicate a temperature of 260°C for this reason.

Quartz is also partly replaced by heulandite at this stage. Laumontite in turn is partly replaced prehnite, either in response to increased temperatures or further evolution of hydrothermal solution chemistry. (From the authors' abstract)

HORN, E.E., 1983, Analysis of fluid inclusions using the Heidelberg proton microprobe (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 34. Author at Geologisches Inst., Goldschmidtstr. 3, D - 3400 Göttingen.

The proton-induced X-ray emission (PIXE) microprobe offers an attractive technique for trace element analysis. The purpose of this paper is to demonstrate the feasibility of using the Heidleberg proton microprobe to study the elements in selected fluid inclusions. First investigations were done on quartz samples.

In principle, it is possible to observe elements with atomic numbers greater than 11, corresponding to Na, but in reality this is matrix dependent. (Author's abstract)

HORN, P., KÖHLER, H. and MÜLLER-SOHNIUS, D., 1983, A Rb/Sr WR-isochron ("fluid inclusion")--age of the Bayerischer Pfahl, eastern Bavaria (abst.): Terra Cognita, v. 3, p. 199. Authors at Min. Petr. Inst. Univ. München; Theresienstrasse 41, 8000 München 2, BRD.

The "Bayerischer Pfahl" consists of a system of morphologically prominent hydrothermal quartz lodes, filling en échelon tension gashes and feather joints. It cuts almost vertically the crystalline basement of the Moldanubian metamorphic complex and runs over a length of some 150 km's at N 120° E. Locally it reaches a thickness of 100 m's. The geologically estimated age for the quartz mineralization ranges from 320 Ma to 65 Ma.

The "Pfahl" consists of monomineralic quartz with traces of primary sericite. According to decrepitation/water-leaching experiments, the Rb- and Sr inventory of the WR is dominated by a ~75% contribution from abundant primary and secondary fluid inclusions in the quartz, the rest is from the sericite. Rb concentations in the WR's are in the range 4.23 ppm to .119 pm, the 87Rb/86Sr-ratios range from 24.3 to .92. We obtain a WR isochron age (5 points; λ 87Rb = $1.42 \times 10^{-11} a^{-1}$) of 239 ±7 Ma and an initial 87Sr/86Sr-ratio of .7126 ±4.

This initial Sr-isotopic ratio coincides with the respective ratios measured on a sequence (old → young) of fluorites - carbonates - barytes found within the Nabburg - Wölsendorf mineral district, at the northern end of the Pfahl zone, which is genetically related to the quartz mineralization.

Assuming one of the adjacent granites having a Rb/Sr- element ratio of ~4 as a likely source for the fluorite/baryte- and quartz mineralization, the (secondary) hydrothermal activity in that region could not have lasted longer than ~20 Ma.

The age result of 240 Ma (Upper Permian) and the initial 87Sr/86Sr-ratios are discussed in their geological and petrological context. The significance of the isochron obtained will be considered either.(sic) (Authors' abstract)

HOVORKA, S.D., 1983, Carbonate-anhydrite-halite cycles San Andres Formation (Permian) Palo Duro Basin, Texas, *in* R.L. Shaw and B.J. Pollan, eds, Permian Basin Cores--A Workshop: S.E.P.M. Core Workshop #2, May 17-18, 1983, Midland, Texas, p. 197-224. Author at Bureau of Econ. Geol., The Univ. Texas at Austin, Austin, TX.

The San Andres Formation in the Palo Duro Basin is composed of stacked regressive cycles consisting of, from bottom to top, limestone, dolomite, nodular anhydrite, laminated anhydrite, bedded halite, and chaotic mixtures of halite and mudstone. The transgressive phase initiating each cycle, unit 5 of the lower San Andres Formation in the DOE-Stone and Webster #1 Mansfield core, is exhibited here. It is composed of four incomplete subcycles which in combination contain examples of all lithologies. (Author's abstract)

The distribution of fluid inclusions is used in interpreting the textures. (E.R.)

HOWER, J.C., FIENE, F.L., WILD, G.D. and HELFRICH, C.T., 1983, Coal metamorphism in the upper portion of the Pennsylvanian Sturgis Formation in western Kentucky: Geol. Soc. Am. Bull., v. 94, p. 1475-1481. First author at Univ. Kentucky, Inst. for Mining & Minerals Res., Iron Works Pike, Box 13015, Lexington, KY 40512.

Coals from the Pennsylvanian upper Sturgis Formation (Missourian and Virgilian) were sampled from a borehole in Union County, western Kentucky. The coals exhibited two discrete levels of metamorphism. The lower-rank coals with vitrinite reflectances indicative of high volatile C bituminous were assumed to represent the normal level of metamorphism. A second set of coals with vitrinite reflectances indicative of high volatile A bituminous was found to be associated with sphalerite, chlorite, and twinned calcite. The latter mineral assemblages indicate that hydrothermal metamorphism was responsible for the anomalous high rank. Consideration of the sphalerite fluid-inclusion temperatures from nearby ores and coals and the time-temperature aspects of the coal metamorphism suggests that the hydrothermal metamorphic event was in the 150 to 200°C range for a brief time (10^5-10^5 yr), as opposed to the longer term (25-50 m.y.) 60 to 75°C ambient metamorphism. (Authors' abstract)

HUDSON, D.M., 1983, Alteration and geochemical characteristics of the upper parts of selected porphyry systems, western Nevada: Ph.D. dissertation, Univ. Nevada, Reno.

HURAI, Vratislav, 1983a Fluid inclusions in quartz from alpine type fissures of Veporic crystalline and their genetic interpretation: Mineralia Slov., v. 15, no. 3, p. 243-260 (in Slovenian; English abstract and summary). Author at Katedra geochemie a mineralogie PFUK, Kalinciakova 8, 832 32 Bratislava.

Microthermometry results (freezing and heating stage) and chemical analyses of leachates obtained by crushing of quartz crystals from Alpine type fissures have shown two types of metamorphic fluids originated in dependence on thermodynamic conditions of Alpine metamorphism and nature of the host rocks. First type contains high amounts of dissolved salts (14-24 wt % NaCl eq.) and second one is CO_2-rich (17-50 wt %) and salt content varies from 2 to 3.5 wt % NaCl eq. Pressures and temperatures of quartz formation were calculated using microthermometry results and atomic ratio K/Na of fluids. Estimated conditions decrease from 487 ± 67°C and 275 ± 70 MPa (salt-rich solutions) to 372 ± 43°C and 115 ± 11 MPa (average value for CO_2-rich solutions). (Author's abstract)

HURAI, Vratislav, 1983b, Exploded fluid inclusions in quartz from Alpine fissures and their significance: Geol. Zborník - Geol. Carpathica, v. 34, no. 4, p. 495-503. Author at Dept. Geochem. & Mineral. of the Faculty of Natural Sci. of the Comenius Univ., Sec. Mineral. & Crystallogr., Kalinciakova 8, 832 32 Bratislava.

From the published geochronological data (K-Ar dating of biotite, apatite fission tracks ages), and thermodynamic conditions of origin of the Alpine type veins, it is deduced that the rate of uplifting of the Veporides in the Upper Cretaceous was at least 0.3 mm/year. In quartz from Alpine veins near Kokava and Klenovec exploded primary inclusions of metamorphic solutions were discovered. The process of dehermetization is improbable in conditions of regional metamorphism, therefore the presence of these inclusions is interpreted as a result of postmetamorphic heat flow. (Author's abstract)

HUTCHISON, C.S., 1983, Economic deposits and their tectonic setting: John Wiley & Sons, New York, 365 pp.

IKORSKIY, S.V. and VOLOSHIN, A.V., 1982, Typical gas-phase compositions in inclusions in quartz from Kola Peninsula granite pegmatites: Geokhimiya, no. 10, p. 1464-1471 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 5, p. 173-179, 1983). Authors at Geol. Inst., Kola Br., Acad. Sci. USSR, Aptity, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 98, 1982. (E.R.)

IKORSKIY, S.V. and NIVIN, V.A., 1983, Gases in the free gas phase in rocks of the Lovozero alkaline massif (Kola Peninsula): Dokl. Akad. Nauk SSSR, v. 269, no. 4, p. 934-936 (in Russian). Authors at Geol. Inst. of Kola Division of Acad. Sci. USSR, Apatity, USSR.

Samples of gases emanating during underground mining in the Lovozero massif were analyzed and the results are as follows (in vol. %, D = initial emanation, cm^3 per hour, t - time of observation, n - number of samples): urtites H_2 18.6-59-2, CH_4 39.3-72.6, C_2H_6 6.4, He 1.5-2.4, D 0.5-325.6, t 78-197, n 11-14; foyaites H_2 33.2-54.5, CH_4 41.3-63.2, C_2H_6 0.9-2.9, He 0.8-3.3, D 9.1-579.0, t 126-197, n 7-20; lujavrite H_2 61.0, CH_4 37.9, C_2H_6 not determined, He 1.1, D 24.5, t 78, n 10. (Abstract by A.K.)

IL, H.K. and YONG, W.J., 1983, A study of environment of mineral formation of quartz vein in Wolak tungsten-molybdenum deposit by heating stage microscope and decrepitation method: J. of the Korean Inst. of Mineral & Mining Engin., v. 20, p. 75-81 (in Korean; English abstract).

The Wolak mine is located in Hwanggang-ri mining district and is producing tungsten and molybdenum ores.

Temperature of mineral-formation of quartz veins in Kwang-cheon ore deposit is estimated by means of heating stage microscope and decrepitation and pressure of mineral-formation is calculated using Shatagin's empirical equation.

A grain size of -45~+80 mesh (0.18~0.32mm) is most satisfactory for decrepitation method. By comparison of Th and Td, the temperature at the beginning of decrepigraph corresponds to Th and the temperature at the maximum frequency of decrepigraph corresponds to the temperature corrected by pressure which is calculated by Shatagin's equation.

Vertical temperature variation is established in that the decrepitation temperature gradually increases with depth at No. 1 vein.

The temperature and pressure of mineral-formation in Wolak mine is estimated as about 350°C and 1213.4 atm. (Authors' abstract)

ILUPIN, I.P., EFIMOVA, E.S., SOBOLEV, N.V., USOVA, L.V., SAVRASOV, D.I. and KHAR'KIV, A.D., 1982, Inclusions in diamond from diamond-bearing dunite: Akad. Nauk SSSR Doklady, v. 264, no. 2, p. 454-456 (in Russian). First author at Central Sci.-Res. Geol.-Prosp. Inst. of Base and Precious Metals, Moscow, USSR.

Diamond from diamond-bearing peridotite (dunite) xenolith from kimberlite pipe "Udachnaya-Vostochnaya" (pure olivine + 2 diamonds + 1 pyrope grain) bears inclusions of olivine and chromite. The inclusions belong to the same paragenesis as the xenolith dunite, with inclusion olivine being a higher-temperature variety (in iron content) than the xenolith olivine. (A.K.)

IL'YIN, V.A., 1983, A method of evaluating the composition, formation mechanisms, and production levels of plutonic fluids in some hydrothermal systems in Kamchatka: Geokhimiya, no. 2, p. 208-214 (in Russian; translated in Geochem. Int'l., v. 20, no. 1, p. 131-137, 1983).

IMAI, Hideki, 1983, Environment of ore deposition at the Akenobe mine, central Japan: Mining Geol., v. 33, no. 3, p. 177-183. Author at 1-53, Haramachi, Shinjuku-ku, Tokyo 162, Japan.

Includes a discussion of the several published reports of fluid inclusion data from Akenobe. (E.R.)

INGRIN, J., MARTIN, F.R., MADON, M. and POIRIER, J.P., 1983, Transmission electron microscopic examination of tephra from Caribbean volcanoes (abst.): Terra Cognita, v. 3, p. 151. Authors at Inst. Phys. Globe de Paris, Univ. Paris VI, 4 Place Jussieu, 75230 Paris Cedex 05, France.

Glass immiscibility was detected. (E.R.)

INSHIN, P.V., ABAULINA, L.I. and TSAREV, V.V., 1983, Behavior of carbon during formation of gold ore deposits in terrigenous "black shale" beds: Dokl. Akad. Nauk SSSR, v. 269, no. 5, p. 1156-1158 (in Russian).

A gold ore deposit (name not given) occurs in Upper Proterozoic sediments in a fault zone as essentially three types of ores: veins, veinlet-disseminated and disseminated. Ore minerals include pyrite, arsenopyrite, pyrrhotite; native gold occurs in quartz, coal-bearing formations, carbonates and as finely dispersed emulsion in sulfides. Quartz of altered wall rocks bears 400-500 (av. 440) μg of H_2O per gram, quartz of ores - 500-1100 (av. 700) μg H_2O per g (7 and 4 determinations, respectively). Wall rock quartz contains in inclusions (g per kg H_2O) CO_2 45-100 (av. 65), 7 determinations, N_2 20-110 (av. 60), 9 determinations, Cl 44-55 (av. 45) 8 determinations, ore-bearing quartz - CO_2 50-500 (av. 230), 4 determinations, 60-140 (av. 100), 2 determinations, Cl 10-40 (av. 20), 3 determinations. The above data indicate higher redox potential of fluids of the ore stage than in the other ones. (Abstract by A.K.)

INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS, 1979, Hydrogeochemistry of mineralized waters, Conf. of Cieplice Spa (Poland), 1978 Proceedings: Geol. Inst. Warsaw, 402 pp.

Consists of papers on four subjects:

1. The dependence of the chemical composition of mineralized waters upon the rock environment.
2. The isotopic composition as an indicator of the origin of mineralized waters and of their components [H, O, C].
3. Mineralized waters as a source of mineral deposits and of information on the occurrence of mineral deposits.
4. Depth of the fresh water-mineralized water boundary. (E.R.)

IRVINE, T.N., KEITH, D.W. and TODD, S.G., 1983, The J-M platinum-palladium reef of the Stillwater Complex, Montana: II. Origin by double-diffusive convective magma mixing and implications for the Bushveld Complex: Econ. Geol., v. 78, p. 1287-1334. First author at Geophy. Lab., Carnegie Inst.

Washington, Washington, DC 20008.

In the first paper of this two-part series, Todd et al. (1982) pointed to evidence that the Stillwater Complex is the product of two parent liquids, the first having ultramafic characteristics, the second, anorthositic affinities. From their data, they argued that the J-M Reef sulfides formed from immiscible sulfide liquid precipitated in response to mixing of the two parents, with the Pt and Pd apparently being derived from the first and most of the sulfur from the second. The present paper is an attempt to describe the chemical and physical processes involved in the mixing event. (From the authors' abstract)

ISHIHARA, Shunso and MORISHITA, Yuichi, 1983, Neogene molybdenite mineralization in the Jokoku mine area, Hokkaido: Bull. Geol. Surv. Japan, v. 34, no. 2, p. 81-87 (in Japanese; English abstract).

A new occurrence of molybdenite was found in the eastern part of the rhodochrosite-mineralized area of the Jokoku mine, Hokkaido. It occurs in altered rhyolitic pyroclastics (Fukuyama formation) and porphyrite of Miocene age. The mineral is fine-grained and small in amount, occurring in microveinlets of quartz, sericite and pyrite. Oxygen isotopic study indicates that the hydrothermal ore solution responsible for the formation of the quartz veinlets is largely of meteoric water origin. Th of fluid inclusions in the quartz is around 277°C. The molybdenite is considered to have formed under a volcanic environment with relatively higher temperature than manganese and base metal veins in the Jokoku mine area. The molybdenite showing has common features to other molybdenite occurrences in volcanic rocks of the Green Tuff belt, which are mafic (quartz diorite-granodioritic) rock related with phyllic (-propylitic) alterations. (Authors' abstract)

ISLAM, S. and HESSE, R., 1983, The P-T conditions of late-stage diagenesis and low grade metamorphism in the Taconic Belt of the Gaspé Peninsula from fluid inclusions: Preliminary results, in Current Research, Part B, Geol. Survey of Canada, Paper 83-1B, p. 145-150. Authors at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec, H3A 2A7, Canada.

In diagenetic and low grade metamorphic terrains of the Taconic Belt of the Gaspe-Peninsula four types of fluid inclusions were observed in vein quartz from ac-joints: 1) CH_4-inclusions; 2) two-phase H_2O-inclusions; 3) three-phase liquid H_2O, liquid CO_2 and vapor CO_2 inclusions and 4) four-phase H_2O, $CO_2(L + V)$ and salt (solid) inclusions. Correlation between maturation zones (established by pyrobitumen reflectance and illite crystallinity), fluid compositions and Th of water-rich inclusions is as follows: Late diagenetic zone: H_2O, CH_4: Th generally below 200°C; Anchimetamorphic zone: $H_2O \pm CO_2$; Th generally between 200 and 270°C (but as low as 130°C); and Epimetamorphic zone: $CO_2 + H_2O$; $CO_2 + H_2O$ + salt crystal; H_2O, Th up to 320°C (but as low as 150°C).

The water-rich fluids are generally low salinity (1.5 equiv. wt. %) NaCl-brines or $CaCl_2$-brines (up to 8% salinity). Minimum subsurface pressures at the time of entrapment determined from CH_4 inclusions ranged from 620 to 780 bars. (Authors' abstract)

ISRAELACHVILI, J.N. and PASHLEY, R.M., 1983, Molecular layering of water at surfaces and origin of repulsive hydration forces: Nature, v. 306, p. 249-250. Authors at Dept. Applied Math., Inst. Advanced Studies, Australian Nat'l. Univ., Canberra, ACT 2600, Australia.

The short-range forces between hydrophilic surfaces in water determine the behavior of many diverse systems such as the stability of colloidal dispersions and soap films, the swelling of clays and the interactions of biological membranes and macromolecules. So far, all experimental measurements of these forces have indicated that they are repulsive and decay monotonically with distance out to separations of up to ~6 nm. These forces, variously termed 'structural' or 'hydration' forces, arise from the energy needed to dehydrate interacting surfaces which contain ionic or polar species. Here we have measured, in some detail, the short-range hydration force between two molecularly smooth surfaces of mica containing hydrated potassium ions. We find that while the hydration force is overall repulsive it is not monotonic at separations ≤1.5 nm but exhibits oscillations, that is, alternating maxima and minima with a mean periodicity of 0.25 ± 0.03 nm, roughly the diameter of the water molecule. These results rationalize apparently irreconcilable observations on clay-water systems and go some way towards clarifying the origin and nature of hydration forces. (Authors' abstract)

ITO, E. and ANDERSON, A.T., Jr., 1983, Submarine metamorphism of gabbros from the Mid-Cayman Rise: Petrographic and mineralogic constraints on hydrothermal processes at slow-spreading ridges: Contrib. Mineral. Petrol., v. 82, p. 371-388.

ITO, Emi, HARRIS, D.M. and ANDERSON, A.T., Jr., 1983, Alteration of oceanic crust and geologic cycling of chlorine and water: Geochimica Cosmo. Acta, v. 47, p. 1613-1624. First author at Dept. Geol. & Geophy., Univ. Minnesota, 310 Pillsbury Dr., S.E., Minneapolis, MN 55455.

We report new estimates of transport rates for H_2O and Cl between the mantle and surface reservoirs. Our estimates take into consideration alteration of oceanic crust, especially that of plutonic rocks, and possible subduction of sediments. The effect of (hydrothermal) alteration on the Cl budget seems to be negligible, but the effect on the H_2O budget is significant. Altered oceanic crust (excluding sediments) contains about 10 times a much H_2O as the unaltered crust, and its subduction may result in a net transport of H_2O to the upper mantle in subduction zones. However, the rate of expulsion of H_2O from the mantle by subduction-zone magmatism is comparable to the amount released by ridge magmatism, and is only about 10% of the amount subducted. Therefore, about 90% of the subducted H_2O must be returned to the mantle or returned to the crust by other processes. In addition, subduction of oceanic sediments to mantle depths will result in (1) a further increase in the return rate of H_2O to the mantle reservoir, and (2) possible net transfer of Cl to the mantle, depending on the rate of pore water expulsion. (Authors' abstract)

IVANOV, Yu.A. and GERTMAN, P.L., 1983, Fluorite-polymetal deposits of the Ata-Kumkol' volcanic structure: Geol. Rudn. Mestorozhd., v. 25, no. 5, p. 55-58 (in Russian). Authors at Middle-Asian Sci.-Research Inst. of Geol. and Mineral Raw Materials, Tashkent, USSR.

Fluorite filling the central parts of veins has Td 200-240°C, accessory barite 200°C. (A.K.)

IVANOVA, G.F., MAROV, I.N., NAUMOV, V.B., ZHUKOV, V.V. and CHERNOGOROVA, S.M., 1983, Manganese and iron in fluorite from tungsten deposits: Geokhimiya, no. 4, p. 502-513 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 2, p. 134-145, 1983). First author at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

Fluorite from various deposits yielded the following Th (°C): Mongolia, W deposit Kyzyl-Tau 247-345; Mo-W deposit Yugodzyr' 133-335; W deposit

Borun-Tsogto 254-282; Mo-W deposit Tumen-Tsogto 210-318; W deposit Ongon-Khayrkhan 151-316; W deposit Ikh-Khayrkhan 45-290; USSR, Transbaikalia, W deposit Dzhida 158-323; W deposit Spokoynoe 271-275; Chukotka, Sn deposit Industrial'noe 305-710; Caucasus, Mo-W deposit Tyrnyauz 625-655. (A.K.)

IVANOVA, N.I., KOGAN, B.S. and PERTSOV, N.V., 1981, Effect of the liquid phase on the formation of joints in mechanically stressed quartz diorite: Dokl. Akad. Nauk SSSR, v. 259, p. 1423-1427 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 259, p. 97-100, 1983).

IZAWA, Eiji and URASHIMA, Yukitoshi, 1983, Gold-silver deposits in southern Kyushu, Japan: Mining & Metallurgical Inst. of Japan/Australian Inst. of Mining & Metallurgy Joint Symposium 1983, Sendai, p. 97-111. First author at Dept. Mining, Kyushu Univ., Fukuoka, Japan.

There are two epochs of gold-silver mineralization in southern Kyushu, a) silver-rich veins related to the middle Miocene felsic intrusives, and b) gold-silver deposits associated with the Pliocene-Pleistocene volcanism.

Several important gold-silver deposits belong to the latter group. Cretaceous sediments and Miocene and younger volcanics serve as hosts for the deposits. The younger mineralization might be correlated with global increase in volcanism during the latest Tertiary and Quaternary.

Mineralization temperatures range generally from 160 to 280°C for both groups of deposits. The Miocene deposits are characterized by relatively reducing conditions of formation and the Pliocene-Pleistocene deposits seem to be formed under more oxidized conditions. These characteristics reflect the differences in depth of formation, host rocks, and possibly the nature of related magmatism between two groups of deposits. (Authors' abstract)

Sixteen deposits are listed with Th values from 128 to 350°C, in part from the literature and in part unpublished work. (E.R.)

JACKSON, K.J., 1983, Chemical and thermodynamic constraints on the hydrothermal transport and deposition of tin: Ph.D. dissertation, Univ. California, Berkeley, 104 pp.

Indexed under fluid inclusions. (E.R.)

JACQUES, D.F. and BOURLAND, B.I., 1983, A study of solubility of strontium sulfate: Soc. Petro. Engrs. J., v. 23, p. 292-300.

JAMES, O.B. and McGEE, J.J., 1979, Consortium breccia 73255: Genesis and history of two coarse-grained "norite" clasts: Proc. Lunar Planet. Sci. Conf. 10th, p. 713-743. Authors at U.S. Geol. Survey, Reston, VA 22092.

Many of the plagioclase grains have cores containing abundant, evenly distributed 5-20 μm inclusions of several other phases. One core has a sharp boundary that defines a subhedral outline (Fig. 3a), but most have poorly defined boundaries. Locally, the inclusions are concentrated in bands and along twin boundaries; such inclusions tend to be relatively large, as much as 50 μm across. Roughly a third of the inclusions in the plagioclase cores are K-feldspar, a third consist of intergrowths of a silica phase and oxide minerals, a third contain both K-feldspar and silica-oxide intergrowths, and a very small number are augite. Rarely the K-feldspar inclusions contain one or two micrometer-sized grains of iron metal and/or whitlockite. The silica phase forms the bulk of individual inclusions, and the oxide minerals form tiny globules or needles within it. In the inclusions consisting of both K-feldspar and silica-oxide intergrowths, the two types of material occupy distinct areas.

In addition to the inclusions described above, the plagioclase grains contain needlelike inclusions much less than 1 μm across. These are scattered uniformly throughout the grains, except that inclusion-free zones as much as 70 μm thick are present at the edges of the grains and bordering planar concentrations of the larger inclusions. From their reflectivities, most of these minute inclusions appear to be a low-refractive-index silica phase or K-feldspar.

The inclusions of K-feldspar and silica-oxide intergrowths within the plagioclase most likely are precipitates that exsolved from the plagioclase rather than inclusions that were incorporated in the plagioclase when it crystallized. K-feldspar, certainly, is much more likely to be an exsolution product than an early-formed phase in a lunar melt that was crystallizing orthopyroxene and plagioclase; moreover, the textures of the K-feldspar inclusions support an origin by exsolution. The textures and compositions of the inclusions of silica-oxide intergrowths also support an origin by precipitation from the plagioclase. First, these inclusions contain a fairly consistent mineral assemblage which suggests derivation by breakdown of another phase, one composed largely of SiO_2, TiO_2, Nb_2O_5, and ZrO_2. A phase composed primarily of these oxides has an unlikely bulk composition for a trapped liquid or an early-formed mineral, and it is more likely that it consisted of a dissolved component in the plagioclase. Second, textures of the inclusions indicate that they replaced the plagioclase; they have highly irregular lobate margins and commonly contain small unreplaced blebs of plagioclase. Third, the intergrowths commonly occur in composite inclusions with K-feldspar; the K-feldspar is more clearly the product of exsolution, and the spatial association suggests an origin by the same process. Fourth, concentrations of such inclusions are typically surrounded by zones that are relatively depleted in minute precipitates; this depletion suggests that the constituents of the inclusions diffused to them through the surrounding plagioclase. Thus, the evidence indicates that the inclusions in the plagioclase cores formed because the earliest crystallized plagioclase incorporated in its structure significant amounts of K-Ba feldspar components and Ti-Nb-Zr silicate components; subsequent exsolution of these components produced the inclusions. The septa of quartz and K-feldspar that mark plagioclase grain boundaries also probably formed by diffusion of exsolved constituents to grain boundaries. The edges of the plagioclase grains commonly show zones free of precipitates, suggesting that their constituents migrated out of the grains; the phase assemblage in the septa is consistent with such an origin. (From the authors' text)

JANARDHAN, A.S., NEWTON, R.C. and HANSEN, E.C., 1983, Transformation of peninsular gneiss to charnockite in southern Karnataka, in Precambrian of South India, S.M. Naqvi and J.J.W. Rogers, eds., based on Proc. of the Indo-U.S. Workshop, Hyderabad, 12-14 January, 1982: Geol. Soc. of India, Bangalore, p. 417-435. First author at Dept. Geol., Univ. Mysore, Mysore 570 006, India.

Chemical and mineralogical studies of charnockites from several localities in the amphibolite facies to granulite facies transition zone in southern Karnataka, including the Kabbal locality, demonstrate that the progressive conversion of amphibole-bearing gneiss to charnockite from north to south is prograde, with arrested charnockite development seen as a general feature. Incipient charnockites have relatively high Rb and other light-element lithophile (LIL) element contents, and some samples are chemically indistinguishable from adjacent amphibole-bearing gneisses, indicating that, in spite of ubiquitous and closely-associated migmatization, igneous processes are not directly responsible for the charnockite. Rather, a low-PH_2O vapor is implicated. Fluid inclusion studies of Kabbal rocks reveal a succession of fluids which started with H_2O-rich compositions and which became more CO_2-rich with time during the metamorphism, culminating in a vapor having less than 20% H_2O. This vapor was followed by late H_2O-rich fluids in small amounts in the waning stages of metamorphism, which effected minor retrogression.

Several charnockites from the Biligirirangan and Nilgiri Hills massifs were also studied. Light element lithophile depletion is generally pronounced in these rocks. Mineralogic geothermometry and geobarometry indicate metamorphism at 750°-900°C and 6 to 9 kbar, conditions considerably more elevated than those which operated on the incipient charnockites (~750°C and 5 to 6 kbar).

At present we have no evidence against the existence of continuity of indicated temperature, pressure, CO_2 activity, and LIL depletion from the incipient to the massif areas, nor does there exist decisive geochronological evidence against such continuous progression in metamorphic grade. Future detailed geochemical traverses across the critical zone will decide whether the massif charnockites differ in kind, rather than in degree, from the incipient charnockites. A simple depth-zone relation between lower-grade gneisses and charnockites in the north, to higher-grade charnockites in the south, as advocated by C.S. Pichamuthu, is probably the simplest way to correlate all of our observations. The source of the large amount of CO_2 necessary for charnockite development is not known at present; crustal and subcrustal sources are possible. (Authors' abstract)

JANECKY, D.R. and SEYFRIED, W.E., Jr., 1983, The solubility of magnesium-hydroxide-sulfate-hydrate in seawater at elevated temperatures and pressures: Am. J. Sci., v. 283, p. 831-860. Authors at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN 55455.

A series of experiments has been performed to assess the chemistry and solubility of magnesium-hydroxide-sulfate-hydrate (MHSH) in seawater solutions at 200° to 350°C and 250 to 1000 bars. Results permitted evaluation of MHSH stability over a range of temperatures and pressures.

Chemical mass balance calculations and mineral stability data indicate that two MHSH stoichiometries exist: MSHS(0.75) and MHSH(0.625). At temperatures ≥300°C and pressures ≤500 bars, MHSH(0.625) is stable relative to MHSH(0.75). Increasing pressures enhances MHSH stability relative to anhydrite and enhances MHSH(0.75) stability relative to MHSH(0.625).

Results of these experiments constrain significantly implications drawn from seawater-basalt interaction experiments and from studies of ridge crest hydrothermal fluids and associated mineralogy. (Authors' abstrat)

JANIK, C.J. and DOBSON, P.F., 1983, Thermodynamic, isotopic, and chemical evidence for equilibrium in the Los Azufres geothermal system (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 603.

JANIK, C.J., NEHRING, N.L. and TRUESDELL, A.H., 1983, Stable isotope geochemistry of thermal fluids from Lassen Volcanic National Park, California: Geother. Resources Council, Transactions, v. 7, p. 295-300.

JAVOY, M. and PINEAU, F., 1982, Carbon isotopes in the upper mantle and the lower crust and the outgassing of the mantle (abst.): Terra Cognita, v. 2, p. 70-71.

JAVOY, M., PINEAU, F. and DEMAIFFE, D., 1983a. The isotopic composition of carbon and nitrogen in diamonds from Mbuji Mayi (Zaire) (abst.): Terra Cognita, v. 3, p. 124. First author at Lab. Géochimie des Isotopes Stables, Univ. Paris 7, U.E.R. des Sci. de la Terre, 2 Place Jussieu, 75251 Paris Cedex 05, France.

We have analyzed a suite of diamonds and kimberlitic carbonates from the district of Mbuji Mayi (Zaire), which consists of 14 pipes and eluvial deposits of late Cretaceous age, most of which aligned on an E.W. fracture of the Archean Kasai craton. The kimberlites here are very typical in chemical composition although significantly enriched in volatiles relative to the average kimberlitic composition. They display the typical "discrete nodule association" or "megacryst suite" and their strontium isotope composition suggests an undepleted mantle source.

The diamonds (mean weight of about 1 gram) are poorly crystallized aggregates although some of them display cubic crystalline habits. Their optical spectrum, when determined, corresponds typically to type Ia as well as their nitrogen content. Some smaller and better crystallized diamonds have been analyzed for the $^{13}C/^{12}C$ ratios and kimberlitic carbonates have been analyzed in the breccias a well as in the so-called primary kimberlitic nodules.

The carbonate content of the nodules varies from 9 to 34%. Their $\delta^{13}C$ range (-5.5 to -11.8‰/PDB) is very similar, if not identical, to the $\delta^{13}C$ range of the diamonds (-10.5 to -5.3‰). The large diamonds are isotopically homogeneous or very homogeneous (0,3 to 0,1% total $\delta^{13}C$ variation), whereas the small and better crystallized diamonds show eventually considerable variations (up to 5.8‰ for a 4.6 mg diamond) with higher $\delta^{13}C$ apparently concentrated toward the center.

The nitrogen congent of the diamonds varies from 100 to 1500 ppm with $\delta^{15}N$ between -9.8 and +10‰, the lowest $\delta^{15}N$ being associated with the highest nitrogen contents. The ^{13}C results are coherent with distillation effects during the growth of diamonds. The nitrogen results suggest that the earth is far from having totally degassed its nitrogen and that the heavy isotopic compositions obtained so far for upper mantle materials are the composite result of strong fractionation processes and dual origin for terrestrial nitrogen. (Authors' abstract)

JAVOY, M., PINEAU, F. and DEMAIFFE, D., 1983b. The diamonds of Mbuji Mayi and the story of terrestrial nitrogen (abst): EOS, Transactions, Am. Geophy. Union, v. 64, no. 45, p. 882. First author at Lab. Géochimie Isotopes stables - LA 196 C.N.R.S. Univ. Paris VII - 2 Place Jussieu - F075230 Paris Cedex 05, France.

The concentration and isotopic composition of nitrogen, measured in large diamonds (gram size) from the Mbuji Mayi kimberlite district (Zaire) show a large range of variation ($250 < N < 1300$ ppm, $-7.5 < \delta^{15}N < +5.5$). The heavier nitrogen is associated with the larger concentrations. Those diamonds are individually relatively homogeneous in $\delta^{13}C$ while rather large variations occur within small octahedral diamonds from the same district. 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 kinberlites ($-11.8 < \delta^{13}C < -5.5$). The carbon data indicate a complex story of crystallization within a deep seated system fractionating its carbon isotopes.

The nitrogen results indicate that deep seated nitrogen is markedly depleted in ^{15}N relative to atmosphere sediments and upper mantle residual nitrogen. This is a strong indication of heterogeneous accretion. (Authors' abstract)

JEBRAK, M., DEBBAH, M. and TOURAY, J.-C., 1983, Brines associated with fluorite veins of central Morocco (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 35 (in French; translation courtesy M.J. Logsdon). First author at BRGM, Orleans, France.

Emplaced in a low-grade, multiply deformed Paleozoic terrain of central Morocco, the fluorite districts of El Hammam and Zrahina show different mineralogy (F-Ca-Pyrrh and F-Ba-Pb), but similar structural control. In these two cases, an optical study of inclusions in calcites and fluorites show the development of Ca-Na-Cl brines.

At Zrahina, the principal fluorite-galena deposition occurred from solutions near 120°C (+ a pressure correction) and show a high concentration of $CaCl_2$ (Tf = -20°C). At El Hammam, the district developed around an apex of peraluminous granite and shows a marked horizontal zonation. In the center of the district, veins of fluorite and calcite, surrounded by metamorphic country rock, were emplaced by highly concentrated brines. Within the veins, there is a very strong [vertical?] temperature gradient (13 degrees/m, between 170 and 130°C Th). Surrounding this, veins of fluorite are surrounded by carbonate. The salinity is comparable to that in the central zone, but the temperatures are lower (120-130°C). In the external zone, veins of fluorite are surrounded by microgranite, with temperatures similar to the middle zone, but with lower salinities.

The presence of secondary inclusions with salt cubes, typical for these secondary inclusions, in microfractures of the enclosing country rock indicates interstitial circulation at some distance from the principal hydrothermal conduits marked by the fluorite veins.

The fluorite veins of central Morocco, emplaced by high salinity solutions, are similar to the deposits of Tarn (France) and the North Pennines (UK), and the structural characteristics and zonations differ little. At El Hammam, the early appearance in the W-Sn mineralization of minerals high in alkalies and halogens suggests an endogenous origin. Thus, these deposits differ from the Triassic-Liassic fluorite veins, for which the early, low-salinity fluids evolved over time toward more concentrated solutions. (Authors' abstract)

JIANG, Bangjie, 1983, Application of a new inorganic gas-chromatograph to research of geochemistry (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 604. Author at Inst. Geochem., Acad. Sinica, Guiyang, PRC.

A new type of inorganic gas-chromatograph with a thermal dissociation device was designed and manufactured for the analysis of volatiles in minerals and rocks. A method for determination of H_2O^-, H_2O^+, CO_2 and S in situ has also been established. It is characterized by high sensitivity (to 10^{-3}%), high speed (within 20 min.), small quantity of sample (0.1 mg) and simplicity in operation.

This method can also be used for fluid inclusion research. It is possible to separately determine the composition of primary and secondary fluid inclusions. We have analyzed fluid inclusions in different types of tungsten and rock-crystal mineral deposits in south China. It has been shown that there are some differences in H_2O and CO_2 contents in different types of ore deposits. Regular variation has been found in the content of water, i.e., it decreases wtih decreasing distance toward parent rocks or with increasing temperature and vice versa.

This method can also be used for studying some geologic objectives. For example, striking distinctions in volatile components between old and young granites, alkaline and acidic rocks, primary and recrystallized biotites in some rocks, as well as early and late stages of magmatic activity have been observed.

This instrument is a valuable research tool in the pursuit of these important studies. (Author's abstract)

JOCKWER, Norbert, 1982, Gas production and liberation from rock salt samples and potential consequences on the disposal of high-level radioactive waste in salt domes, in W. Lutze, ed., Scientific Basis for Nuclear Waste Management V: Proc. of the Materials Res. Soc. 5th Int'l. Symp. on Sci. Basis for Nuclear Waste Mgmt., June 7-10, 1982, Berlin, Germany, p. 467-475. Author at Gesellschaft für Strahlen- und Umweltforschung mbH, Inst. Tieflagerung, Theodor-Heuß-Str. 4, D-3300 Braunschweig, FRG.

Loss in weight on heating and chemical analyses (20) for HCl, H_2S and CO_2 evolved at 500°C are given, as well as evolution with time during heating to 450°C for H_2O, H_2S, HCl, CO_2, CH_4 and SO_4. (E.R.)

JOHAN, Z., DUNLOP, H., LE BEL, L., ROBERT, J.L. and VOLFINGER, M., 1983, Origin of chromite deposits in ophiolitic complexes: evidence for a volatile- and sodium-rich reducing fluid phase: Fortschritte der Mineral., v. 61, part 1, p. 105-107.

See abstract by Johan et al., 1982, in previous volume of Fluid Inclusion Research--Proceedings of COFFI. (E.R.)

JOHANSSON, Åke, 1983, Fluid inclusion and stable isotope studies on some Caledonian sulfide-bearing veins in Sweden (abst.): Program & Abstracts, Symp. on Stratabound Sulfides of the Appalachian-Caledonian Orogen, Ottawa, Canada, Sept. 16-17, 1983, Int'l. Geol. Correlation Prog. Project No. 60, p. 17.

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 versus CDT, while 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, Nasafjall, however, shows little variation within the 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 to +28) have been found during this study.

Fluid inclusion data from the Akerlandet calcite vein suggest that it formed at temperatures between +75 and +165°C (no pressure correction) during mixing between two hot saline brines. Oxygen isotope data on calcite from this vein suggest that the water of these brines was wholly or partially sea water, meteoric, or of connate origin. Carbon isotope values, with $\delta^{13}C$ of the calcite close to 15 per mil versus PDB, point to a significant contribution of reduced carbon to the ore-forming fluid. These data are used in an effort to reconstruct the chemical environment, in terms of pH and oxygen fugacity, for the formation of the Akerlandet deposit. A similar tentative reconstruction is also made for the Nasafjall quartz vein deposit.

A comparison is made between lead and sulfur isotopes in galena from the investigated deposits, and for the calcite veins a tendency for more radiogenic lead to be associated with light sulfur may be seen. The sulfur in the calcite veins is probably derived from leaching of sulfides in the granitic basement, in contrast to the organic reduction of sea water 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 from both the granitic basement and the overlying metasediments and metavolcanites of the Caledonian nappes, the sulfate being inorganically reduced through reactions with wall rocks prior to sulfide precipitation.

The sulfur isotope data thus suggest that different processes were 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 stratabound ores, but form distinct ore types of their own. (Author's abstract)

JONES, A.P., SMITH, J.V. and DAWSON, J.B., 1983, Glasses in mantle xenoliths from Olmani, Tanzania: J. Geol., v. 91, p. 167-178. First author at Dept. Geophys. Sci., The Univ. Chicago, Chicago, IL 60637.

Nineteen mantle xenoliths from Olmani, Tanzania, have deformation textures and fluid inclusions like those in olivine-rich peridotites from Hawaii. Group A comprises 7 barren harzburgites (spinel, TiO_2 <.1 wt %) and group B (spinel, TiO_2 .8-2.6 wt %) contains 6 clinopyroxene-dunites, 2 lherzolites, 1 wehrlite, 1 two-pyroxene-dunite, and 1 olivine-orthopyroxenite. Both groups lack garnet and porphyroclastic textures and display fingerprint intergrowths of spinel with ortho- or clinopyroxene. Many secondary inclusions of several generations within olivine are rich in CO_2. Alkali-rich glasses (Na_2O .4-7.3 wt %, K_2O 3.3-5.1, P_2O_5 ~1) in B xenoliths are unrelated chemically to the olivine-augite-phyric ankaramite host. Aphyric intergranular glass occurs along with larger patches of residual glasses associated with euhedral olivine, clinopyroxene and spinel. Clinopyroxenes of B xenoliths show decreasing Na_2O (2.1-.3 wt %) and Cr_2O_3 from olivine-brown cores to clear margins of larger grains, and to finer grains associated with residual glass. These properties of the xenoliths are consistent with establishment of a coarse texture during prolonged metamorphism in the mantle (~28 kb, 1100 K?), partial melting in the presence of a CO_2-rich fluid (~26 kb, 1400 K?), transport by ankaramite magma to the Earth's surface, and rapid crystallization of some of the melts at 1300-1200 K. (Authors' abstract)

JONES, A.P. and WYLLIE, P.J., 1983, Low-temperature glass quenched from a synthetic, rare earth carbonatite: implications for the origin of the Mountain Pass deposit, California: Econ. Geol., v. 78, p. 1721-1723.

JONES, Elizabeth, 1983, Chemistry of fluid inclusions from the Carrock Fell W deposit: (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 3. Author at Imperial College, London.

Fluid inclusion populations in 80 samples of vein quartz were analyzed by the ICP-linked decrepitation technique. Na, K and Ca were the dominant cations in the decrepitates. Minor and trace elements were detected, including W, but at such low levels it is difficult to assess whether their response was real and not due to admixed mineral grains. Major and minor element analyses were compared with variations in H_2O, CO_2 and ore grades but little correlation was found. The Na-K-Ca rations show that fluids were in equilibrium with the granite host, but changes in fluid compositions occur across the granite-hornfels-gabbro boundary. Fluid inclusion chemistry therefore has little value as a guide to mineralization at this time. (Author's abstract)

JOSEPH, N.L., 1982, Epithermal veins in the Silver Bell district, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 49 pp.

Epithermal vein mineralization in the Silver Bell district is mid-Tertiary in age and represents a hydrothermal system separate from the

Laramide porphyry copper deposits in the area. The mineralized zones consist of an early quartz-cemented breccia followed by quartz-calcite-hematite-barite-fluorite mineralization, which is cut by late fluorite-barite-galena-sphalerite-quartz-calcite veins. Differences in outcrop patterns of the various vein types suggest that the early veins were structurally controlled by horizontal shearing with a right lateral sense, and that the later veins were emplaced under a vertical maximum principal stress.

Fluid inclusion data indicate that temperatures of the hydrothermal fluids ranged from 370 to 160°C in a 2.6 m NaCl solution. Mineral deposition may have occurred due to simple cooling. Stratigraphic reconstructions and fluid inclusion data indicate that the veins were emplaced at a depth of at least 600 m. (Author's abstract)

JUZA, J., HOFFER, V. and SIFNER, O., 1983, Thermodynamic functions of H_2O in the region of very high pressures, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 165-172.

KABLE, E.J.D., 1983, Characterization of quartz and pyrite in Witwatersrand gold-bearing conglomerates by minor and trace elements: Spec. Publ. Geol. Soc. S. Afr., v. 7, p. 59-66.

KADIK, A.A. and MAKSIMOV, A.P., 1982, The origin of andesite magmas: water conditions and temperatures: Geokhimiya, no. 6, p. 797-821 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 3, p. 134-157, 1983). Authors at Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 104, 1982. (E.R.)

KALOGEROPOULOS, S.I. and SCOTT, S.D., 1983, Mineralogy and geochemistry of tuffaceous exhalites (tetsusekiei) of the Fukazawa mine, Hokuroku district, Japan: Econ. Geol. Monograph 5, p. 412-432. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

Tetsusekiei, translated literally from Japanese as iron quartz, occurs primarily in the immediate hanging wall of the massive stratiform Kuroko ore and, in places, well within the overlying tuff. There are two forms: bedded, which is predominant, and networks cementing hanging-wall breccia fragments. Bedded tetsusekiei is discontinuous and usually covers an area about twice that of the ores without exceeding a thickness of 20 to 30 cm. It appears to have formed late in the development of the stratiform ores and consists of two contrasting constituents: a predominantly aluminosilicate (chlorite + sericite) tuffaceous or, simply, clastic constituent, and a predominantly chert, hematite, and pyrite or, simply, chemical constituent. Textures, mineralogy, and compositions of the tetsusekiei and related tuffs are consistent with the formation of tetsusekiei by the mixing in various proportions of the chemical and clastic constituents. The major source of iron, sulfur, and silica in tetsusekiei was hydrothermal.

During intensification of the hydrothermal system at the time of sulfide deposition, tetsusekiei formed at low temperature (<150°C) around and at some distance from zones of main fluid discharge whereas, during declines in hydrothermal activity, it formed in close spatial association with the ore. High temperatures (~300°C) recorded by fluid inclusions in cavity-filling quartz, chalcopyrite disease in sphalerite, and sulfidation of hematite and chlorite, indicate that tetsusekiei was chemically and texturally modified after deposition. Several stages of tetsusekiei

formation are envisaged to have occurred during the lifetime of the ore-forming system. (From the authors' abstract)
KALYUZHNYI, V.A., 1982 See Translations
KALYUZHNYI, V.A., NAUMKO, I.M., KHMELEVSKII, V.A., LASHMANOV, V.I., 1983, Topaz from coastal sands of Shatsk Lakes (Volyn district) and fluid inclusions in it: Mineral. Zh., v. 5, no. 4, p. 64-69 (in Russian; English abstract). Authors at Inst. Geol. Geokhim. Goryuch. Iskop., L'vov, USSR.

Crystallization conditions of topaz from the coastal sands of the Peschanoe Lake (a group of Shatsk lakes, Volyn Region) are characterized by data on fluid inclusions. The mineral was formed at sufficiently high temperatures (>500-300°C) from solutions of sodium-potassium-chloride composition with predominance of nitrogen in the gas phase. It is shown that the genetic peculiarities of terrigenous topaz are most similar to those of topaz from some pegmatite or greisen deposits. (Authors' summary)

KAMSHILINA, Ye.M., 1983, In the Scientific Council on Ore-Formation and its sections: Geol. Rudn. Mestorozhd., v. 25, no. 3, p. 108-110 (in Russian).

The author of the review states that "Section of ore-forming solutions in inclusions (Chairman N.P. Ermakov) did not submit report on its activity." Among books on ore problems the following issue is listed: "Use of methods of thermobarogeochemistry during prospecting and studies of ore deposits," N.P. Laverov, editor, Moscow, "Nedra" 1982. [This was abstracted in Fluid Inclusion Research--Proceedings of COFFI, vol. 15, 1982.] (A.K.)

KANBERAS, Karlis, 1980, Fracturing along the margins of a porphyry copper system, Silver Bell district, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 90 pp.

This study focuses on the style and distribution of mineralized fractures as they extend away from the center of the El Tiro porphyry copper deposit. Fracture density, mineralogy, filling temperatures, and orientations in Mesozoic-age alaskite wall rock were investigated in the context of their temporal and spatial evolution.

Vein paragenesis within the periphery consists of early chlorite-biotite, followed by K-feldspar-quartz, quartz-epidote ± plagioclase, quartz-chlorite, and volumetrically prominent barren quartz. Integrated fracture density is highest in the ore body and decreases systematically away from the ore center. The edge of the porphyry system is characterized by areas of intensely fractured rock adjacent to relatively unfractured domains. Propylitic veins and quartz veins are predominantly restricted to the periphery and coincide with an arcuate fracture pattern concave toward the ore body.

The peripheral fracture patterns were likely controlled by the structural setting and interplay of local and regional stress fields. Fracture orientations within the ore body more closely mirror the regional east-northeast stress direction. It is suggested that stresses associated with intrusion and cooling of a Laramide-age quartz monzonite porphyry stock, central to the ore system, strongly shaped fracture style, density, and orientation at the periphery. (Author's abstract)

KARWOWSKI, Łukasz, WŁODYKA, Roman and KURDZIEL, Marek, 1983, Conditions of formation of druse minerals from Michalowice (Karkonosze massif--southwestern Poland): Archiwum Mineral., v. 39, part 1, p. 29-38 (in Polish, English abstract). Authors at Inst. Anayses of Min. Raw Material, The Silesian Univ., Poland.

The paper presents the results of thermobarogeochemical investigations of quartz, albite, cleavelandite, titanite, fluorite, epidote and calcite associated with pegmatitic nests in the Michalowice granite. Crystallization of druse minerals from pneumatolytic fluid began at about 500°C. The next stages of crystallization of druse minerals were connected with evolution of hydrothermal fluid, from about 450°C and 85-80 MPa to 100°C and 50 MPa. Zeolites were the latest minerals of the reported association. (Authors' abstract)

KAY, Alexandra and STRONG, D.F., 1983, Geologic and fluid controls on As-Sb-Au mineralization in the Moretons Harbour area, Newfoundland: Econ. Geol., v. 78, p. 1590-1604. Authors at Dept. Earth Sci., Memorial Univ. Newfoundland, St. John's, Newfoundland, Canada.

Mineralized hydrothermal veins of the Moretons Harbour area occur within a thick sequence of dominantly basaltic pillow lavas and pyroclastic rocks, are concentrated within a central volcanoclastic unit, and are closely associated with felsic dikes which feed rhyolite-dacite pyroclastics at the top of the sequence. Within an area of about 6 km^2, there are about 50 veins up to 30 cm thick occupying fractures perpendicular to the bedding. They can be classified into three types: arsenopyrite dominated, stibnite dominated, and base metals + arsenopyrite dominated. All contain quartz and calcite as the major gangue minerals.

Type I veins are enriched in Au, type III are enriched in Au + Ag, and type II are poor in Au but slightly enriched in Ni and Pd. Fluid inclusion data indicate deposition of type I veins from CO_2-rich, low-salinity fluids at temperatures above 300°C. Type II Au-poor veins were deposited from relatively saline, low-CO_2 fluids at temperatures below 220°C. Fluid inclusion and arsenopyrite composition data suggest pressures of 900 to 1,500 bars, which is in agreement with the lithostatic pressure inferred from the thickness of the overlying volcanic pile.

Gold mineralization is considered to have resulted from a temperature drop through 300°C, below which the solubility of Au, at least as a chloride complex, declines rapidly, although the abundance of CO_2 may reflect the involvement of carbonate complexes in element transport. Retrograde boiling results in a loss of CO_2 and drop in carbonate activity, brecciation of arsenopyrite, and deposition of calcite. A range of criteria suggest that ore fluids were derived from the felsic magma. (Authors' abstract)

KAZAHAYA, Kohei, 1983, Isotopic study of fluid inclusion in Japanese vein-quartz: Masters thesis, Tokyo Institute of Technology, 130 pp.

A new type ball-mill designed by Kita (1981) was used for the extraction of not only water but also CO_2, N_2 in fluid inclusions in Japanese vein quartz. Stepwise heating was also applied to the extraction of water, CO_2, N_2, CH_4, CO and H_2 in quartz. The daughter minerals in fluid inclusion were examined by SEM with a solid-state detector. The procedures are described in Chapter II.

The isotopic compositions of water in inclusions, i.e., D/H and $^{18}O/^{16}O$ ratios in quartz were measured directly by the MCE (micro CO_2-H_2O equilibration) technique suggested by Kishima and Sakai (1980). The conventional method for estimating the $^{18}O/^{16}O$ ratio of quartz, using the filling temperature of fluid inclusions and the oxygen isotopic fractionation factor between quartz and water (e.g., Hattori and Sakai, 1979) was applied. In this procedure, establishment of the oxygen isotopic exchange reaction between inclusion fluid and the host quartz at the time of entrapment of fluid inclusions is assumed (Rye and O'Neil, 1968). Even if the $^{18}O^{16}O$ ratio of water in ore fluid is not preserved in the water of fluid inclusions, the examination of the present $^{18}O/^{16}O$ ratio of water gives useful information (Chapter III). The origin of gases in fluid inclusions in Japanese vein quartz is also discussed in the same chapter. (Modified from the author's introduction)

KELLY, W.C. and BURGIO, P.A., 1983, Cryogenic scanning electron microscopy of fluid inclusions in ore and gangue minerals: Econ. Geol., v. 78, p. 1262-1267. First author at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

The steps involved are: 1) crystal preparation; 2) shock freezing and fracturing to expose inclusions; 3) transfer to sample holder; 4) transfer to SEM cold stage; 5) imaging inclusions; 6) X-ray microanalysis of the inclusions. Throughout steps 2-6 the inclusions are kept at -180°C or colder, except 5. At present only semiquantitative data are obtained, but further developments are in progress. (E.R.)

KELLY, W.C., SHARP, J.M., Jr. and WHITE D.E., 1983, Hydrodynamics and geochemistry of ore generation in sedimentary environments: Geology, v. 11, p. 309-311.

A review of the (unpublished) papers given at a Penrose conference, May 23-28, 1982, in Missouri. (E.R.)

KELLY, W.C., PETERSEN, E.U., FREDERICK, F.S. and BIGELOW, W.C., 1983, Cryogenic scanning electron microscopy and energy dispersive analysis of hydrothermal fluid inclusions (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 610. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Cryogenic techniques developed in the biological sciences for observation and chemical analysis of frozen-hydrated tissues under the scanning electron microscope (SEM) have been adapted to studies of fluid inclusions in minerals. Inclusions are "shock frozen" in situ in supercooled freon-22, are next exposed by cleaving their host crystals under liquid nitrogen temperatures throughout all states of preparation, imaging and analysis.

Semi-quantitative inclusion brine analyses are obtained by comparing sample X-ray spectra with those of frozen standard saline solutions placed in the sampleholder alongside the unknowns. Low accelerating voltages (9 kv) and a rastering mode are employed to eliminate sample ice sublimation and loss of other volatiles. Initial tests of the technique on fluid inclusions from various mining districts (Panasqueira Sn-W, Tri-State MVT ores, Balmat massive sulfides) give salinities and brine compositions consistent with those inferred from independent methods.

Brine compositions derived by this new technique can be used for empirical Na-K-Ca thermometry (Fournier and Truesdell, 1973) of individual fluid inclusions. Moreover, the technique can be applied to the imaging and analysis of fluid inclusions in both opaque and transparent host crystals. It has the potential for fully quantitative analysis of major cations and anions in individual fluid inclusions optically pre-selected for analysis. (Authors' abstract)

KENDALL, C., CHOU, I.-M. and COPLEN, T.B., 1983, Salt effect on oxygen isotope equilibria (abst.): EOS, v. 64, p. 334-335. Authors at U.S. Geol. Survey, 431 National Center, Reston, VA 22092.

The presence of NaCl in concentrations up to 4 molal has been found to have no effect on the equilibrium oxygen isotope fractionation between calcite and water at 275°C. (From the authors' abstract)

KENT, G.R., 1983, Temperature and age of precious metal vein mineralization and geochemistry of host rock alteration at the Eberle mine, Mogollon mining district, southwestern New Mexico: M.S. thesis, Michigan Tech. Univ., Houghton, MI, 84 pp.

Indexed under Fluid Inclusions. (E.R.)

KERRICH, Robert and FYFE, W.S., 1983, The δ^{34}S of Archaean ocean bottom water (~2.8 Ga) (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A37. Authors at Dept. Geol., Univ. Western Ontario, London, Ontario, N6A 5B7, Canada.

Numerous subvolcanic to extrusive quartz-feldspar porphyries in the Abitibi greenstone belt contain massive to disseminated sulphate. Examples include the Pearl Lake porphyry, Timmins, and Lamaque porphyry, Val d'Or. The porphyries are intruded into or occur as interflow tuffs to pillow basalts, and have alteration domains characterized by the mineral assemblage albite - Mg chloride-quartz-hematite-calcite-anhydrite. The geological evidence for a submarine environment, coupled with the mineralogical similarities to modern ocean floor spilites, imply that the sulphate domains may represent regions of intense low temperature penetration of ocean water into cooling subvolcanic stocks and their extrusive equivalents.

The δ^{18}O of triply concordant quartz (~12.5%) (sic), albite (~8.9‰), and chlorite (~1.5‰) correspond to fluid temperatures of 180 to 230°C, and a fluid isotopic compositoon of 0 + 1‰. Filling temperatures of primary fluid inclusions in quartz fall into the range 190-230°C. Given such data which increases confidence in the δ^{18}O of ancient marine water, then the secular trend in δ^{18}O of marine cherts from ~22‰ at 3.6 Ga to 36‰ now (Krauth and Lowe, 1978) can be interpreted in terms of warmer Archaean bottom water temperatures and specifically ambient bottom water temperatures of ~70°C at 2.8 Ga. The δ^{34}S of anhydrite spans 12-14‰, somewhat lower than the minimum value recorded for Phanerozoic marine sulphates. (Authors' abstract)

KESLER, S.E., RUIZ, Joaquin and JONES, L.M., 1983, Strontium-isotopic geochemistry of fluorite mineralization (Coahuila, Mexico): Isotope Geosci., v. 1, p. 65-75. First author at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109, USA.

Includes a discussion of previously unstudied Paila district vein deposits. The inclusions show evidence of boiling and immiscible petroleum fluids; Th = ~100 to 300°C and average 150°C. (E.R.)

KHASANOV, A.Kh., 1983, Hydrothermal-metasomatic origin of celestite mineralization of the southern Tyan'-Shan' and Afghano-Tadzhik depression: Doklady Akad. Nauk SSSR, v. 270, no. 3, p. 679-682 (in Russian). Author at Tadzhik State Univ., Dushanbe, Tadzhikistan.

Fluid inclusions in fluorite, barite and calcite from S. Gissar and Kugitang-tau (Th 250-60°C) bear strontium as a component. (A.K.)

KHASS, D. and PETROSYANTS, S.P., 1983, Peculiarities of formation of fluoride complexes of aluminum and gallium in solution: Dokl. Akad. Nauk SSSR, v. 269, no. 2, p. 380-383 (in Russian). First author at Inst. of General and Inorganic Chemistry.

The paper describes properties of $[AlF_6]^{-3}$ and $[GaF_4]^-$, pertinent to inclusion fluids. (A.K.)

KHETCHIKOV, L.N., POLENKOV, A.I., DOROGOVIN, B.A. and SANDOMIRSKAYA, S.M., 1983, Primary composition of acid volcanites of continuous formation of the Southern Urals from data of studies of inclusions in quartz: Dokl. Akad. Nauk SSSR, v. 269, no. 6, p. 1460-1462 (in Russian). Authors at Inst. of Lithosphere of Acad. Sci., Moscow, USSR.

Quartz phenocrysts in liparites and liparite-dacites bear S G/L inclusions (Th 220-240°C) and P melt (glass) inclusions with Th 1180-1200°C and P partly crystallized melt inclusions with Th 1050-1100°C. Five melt inclusions were studied by the electron microprobe method, and the results were compared with averages of 1) 23 chemical analyses of liparite-dacites and 2) 185 liparites. The results are as follows, in wt. % (first ranges of rock analyses, second ranges of inclusion melt analyses): SiO_2 68.71-70.31, 43.72-50.65;TiO_2 0.34, not found; Al_2O_3 13.31-14.02, 23.67-30.00; Fe_2O_3 1.63-2.14, included in FeO; FeO 2.20-2.72, 3.18-9.18; MgO 1.36-2.39, 2.29-6.86; CaO 2.47-2.68, 0.00-0.60; Na_2O 3.12-3.49, 0.03-0.56; K_2O 1.14-1.25, 6.61-10.51. Thus, primary melts from which rocks crystallized were rich in SiO_2 and K_2O. The conclusion of high SiO_2 contents is made from the statement that "about 25% of vacuole surface is occupied by silica" that should be added to the electron microprobe analysis results. Inclusions were not homogenized before analysis. (Abstract by A.K.)

KHITAROV, D.N., 1982, Solutions in fluid inclusions from hydrothermal molybdenum-uranium deposits: Sovetskaya Geologiya, no. 12, p. 109-115 (in Russian, translated in Int'l. Geol. Review, v. 25, no. 10, p. 1117-1124, 1983).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 111, 1982. (E.R.)

KHITAROV, N.I., MALININ, S.D., LEBEDEV, Ye.B. and SHIBAEVA, N.P., 1982, Partitioning of Zn, Cu, Pb and Mo between fluid phase and silicate melt of granite composition at elevated temperatures and pressures: Geokhimiya, no. 8, p. 1094-1107 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 4, p. 123-236, 1983). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 111, 1982. (E.R.)

KHITAROV, N.I. and PUGIN, V.A., 1983, Probability of immiscibility in andesite magmas: Doklady Akad. Nauk SSSR, v. 271, no. 4, p. 952-955 (in Russian). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Andesite magma probably splits into basalt, andesite and rhyolite melts at shallow depths and the degree of splitting depends on T, P, composition of the primary melt, and volatile influence. (A.K.)

KHOLMOGOROV, A.I., POPOV, A.A., STEPANOV, E.R. and KUZ'MINOV, M.A., 1983, Temperature fields of a deposit of tin-containing greisens: Tipomorfnye Osob. Rudn. Miner. Endog. Obraz. Yakutii, 1983, p. 19-31 (in Russian).

The zonal distribution of formation temperatures was studied in Sn ore-bearing greisens localized in a Late Cretaceous granite porphyry stock of northeastern Yakutia. Pre-ore greisenization, ore, and post-ore post-magmatic stages are recognized in the deposit. Temperature estimates were made from known temperatures of stability of the observed mineral parageneses, decrepitation temperatures (Td) of fluid inclusions, and the thermoluminescence (TL) of the ore-hosting rocks. Increase upsection in thickness of greisenized rocks, strong alteration in the dome part of the stock, high Td, and jacket-type of metasomatic zoning are all evidence of long-persisting heat anomaly, at the time metasomatites were forming, along the axis of the ore field. Models of fields of the TL and Td for the deposit reflect the nonuniformity and variation in time of the heat field during ore formation. (C.A. 101: 174926a)

KIM, K.-R., 1983, Methane and radioactive isotopes in submarine hydrothermal systems: Ph.D. dissertation, Scripps Inst. Ocean., Univ. California, San Diego.

KIRKPATRICK, R.J., 1983, Theory of nucleation in silicate melts: Am. Min., v. 68, p. 66-77.

KIRSTEN, T., OEHM, J., RICHTER, H. and ROCHOLL, A, 1983a, Rare gas isotopes from the upper mantle in Hawaiian peridotites: Meteoritics, v. 18, no. 7, p. 325. Authors at Max-Planck-Inst. f. Kernphysik, Heidelberg, Germany.

A series of Hawaiian ultramafic samples including lherzolites, hornblende-phenocrysts, and garnet-spinel-pyroxenites has been analyzed for all rare gas isotopes, including high precision ^{3}He/^{4}He-determinations. This was made possible by a tandem-arrangement of two mass spectrometers. One spectrometer was specially tuned for He and had a resolution of 700. Most samples were degassed in two steps: a 600°C predegassing and the melt run. Mostly less than 30% of the total rare gas quantities were released at 600°C. Absolute concentration ranges are (in units of 10^{-11} cc/g) ^{4}He: 4000-30000; ^{20}Ne: 10-300; ^{36}Ar: 10-200; ^{40}Ar(10-300)x10^{3}; ^{84}Kr: 1-10; ^{132}Xe: 0.1- 2. The elemental abundance patterns resemble those of oceanic tholeiites measured by us previously. The same is true for ^{3}He/^{4}He ratios. Excess ^{129}Xe in Hawaiian ultramafics is the rule, whereas for tholeiitic basalts it is less frequent. Isotopic systematics and possible implications for the origin of these gases will be discussed. (Authors' abstract)

KIRSTEN, T., OEHM, J., RICHTER, H. and ROCHOLL, A., 1983b, Rare gas isotopes from the upper mantle in Hawaiian peridoties (abst.): Jahresbericht 1983, Max-Planck-Inst. fur Kernphysik, Heidelberg, Germany, p. 176-177 (in German).

See previous item. (E.R.)

KISVARSANYI, Geza, GRANT, S.K., PRATT, W.P. and KOENIG, J.W., eds., 1983, Proc. Int'l. Conf. on Mississippi Valley type lead-zinc deposits: Univ. Missouri-Rolla, Rolla, Missouri [1982], 603 pp.

KIYOSU, Yasuhiro and KURAHASHI, Makoto, 1983, Origin of sulfur species in acid sulfate-chloride thermal waters, northeastern Japan: Geochimica Cosmo. Acta, v. 47, p. 1237-1245. Authors at Dept. Earth Sci., Faculty of Sci., Nagoya Univ., Chikusa, Nagoya 464, Japan.

Acid sulfate-chloride thermal water samples collected together with fumarolic gases from various volcanic areas in northeastern Japan were studied chemically and isotopically. δ^{34}S(CDT) values of sulfate and hydrogen sulfide from these volcanic hot springs range from +4.0 to +31 and from -15.0 to -2.0‰, respectively, with δ^{34}S(ΣS) value of +2.5 to +31. The δ^{34}S of the sulfate in the more saline waters tends to become smaller with increasing ratio of SO_4 to Cl, although the chemical and isotopic composition of acid thermal water within some areas may be altered by secondary processes during the discharge of the thermal waters. This trend can be explained by the reaction of the volcanic gases, having S/Cl of 4 ~ 7 and total sulfur of ~0‰ in δ^{34}S, with ground water at 200°C, and/or the removal of sulfide phase depleted in ^{34}S from the acid thermal water formed by the disproportionation of volcanic sulfur. The sulfur species in acid sulfate-chloride thermal water are shown to be volcanic exhalations. (Authors' abstract)

KLEMM, W. and GRANDE, S., 1983, On the analysis of water content in gas-fluid-inclusions by means of magnetic core resonance: Zeitschrift fur Angewandte Geol., v. 29, no. 4, p. 181-183 (in German; English abstract). Authors at Sektion Geowissenschaften an der Bergakademie Freiberg, DDR.

The quantitative analysis of the composition of fluid inclusions by means of the extraction method calls for the analysis of the water content of the samples. The method used up to now rests upon opening the inclusions and quantitatively analyzing the water, which is released. The method described here allows for a quick nondestructive analysis of the water content in inclusions of samples of 1.5 to 2 grams with a good reproducibility. (Authors' summary)

KLINKHAMMER, G., 1983, The hydrothermal plume over the East Pacific Rise at 20°S (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 3-4. Author at Univ. of Cambridge.

The two major manifestations of hydrothermal activity in the deep sea are the emanation of buoyant plumes and the accumulation of metal-rich sediments. These phenomena appear to be closely related in the South Pacific where the opening rate of the spreading center is extremely fast (16 cm/yr) and the occurrence of hydrothermal vents numerous. Recent exploration has identified a plume of hydrothermal manganese and primordial helium coincident with the asymmetrical distribution of metalliferous sediments about the rise crest. The distance the plume ascends above the sea floor provides an estimate of the advective velocity of ambient waters. This estimate combined with the relationship of manganese to helium in these waters provides an insight into the fundamental link between the plume and metalliferous sediments. Preliminary evidence from surface ships suggests that the chemistry of hydrothermal fluids at 20°S are very similar to the chemistry of those sampled by submersible at 21°N. (Author's abstract)

KLINKHAMMER, G. and HUDSON, A., 1983, The manganese plume at 20°S (abst.): IUGG, XVIII General Assembly, Program and Abstracts, v. 2, p. 815. First author at Earth Sci. Dept., The Univ. Cambridge, England CB3 0EZ.

In 1981 two vent fields were discovered during SIO's Vulcan Expedition on the EPR at 20°S, 114°W. The fluids from these vents produce a Mn and ^{3}He plume which rises 200-300 meters above the sea floor and is detectable as manganese and helium anomalies in the water column for some 200 km. (From the authors' abstract)

KNUTSON, J., DONNELLY, T.H., EADINGTON, P. and TONKIN, D.G., 1983, Hydrothermal alteration in the Mount Gunson area of the Stuart Shelf and its possible relevance to copper mineralization (abst.): Abstracts, 12th BMR Symp., BMR J. of Australian Geol. & Geophys., v. 8, no. 2, p. 173. First author at Baas Becking Lab., Australia.

The aim of this project is to determine the depositional and post-depositional processes operative in the pre-Adelaidean rocks in the Mount Gunson area, SA, and to assess the possible significance of these to base-metal mineralization throughout the sequence. Geochemical, petrological, stable isotope, and fluid inclusion studies are being carried out in order to identify the types and extent of secondary alteration in these pre-Adelaidean rocks and the major processes responsible for the alteration.

Carbon isotope results indicate that calcite in vugs and veins of the feldspathic rocks overlying the calc-silicate unit is of magmatic origin. Generally, there is a tendency for $\delta^{13}C$ values to become less negative away from these rocks. Preliminary sulphur isotope results also indicate that sulphides with isotopic values consistent with an origin from magmatic-hydrothermal fluids occur at the same stratigraphic levels as the magmatic $\delta^{13}C$ values.

Fluid-inclusion results suggest the presence of magmatic, mixed magmatic and connate, connate, and meteoric fluids. It may be significant that the magmatic-hydrothermal fluids occur in the same rock types in which the $\delta^{13}C$ values indicate a substantial magmatic component. Estimated salinities of these hydrothermal fluids range up to 30-35 wt % NaCl and temperatures range up to 390°C. Some of the fluid inclusions of magmatic origin are vapor-rich, suggesting that boiling has taken place. (From the authors' abstract)

KOGARKO, L.N., LAZUTKINA, L.N. and ROMANCHEV, B.P., 1982, The origin of eudialyte mineralization: Geokhimiya, no. 10, p. 1415-1432 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 5, p. 128-145, 1983).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 115-116, 1982. (E.R.)

KOGARKO, L.N. and ROMANCHEV, B.P., 1982, Phase equilibria in alkaline melts: Vses. Mineralog. Obshch. Zapiski, v. 2, p. 167-182 (in Russian; translated in Int'l. Geol. Review, v. 25, no. 5, p. 534-546, 1983).

KOGARKO, L.N. and RYABCHIKOV, I.D., 1983, Phosphorus in processes of mantle melting: Dokl. Akad. Nauk SSSR, v. 269, no. 5, p. 1192-1194 (in Russian). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

On the basis of experiments and calculations it is shown that under upper mantle conditions anomalous regions of apatite-bearing peridotite occur; their melting is the origin of melts distinctly enriched in P_2O_5, up to few percents. (A.K.)

KOGARKO, L.N., VEKSLER, I.V. and KRIGMAN, L.D., 1983, Magmatic crystallization of loparite in the system loparite-nepheline: Dokl. Akad. Nauk SSSR, v. 268, no. 5, p. 1213-1215 (in Russian). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The paper presents the experimentally obtained phase plot: nepheline-loparite for T interval 1250-1480°C. (A.K.)

KOIVULA, J.I., 1983, Induced fingerprints: Gems & Gemology, Winter 1983, p. 220-227. First author at Gem Identification Dept, Gem Trade Lab., Inc., Santa Monica, CA.

Over the past few years, numerous Verneuil-type (flame fusion) synthetic sapphires and rubies with somewhat natural-appearing induced fingerprint inclusions* have surfaced in the trade. This article reports the results of a series of experiments conducted to explain the phenomenon of induced fingerprints and how they are produced in gemstones generally and in flame-fusion synthetic corundum specifically. (Author's abstract)

*Planes of connected secondary tubular inclusions. (E.R.)

KOIVULA, J.I., FRYER, Chuck and KELLER, P.C., 1983, Opal from Querétaro, Mexico: occurrence and inclusions: Gems & Gemology, v. 19, p. 87-96. First author at Gem Identification Dept, Gem Trade Lab., Inc., Santa

Monica, CA.

Both two- and three-phase inclusions are recognized in this opal. (E.R.)

KOLOMNIKOV, I.S., LYSYAK, T.V., KONASH, Ye.A., RUDNEV, A.V., KALYAZIN, Ye.P. and KHARITONOV, Yu.Ya., 1983, Reduction of CO_2 in water solutions in presence of titanium dioxide by γ-radiation: Zhurn. Neorg. Khimii, v. 28, no. 2, p. 528-529 (in Russian). First author at Chem.-Technol. Inst., Moscow, USSR.

The system CO_2-H_2O-TiO_2 under P 10 to 60 atm submitted to γ radiation produces formaldehyde, $(COOH)_2$ and traces of formic acid. (A.K.)

KOLPAKOVA, N.N., 1982a Laboratory and field studies of ionic equilibria in the Sb_2S_3-H_2O-H_2S system: Geokhimiya, 1982, no. 1, p. 47-55 (in Russian; translated in Geochem. Int'l., v. 19, no. 1, p. 46-54, 1983).

KOLPAKAVA, N.N., 1982b Determination of hydrogen sulfide in gas-liquid inclusions in vein minerals: Geokhimiya, no. 2, p. 271-276 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 1, p. 184-189, 1983). Author at Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 118, 1982. (E.R.)

KONDAKOV, L.A. and NABROVENKOV, O.S., 1983, Essential features of Nicaragua: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 3, p. 91-104 (in Russian). First author at All-Union Sci.-Research Inst. "Zarubezhgeologiya," Moscow, USSR.

The paper bears Th data for gold ore deposits quoted from papers of other authors. (A.K.)

KONNERUP-MADSEN, Jens, 1983, Compositions of fluid inclusions in some granites and quartz syenites from continental rifts (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 36. Author at Inst. for Petrology, Univ. Copenhagen, Øster Voldgade 10, 1350 Copenhagen K, Denmark.

Fluid inclusions in quartz from alkali-feldspar granite and quartz syenite from eight igneous complexes belonging to the Precambrian Gardar province (south Greenland) and the Permian Oslo province (south Norway) have been examined. The fluid inclusions were found to vary in composition from CO_2-CH_4, through CO_2-CH_4-H_2O mixtures, to entirely aqueous, saline fluids. No distinct correlation between rock type and composition of entrapped fluids was found. The inclusions primarily represent fluids present during post-magmatic stages involving repeated episodes of microfracturing and progressive introduction of water during uplift and cooling.

Aqueous inclusions are the dominant type in all examined complexes. Salinities vary between 1 and 64 weight percent, but the majority contains less than 40 equivalent weight percent NaCl and have densities from 0.9 to 1.15 g/cc. Microthermometry, however, indicates that other cations such as K^+, Ca^{2+}, Mg^{2+} and/or Fe^{3+} are present in the inclusion fluids. 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 percent CH_4 and have densities from 0.75 to 1.0 g/cc, but later fluids may contain up to about 80 mole percent CH_4. Quantitative chemical analyses show other gases such as C_2H_6 and H_2S to be present in only small amounts.

Conditions for entrapment of most of the examined inclusion fluids at 250°-400°C and 1-2 kb are indicated. A minor number of more primary aqueous inclusions may have been trapped around 1-1.5 kb and 600°C. (Author's abstract)

KONNERUP-MADSEN, Jens and ROSE-HANSEN, John, 1983, Composition and significance of fluid inclusions in the Ilímaussaq peralkaline granite, south Greenland (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 37. Authors at Inst. Petrology, Univ. Copenhagen, Øster Voldgade 10, 1350 Copenhagen K, Denmark.

Fluid inclusions were studied in quartz from peralkaline granite and hydrothermal veins from the essentially Si-undersaturated foyaitic Ilímaussaq intrusion, south Greenland.

In contrast to the hydrocarbon-dominated fluids of the foyaitic rock types, the fluids in the Ilímaussaq granite (s.s.) are entirely aqueous solutions with salinities from about 2 to almost 65 equivalent weight percent NaCl and densities from 0.2 to 1.2 g/cc. The majority of aqueous inclusions are considered to represent fluids present at post-magmatic stages. A minor number of more primary inclusions, those richest in salts, might however represent remnants of fluids of a closer magmatic affinity and with estimated conditions of entrapment at 600°-650°C and about 1 kb. Stable isotope analyses suggest that the majority of the aqueous inclusion fluids may reflect stages of influx of low-^{18}O, low-temperature water, possibly being initiated by the emplacement of the Si-undersaturated Ilímaussaq magma(s).

Fluid inclusions in veins of alkali granite formed from reaction of augite syenite with quartzitic country rock, and in quartz veins contain varying, though significant amounts of CO_2 and CH_4 in addition to aqueous fluids. Conditions for fluid entrapment at 300°-350°C and 0.5-1.0 kb are indicated.

The difference in fluid composition between the main Ilímaussaq alkali granite and the granitic vein suggests that the alkali granite is not related to the nepheline syenites and augite syenite through assimilation of sandstone by the augite syenite magma, but that it represents an independent alkali acidic magma alien to the Si-undersaturated Ilímaussaq magma(s). (Authors' abstract)

KONONOV, V.I. and POLYAK, B.G., 1982, Identification of the juvenile component in modern hydrothermal systems: Geokhimiya, no. 2, p. 163-177 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 1, p. 119-133, 1983). Authors at Geol. Inst., Acad. Sci. USSR, Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 118-119, 1982. (E.R.)

KORENBAUM, S.A., BUTSIK, L.A. and six others, 1983, Mineral composition and certain aspects of genesis of wolframite deposit Lyung Myoi (Vietnam): Geol. Rudn. Mestorozhd., v. 25, no. 6, p. 24-37 (in Russian). First author at Far East Geol. Inst., Vladivostok, USSR.

The paper bears description of fluid inclusions in vein quartz. (A.K.)

KOROBEYNIKOV, A.F., 1983a, Ore-metasomatic zoning in gold deposits: Geol. Rudn. Mestorozhd., v. 25, no. 1, p. 96-99 (in Russian). Author at Polytechnical Inst., Tomsk, USSR.

In gold ore deposits early alkaline (microcline) metasomatites formed at (Th) 480-300°C, albitites at 440-260°C, greisens at 400-240°C, berezites and listvenites at 390-110°C. Quartz-gold-sulfide vein ores in endocontact biotite metasomatites developed at 390-280°C, gold-pyrrhotite-Cu-sulfide ores in contact with marbles at 320-180°C, carbonate-gold-hematite ores in silicified marbles at 260-110°C. Usually in the bottom parts of ore stockworks quartz-gold-pyrite-arsenopyrite ores prevail (Th 390-280°C), in the middle parts quartz-gold-polymetal ores (Th 320-200°C) and in upper parts quartz sulfosalt ores (Th 260-110°C). Th show gradient of 10-20°C per 100 m of depth, from 130 to 420°C for ore formation period. Td typical of ore stockworks are in ranges 360-70°C. As geochemical indices for water leachates the following ratios are recommended: K/Na, NH_4/Na, SO_4/HCO_3 and (SO_4 + HCO_3)/Cl. (Abstract by A.K.)

KOROBEYNIKOV, A.F., 1983, Regularities of formation of gold-skarn formation deposits, in Skarns and ores, Transactions of Inst. Geol. and Geoph. of Sib. Branch of Acad. Sci. USSR: "Nauka" Siberian Branch, Novosibirsk, v. 546, p. 50-55 (in Russian). [The book presents materials of All-Union Symp. "Skarns and Ores," held in Novosibirsk, 18-19, May, 1981, A.K.]

Inclusions in minerals of Mg-skarns (formed at magmatic stage) yielded Th 830-570°C; inclusions are filled by salt-melts of composition Mg, alkalis, HCO_3-Cl, Na:K 1.2:1 to 2:1, Cl:F 33:1 to 50:1. Lime skarn minerals yielded Th 630-360°C, inclusion fluid composition Na, Ca, Cl, HCO_3, post-skarn metasomatic minerals (tremolite, actinolite, epidote, chlorite, serpentine, magnetite, hematite, pyrrhotite, quartz, calcite, pyrite) - Th 560-170°C, Cl-HCO_3 solutions. At (Th) 420-240°C skarn minerals are replaced by actinolite and at 320-180°C by dolomite, calcite, magnesite, quartz, chlorite (listvenite minerals), fluid composition HCO_3-Cl-S-Ca-K. Commercial associations occur in skarns in three types of bodies: 1) high-T (420-260°C) gold-quartz-actinolite stockworks, 2) moderate T (320-240°C) gold-sulfide patches and veinlets in listvenites and recrystallized skarns and 3) gold-pyrrhotite-copper sulfide mineralzation in skarned marbles. Ore-metasomatic zones bear quartz-gold-sulfide (380-280°C), gold-pyrrhotite-copper sulfide (300-180°C) and carbonate-gold-hematite (270-110°C) ores. (Abstract by A.K.)

KORONOVSKIY, N.V., POPOV, V.S. and NIKOLAENKO, Yu.S., 1982, Geology of acid lavas and problem of ignimbrite origin: Vestnik Moskovsk. Univ., Ser. 4, Geologiya, no. 5, p. 26-35 (in Russian).

Quartz and plagioclase from ignimbrites from Nizhniy Chegem and Verkhniy Chegem (Caucasus) bear melt inclusions with Th 900-1000°C. (A.K.)

KOROTAEV, M.Yu. and NIKISHIN, A.M., 1983, Evolution of fluid regime of the asthenosphere, elevation and stages of magmatism, metamorphism and metallogeny of intracontinental linear mobile belts: Doklady Akad. Nauk SSSR, v. 273, no. 2, p. 415-418 (in Russian). Authors at State Univ., Moscow, USSR.

The paper bears considerations of the influence of CO_2, H_2O, N_2 and Ar on mantle melts, using Verkhoyan'ye zone, USSR, as an example. (A.K.)

KORYTOV, F.Ya. and PROKOF'YEV, V.Yu., 1983, New data on genesis of rhodonite of the Urals: Dokl. Akad. Nauk SSSR, v. 269, no. 6, p. 1433-1435 (in Russian). Authors at Inst. of Mineralogy, Geochemistry and Crystallochemistry of Rare Elements, Moscow, USSR.

In rhodonite, bustanite and paragenetic quartz from the deposit Malo-Sedel'nikovskoe P and S fluid inclusions were found. Highest Th were determined for quartz (280-360°C), inclusion filling G + L + H_2O + LCO_2, Th LCO_2 + G → LCO_2 15-18°C, hence LCO_2 density 1.15-1.20 g/cm^3[sic] and evaluated P 1.6-2.2 kbar. Tm of LH_2O equals -35 to -40°C. Rhodonite (Th 180-280°C) and bustanite (Th 240-270°C) bear only G + LH_2O inclusions. (Abstract by A.K.)

KORZHINSKIY, D.S., EPEL'BAUM, M.B. and SOROKIN, V.I., 1983, Relation between acidity of magma-derived fluids and temperature: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 6, p. 3-9 (in Russian). First author at IGEM, Moscow, USSR.

The paper presents experimental data for T 350-900°C and P 20-40 and 100 MPa. (A.K.)

KOSALS, Ya.A. and KOLONIN, G.R., 1983, Genetic principles of model of rare-metal ore formation connected with polyphase granitoid intrusions, in Genetic models of endogeneous ore formations: "Nauka" Pub. House, Siberian Branch, v. 2, p.39-484 (in Russian).

Th of melt inclusions in ore-bearing polyphase granitoid intrusions are as follows; granodiorite-granite formation I (phase number) 1050-850°C, II 890-750°C, III 780-650°C; granite-leucogranite-alaskite formation I 1050-800°C, II 850-680°C, III 750-580°C, IIIa 750-550°C; syenite-granosyenite-alkaline granite formation I 1050-800°C, II 780-600°C; granite-leucogranite formation I 1050-740°C, II 1050-680°C, III 850-650°C, IV 800-650°C, V 800-640°C, VI 850-650°C; alkaline syenite-granite-leucogranite formation I 1100-880°C, II 1020-890°C, III 920-740°C. Three complex figures present P, Th and pH regimes of rare metal mineralization, derived at least in part from earlier published fluid inclusion studies. (Abstract by A.K.)

KOSTYUK, V.P., 1983, Potassium alkaline magmatism of the Baykal-Aldan belt: Geol. i Geofiz., no. 5, p. 33-42 (in Russian; English abstract). Author at Eng.-Constructing Inst., Kuybyshev, USSR.

The paper bears Th values for leucite and pyroxene (1250-1150°C) quoted from Panina, 1978. (A.K.)

KOTOV, N.V. and six others, 1982, Certain peculiarities of thermodynamic regime of formation of gold ore metasomatites in black shales of the Western Uzbekistan: Vestnik Leningr. Univ.-Geologiya, geografiya, no. 18, p. 13-19 (in Russian; English abstract).

Gold-ore bearing metasomatites (sericite rocks, albitized rocks and argillite rocks) developed in Ordovician-Silurian black-shale-type flyschoids (flysch-like rocks). Kaolinite argillites bear quartz with G/L inclusions with Th 350° (in G), 210-275°C (in L); vein quartz yielded water leachates containing (in g per L of inclusion fluid) Na 9-11, K 4-5, Ca 3-8, Mg 3-8, Fe^{2+} 1-1.5, Cl 6-13, SO_4 11-20, HCO_3 33-56, total mineralization 72-122. (Abstract by A.K.)

KOTRA, R.K. and GIBSON, E.K., Jr., 1983, Direct analysis by laser microprobe-gas chromatography of trapped ancient volatiles (abst.): Int'l. Conf. on the Origins of Life, Mainz, FRG, July 1983, Abstracts (unpaginated), Abstract B2-10. First author at LEMSCO C-23/NASA Johnson Space Center, 1830 NASA Rd. 1, Houston, TX 77258, USA.

The composition of volatiles present in inclusions or complete rock samples may represent the volatiles present at the time of formation of the host material. Direct 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 trapped in inclusions their direct analysis is indeed a formidable challenge. Further complications are introduced in attempting to relate volatile composition in inclusions to those in equilibrium during igneous, sedimentary or metamorphic processing.

Bulk volatile composition can be determined by releasing gases using crushing or pyrolytic techniques with identification by mass spectrometry, gas chromatography, etc. Spatially resolving techniques such as micro-Raman spectroscopy and microthermometric methods have been utilized to estimate qualitatively the chemical composition of individual inclusions. 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 (size about 20 microns up) or to release gases from the host mineral. A stream of high-purity helium is used to sweep the released gases into a chromatographic system with an ultra-sensitive helium ionization detector. In an alternate configuration the released volatiles are admitted into a quadrupole mass spectrometer for identification and quantitation.

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 chromatography/mass spectrometry techniques to the study of inclusions in Archean samples (e.g., Isua, North Pole and younger material) and meteorites will be illustrated. (Authors' abstract)

KOVALENKO, V.I. and RUB, M.G., 1983, Problems of potential ore-capacity of magmatic rocks, p. 113-120, in Problems of petrology, mineralogy and ore genesis: "Nauka," Moscow, 224 pp., 900 copies printed, price 3 rbls. 70 kopecks (in Russian).

The lowest T of formation of granites were obtained for sialic granites close to Li-F varieties (550-650°C); Sn-W-bearing palingenic granites yielded Th 700-750°C; highest Th (750-850°C) was from adjacent granites of different origin. (A.K.)

KOVALENKO, V.I., ANTIPIN, V.S., NAUMOV, V.B., IVANOVA, G.F. and VLADYKIN, N.V., 1982, Mineralogical evidence on the rare-metal ores connection with the acid magmatism: Proc. XI General Meeting Int'l. Mineral. Assoc., Novosibirsk 4-10 Sept., 1978: Leningrad, Nauka Press, p. 30-38 (in Russian). (Published 1982)

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 11, p. 113, 1978. (E.R.)

KOVALYOV, V.P., HEL'GUNOV, S.V., NOZHKIN, A.D., MITROPOL'SKIY, A.S., KULIK, N.A., TURKINA, O.M., MALYASOVA, Z.V., NOSOVA, T.G. and PETROV, Yu.M., 1983, Uranium and thorium in magmatic and metamorphic petrogenesis, Siberian Branch of "Nauka" Publ. House, Novosibirsk, 184 pp., 800 copies printed, price 2 rbls 30 kopecks (in Russian). Authors at Inst. Geol. and Geophys., Novosibirsk, USSR.

Carbonates and fluorites in hydromica-carbonate metasomatites of the Uvolga graben yield Th 100-180°C. (A.K.)

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).

KOZLOV, Vl.K., KUZNETSOV, V.N. and KHODAKOVSKIY, I.L., 1983, The thermodynamic parameters of Ag_2O_c and silver (I) hydroxy complexes in aqueous solution at elevated temperatures: Geokhimiya, no. 2, p. 215-227 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 1, p. 137-149, 1983).

KOZLOVA, O.G., 1983, Formation of inclusions in crystals: Izv. Vyssh.

Uchebn. Zaved.-Geol. i Razvedka, no. 7, p. 130-133 (in Russian). Author at State Univ., Moscow, USSR.

The author notes the formation of G/L inclusions in the boundary of twins in several minerals and synthetic crystals. (A.K.)

KRANZ, R.L., 1983, Microcracks in rocks: A review, in M. Friedman and M.N. Toksoz, eds., Continental Tectonics: Structure, Kinematics and Dynamics: Tectonophysics, v. 100, p. 449-480. Author at Los Alamos Nat'l. Lab., Mail Stop J980, Los Alamos, NM 87545, USA.

In the past decade the number of studies about microcracks in rocks has rapidly increased. This review of recent work concentrates on microcracks in rock as separate entities, emphasizing microcrack morphogenesis, kinematics, dynamics, population statistics and observational techniques.

Cracks are produced when the local stress exceeds the local strength. The local stress may be augmented by twin lamellae interactions, kink bands and deformation lamellae, stress concentrations at grain boundary contacts and around intracrystalline cavities. Local strength may be reduced along cleavage planes, along grain boundaries, and along any internal surface as a result of corrosion by chemically active fluids. Dislocations appear not to be a significant factor for crack nucleation below about 500°C in silicates.

Spatial and temporal changes in temperature can also induce microcracking as a result of differential thermal expansion between grains with different thermoelastic moduli and thermal conductivities. The amount of quartz in the rock has a significant effect on thermally induced microcracks because of its large and variable thermal expansivity.

The application of hydrostatic pressure between 100 and 200 MPa effectively closes most cracks, but the closure may not be uniform if crack wall asperities exist. Hydrostatic pressure appears to stabilize cracks and make crack growth more difficult. The number and average size of mechanically induced microcracks is greater in rock deformed at higher pressures.

The application of a deviatoric stress field on the boundaries of a rock mass results, on a microscopic scale, in a very complex stress system which greatly affects nucleation and propagation paths. The relative amount of intragranular and intergranular cracking appears to depend upon mineralogy, rock type and stress state. The vast majority of stress-induced microcracks in rocks appear to be extensional. Statistically, they are predominantly oriented within 30° of the macroscopic maximum stress direction. Crack densities increase as macroscopic deviatoric stress increases above a threshold level. Crack size distributions may be either lognormal or exponential.

Fracture in rock under compressive boundary loads is a result of the coalescence of many microcracks, not the growth of a single crack. Some crack configurations are more favorable for coalescence than others. As deviatoric stress increases and rock failure is approached, the microcrack population changes spatially from random to locally intense zones of cracking. Away from the fault, the crack density dies off rapidly to the background level a few grains away.

Under lesser deviatoric stresses, slow, subcritical microcrack growth can occur as a result of stress-aided corrosion at the crack tip. The rate governing mechanism may be either the chemical reaction rate or the rate at which water can get to the crack tip. Important details still remain to be worked out. (Author's abstract)

KRĂSTEVA, M., 1983, Fluid inclusions in sphalerite, quartz and carbonate from Zvezdel-Galenit ore field: Geochem., Miner. and Petr., v. 17, p. 41-50 (in Russian; English abstract). Author at Bulgarian Acad. Sci., Geol. Inst., 1113 Sofia, Bulgaria.

The ore mineralizations in the Zvezdel-Galenit ore field occur mostly as carbonate-sulphide veins and ore breccias confined to fault structures and as metasomatic ore bodies formed in Paleogene reef limestones and Proterozoic marbles. Fluid inclusions in various generations of sphalerite, quartz, and carbonate from the Botka, Galenit, Zvezdel, Pcelojad and Eseler deposits have been examined. Their characterization includes descriptions of their morphology and occurrence and measured Th.

Sphalerite from all deposits studied is rich in fluid inclusions, of three-dimensional shapes, less frequently platy. Their size ranges between 0.10 and 0.002 mm. Th of the fluid inclusions in sphalerite from the ore veins and breccias fall within the temperature interval 300-220°C. Cleiophane from the ore breccias has a Th of 220-150°C.

Fluid inclusions in quartz are numerous and of various size (0.190-0.004 mm). Their shape depends on the degree of face development. The highest Th are found in the earliest grey quartz from the Botka deposit, 350°C. The fluid inclusions in quartz, which accompanies the ore mineralization, have Th of 300-180°C. The barren quartz shows analogous Th. The fluid inclusions in the metasomatic quartz have Th of 330-180°C.

The inclusions in the carbonate are gaseous-liquid and liquid, of irregular shape mostly. Their size ranges between 0.050 and 0.003 mm. Th of the fluid inclusions in carbonate from the ore veins, ore breccias and the barren veinlets fall almost in one and the same temperature interval (about 300-180°C). (Author's abstract)

KREITLER, C.W. and DUTTON, S.P., 1983, Origin and diagenesis of Cap Rock, Gyp Hill and Oakwood salt domes, Texas: Report of Investigations No. 131, Bureau of Econ. Geol., The Univ. of Texas at Austin, Austin, TX, 58 pp.

Includes analysis (p. 37) of a fluid inclusion in salt for $\delta^{18}O$ (+5.4‰) and δD (-69.2‰), and gas chromatograms of organic matter from (organic inclusions?) in calcite and various other samples (p. 38). (E.R.)

KREULEN, Rob., 1982, Nitrogen and carbon isotopes in fluid inclusions from the Dôme de l'Agout, France (abst.): Terra Cognita, v. 2, p. 71. Author at Inst. Earth Sci., Univ. Utrecht, POB 80021, 3508TA Utrecht, The Netherlands.

The Dôme de l'Agout consists of an ellipsoidal mass of gneisses and migmatites, emerging from a large area of chlorite-sericite schists. Metamorphism is characterized by a rapid succession of metamorphic zones; temperatures of metamorphism increase from less than 500°C to 700°C over a horizontal distance of about 5 km. Fluid inclusions in syn-metamorphic quartz segregations contain N_2, CH_4 and CO_2 as their main components. N_2 contents range from 2 to 72 mol% and tend to increase with increasing degree of metamorphism. CO_2 and CH_4 show an erratic distribution with the exception of the lowest grade samples, which invariably have a very high CO_2 content. $\delta^{15}N$ values of the fluid inclusions range from -3 to 5‰; negative values typically occur in the least metamorphosed rocks, and positive values in the higher grade rocks. The source of nitrogen in the fluid is as yet unknown. $\delta^{13}C$ values of total carbon in fluid inclusions (CH_4 + CO_2) range from -26 to -9‰, and are clearly related to CO_2/CH_4 ratios in the inclusions. The data are interpreted as mixing of organic CH_4 with anorganic CO_2; this simple model is complicated by local oxidation and reduction of the fluid. $\delta^{13}C$ of CO_2 from fluid inclusions ranges from -19 to +1‰ and reflects isotope reequilibration with CH_4 within the inclusions during cooling of the rocks. (Author's abstract)

KREULEN, Rob, 1983, Nitrogen and carbon isotopes of metamorphic fluids in the Dôme de l'Agout; origin and fluid-rock interaction (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 38. Author at Inst. Earth Sci., Univ. Utrecht, P.O.B. 80021, 3508 TA Utrecht, The Netherlands.

Fluid inclusions in metamorphic rocks from the Dôme de l'Agout contain N_2, CH_4 and CO_2 as their main components. The nitrogen and carbon isotopic compositions of these fluid inclusions have been studied, together with nitrogen isotopes of NH_4^+ in the rocks.

The Dôme de l'Agout consists of an ellipsoidal mass of gneisses and migmatites emerging from a large area of chlorite-sericite schists. Metamorphism is characterized by a rapid succession of metamorphic zones; temperatures of metamorphism increase from less than 500°C to 700°C over a horizontal distance of about 5 km.

Nitrogen isotopic compositions of fluid inclusions are negative in the chlorite-sericite schists (zone I) and positive in the higher grade rocks; $\delta^{15}N$ values of ammonium in the rocks show a similar distribution, but 4 to 5‰ higher (figure 1). The nitrogen isotope systematics suggest equilibrium and open communication of the nitrogen reservoirs over large distances.

$\delta^{13}C$ of total carbon (CH_4 + CO_2) in fluid inclusions ranges from -26 to -13‰. The $\delta^{13}C$ values are not related to metamorphic grade, but when data from zone I are excluded they show a clear relationship with XCO_2 of the metamorphic fluid. The data in figure 2b suggest that XCO_2 and $\delta^{13}C$ changed concomitantly as a result of mixing, whereas oxidation and reduction of the fluid were limited.

Nitrogen and carbon give contradicting information on the interaction of fluids and rocks and on the amounts of fluid that were involved.

Ultimate source of the nitrogen and at least part of the carbon is probably land derived organic matter. (Author's abstract)

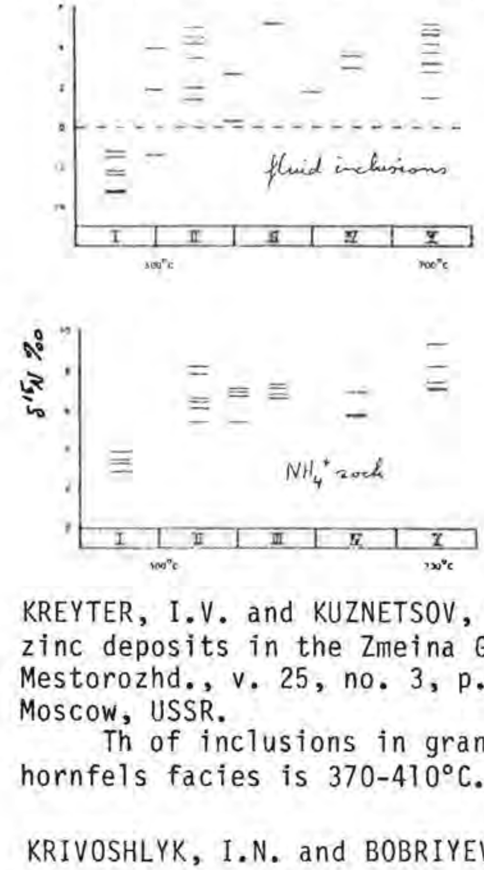


FIGURE 1

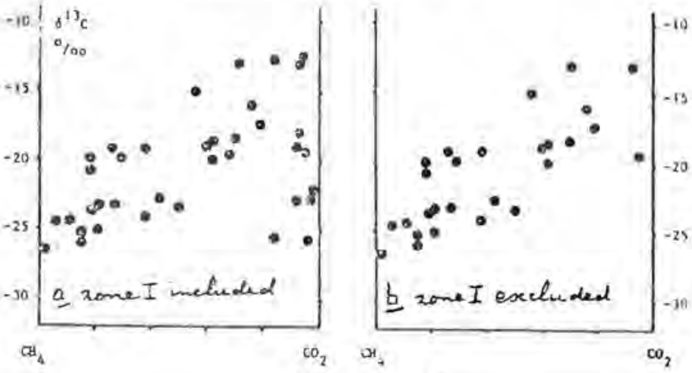


FIGURE 2

KREYTER, I.V. and KUZNETSOV, V.V., 1983, Contact metamorphism in the lead-zinc deposits in the Zmeina Gora ore region (Rudnyi Altai): Geol. Rudn. Mestorozhd., v. 25, no. 3, p. 95-99 (in Russian). Authors at TsNIGRI, Moscow, USSR.

Th of inclusions in granoblastic quartz from rocks of the muscovite-hornfels facies is 370-410°C. (A.K.)

KRIVOSHLYK, I.N. and BOBRIYEVICH, A.P., 1981, Spherules of immiscible carbonatite in kimberlite: Dokl. Akad. Nauk SSSR, v. 260, p. 986-988 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 260, p. 121-123, 1983).

KRIVOVICHEV, V.G. and KRYLOVA, L.Ya., 1983, Peculiarities of fluorine distribution in minerals and rocks of apobasite rare-alkali-metal metasomatites: Zapiski Vses. Mineralog. Obshch., v. 112, no. 5, p. 527-534 (in Russian). Authors at Leningrad Univ., USSR.

Quartz-chlorite metasomatic rocks of an unnamed Li-Rb-Cs deposit bear quartz and tourmaline with Td 330-370°C. (A.K.)

KRIVOVICHEV, V.G., PORITSKAYA, L.G. and KOCHERGINA, O.K., 1982, Peculiarities of distribution of admixture elements between biotite and chlorite from apobasite metasomatites: Vestnik Leningr. Univ.-Geologiya, geografiya, no. 6, p. 86-90 (in Russian; English abstract).

Td for nest metasomatites are 620-640°C, internal zones of regional metasomatites 420-470°C, same, external zones (quartz-chlorite) metasomatites 320-350°C. (A.K.)

KRONENBERG, A.K., KIRBY, S.H., AINES, R.D. and ROSSMAN, G.R., 1983, Hydrogen uptake in hydrothermally annealed quartz: implications for hydrolytic weakening (abst.): EOS, v. 64, p. 839. First author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

The uptake of hydrogen in quartz has been studied by hydrothermally annealing nominally dry, Brazilian quartz crystals at T = 800°C and PH_2O = 8.9-15.7 kb for times of up to 2 days and examining the infrared absorptions due to O-H stretching modes at wavelengths near 3 μm. Annealed specimens, taken from the same crystal used in the classic hydrolytic weakening experiments of Griggs and Blacic (1965), exhibit a progressive increase in sharp dichroic absorptions at wavenumbers of 3464, 3428, 3364, and 3303 cm^{-1} (as measured at 77 K) and lack any detectable broad-band absorptions. The principal absorptions at 3428 and 3364 cm^{-1} correspond to those identified by Kats (1962) with hydrogen interstitials charge compensating for aluminum substitutions for silicon. In addition, the equilibrium H concentration of 83 ± 10 ppm appears to depend upon the initial Al concentration of 91 ± 1 ppm. The observed increase in H uptake with time has been used to determine an H diffusivity of $(2 \pm 1.6) \times 10^{-7}$ cm^2s^{-1} at T = 800°C and PH_2O = 8.9 kb, comparable with the rate of ^1H-^2H exchange in quartz ($D = 1.4 \times 10^{-8} cm^2s^{-1}$) determined by Kats et al. (1962) at much lower pressures (PH_2O = 25 bars). Although the sharp dichroic absorptions observed in this study are common in other natural quartz crystals, these absorptions are not known to be associated with hydrolytic weakening. The absence of any detectable broad-band absorptions therefore calls into question whether hydrogen incorporation as molecular water may be taken up in significant concentrations and affect the strength of natural quartz crystals at our experimental conditions. (Authors' abstract)

KRONENBERG, A.K., TULLIS, J. and KIRBY, S.H., 1983, Strain localization along ductile shear zones: possible roles of grain size and H_2O diffusion (abst.): EOS, v. 64, p. 323.

KRUZHANOV, V.S. and STARUKHINA, L.V., 1983, The effect of intergranular boundaries on the movement of inclusions in a crystal: Kristallografiya SSSR, v. 28, no. 6, p. 1220-1221 (in Russian).

KUDEL'SKIY, A.V. and SHIMANOVICH, V.M., 1981, Viscosity of subterranean brines: Dokl. Akad. Nauk SSSR, v. 259, p. 450-452 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 259, p. 144-146, 1983).

KULIKOV, I.V., 1982, Polyphase brine inclusions in fluorite and calcite and their genetic significance: Akad. Nauk SSSR Doklady, v. 264, no. 4, p. 958-961 (in Russian). Author at Moscow Geol.-Prosp. Inst., Moscow, USSR.

See Fluid Inclusion Research--Proceedings of COFFI, v. 14, entries: Kulikov, 1981, p. 117; Kulikov 1981a and b, p. 257-258; Mel'nikov, Kulikov and Gromov, 1979, p. 259. (A.K.)

KUO, L.-C. and ESSENE, E.J., 1983, Thermal history of the upper mantle beneath the Arabian Shield: evidence from a spinel harzburgite (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 620. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

A spinel harzburgite nodule 9 cm in diameter from the al Kishb Plateau, Saudi Arabia is characterized by a transition from protogranular to porphyroclastic texture, with vermicular spinel embayed in enstatite and associated with diopside and olivine neoblasts. Porphyroblastic olivines have average composition of Fo(90.5)Fa(8.9), and enstatites of En(87.7)Fs(8.3)Wo(0.1). Average compositions in the neoblastic assemblage are: olivine: Fo.(904)Fa.(088); enstatite: En.(867)Fs.(085)Wo.(010); diopside: En.(486)Wo.(398)Fs.(016)CaTs.(037)Jd.(021)Ac.(020); and spinel: Mg.(742)Fe^{2+}.(250)Al.(734)Cr.(256)Fe^{3+}.(011)O(4). Clear, light-green glasses occur along the boundaries of porphyroblasts with widths of a few microns. The glass is homogeneous with no suggestion of local chemical control by adjacent solids. Successful microprobe analysis of the Na in the glass was obtained only at 5 kV, with a sample current of 0.006 μA, for counting times of <7 sec; higher settings resulted in rapid loss of Na. Other workers' analyses of mantle melt glasses in nodules may have systematic errors in alkalis. Our glass analyses are characterized by relatively high wt% SiO_2 (55.8-58.7), Na_2O (6.4-7.3), and Al_2O_3 (20.0-21.5), yielding 0-5.2 wt% nepheline in the norm. Analytical totals of 99.8-101.1 wt% suggest that little H_2O or CO_2 is contained in these glasses.

Geothermometry yields 900-1200°C temperatures using Ca and Al partitioning in the neoblastic assemblage, while 800-900°C is obtained with Mg and Fe partitioning. We suggest that the peridotite mantle protolith was heated to 1000-1200°C at 14-18 kb under an average geothermal gradient of ~25°C/km, resulting in a small degree of partial melting. Subsequent cooling in the mantle unmixed spinel from reaction between aluminous pyroxene and olivine, and intercrystalline Mg/Fe exchange froze in at ~800°C. Transport of the nodule by the ascending basalt magma did not affect the mantle melt or reset the thermometers. (Authors' abstract)

KUROVSKAYA, N.A. and MALININ, S.D., 1983, Experimental studies of CaF_2 solubility in water solutions of $CaCl_2$-HCl-NaCl at temperatures 25-200°C. Determination of values of CaF_2 activity: Geokhimiya, no. 1, p. 16-29 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 1, p. 13-27, 1983). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

The concentrations used ($CaCl_2$ 0.009-0.4 M, HCl 0.1-0.4 M, ionic strength 0.7-2.0 M) yielded data that prove that the activity of CaF_2 (L CaF_2) at T >90°C depends not on Ca concentrations over a wide range, but at 25°C and 50°C this connection is very distinct. (A.K.)

KUSAKABE, Minoru and CHIBA, Hitoshi, 1983, Oxygen and sulfur isotope composition of barite and anhydrite from the Fukazawa deposit, Japan: Econ. Geol. Monograph 5, p. 292-301. First author at Dept. Earth Sci., Toyama Univ., Gofuku, Toyama 930, Japan.

Oxygen and sulfur isotope ratios were determined for barite and anhydrite samples from the Fukazawa deposit, a typical Kuroko deposit in the Hokuroku basin of northeastern Japan. There is no systematic variation in the $\delta^{18}O$ and $\delta^{34}S$ values of barite with the mode of occurrence and locality within an orebody. Barite has lower $\delta^{18}O$ values (6 ~ 9‰) than anhydrdite (11 ~ 14‰), whereas the $\delta^{34}S$ values of the two minerals are similar to each other and close to the seawater value. The oxygen isotope systematics suggest that barite and anhydrite were precipitated in oxygen isotope equilibrium with a solution which was a mixture of seawater and hydrothermal fluids.

The lower $^{87}Sr/^{86}Sr$ ratios of barite relative to anhydrite at the Fukazawa deposit obtained by Farrell (1979) may indicate a larger contribution of hydrothermal fluids to barite precipitation, although a lower water/rock ratio in the hydrothermal system could also explain this feature. The $\delta^{18}O$ vs. $^{87}Sr/^{86}Sr$ relationship of barite may be explained by a mixing model with a seawater contribution of less than 20 percent at temperatures around 210° ± 30°C, while the oxygen and Sr isotope relationship of anhydrite indicates that anhydrite may have precipitated at temperatures around 180° ± 20°C either from a mixed solution of seawater and a hydrothermal fluid which was more diluted in ore metals or from heated seawater which had circulated through volcanic rocks. Strontium and sulfur isotope data support the idea that the sulfates in the hydrothermal fluid were directly derived from the Micoene seawater. (Authors' abstract)

KUSHNIR, S.V. and SHUTER, Ya.N., 1983, Bonding of water in hydrated forms of calcium sulfate, from data of IR spectroscopy: Zhurn. Neorg. Khimii, v. 28, no. 3, p. 593-596 (in Russian). Authors at Inst. Geol. and Geokhim. of Mineral Fuels, L'Vov, Ukraine.

IR specta of gypsum $CaSO_4 \cdot 2H_2O$ α-semihydrate $CaSO_4 \cdot 0.67H_2O$ and β-semihydrate $CaSO_4 \cdot 0.5H_2O$ are characterized; the data may be used for dm identification. (A.K.)

KUZNETSOVA, S.V., KULIK, Zh.V. and LAZARENKO, E.E., 1983, Amino acids in the gas-liquid inclusions from the Ukrainian shield rocks: Dopovidi Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim., Biol. Nauki, 1983, no. 9, p. 15-17 (in Ukrainian). Authors at NDI Mors'koi Geofiz., Krasnodar, USSR.

A relation is established between the presence of amino acids in water extracts of rocks and the volcanic activity or the influence of high tectonic stresses on rocks. Amino acids as components of mineral-forming solutions contribute to metal mobilization and transport under reduction conditions within a wide range of environmental pH. (Authors' abstract)

KVASNITSA, V.N., GALABURDA, Yu.A. and SIMBIRTSEV, L.A., 1982, Minerals of coal-bearing beds: Mineralog. Zhurnal., v. 4, no. 6, p. 104 (in Russian). First author at Inst. Geochem. and Physics of Minerals, Kiev, Ukraine.

Quartz crystals from coal beds (depth 900-1000 m) of Middle Carboniferous from one of the mines in the Donets-Makeevskiy region bear P inclusions of G and G/L type (L 5 to 80 vol. %). At +16 to +6°C fine crystals appear in L, total solidification T is -40 to -60°C, G phase heterogenizes to L + G at -33 to -87°C, Th of originally G inclusions -24 to -16°C, and Th of former G phase of G/L inclusions -78 to -66°C; at +80°C some inclusions decrepitate (P ~10^8 Pa). Quartz then crystallized from heterogeneous solutions under high P. L phase consists of organic compounds, G phase - essentially of CH_4, but with significant admixture of CO_2 and other gases. Water was either absent or present in very small amounts. (Abstract by A.K.)

KVENVOLDEN, K.A., BARNARD, L.A., BROOKS, J.M. and WIESENBURG, D.A., 1983, Geochemistry of natural-gas hydrates in oceanic sediment, in M. Bjoroy et al., eds., Advances in Organic Geochem. 1981, Proc. 10th Int'l. Meeting on Organic Geochemistry, Univ. Bergen, Norway, 14-18 Sept., 1981: John Wiley & Sons Ltd, New York, p. 422-430.

KYLE, J.R., 1983a Temporal and spatial aspects of mineralization in the K57 orebody, Pine Point district, Northwest Territories, Canada: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 338-346. Author at Dept. Geol. Sci., The Univ. Texas at Austin, Austin, TX 78712.

The K57 orebody provides an excellent example of the nature and controls of mineralization in the upper part of the Middle Devonian Pine Point carbonate barrier complex. K57 is a prismatic sulfide body with an adjacent discontinuous tabular sulfide zone totalling 1.8 million tons of ore averaging 7.0% Pb, 5.6% Zn, and 1.2% Fe. The high grade portion is about 150 m long and a maximum of 75 m wide; it contains a maximum of 38.7% combined Pb-Zn over a 53-m interval. K57 occurs within the coarse-crystalline Presqu'ile dolostone along the Main Hinge Zone in the western part of the district. The coarse-crystalline dolostone has a maximum preserved thickness of about 45 m in this area and may be divided into lower and upper units. The lower unit consists of tan to light gray, coarse-crystalline dolostone which contains megafossil and uniform granular lithologic types, interpreted to represent reefal and proximal fore-reef depositional environments, respectively. Direct evidence concerning the original nature of the upper Presqu'ile unit has been largely obliterated by the pervasive introduction of gray and white dolomite. The prismatic ore zone is superimposed over an irregularly elliptical, detritus-filled paleodoline approximately 190 m long oriented along the direction of the hinge zones and the depositional facies boundaries. The maximum detritus thickness is 35 m and directly overlies the fine-crystalline dolostones of the lower Pine Point barrier. The tabular ore zone represents porosity enhancement along the upper paleo-phreatic zone within the proximal fore-reef material near the transition with the reef.

Ore textures in the K57 and other orebodies are complex. Paragenetically early marcasite and pyrite are followed by colloform and banded sphalerite with skeletal galena; large, euhedral sphalerite and galena crystals are late. Dolomite occurs both earlier and later than sulfides; calcite typically is a late, porosity-occluding mineral. Fe content of sphalerite ranges from less than 1 to as much as 5.5%, and there is a general correlation of greater Fe content and darker sphalerite colors. Fluid inclusion evidence indicates that the sphalerite was deposited by highly saline, 60-100°C brines. Sulfur isotopic composition of K57 sulfides ranges from 13.1 to 23.5‰ $\delta^{34}S$ and indicates nonequilibrium precipitation. The lead isotopic composition of galena is nonradiogenic with a $^{206}Pb/^{204}Pb$ ratio of 18.2, suggesting a mid-Carboniferous age of mineralization. Colloform sphalerite and skeletal galena indicate rapid early sulfide precipitation, while coarse crystals suggest slower rates of precipitation for late sulfide growth. Sulfide concentrations are localized in paleo-dolines and breccia zones because these features were the bypasses between different aquifers and acted as natural mixing sites for basinal-derived fluids containing metals and reduced sulfur. (Author's abstract)

KYLE, J.R., 1983, Textural and geochemical character of the K57 Pb-Zn orebody, Pine Point district, Northwest Territories (abst.): Geol. Assoc. Canada; Mineral. Assoc. of Canada; Canadian Geophy. Union; joint annual meeting, Victoria, B.C., Canada, May 11-13, 1983, Geol. Assoc. Canada Program with Abstracts, v. 8, p. A39. Author at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78712.

K57 is a prismatic Pb-Zn orebody with an adjacent tabular sulfide zone within the coarse-crystalline Presqu'ile (Facies K) dolostone in the upper part of the Middle Devonian Pine Point carbonate barrier complex. The orebody is zoned with a high grade, Pb-rich core surrounded by increasingly Zn- and Fe-rich zones toward the periphery. Studies of doubly polished thick sections from samples throughout the sulfide zone indicate a complex history of mineralization. Colloform and banded sphalerite with skeletal galena is typical of the paragenetically early sulfide concentration in the prismatic zone; large, euhedral sulfide crystals are common in secondary porosity within the tabular zone. Baroque dolomite occurs both earlier and later than sulfides; calcite typically is a late, porosity-occluding mineral. Fluid inclusion data indicate that sphalerite was deposited from 60-100°C brines. Sulfur isotopic composition of sulfide minerals ranges from +13.1 to +23.5‰ $\delta^{34}S$ with a mean of +19.2‰ for 14 samples; the mean values of galena, sphalerite, and marcasite + pyrite are +17.7‰, +20.8‰, and +19.1‰, respectively. Δ values of less than 1.5‰ for co-precipitated sphalerite-galena pairs indicate nonequilibrium precipitation at these low temperatures. The lead isotopic composition of galena is nonradiogenic with a $^{206}Pb/^{204}Pb$ ratio of 18.16, suggesting a late Paleozoic age of mineralization. (Author's abstract)

LAL, D., MATHER, A.E. and OTTO, F.D., 1983, Solubility of hydrogen, hydrogen sulfide and carbon dioxide in bitumens and heavy gas oils, in Chemical Engineering Thermodynamics, S.A. Newman, ed.: Ann Arbor, Ann Arbor Sci., p. 75-84.

LAND, L.S., 1983, Frio sandstone diagenesis, Texas Gulf Coast: a regional isotopic study (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 622.

LAPIN, A.V., 1983, Limited miscibility in silicate-carbonate melts and its significance for petrology and carbonatite origin: Geol. Rudn. Mestorozhd., v. 25, no. 2, p. 3-20 (in Russian). Author at IMGRE, Moscow, USSR.

The paper presents analysis of experimental and geological data concerning the conditions of carbonatite origin and its genetic relation to alkaline rocks and proves that processes of magmatic differentiation caused by limited miscibility of carbonate and alkaline alumosilicate displayed the most important role in fractionation of primary mantle magmas and separation of carbonatite fluid. These processes were stimulated by streams of juvenile solutions which enrich the magmatic system in CO_2 and alkalies. Carbonatite and alkaline alumosilicate melts may exist as jointly formed but immiscible fluids. Tendency of carbonate-silicate and ore-carbonate-silicate to immiscibility may be recognized also in further evolution of carbonate melts relatively rich in ore-silicate components. The studied spherolitic and orbicular structures prove the presence of immiscibility in the development of the genetically connected carbonatite-kamaphorite rock series. (From the author's conclusions, translated by A.K.)

LAPIN, A.V. and VARTIAINEN, H., 1983, Orbicular and spherulitic carbonatites from Sokli and Vuorijärvi: Lithos, v. 16, p. 53-60. First author at Inst. Mineral., Geochem. & Crystal Chem. of Rare Elements, Moscow, USSR.

The main types of spherulitic and orbicular structures in carbonatites of Sokli (Finland) and Vuorijärvi (USSR) are described. The structures have small-scale morphological differences although generally they show fairly similar characteristic features. All the rocks investigated are composed of two structurally different portions: regular ellipsoidal and spherical segregations containing forsterite, magnetite, phlogopite and sometimes calcite and apatite, and a substantially calcitic matrix containing some apatite, silicate and opaque components. These two portions correspond to phoscorite and sövite fractions separated during the crystallization of an initial melt of mixed composition. The structures described are regarded as evidence of liquid immiscibility processes in the formation of sövite and phoscorite rock series which were promoted by limited solubility of ore-silicate and carbonate fractions. Crystallization differentiation by early settling of apatite, silicate and ore minerals plays a leading role in the fractionation of substantially sövitic solutions that contain comparatively small amounts of silicate, ore and phosphate components. (Authors' abstract)

LAUGIER, S., RICHON, D. and RENON, H., 1983, Vapor-liquid equilibria of hydrogen-hydrocarbon mixtures up to 40 MPa, 400°C: measurements and representation, in Chemical Engineering Thermodynamics, S.A. Newman, ed.: Ann Arbor, Ann Arbor Sci., p. 47-58.

LAWLER, J.P. and CRAWFORD, M.L., 1983, Stretching of fluid inclusions resulting from a low-temperature microthermometric technique: Econ. Geol., v. 78, p. 527-529. First Author at Exxon Min. Co., P.O. Box 2189, Houston, TX 77001.

If an inclusion, particularly in soft minerals such as fluorite and sphalerite, loses its vapor bubble on freezing, the expansion to form ice may stretch the walls. (E.R.)

LEACH, D.L. and HOFSTRA, A.H., 1983, Fluid inclusion studies in the Coeur d'Alene district, Idaho (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 327. Authors at U.S. Geol. Survey, Box 25046, MS 973, Federal Center, Denver, CO 80225.

Reconnaissance microthermometric studies of fluid inclusions in quartz and sphalerite from mines within the Coeur d'Alene district have been conducted as a prelude to more detailed work. Preliminary results show that fluid inclusions in quartz and sphalerite consist of CO_2-bearing saline fluids (7 to 15 eq. wt. % NaCl) trapped at high confining pressures (1.5 Kb minimum). Inclusions in quartz homogenize at 230°-305°C. The minimum pressure correction to be added to these data is 125°C. Homogenization temperatures of fluid inclusions in sphalerite have not been determined because of decrepitation or stretching of the inclusions prior to homogenization. Little variation exists in either homogenization temperatures or salinities from deposit to deposit, even for samples collected from deposits more than 100 km from the district. Fluids depositing the early quartz-siderite-sphalerite veins may have had slightly lower temperatures and CO_2 content relative to the later quartz-galena veins. Most inclusions are dominantly water, and trapping of homogeneous fluid is indicated. However, some coeval primary inclusions consisting of dominantly CO_2 or water are observed in a few samples, indicating that immiscible fluids were present during some periods of ore deposition. The importance of the separation of immiscible phases in the ore fluids to deposition of the Coeur d'Alene veins is uncertain. Our fluid inclusion data are consistent with other geologic information that suggests a regional metamorphic event concurrent with Proterozoic folding and faulting may be responsible for deposition of the Coeur d'Alene vein deposits. (Authors' abstract)

LEACH, D.L., ROWAN, L.P. and HEDAL, J.A., 1983, Evidence for ore fluid migration in the Bonneterre Formation, southeast Missouri (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 625. Authors at Geol. Survey, P.O. Box 25046, Denver Fed. Center, Denver, CO 80225.

Dolomite crystals are ubiquitous in the lead-zinc deposits in the Viburnum Trend, southeast Missouri. In addition, saddle-shaped dolomite crystals commonly thought to have a hydrothermal origin are widespread in the Bonneterre Formation which hosts the lead-zinc ore deposits in the Viburnum Trend. Samples of dolomite provide the best opportunity to determine temporal and spatial variations in the ore fluid within the ore deposits as well as on a regional scale. Most of the inclusions in ore-zone dolomite yield homogenization temperatures (Th) between 95° and 137°C with a few around 160°C. Melting temperatures (Tm) for the ore fluids in dolomite are typically between -23° and -21°C. These data are comparable to reported data for sphalerite in the Viburnum Trend.

Fluid inclusions in dolomite in core samples from five drill holes transecting the Viburnum Trend from the fore-reef limestone facies to the back-reef "white-rock" dolomite facies of the Bonneterre Formation yield Th and Tm values essentially identical to those in the lead-zinc deposits. Inclusions in late pore- and fracture-filling calcite in the Bonneterre Formation yield Th values indistinguishable from those of the dolomite. Salinities are much lower with typical Tm values close to -5°C. Measurements made on dolomite indicate no vertical zonation in either Tm or Th within a 400-foot stratigraphic interval or lateral distance of 10 miles. These data suggest that the ore fluid migration was pervasive throughout huge volumes of the Bonneterre Formation. These data also suggest that ore deposition was not related to drastic changes in salinity or temperature. Zones of local permeability contrast (e.g. breccia zones) played an important role in localizing ore deposition. (Authors' abstract)

LEACH, T.M., WOOD, C.P. and REYES, A.G., 1983, Geology and hydrothermal alteration of the Tongonan geothermal field, Leyte, Republic of the Philippines (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 275-278. First author at KRTA Ltd., P.O. Box 4498, Auckland, New Zealand.

Some fluid inclusions had Th greater than 350°C Leach (1982) and freezing point depressions (Napoles 1981) indicate solutions far more saline than current fluids. It is therefore apparent that the majority of mineral assemblages on the periphery of the Tongonan field are relict. Temperature ranges of various hydrothermal minerals from fluid inclusion studies were as follows (°C): illite(sic) 240-305; pyrophyllite-illite 210-310; anhydrite 205-305; laumontite 210-220; wairakeite 250-305; albite 260-305; actinolite 295-315; epidote 250-310; diaspore 300-310; garnet 285-300; sphalerite 315-325. (From the authors' abstract)

LeANDERSON, Jim, LUDINGTON, Steve and BOOKSTROM, Art, 1983, Origin of fluids and metals in porphyry and epithermal mineral deposits: Geology, p. 557-558. First author at Dept. Geol. Engrg., Colorado Sch. Mines, Golden, CO 80401.

A short summary of the (unpublished) discussions at a Penrose Conference on this subject, held Aug. 8-13, 1982, in Dillon, Colorado. (E.R.)

LEBEDEV, L.M., 1983, Cheleken hydrothermal system - natural laboratory of mineral formation: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 7, p. 60-75 (in Russian). Author at IGEM, Moscow, USSR.

The paper presents contents of metals (Fe, Pb, Cu, Zn, Cd, Tb, As, Mo, Sb, Bi and Ag) in Cl-Na-Ca brines and HCO_3-Na, SO_4 and H_2S-bearing waters, and mechanism of formation of the following minerals: atacamite, botallakite, boleite, pseudoboleite, kumengite[sic], diaboleite, laurionite, cerussite, etc. (A.K.)

LENKOWSKI, Waldemar, 1983, Physico-chemical conditions of crystallization of the low- and moderate-temperature mineral parageneses in the Strzegom massif: Archiwum Mineral., v. 39, part 1., p. 53-66 (in Polish; English abstract). Author at Inst. Geochem., Miner. & Petr. of the Warsaw Univ., Poland.

The paper presents results of studies of fluid inclusions in hydrothermal minerals (quartz, fluorite, epidote, axinite, cleavelandite and calcite) from the Strzegom granitoid massif pegmatites. Th and pressure inside inclusions indicate that most of hydrothermal minerals crystallized in relatively narrow range 250-150°C under pressure 20-80 MPa. (Author's abstract)

LENTINI, M.R. and SHANKS, W.C., III, 1983, Experimental study of brine-arkose interaction at 200°C and 500 bars: origin of metalliferous oil field brines and Mississippi Valley type ore deposits: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 195-205. First author at P.O. Box 60775, One Shell Square, New Orleans, LA 70160.

Diagenetic brine-arkose interactions were investigated experimentally at 200° and 500 bars total pressure to obtain quantitative evidence regarding generation of metalliferous basinal brines from arkosic source rocks. Duplicate experiments using two artifical brines similar in composition to natural oil-field brines were performed.

An iron-rich arkosic sandstone appears to be an excellent source rock. Destruction of highly reactive iron oxides in the arkose accounts for appreciable amounts of iron, zinc, lead, and manganese in solution. The alteration of barium-rich potassium feldspar released significant amounts of barium into the brines. Relatively high concentrations of metals in the brines demonstrate that at 200°C chloride complexing is sufficient to maintain heavy metals in solution.

Rock alteration by magnesium-rich brines at 200°C produces alteration minerals, principally smectite, at the expense of illite, potassium feldspar and quartz. This results in low solution pH and significant heavy metal solubilization. Rock alteration by magnesium-free brines is less intense due to less acidic conditions and metal release is thus reduced. Interlayered illite-vermiculite-smectite formed at the expense of illite and kaolinite during the magnesium-free brine experiment.

The extent of arkose alteration was relatively minor in both brine experiments and would be extremely difficult to detect in the field. The changes in mineralogy due to rock alteration are the same as those atributed to normal basinal diagenetic processes. (Authors' abstract)

LEPEZIN, G.G. and MELENEVSKIY, V.N., 1983, Problem of H_2O and CO_2 in cordierites: Dokl. Akad. Nauk SSSR, v. 269, no. 4, p. 920-924 (in Russian). Authors at Inst. Geol. and Geophysics, Novosibirsk, USSR.

The paper presents the comparison of H_2O and CO_2 contents in cordierites in G/L inclusions and in structural channels. (A.K.)

LEPEZIN, G.G. and MIRIYEVSKAYA, O.S., 1983, Behavior of metapelite- and metamafite-forming elements in regional metamorphism: Dokl. Akad. Nauk SSSR, v. 273, no. 2, p. 452-455 (in Russian).

LETNIKOV, F.A. and ZHATNUEV, N.S., 1983, Fluoride-water-silicate system in thermogradient conditions: Dokl. Akad. Nauk SSSR, v. 268, no. 1, p. 199-201 (in Russian). Authors at Inst. of the Earth's Crust, Irkutsk, USSR.

During experiments in a T gradient field of 773-585 K, P - 98.13 MPa, time 250 hours under action of 10% HF water solution, pegmatite composition alters to albitized product, muscovite-quartz and quartz greisen in various T zones. (A.K.)

LEVITSKIY, V.V., LEPIN, V.S., KOLOSNITSYNA, T.I. and BRANDT, S.B., 1983, Use of Rb-Sr isochron method for determination of absolute age of gold-quartz hydrothermal ore mineralization: Doklady Akad. Nauk SSSR, v. 270, no. 6, p. 1424-1426 (in Russian). First author at East-Siberian Inst. of Geol., Geophysics and Mineral Raw Materials, Irkutsk, USSR.

The gold ore system of the Baikal-Muy greenstone belt formed in the following stages (Th values in parentheses): quartz-tourmaline-pyrite (350-400°C, ~1.5 kbar), quartz-pyrite-chalcopyrite (250-350°C), gold-polymetal-quartz (270-170°C, 2.0 kbar), quartz-sulfosalt-silver (250-110°C, 0.8-0.6 kbar) and quartz-carbonate (<100°C). (A.K.)

LEVITSKIY, V.V., RAZVOZZHAEVA, E.A., DEMIN, B.G., KHRENOV, P.M., BABURIN, L.M. and ODINTSOVA, I.V., 1983, Asphaltenes of oil and gold ores - concentrators of metal-organic compounds: Doklady Akad. Nauk SSSR, v. 270, no. 1, p. 196-199 (in Russian). Authors at E.-Siberian Sci.-Research Inst. of Geol., Geophysics and Mineral Raw Materials, Irkutsk, USSR.

The paper presents role of organic matter in concentration of V, Fe, Co, Ni, Cu, Zn, Au, Ag, Pb, U. (A.K.)

LI, Benchao and SHI, Jixi, 1983, Continuous determination of stable isotopes of hydrogen--gases and salts in fluid inclusions: Scientia Sinica, Ser. B., v. 26, no. 1, p. 93-102 (in English). Authors at Guiyang Inst. Geochem., Acad. Sinica, China.

In this paper, a newly developed method is described for the analysis of inclusion populations in the milligram range.

The authors have designed a series of devices by which the heating decrepitation of fluid inclusions in an inert gas flow, and the grading refrigeration for extracting water and gases can be realized, and which also can be used in combination with a gas chromatograph. Making use of electrodialysis technique can directly extract the remaining salts in the decrepitated inclusions. The equipment is simple. It not only avoids drawbacks of the conventional methods, but also facilitates the continuons determination of stable isotopes of hydrogen, gases and salts on the same sample.

With the newly developed method, inclusion compositions for samples collected from various types of ore deposits in China have been first determined, and this provides fundamental grounds for expounding the origin of mineral deposits. (Authors' abstract)

LI, V.G., MITRYAEVA, N.M., PATALAKHA, G.B., PARILOV, Yu.S., SYROMYATNIKOV, N.G. and ZAMYATIN, N.I., 1983, Generalized model of stratiform lead-zinc deposits of Kazakhstan, in Genetic models of endogeneous ore formations:

"Nauka" Pub. House, Siberian Branch, v. 2, p. 95-102 (in Russian).

Hydrothermal-sedimentary Zn-Pb ores from the deposits Shalkiya and Tekeli have Td <100°C, inclusion solutions bear up to 4% G (H_2S, CO_2, SO_3, N_2) + $\sim$28% of salts (Cl, SO_4, HCO_3, Na, K, NH_4, Mg; for metamorphosed ores Td $\sim$120 to 360-280 and 550-480°C. Ores from deposit Akzhal (galena-sphalerite) yielded Td 540-460°C (from contents of small intrusions); from the deposit Zhayrem <100°C (sedimentary-hydrothermal ores) and 100-120°C (metamorphosed ores), gases CO_2, H_2S and N_2, ions - F, Cl, Mg, Ca; contact-metamorphosed ores - Td $\sim$450°C, gases ($\sim$1% of solution) - H_2S, CO_2, N_2, NH_3, SO_3, ions - SO_4, HCO_3, Na, Ca and Fe^{2+}. (Abstract by A.K.)

LI, Ying, 1983, Mineralization mechanism of stratabound lead-zinc ore deposits in Xicheng ore field: Geochimica, no. 3, p. 241-249 (in Chinese; English abstract). Author at Inst. Geochem., Acad. Sinica, China.

The material source, physico-chemical conditions and reworking geological agents have been explored of stratabound Pb-Zn-barite deposits occurring in western Qinling based on the data on mineralogy, petrochemistry, dispersed elements, isotopic geochronology, stable isotopes (common lead, carbon, sulfur, oxygen and hydrogen), fluid inclusions, and high temperature-high pressure experiments. Evidnece shows that the marine carbonate formation of the Middle-Upper Devonian series is the source bed of these ore deposits. Biochemical process, detrital transportation and subcontemporaneous dolomitization are responsible for the contemporaneous enrichment of ore-forming components. Ore deposition in response to tectonism and regional metamorphism took place during the Indosinian-Yenshanian orogenic movement. All these deposits can be divided into two genetic types: sedimentary-metamorphosed and sedimentary-reworked although they still possess their own metallogenetic characteristics. (Author's abstract)

LICHTNER, P.C., HELGESON, H.C. and PRUESS, Karsten, 1983, Numerical modeling of fluid flow with simultaneous chemical reaction in hydrothermal systems (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 627.

LILLEY, M.D., de ANGELIS, Marie and GORDON, L.I., 1983, CH_4, H_2, CO and N_2O in submarine hydrothermal vent waters: Nature, v. 300, p. 48-50. Authors at Sch. Oceanogr., Oregon State Univ., Corvallis, OR 97331, USA.

Hydrothermal circulation systems of mid-ocean ridges profoundly influence the chemistry of the oceans and the oceanic crust. This has been demonstrated for several major and minor constituents of seawater and trace metals. In addition, several volatile compounds including helium as well as methane and hydrogen are introduced to the sea floor in concentrations greatly exceeding that of ambient bottom water. We present here our measurements of concentrations of methane, hydrogen, carbon monoxide and nitrous oxide in the hydrothermal vent waters from the Galapagos Spreading Center (GSC). The relationships of these constituents to silicon were unique for each vent field, with nitrous oxide at East of Eden being the only instance of negative correlation. These gases could serve as important energy sources, in addition to hydrogen sulphide, for the chemosynthetic bacteria which support the extensive and diverse animal population living in these environments. (Authors' abstract)

LINDBLOM, S., 1983a Fluid inclusions in quartz associated with the Siljan astrobleme, Sweden (abst.): Terra cognita, v. 3, p. 76. Author at Ore Res. Group, Geol. Inst. Stockholm Univ. S-106 91 Stockholm, Sweden.

The Siljan structure represents a deep erosion level of an astrobleme.

A center of mainly Proterozoic granites is surrounded by a ring of Paleozoic rocks. The relation between rock types and structures is complicated because of (1) post-impact slumping of large blocks of the rocks forming the initial crater walls. (2) Bad exposure of rocks in the district.

Post-impact formations of minerals as various types of vein fillings are common. Non-shocked milky quartz from a large vein revealed fluid inclusions of three types (1) one-phase, <1 to 10 cm* regular shaped inclusions, (2) two-phased regular shaped inclusions, 2 to 7 cm, (3) larger irregular two-phase inclusions 6-20 cm. The one-phase inclusions dominate, density of inclusion occurrence is estimated at $46 \cdot 10^4$ inclusions per cm^2. Melting temperatures indicate a total salinity of 1.0 eq. wt. % NaCl. Th range between 146.7°C and 309.4°C. The fluid inclusion data imply formation of the quartz from deep circulated meteoric waters at successively cooling temperatures initially over 300°C. (Author's abstract)

*Presumably a misprint for μm. (E.R.)

LINDBLOM, Sten, 1983b, A preliminary study of cathodoluminescence of calcite and sphalerite at Laisvall: ORG 83, Annual Report Ore Research Corp., Stockholm Univ., p. 61-73.

Cathodoluminescence studies of uncoated doubly-polished thin sections of Laisvall ore-bearing sandstone showed detailed zoning of sphalerite and calcite cement. Color-zoned sphalerite could be divided into still further zones based on different luminescence. Luminescence colors were more distinct than ordinary colors in these sections as characteristics of the different sphalerite stages. In particular small sphalerite grains could be identified as to which stage they belong when color alone was insufficient as a diagnostic tool. The complexity of calcite deposition in many stages was confirmed by the revelation of several zones of luminescence colors. (Author's abstract)

LINDBLOM, Sten, 1983c, Inclusion morphology of detrital quartz in the Laisvall ore-bearing sandstone: ORG 83, Annual Report Ore Research Corp., Stockholm Univ., p. 75-101.

A microscopic study of detrital quartz grains of the Laisvall ore-bearing sandstone has demonstrated the occurrence of a wide variety of inclusions. Solid inclusions consist of rutile needles, apatite prisms, zircons, opaques and glass. Fluid inclusions contain one, two or three phases of water (with dissolved salt between 1 and 24 wt%) and carbon dioxide. Daughter minerals of halite and/or apatite occur sparingly.

The distribution and variety of inclusions indicate the same granitic source rock for the sedimentary material of both the upper and lower sandstone. The many different inclusion types also indicate a complex history of fluid-rock interaction in the detrital material of the ore-bearing sandstone. (Author's abstract)

LINDBLOM, S., 1983d Fluid inclusion and stable isotope evidence for ore formation at Laisvall, Sweden (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 39. Author at Ore Res. Group, Geol. Inst., Stockholm Univ., S-106 91 Stockholm, Sweden.

The Laisvall sandstone lead-zinc deposit located at the Caledonian border zone, 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 inclusion and carbon and oxygen isotope data from calcite associated with the ore mineral assemblage imply ore formation from mixing of two solutions. Temperatures between 180°C and 120°C and a total salt content of 24 eq.

wt % NaCl characterized the ore-forming environment.

A range of carbon isotope ratios between -13 and -15 per mil was found for both the upper and lower sandstone ore calcite. Oxygen isotope ratios were generally heavier for the upper sandstone (+14 per mil) than for lower sandstone (+12 per mil).

Stable isotope and fluid inclusion data on the same samples show that initial deposition of calcite started in the upper sandstone before the ore was formed. Fewer stages of calcite deposition occurred in the lower sandstone. The resulting calcite paragenesis was complex and was initiated by heating an in-situ-groundwater solution saturated with respect to calcium carbonate. Subsequent mixing with the incoming hot brine solution deposited the ore at 150°C. The mixing process repeated in successive pulses giving alternating carbonate and sulfide deposition. (Author's abstract)

LISITSYN, A.Ye., 1983, Spatial and time relations between skarns and boron ores, in Skarns and ores, Transactions of Inst. Geol. and Geoph. of Sib. Branch of Acad. Sci. USSR: "Nauka" Siberian Branch, Novosibirsk, v. 546, p. 71-76 (in Russian). [The book presents materials of All-Union Symp. "Skarns and Ores," held in Novosibirsk, 18-19, May, 1981, A.K.]

The author quotes inclusion data on the deposit Solongo in Siberia. (A.K.)

LITTLEJOHN, A.I. AND BALLANTYNE, S.B., 1983, Paragenesis of cassiterite and associated minerals in the Surprise Lake batholith, Atlin, British Columbia (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A43. First authors at Vancouver Petrographics, 8887 Booth St., Ottawa, Ont., K1A 0E8, Canada.

Cassiterite in the Surprise Lake Batholith, an epizonal, goechemically specialized granitoid complex of mainly quartz-monzonite composition, occurs in spatially and genetically associated greisens and base metal veins. The veins are localized along subvertical fractures which formed as a result of pressure build-up during evolution of an aqueous residual magmatic fluid enriched in Si, Na, K, Li, Be, F, Cl, S, Zn, As, Rb, Y, Nb, Ag, Sn, REE, W, Pb, Th, U.

Paragenetic relationships between minerals and mineral assemblages indicate four stages of mineralization which are functions of the changing composition of the fluid phase(s). Initially, boiling produced a F-rich fluid which deposited, in small pods and veins in the roof zone, one or more of quartz, fluorite, Li-mica, beryl, cassiterite, topaz, wolframite, arsenopyrite, columbite-tantalite. Fracturing caused a drop in pressure and allowed the influx of meteoric water which diluted the fractionated residual melt. This resulted in the precipitation of sphalerite, galena, chalcopyrite, pyrite which replaced the greisens and the quartz-monzonite below them. Continued addition and convection of meteoric water changed conditions from reducing to oxidizing and hematite followed by magnetite formed around the sulphides. Biotite and chlorite veins occur with magnetite in the upper levels of the system. Minor minerals include anatase, cassiterite, gadolinite, uraninite, brannerite. Localized extremes of fluid pressure and composition are exemplified by the occurrence of ilvaite in the sulphide assemblage and helvite in the oxide assemblage. Upon cooling, the last stage was the formation of a CO_2-rich fluid which deposited siderite and the REE minerals allanite, bastnaesite and synchysite.

Authigenic U and As minerals occur in some greisens and associated argillized and fractured quartz-monzonite. (Authors' abstract)

LITVINOVSKIY, B.A., ZANVILEVICH, A.N., BUSHLYAKOV, I.N. and KAPERSKAYA, Yu.N., 1983, Regularities of evolution of chemical composition and fluid regime of granitoids of folded area (Transbaikalia): Doklady Akad. Nauk SSSR, v. 273, no. 5, p. 1197-1202 (in Russian). Authors at Geol. Inst. of Buryatian Division of Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

Gas contents (H_2O, CO_2, H_2, CH_4, N_2) in 330 granitoid samples were measured by gas chromatography. In genetic sequences of granitoid rocks a continuous decrease of reduced components and an increase of oxidized components was found. Early Paleozoic granites yield Th 800-830°C (higher H_2O content in melt), but later alkaline and subalkaline granitoids - 900-1020°C (drier melts). (Abstract by A.K.)

LIVNAT, A., 1983, Metamorphism and copper mineralization of the Portage Lake lava series, northern Michigan: Unpub. Ph.D. dissertation, Univ. Michigan, Ann Arbor, MI, 270 pp.

Inclusions in calcite in the native copper lodes and fissures of the Keweenaw peninsula show Th up to 119°C (quoted by Nishioka et al., 1984). (E.R.)

LOBATO, L.M., FORMAN, J.M.A., FUZIKAWA, Kazuo, FYFE, W.S. and KERRICH, Robert, 1983, Uranium in overthrust Archean basement, Bahia, Brazil: Can. Mineralogist, v. 21, p. 647-654. First author at Dept. Geol., Univ. Western Ontario, London, Ontario N6A 5B7, Canada.

In the Lagoa Real region of western Bahia State, Brazil, basement acid gneisses of the São Francisco craton (3 Ga) show localized zones of uranium enrichment that in places attain ore grade. The enrichment occurs in linear shear-zones associated with retrograde metamorphism and extensive metasomatism of the amphibolite- to granulite-facies basement. Zones of uranium enrichment contain the mineral assemblage plagioclase-epidote-amphibole-aegirine-garnet typical of the epidote-amphibolite facies. Metasomatic processes include: oxidation, sodium addition, potassium depletion, quartz removal, and addition of U-V-Y and some REE. The typical product is dominated by albite and a sodic pyroxene. Oxygen-isotope data for quartz (-0.02%.), albite (-1.95%.), magnetite (-8.70%.) and pyroxene (-4.15%.) show that fluids involved were ~ -4%. and that the major phase of alteration occurred near 500°C. This is confirmed by fluid-inclusion studies, which also show the presence of highly saline fluids. A model is proposed in which a slice of Archean basement (~15 km thick) has been thrust to the west over Proterozoic sediments. Isotopicaly light formation brines carrying uranium have been expelled through hydrofractures into the hotter overthrust plate, causing the observed mineralogical and chemical changes. The rocks provide an example of mobilization of U and some trace elements from a saline, organic-matter-rich, low-temperature environment, with precipitation in response to rising temperatures. (Authors' abstract)

LOGINOV, V.P., MAGRIBIN, A.A., RUSINOV, V.L., BORISOVSKIY, S.Ye. and NOSIK, L.P., 1983, First finding of goldfieldite at a deposit of pyrite type: Doklady Akad. Nauk SSSR, v. 273, no. 2, p. 437-440 (in Russian). Authors at Inst. Geol. Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow, USSR.

Paragenesis with goldfieldite (Te-tetrahedrite) at the Bittibulakh deposit (Little Caucasus) bears barite with G/L inclusions of Th 180-210°C. (A.K.)

LOHMANN, K.C., 1983, Role of fluid inclusions in diagenesis of metastable marine cements (abst.): AAPG Bull., v. 67, no. 3, p. 505. Author at

Univ. Michigan, Ann Arbor, MI.

An abundance of associated fluid inclusions is characteristic of fibrous cement mosaics. Such fluids, trapped along intercrystalline boundaries during early coalescence, migrate through the metastable host. As metastable phases dissolve, driven by their solubility differences with low magnesium calcite, they concomitantly precipitate low magnesium calcite, which paramorphically replaces the precursor cement. Such a mechanism not only provides for the retention of overall crystal fabric, via a submicron dissolution-precipitation process, but also provides for the maintenance of chemical signatures of the dissolving, metastable precursor cements. (From the author's abstract)

LOMTEVA, S.A. and KYDYNOV, M.K., 1983, Process of salt precipitation in chloride systems of alkaline metals: Zhurn. Neorg. Khimii, v. 28, no. 5, p. 1294-1298 (in Russian). Authors at Inst. of Neorg. and Physical Chemistry of Acad. Sci. of Kirgiz SSR.

The paper presents systems $LiCl-NaCl-SrCl_2-H_2O$, $LiCl-KCl-H_2O$, $LiCl-MgCl_2-H_2O$, $LiCl-NH_4Cl-MgCl_2-H_2O$ and $LiCl-NH_4Cl-ZnCl_2-H_2O$ at T 0-75°C. (A.K.)

LONDON, D., 1983, The magmatic - hydrothermal transition in rare-metal pegmatites: fluid inclusion evidence from the Tanco mine, Manitoba (abst.): EOS, v. 64, p. 874. Author at Sch. Geol. & Geophys., Univ. Oklahoma, Norman, OK 73019.

Fluid inclusions in lithium aluminosilicates from the Tanco pegmatite, Bernic Lake, Manitoba, contain a complex assemblage of daughter minerals that includes albite, cookeite, Cs-analcime or pollucite, quartz, and lithium tetraborate ($Li_2B_4O_7$). This assemblage appears to represent crystallization products from a dense, silicate-rich aqueous fluid, or from a dense two-phase suspension of aqueous fluid + silicate melt. The $Li_2B_4O_7$ component acts as a flux to increase miscibility of H_2O and silicate components and to depress the solidus(?) of this system to 450°-480°C at approximately 3 kbar. The system $LiAlSiO_4-NaAlSi_3O_8-SiO_2-Li_2B_4O_7-H_2O$ has been investigated experimentally as an analogue to the natural fluids at Tanco. The solidus of this model system lies at 500°C at 2 kbar (fluid). Crystallization of albite, lithium aluminosilicates, and quartz drives the melt composition toward the middle of the albite-$Li_2B_4O_7$ sideline; addition of Cs should further reduce the solidus temperature and lead to the crystallization of Cs-aluminosilicates. As in the Tanco inclusions, the aqueous fluid and silicate melt of the model system exhibit extensive miscibility over a large range of bulk compositions. Evidence from the fluid inclusions and these preliminary experiments indicate that (1) late-stage fluids at Tanco (and similar pegmatites?) were dense borosilicate aqueous gels or melts; (2) the B content of solution/melt phases may have reached 7 wt % B_2O_3 or greater; and (3) the transition from magmatic to hydrothermal crystallization may have been essentially continuous (i.e., supercritical). (Author's abstract)

LONG, K.R., KELLY, W.C. and OHLE, E.L., 1983, Ground preparation and zinc mineralization in bedded and breccia ores of the Monte Cristo mine, north Arkansas (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 630. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Fluid inclusion and stable iosotope (C, O) data suggest a mixing of two brines during mineralization, one a brine of deep burial, diagenetic origin and the other a brine of uncertain origin. The mixtures were hot (100-150°C) and highly saline (24 equiv. wt.% NaCl). These brine mixtures were displaced by cool, dilute, presumably meteoric waters during late gangue (quartz, calcite) deposition. It is noteworthy that, within this one small mine, the bedded and breccia mineralization are physically and mineralogically continuous and yield identical fluid inclusion, stable isotope and rare earth element signatures. Hence, the bedded ores which possess many characteristics of MVT deposits claimed to be syngenetic or diagenetic in origin elsewhere are, at least in Arkansas, of definite epigenetic origin. (Authors' abstract)

LOOMIS, T.P., 1983, Metamorphic petrology: Reviews of Geophys. & Space Physics, v. 21, no. 6, p. 1386-1394 (U.S. Nat'l. Report to Int'l. Union of Geodesy & Geophysics 1979-1982). Author at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

An extensive review (300 references), including discussion of various fluid inclusion studies of metamorphic fluids and fluid-rock equilibria. (E.R.)

LORAND, J.P., 1983, Immiscible sulfides in spinel-lherzolite bodies. Some precisions about uppermost mantle metallogeny (abst.): Terra cognita, v. 3, p. 174.

LORAND, J.-P. and CONQUERE, Fernand, 1983, Contribution to the study of sulfide parageneses in spinel lherzolite xenoliths from alkali basalts (Massif Central and Languedoc, France): Bull. Minéral., v. 106, p. 585-605 (in French; English abstract). Authors at Lab. Min. Museum Nat'l. d'Histoire Naturelle, LA no. 286, 61, rue Buffon, 75005 Paris, France.

Spinel lherzolite xenoliths from Massif Central and Languedoc (France) have equilibrated between 900°C and 1200°C. They contain traces of sulfide that occur mainly as enclosed bodies within silicates and less frequently as interstitial grains. Modal proportions and bulk chemical compositions have been systematically reconstructed for these two kinds of sulfide occurrence. Experimental data in the Cu-Fe-Ni-S system indicate that the enclosed sulfide bodies have totally crystallized between 1200 and 900°C from a homogeneous, Ni-rich, immiscible sulfide liquid separated before deformations; in the same temperature range, they have suffered some local remobilization in a closed system. Present assemblages in the enclosed bodies (two Ni-rich pyrrhotite solid solutions, pentlandite, and chalcopyrite) result from reactions in the solid state continuing down to temperatures between 250 and 300°C.

The same origin and evolution are proposed for interstitial sulfides. However, these probably have been differentiated in an open system which might explain systematic modal and chemical variations between enclosed and interstitial sulfides. Basaltic modifications on sulfide assemblages were probably limited to remobilization during partial melting.

All these results are compared with present data on sulfide assemblages from spinel lherzolite ultramafic bodies. It is concluded that in upper mantle peridotite samples, sulfides have a mantle origin as [do] their silicate host rocks. (Authors' abstract)

LOREDO PEREZ, Jorge and GARCIA IGLESIAS, Jesus, 1983, Morphology and primary fluid inclusions of fluorite crystals synthesized at low temperatures: Rev. Minas, v. 3, p. 49-54 (in Spanish; English abstract). Authors at Dept. Metal., ETS Ing. Minas, Oviedo, Spain.

A simple experimental device has allowed synthesizing of hydrothermal fluorite crystals at atmospheric pressure and low temperature (40-100°C). These crystals contain primary fluid inclusions for which the temperature of homogenization shows exactly the temperature of crystallization of the host mineral.

The influence of temperature on the average size of the crystals and the presence of troncations[sic] has been determined. This last phenomenon is in accord with observations made in the fluorite district of Asturies, where the presence of such truncations is known in deposits where the temperature of homogenization of primary fluid inclusions is the highest. (Authors' abstract)

LU, Huanzhang, 1983a, Fluid inclusion study of Fankou Pb-Zn ore deposit, Fankou, Guangdong, China: Geochemistry, v. 2, no. 1, p. 45-57. Author at Inst. Geochem., Acad. Sinica, China.

The Fankou Pb-Zn ore deposit occurs in Devonian and Carboniferous carbonate rocks. This deposit was thought to be a hydrothermal ore deposit related to a granite, but the present research suggests it is a strata-bound, stratiform mineral deposit.

As a result of geological studies, primary sedimentary and later replacement features were found. Part of some ore bodies are concordant with the host rocks, but most are discordant lenses and veins in the carbonate rocks. Thus there are two types of ores, primary sedimentary and later replacement. The replacement type is very common. Isotopic studies indicate that most of the Pb and S are of sedimentary origin, but part of Pb is of radioactive origin, possibly introduced during later replacement. A regional geochemical survey indicates that the Pb and Zn contents of the Fankou region are respectively 1.5 and 3 times higher than the world average. Only a few one-phase liquid fluid inclusions were found in the primary sedimentary type. Gas-liquid fluid inclusions were found in the replacement type ore but not in the primary sedimentary type. The fluid which replaced the primary sedimentary rocks had temperatures of 100-200°C, with a salinity of 3-6 wt. % NaCl equiv. Under the action of such fluid the original sedimentary rocks were replaced to form the present ore deposit. (Author's abstract)

LU, H.-Z., 1983b, Genesis of tungsten ore deposits in south China: Ph.D. dissertation, Univ. Pennsylvania, 251 pp.

The major tungsten ore reserves and production in the world are in south China. Twenty-five tungsten mines located in five provinces of south China were studied. Geological, mineralogical, isotopic, fluid inclusion, chemical, and electron microprobe analysis methods were used for studying 457 samples which are from different types of tungsten deposits and granites. Based on detailed geological study, a new tungsten ore classification is suggested. There are ten types of tungsten ore deposits: (1) granite, (2) porphyry, (3) volcanic rock, (4) porphyrite, (5) pegmatite, (6) greisen, (7) skarn, (8) hydrothermal veins, (9) strata-bound and stratiform, and (10) placer. The most important ore deposits are hydrothermal veins, skarns, granite, and porphyry, which are all related to the Yanshanian age (70-195 m.y.) granites. The porphyry, granite, and W-Sb-Au strata-bound types of tungsten deposits have not been described before. The fluid inclusion studies of different types of tungsten ore deposits indicate that the ore forming fluid for hydrothermal veins, skarns (tungsten mineralization stage), granite, and greisen types had low salinity (less than 10 wt.% NaCl equivalent), with temperatures of 200-350°C. The fluid of these tungsten mineralizations were dilute. However, there are two types of salinity in fluid inclusions in both tungsten porphyry and skarn deposits. This feature could have been produced by either one of two processes. One explanation would be that a high salinity fluid was diluted by groundwater. An alternative model suggests boiling of the ore fluid. In a boiling fluid dissolved salts concentrate in the liquid phase. Thus, the daughter mineral bearing fluid inclusions (high salinity) and gas-rich inclusions (low salinity) can be trapped from an originally low to moderate salinity fluid. (Author's abstract)

LU, H.-Z., 1983c, Fluid inclusion studies of a new type of ore deposit: porphyry tungsten occurrence in China (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 139. Author at Dept. Geol., Univ. Pennsylvania, Philadelphia, PA 19104.

The Laihua Shan mine in south China represents a new type of tungsten ore deposit which can be described as a porphyry tungsten deposit. It is associated with a quartz porphyry stock of Yenshen age (about 70-135 m.y.). The ore occurs in a zone surrounding the contact of the quartz porphyry with Jurassic sandstone and extends into both rock bodies. The ore occurs either as the matrix of breccia or in the form of a very fine network of cross cutting veinlets. The major tungsten minerals are wolframite and scheelite associated with Mo, Fe, Cu, Pb, Zn sulfide minerals and cassiterite. The minerals are fine-grained. There is zoned alteration in the wall-rocks. From the center of the quartz porphyry to the country rock one found: potassic alteration, silicification-sericitization, and chloritization. All these features are similar to porphyry copper mineralization.

Fluid inclusion studies show three types of inclusions: liquid-rich (type I), gas-rich (type II), and polyphase with daughter minerals (type III) fluid inclusions. The homogenization temperatures of type I range from 210 to 380°C, with salinity of 2-13 wt.% NaCl equiv., that for type II fluid inclusions range from 270 to 420°C, and that for type III fluid inclusions range from 240 to 400°C, with salinity of 31-33 wt.% NaCl equiv. The closely associated group of gas-rich and daughter mineral bearing fluid inclusions homogenized at almost the same temperatures. Such results indicated boiling of the ore-forming fluid. These fluid inclusion data can be compared with the low salinity fluid (type I) and high salinity fluid (type III) of porphyry copper deposits.

These observations suggest that the Laihua Shan tungsten ore deposit is a porphyry type deposit and was formed by hydrothermal fluids similar to the well known porphyry copper deposits. (Author's abstract)

LUCIDO, G., 1983, A mechanism forming silicic segregations from basaltic magma discovered in igneous rocks of western Sicily: Geol. Mag., v. 120, no. 4, p. 321-416.

The evidence presented is believed to suggest strongly that silicate immiscibility was involved. (E.R.)

LUKANIN, O.A. and KADIK, A.A., 1983, Problems of genesis of tholeiites from Atlantic Ocean: conditions of generation and dynamic factors of magma evolution: Geokhimiya, no. 5, p. 685-702 (in Russian; English abstract). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

Petrochemical and geochemical considerations. (A.K.)

LUKANIN, O.A., KADIK, A.A., DMITRIYEV, L.V. and BIGGAR, G.M., 1983, Subsurface evolution of magmas of oceanic tholeiites in Atlantic Ocean: Geokhimiya, no. 3, p. 382-406 (in Russian; English abstract). First author at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

The paper presents the following problems: composition of remnant liquids formed during crystallization at small depths (P <3 kbar), mineral composition of oceanic tholeiites, thermal conditions of differentiation of oceanic tholeiites, differentiation of oceanic tholeiites at P >10 kbar, and liquids formed during partial melting of ultrabasic mantle rocks. (A.K.)

LUPTON, John, 1983a, Helium-3: Indicator of volatiles from the mantle (abst.): Amer. Chem. Soc. 1983 Ann. Meeting Program GEOC Abst. 16 (unpaginated). Author at Univ. California, Santa Barbara, CA 93106.

The occurrence of elevated ^{3}He/^{4}He ratios in terrestrial samples is an unambiguous indicator of volatiles extracted from the Earth's mantle. While gases found in continental rocks are depleted in ^{3}He relative to atmospheric helium ($R/R(A) \simeq 0.1$ where $R = {}^3He/{}^4He$ and $R(A) = R(air) = 1.4 \times 10^{-6}$), mantle helium is highly enriched in $^3He(R/R(A) \simeq 5 - 35)$ due to the presence of primordial helium which has been retained in the Earth's interior since the time of its formation. This ^{3}He-rich primordial component has been detected in a wide variety of localities, such as mid-ocean ridge basalts, continental geothermal areas (Yellowstone Park, Imperial Valley, East African Rift, etc.), subduction zones (Cascades, Aleutians, New Zealand, Marianas, Japan, etc.), and in submarine hydrothermal systems (East Pacific Rise, Galapagos Rift, Red Sea, and Guaymas Basin). Important applications of helium isotope measurements include mapping deep ocean circulation patterns, prospecting for deep-sea hydrothermal systems and estimating chemical fluxes from such systems, and studies of continental geothermal areas. (Author's abstract)

LUPTON, J.E., 1983b, Terrestrial inert gases: isotope tracer studies and clues to primordial components in the mantle: Ann. Rev. Earth Planet. Sci., v. 11, p. 371-414.

L'VOV, S.N. and ZAREMBO, V.I., 1982, The limiting partial volumes of dissolved electrolytes at high state parameters: Geokhimiya, no. 2, p. 565-575 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 2, p. 165-176, 1983).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 143, 1982. (E.R.)

LYASHCHENKO, A.K. and CHURAGULOV, B.R., 1983, Pressure relation of salt solubility in water: Zhurn. Neorg. Khimii, v. 28, no. 2, p. 456-465 (in Russian). First author at Inst. of General and Inorg. Chemistry, Moscow, USSR.

Influence of pressure (to 1000 MPa) on solubility of several salts, including NaCl, K_2SO_4, $MgCl_2 \cdot 6H_2O$, $CaCl_2 \cdot 6H_2O$ is shown in form of coefficient of solubility. (A.K.)

LYON, G.L. and HULSTON, J.R., 1983, Carbon and hydrogen isotope compositions of geothermal gases: Proc. 5th New Zealand Geothermal Workshop, p. 169-173. Author at Inst. Nuclear Sci., DSIR, Lower Hutt, New Zealand.

Carbon and hydrogen isotopic compositions are compared for the gases methane, hydrogen and carbon dioxide from Ngawha, Wairakei, Ohaki-Broadlands and Tikitere (Ruahine Springs). The different areas have different isotopic compositions with some general relationships to reservoir temperature and inferred origins. The isotopic exchange of hydrogen with water was found to indicate reservoir temperatures 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 either partial isotopic equilibration or to source conditions of methane. Possible sources for carbon dioxide and methane are shallow or deep crustal (inorganic or organic) material with the possibility of some juvenile contribution. (Authors' abstract)

LYSYAK, T.V., KONASH, Ye.A., RUDNEV, A.V., KALYAZIN, Ye.P., KOLOMNIKOV, I.S. and KHARITONOV, Yu.Ya., 1983, Radiolysis in the system $CO_2 + H_2O$ in presence of sodium phosphomolybdate: Zhurn. Neorg. Khimii, v. 28, no. 6, p. 1603-1604 (in Russian). First author at Chem.-Technolog. Inst., Moscow, USSR.

Formaldehyde, $(COOH)_2$ and formic acid are products of radiolysis in the system CO_2-H_2O with catalytic activity of $Na_3H_4[P(Mo_2O_7)_6]$. (A.K.)

MA, Xiujuan and CHEN, Weishi, 1983, Experimental studies of mineral inclusions from the Dajishan quartz-vein type tungsten deposit with regard to ore genesis: Zhongguo Dizhi Kexueyuan Kuangchan Dizhi Yanjiuso Sokan, v. 11, p. 57-69 (in Chinese). Authors at Inst. Miner. Deposits, Chin. Acad. Geol. Sci., Beijing, PRC.

The Dajishan W-bearing quartz veins (China) are of the post-magmatic high-temp. hydrothermal type, formed by contact metasomatism and fissure filling. Microscopic examination of the fluid inclusions and homogenization and decrepitation measurements give ore-forming temps. of 238-328°, showing a gradual increase in temp. with depth (30-50°/100 m). Salinities of various inclusions (primary, secondary, and metasomatism-related) indicate that the salinities of the inclusions also increase with depth. The ore-forming fluids contained volatiles with a d. of 0.8-0.9 g/cm^3; the ore-forming pressures were 110-160 bar. (C.A. 102: 28752v)

McALASTER, Penelope, 1980, The geology and genesis of jasperoid in the northern Swisshelm Mountains, Cochise County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 78 pp.

The Swisshelm mining district is situated in the northern Swisshelm Mountains, Cochise County, Arizona. The range is an eastward-tilted fault block complex consisting of a Precambrian basement overlain by Paleozoic sedimentary rocks. Laramide(?) and Tertiary intrusive and extrusive rocks are also present. The range is cut by both eastward-dipping thrust faults and high- and low-angle normal faults.

Silicic replacement bodies, or jasperoids, related to Tertiary volcanism rather than the mineralized dikes, crop out conspicuously north of the mining activity. The distribution of jasperiod is controlled both by faults and by favorable limestone beds.

Studies of the jasperoid suggest that it is limestone replaced by silica gel which then crystallized to microcrystalline quartz. Coarse-grained quartz precipitated directly from solutions in open spaces. Fluid inclusion study suggests homogenization temperatures of coarse-grained quartz from 145 to 216°C. Microprobe analyses of aluminum in varieties of quartz suggest that microcrystalline quartz formed at temperatures higher than 216°C. Geochemical analyses show that the jasperiod is nearly pure SiO_2. Decreasing temperature and increasing PCO_2 of solutions carrying silica encouraged replacement of limestone by flow through permeable fault zones and by diffusion. (Author's abstract)

McCARTNEY, R.A., 1983, Physical and geochemical controls on hot dry rock geothermal fluid in Cornwall (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 3. Author at Camborne School of Mines.

Two geothermal boreholes have been drilled to 2 km depth in the Carnmenellis granite, Cornwall. Downhole temperature was 79°C. A hot dry rock geothermal reservoir was developed by subsequent explosive and hydraulic fracturing. Water samples have been collected, and analyzed for their chemical and isotopic (O^{18} and H^2) composition, during 4000 hours of circulation tests. Interpretation of these data has indicated that reaction with casing cement did occur although this effect may be subtracted. Conceptual geochemical and physical models of the reservoir are presented, and geochemical implications to further hot dry rock geothermal research are assessed. (Author's abstract)

MacDONALD, G.J., 1983, The many origins of natural gas: J. Petroleum Geol., v. 5, no. 4, p. 341-362. Author at The Mitre Corp., Vienna, VA 22180, USA.

Thermodynamic calculations for the C-O-S-H system indicate that at a fixed oxygen fugacity methane is a stable phase relative to carbon dioxide at high pressures and low temperatures. At a constant temperature and pressure, methane is favored at low oxygen fugacities. Volcanic gases and near-surface igneous rocks exhibit high values of oxygen fugacity. However, direct measurement of the oxygen fugacity of spinels from peridotites of deep origin indicate that the oxygen fugacity of these rocks is low, corresponding to an iron-wüstite buffer. The relative abundance of the carbon isotopes C^{12} and C^{13} varies widely in natural gases. Methane formed by bacterial fermentation is highly enriched in the lighter isotope, while methane from deep deposits is much less so as is the methane flowing from hydrothermal vents on the East Pacific Rise. Except in extreme cases, the carbon isotope ratio cannot be used alone to asses whether methane is biogenic or abiogenic. The carbon isotope ratio in coexisting methane and carbon dioxide can be used to estimate the temperature at which the two gases came into isotopic equilibrium. This ratio indicates a high temperature of equilibration for a number of gas deposits. The carbon and helium isotope ratios together with their geologic settings are strongly suggestive that the large quantities of methane in Lake Kivu and the gases venting along the East Pacific Rise are abiogenic. Methane associated with the Red Sea brines and various geothermal areas may also be in part abiogenic. The high abundance of carbon in the Sun, the atmosphere of the outer planets, carbonaceous chondrites and comets, suggests that carbon may be more abundant in the Earth than it is in near-surface igneous rocks. Such a high abundance could lead to a progressive outgassing of methane at depth, which then is oxidized near the surface or in the atmosphere. Methane hydrates are stable at low temperatures and high pressures. Today, methane hydrates are found in areas of permafrost and in ocean sediments. Methane hydrates in ocean sediments were first formed about 20 mya (million years ago) when the Antarctic ice sheet reached sea level. Terrestrial methane hydrates formed more recently during the glaciations beginning 1.6 mya. Methane hydrates and trapped gas are probably abundant under the Antarctic ice sheet. The formation of methane hydrates may be related to the low values of carbon dioxide in the atmosphere some 20,000 years ago. (Author's abstract)

McDOUGALL, T.J., 1983, Fluid dynamic implications for massive sulphide deposits of hot saline fluid flowing into a submarine depression from below (abst.): IUGG, XVIII General Assembly, Program and Abstracts, v. 2, p. 822.

McKIBBEN, M.A., 1983, Active ore mineralization in the Salton Sea geothermal system, Imperial Valley, California (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 640. Author at Ore Deposits Res. Sec., Pennsylvania State Univ., University Park, PA 16802.

The Salton Sea geothermal system is an area of active hydrothermal metamorphism in a Pleistocene deltaic/lacustrine sequence, containing incipient sulfide and oxide mineralization. Shallow diagenetic mineralization consists of fine-grained iron sulfide cement altering to pyrite.

Progressive overgrowth and recrystallization of pyrite upon burial and heating leads ultimately to metamorphic porphyroblastic textures at depth, accompanied by dissolution and replacement of pyrite by pyrrhotite, chalcopyrite, sphalerite and galena.

Vein and related pore-filling mineralization occurs as two distinct types: (1) early, scattered, thin zones of sphalerite-chalcopyrite-pyrrhotite-calcite veins which formed from fluids more reduced and sulfur-rich than the presently-extracted brines, and (2) later, thick zones of hematite-chalcopyrite-quartz and hematite-chalcopyrite-epidote-anhydrite veins which are in equilibrium with the present oxidized, sulfur-poor brines. Textures indicate that sulfur and metals for the early veins were derived from the host sediments. These veins may represent fluids derived by compaction and dehydration of the sediments. The oxide veins may represent influx of surficial waters, or may result from boiling in the system. Base metal deposition is currently limited by access of the sulfur-poor brines to iron sulfide sulfur in the host sediments, periodically provided during seismic fracturing events. Calculated metal chloride solubilities are in agreement with measured brine analyses, implying that chloride complexing accounts for base metal transport in the present brines.

The Salton Sea system illustrates that diagenetic, epigenetic, and metamorphic ore mineralization can occur simultaneously in a modern sedimentary basin located in a tectonic rift zone having high heat flow and seismicity. (Author's abstract)

MACKWELL, S.J., KOHLSTEDT, D.L. and PATERSON, M.S., 1983, Diffusivity and solubility of OH-species in olivine (abst.): EOS, v. 64, p. 839.

McLAREN, A.C., COOK, R.F., HYDE, S.T. and TOBIN, R.C., 1983, The mechanisms of the formation and growth of water bubbles and associated dislocation loops in synthetic quartz: Phys. Chem. Minerals, v. 9, p. 79-94. Authors at Dept. Physics, Monash Univ., Clayton, Victoria, Australia, 3168.

The development of water bubbles in synthetic quartz has been monitored by measurements of (i) the intensity of the light scattered and (ii) the increase in volume of the crystal, both as a function of temperature and time. These macroscopic measurements have been complemented by observations of the resulting microstructures, using transmission electron microscopy (TEM). A mechanism is proposed on the assumption that hydrogen is incorporated in the quartz structure by means of $(4H)_{Si}$ defects. On heating, these defects diffuse and clusters develop. A cluster of $n(4H)_{Si}$ produces a water bubble of $(n-1)H_2O$, without any change of volume of the crystal. At any temperature T there is a critical bubble diameter above which the "steam" pressure P exceeds the pressure p for a spherical bubble in mechanical equilibrium. If P becomes greater than p, then the bubble increases in volume until P=p, the increase in volume being achieved by the pipe diffusion of Si and O away from the bubble site into a linked edge dislocation loop. This process produces the observed increase in volume of the crystal. The two diffusion processes take place virtually simultaneously and continue until all the $(4H)_{Si}$ defects have been trapped in the bubbles. Values of the diffusion constant and the activation energy for the diffusion of the $(4H)_{Si}$ defects are deduced. The relevance of these observations to the hydrolytic weakening of quartz is briefly discussed. (Authors' abstract)

McNAUGHTON, K.C., 1983, A fluid inclusion study of the Nanisivik lead-zinc deposit, Baffin Island, N.W.T.: M.S. thesis, Univ. Windsor, Windsor, Ontario, Canada, 95 pp.

MACQUEEN, R.W. and POWELL, T.G., 1983, Organic geochemistry of the Pine Point lead-zinc ore field and region, Northwest Territories, Canada: Econ. Geol., v. 78, p. 1-25. First author at Dept. Earth Sci., Univ. Waterloo, Waterloo, Ontario N2L 3G1, Canada.

Indigenous organic matter, heavy oil, and bitumens are common within the Middle Devonian barrier complex within which the Pine Point lead-zinc ore field is located. A study of the organic geochemistry of the indigenous organic matter demonstrates that the barrier complex in the ore field is within the immature to marginally mature zone with respect to petroleum generation. Certain of the host rocks of the ore field were deposited in highly reducing conditions such that organic matter of algal or microbial origin has been preserved to a remarkable degree. One consequence of this depositional environment is that, at this immature level of kerogen catagenesis, the yields of extractable (soluble) material relative to organic carbon are extremely high, which has resulted in the local migration of immature bitumens and heavy oil within the shallow regime. Locally, within this low maturity area, these bitumens have been altered by heat and probably by reaction with elemental sulfur during dolomitization and mineralization to form an insoluble hydrogen-rich pyrobitumen. This process is attributed to polymerization of NSO (nitrogen, sulfur, and oxygen compounds) and asphaltenes. Biodegradation of bitumens is a relatively late process which appears to have occurred as rocks of the barrier complex reached their present ground-water regime. No evidence has been discovered in this study for long-distance migration of oil or bitumen from the adjacent sedimentary basin.

The immature nature of the indigenous organic matter on the Pine Point property indicates generally a low-temperature heating (≈60°C max), and geologic data indicate only shallow burial. Previously published fluid inclusion data from sphalerite and coarsely crystalline dolomite indicate mineralization temperatures of up to ≈100°C, indicating that some mineralization and dolomitization events represent thermal anomalies with respect to the host rocks. The existence of thermal anomalies is confirmed by the occurrence of pyrobitumen derived from immature organic matter in the dolomitized and mineralized zones. This local alteration of preexisting organic matter does not preclude later migration of locally derived bitumen or heavy oil leading to the association of unaltered bitumen with the sulfides.

The question of a genetic relationship between lead-zinc sulfide and organic matter remains open. Present sulfur isotope data suggest a role for the in situ generation of hydrogen sulfide by abiogenic reduction of sulfate, an attractive explanation for the altered bitumen and known sulfur isotope distributions. (Authors' abstract)

McTIGUE, J.W., Jr., 1981, Chemical interaction of aqueous solutions with an alkali-feldspar-muscovite-quartz assemblage in a crystallizing pegmatite: Spruce Pine district, North Carolina: M.S. prepublication manuscript, The Univ. Arizona, Tucson, AZ, 42 pp.

Geological observation, geochemical data, and theoretical geochemistry afford detailed analysis of the formation temperatures and pressures and the activities of aqueous species in equilibrium with minerals crystallizing in a Spruce Pine pegmatite. Fluid inclusion homogenization temperatures in quartz from the wall zone and center of the pegmatite fall within the range 650°C to 380°C, corrected to 2 kb pressure, with salinities ranging from 2.8 to 2.2 molal NaCl equivalent. Structural states and exsolution textures of alkali feldspars provide independent estimates of equilibration temperatures, 350-300°C, and a means of qualitatively describing fluid-rock interactions during pegmatite formation. Thermodynamic analysis of the system K_2O-Na_2O-Al_2O_3-SiO_2-H_2O-HCl at 2 kb and up to 900°C allows quantitative description and interpretation of observed phase relations among alkali feldspar, quartz, and muscovite in equilibrium with an aqueous solution through the temperature range of crystallization. (Author's abstract)

MADALINSKA, Maria, 1983, Pegmatoids of the Garby Izerskie contact zone, W. Sudetes, Poland: Archiwum Mineral., v. 39, part 1, p. 67-75 (in Polish; English abstract). Author at Inst. Geochem., Miner. & Petr. of the Warsaw Univ., Poland.

Contact-metamorphic rocks of the fault zone bordering granitoid Karkonosze massif from metamorphic Izera rock series, bear numerous aplite veins and coarse-grained pegmatoid aggregates. Microscope, mineralogical and geochemical studies of aplites and pegmatoids are presented in the paper, which concludes that the veins are apophyses of the Karkonosze massif. Pegmatoids formed from aplites by hydrothermal recrystallization and metasomatism at temperatures at least 390-320°C (Th). Metasomatic topaz in that zone was first described. (Author's abstract)

MAHER, S.W. and SPENCER, B.C., 1983, Fluorspar in Tennessee: Tennessee Dept. Conservation, Div. Geol., Rept. of Investigations No. 42, 30 pp.

Includes a brief discussion of literature data on inclusions in fluorite. (E.R.)

MALININ, S.D. and KHITAROV, N.I., 1983, correlations in the system fluid-melt in connection with distribution of elements between the phases: Doklady Akad. Nauk SSSR, v. 270, no. 2, p. 427-428 (in Russian). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The paper discusses the partition of Cu, Pb, Fe, Zn, Cs, Rb, Mn, Na, K, Ba, Mo^{4+}, Sr, Mg, Ca, Eu, Ge, Yb, Gd between silicate melt of various composition and 1 molar solution of NaCl + KCl at T 700-900°C, P 1-3 kbar. (A.K.)

MALLEY, P., JUTEAU, T. and BLANCO-SANCHEZ, J.A., 1983, Hydrothermal alteration of submarine basalts: from zeolitic to spilitic facies in the upper Triassic pillow-lavas of Antalya, Turkey: Sci. Geol., Bull., v. 36, no. 2-3, p. 139-164.

This is one of 7 papers in this issue, all on interaction of basalt with sea water at low temperature. (E.R.)

MALONE, R.D. and GREGOIRE, C.E., eds., 1983, Interdisciplinary gas hydrate literature bibliography: DOE/METC-83-65 (revised) (DE84001900), 54 pp.

Contains ~700 references to gas hydrate formation, nature, properties, and compositions. (E.R.)

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). Author at All-Union Research Inst. of Mineral Synthesis, Aleksandrov, USSR.

Reviews some Th data. (E.R.)

MANANKOV, A.V. and SHARAPOV, V.N., 1983, Mechanism and kinetics of magnetite segregations in basic melts: Doklady Akad. Nauk SSSR, v. 272, no. 3, p. 670-674 (in Russian). First author at State Univ., Tomsk, USSR.

The paper presents results of experimental modelling of magnetite segregation in alkaline basalt and high-alumina leucobasalt with and without admixture of 16 wt. % of magnetite, melted at 1400-1460°C in atmosphere of air, He and H_2. T ranges of investigation were 950-1250°C. (A.K.)

MANILICI, Vasile, DUMITRESCU, Aurelia and MACALET, Viorel, 1983, Data on the temperatures of hydrothermal and epigenetic transformations: Anuarul Inst. de Geol. si Geofizica, v. 62, p. 135-141 (in English). Authors at Polytechnical Inst., Bucharest.

The improvement of the dilatometric method for determining the formation temperature of minerals (Bolgiu, Manilici, 1976) enabled the direct determination of the hydrothermal or other type of transformation. This method has been used for establishing the temperature of the hydrothermal transformations in the Baia Mare region, being correlated with the crystallization temperature of the mineralization (Manilici et al., 1978, 1981), for establishing the formation temperature of barite from Romanian (1980) as well as for determining the epigenesis temperature of limestones from the Piatra Craiului and Bucegi synclines (Manilici et al., 1982). (From the authors' text)

MANNING, D.A.C. and HENDERSON, P., 1983, The effect of fluid composition on tungsten partitioning between granitic melt and vapor (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 2. First author at Univ. Newcastle.

A recent experimental study has shown that at 800°C and 1 kbar the behavior of tungsten in granitic melt-vapor systems is controlled by both fluid composition and concentration. With chloride and phosphate solutions tungsten partitions strongly into the fluid whereas with fluoride, carbonate and borate solutions, and water alone, tungsten partitions into the melt. The data suggest that W-Cl complexes are present within chloride solutions and that their Cl:W ratio increases with chloride concentration. Phosphorus heteropolytungstates are believed to be present within phosphate solutions. No evidence was obtained for the presence of tungsten complexes with F, CO_2 or B, and isopolytungstates may predominate in solutions of these elements and water alone. (Authors' abstract)

MANNING, D.A.C. and PICHAVANT, M., 1983, The role of fluorine and boron in the generation of granitic melts, in M.P. Atherton and C.D. Gribble, eds., Migmatites, Melting and Metamorphism: Cheshire, U.K., Shiva Pub. Ltd., p. 94-198.

Recent experimental studies have shown that both F and B, in addition to water, may have a very great effect on phase relationships in the hydrous, silica-saturated residua system, Qz-Ab-Or. The presence of both elements causes a marked reduction in solidus temperature at 1 kbar from 715°C (water alone) to less than 600°C (15% B_2O_3 in the charge) and to less than 550°C (4% F in the charge). These results suggest that (a) F or B-bearing rocks may begin to melt at lower temperatures than similar F or B-free rocks, and (b) that enrichment in either F or B by fluid-rock interaction may allow melting to take place at lower temperatures than would otherwise be possible.

In order to examine these possibilities more closely, existing experimental data are extrapolated to higher pressures and water-undersaturated conditions. It is apparent that under dry conditions F-bearing hydroxysilicates have a greater thermal stability than F-free equivalents, but this relationship may, for micas and amphiboles, be reversed if water is present, in which case breakdown involves melting. Borosilicate minerals show complex phase relationships, but are essentially refractory, retaining B on breakdown within the borosilicate phase appropriate for the P-T conditions.

Fluorine occurs within most high-grade metamorphic rocks as 'background' concentrations within micas and amphiboles, and as much higher concentrations within topaz in certain gneisses. The 'background' fluorine contents are probably the most significant in affecting anatectic melt generation, as the topaz-bearing gneisses are evidently very refractory. Borosilicate minerals, particularly tourmaline, commonly occur within pegmatites, and in quartz-tourmaline veins, in high-grade metamorphic terrains and demonstrate the great mobility of B as a component of the metamorphic fluid phase. (Authors' abstract)

MANSKE, S.L., 1980, Fracturing events in the Ruby Star granodiorite adjacent to the Esperanza porphyry copper deposit, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 102 pp.

Fracturing and attendant hydrothermal alteration-mineralization northeast of Esperanza falls into two distinct groups. One such group is a system of three major sets of veins whose areal distribution and magnitude of fracture density are some function of distance from the progenitor stock at Sierrita-Esperanza. The second group comprises veinlet-controlled and pervasive alteration distal to the system at Sierrita-Esperanza, and whose areal distribution and fracture density are not functions of distance from the progenitor stock. Fluid inclusion homogenization temperature profiles of the peripheral alteration are distinctly warmer than those of prophyry-center vein sets which it cuts and overprints. The implication is that the peripheral alteration is the product of hydrothermal activity separate from the hydrothermal event related to the system at Sierrita-Esperanza.

Patterns of fracturing and vein sets northeast of Esperanza have been greatly influenced by a zone of structural weakness cutting through the area from southwest to northeast. The existence of this zone is graphically exemplified by the intrusion pattern of two generations of quartz latite dikes. The zone has had a profound impact on fracture attitudes, fracture densities, and the areal distribution of hydrothermal effects adjacent to Esperanza. (Author's abstract)

MANUYLOVA, M.M., DANILEVICH, A.M., KOTOV, A.B. and KIRIKOV, A.D., 1983, Structural admixture of aluminum in quartz as index of conditions of granitoid formation: Sovetskaya Geologiya, no. 7, p. 77-87 (in Russian). First author at IGGD, USSR.

Td of quartz from Tatarnikovo granites (NW Pribaykal'ye) equals 540°C. (A.K.)

MARAKUSHEV, A.A., 1983, Liquation origin of andesites and related rocks: Doklady Akad. Nauk SSSR, v. 273, no. 6, p. 1456-1459 (in Russian). Author at Inst. Exper. Mineralogy, Chernogolovka near Moscow, USSR.

Immiscibility structures are reported in this paper from basalt lavas of Tingmuli (Iceland); the immiscibility model of andesite rock formation is presented. (A.K.)

MARAKUSHEV, A.A., FENOGENOV, A.N., EMEL'YANENKO, P.F., DYUZHNIKOV, O.A. and SKRIPNICHENKO, V.A., 1982, Genesis of stratiform intrusives of the Norl'sk type: Vestnik Moskovsk. Univ., Ser. 4, Geologiya, no. 1, p. 3-19 (in Russian).

The paper discusses natural silicate melt immiscibility and experiments with splitting of syenite-gabbro melt to basalt melt, trachyte melt and magnetite ore melt under action of 10% of (K, Na)H_2PO_4 added, at 1200°C. (A.K.)

MARAKUSHEV, A.A., GRAMENITSKIY, Ye.N. and KOROTAEV, M.Yu., 1983, Petrologic model of endogeneous ore formation: Geol. Rudn. Mestorozhd., v. 25, no. 1, p. 3-20 (in Russian). Authors at Moscow State Univ., USSR.

The paper discusses the partition of Mo, Cu, Zn, Fe, Sn between granite melt and various hydrothermal solutions, influence of PCO_2 on solvus of the phonolite-carbonatite system, relations between granite melt, salt melt and hydrothermal water solution, 450 and 500°C isotherms for equilibrium of sulfate salt melt and hydrothermal water solution plus distribution of normative scheelite between coexisting phases, equilibria between salt halide melt and water solutions, separation of H_2O, CO_2 and H_2 phases from fluid under 50 and 100 MPa etc. (Abstract by A.K.)

MARIANO, A.N., 1983, Fenitization in alkaline rocks (abst.): Abstracts Volume, '83 MSA Symposium on Alkaline Complexes, Wausau, Wisconsin, Sept. 16-18, 1983 (unpaginated). Author at 48 Page Brook Road, Carlisle, MA 01741.

Fenitization is a process of alkali metasomatism whereby late residual solutions enriched in alkalis, from an alkaline igneous rock complex, replace preexisting rocks. The process was first proposed by the Norwegian geologist W.C. Brøgger in 1921 during his study of the classic Fen carbonatite complex in Ulefoss, Norway.

The physicochemical conditions and evolved minerals and rocks are also found in alkaline igneous environments where carbonatites are not present.

In addition the process of fenitization is not confined to counry-rock but almost invariably invades the earlier crystallized igneous rocks in carbonatite complexes.

Under the influence of electron excitation, Fe^{3+} functions as an activator for brilliant red cathodoluminescence (CL) in feldspars. With the aid of CL some of the most subtle conditions of fenitization can be easily detected and the type of fenitization can be classified, e.g., incipient, massive and internal.

Incipient fentitization appears as veinlets of fenite feldspars which usually occupy microfractures in the rock. Preexisting country-rock is totally replaced, on a massive scale, by massive fenite mineralization. Usually remnant texture of the preexisting rock is preserved. However, when carried out to the extreme case, the fenite rock may assume an igneous texture. In alkaline igneous rocks, during internal fenitization, the late stage fluids become increasingly enriched in alkaline components. This stabilizes Fe^{3+} in the solutions. These late solutions act on the previously formed primary minerals along their edges and within their microfractures. They especially act on feldspars replacing them with a ferric iron substituted fenite feldspar. The alkali solutions also act on primary amphiboles or pyroxenes mantling them with peralkaline ferromagnesian mineralization.

Internal fenitization cannot be regarded as metasomatism because it takes place in a closed system. No extraneous solutions are brought in. It is a deuteric affect. However the chemical processes are the same. (From the author's abstract)

MASON, C.W., ed., 1983, Handbook on Chemical Microscopy, Vol. 1, 4th Edition: John Wiley & Sons Publ., New York, 505 pp. Author at Cornell Univ., Ithaca, NY.

A good general review of most aspects of microscopy. (E.R.)

MATHEZ, E.A., 1983, Influence of degassing on oxidation states of basaltic magmas (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 637.

MATKOVSKIY, O.I., BARTOSHINSKIY, V.Z., GRITSIK, V.V. and SHKLYANKA, V.M., 1982, Mineralogically new barite from the deposit Beregovo: Mineralog. Zhurnal., v. 4, no. 6, p. 62-72 (in Russian; English abstract). First author at the L'vov Univ., L'vov, Ukraine.

The studied barite bears two types of inclusions: G/L and solid. Solid inclusions are crystals of galena, sphalerite, pyrite, G/L inclusions are two-phase ones with Th 60-140°C, rarely 250-275°C. (A.K.)

MATTEY, D.P., PILLINGER, C.T. and FALLICK, A.E., 1983, Hydrogen isotopic composition of water in fluid inclusions in the Peetz L6 chondrite: Meteoritics, v. 18, no. 4, p. 348-349. First author at Dept. Earth Sci., Univ. Cambridge, Cambridge CB2 3EQ, England.

Recently interest has been aroused concerning the nature and origin of fluid inclusions contained in certain stony meteorites. The observation of unambiguous fluid inclusions is confined to only seven meteorites (ALHA 77256 (diogenite), Bjurbole (H4), Holbrook (L4), Faith (H5), Jilin (H5), Peetz (H6) and St. Severin (L6)[1]). In Peetz and St. Severin, primary aqueous fluid inclusions are contained in feldspar and phosphate grains[2,3]. No CO_2 rich fluid inclusions have yet been found in these or in any of the other meteorites listed above.

We have measured hydrogen isotopic compositions for Peetz, and for comparative purposes, four other type 6 ordinary chondrites (Alfianello, Salles Rhone, ALHA 77271 and MBRA 76001). For D/H analysis, samples were pyrolyzed and combusted at 350°C to remove contaminant H-bearing species and then combusted at 1000°C to release indigenous water and hydrogen.

Yields of H_2O released at 350°C varied from 0.2% to 0.04% in all samples studied, with δD ranging from +18.6 to -139‰. At 1000°C, Peetz is characterized by the largest water release (1.25%) of all the samples studied. Apart from Salles Rhône, which was found to contain 0.64% water, the remaining Type 6 chondrites contained less than 0.07% water. Despite the much larger 1000°C water release of Peetz, its measured δD (+2.5‰) is essentially the same as Alfianello and Salles Rhone (-1.4 and -6.6‰) respectively). The δD of water released at 1000°C from the two Antarctic meteorites (ALHA 77271 and MBRA 76001) is found to be lighter with measured δD values of -129‰ and -126‰ respectively and possibly consistent with these meteorites having exchanged with isotopically light Antarctic precipitation. None of the samples liberated large amounts of CO_2 at high temperature.

The large water release observed in Peetz is attributed to the presence of fluid inclusions which can be observed in a thin section of the sample used for the investigation. Isotopically, the water released from Peetz, Alfianello and Salles Rhône has δD values in the terrestrial range quite unlike that from St. Severin (L6) which is reported by Robert et al.[3] to have a δD vlaue of -500‰ at 600°C. The reason for such a difference is not apparent at the present time. References: [1] Warner et al., P13LPSC, J.G.R., 88, A731 (1983); [2] Fieni et al., Meteoritics, 13, 460 (1978); [3] Robert et al., Terra Cognita, Spring 1981, p. 47. (Authors' abstract)

MATTEY, D.P., SWART, P.K., PILLINGER, C.T., MILLEDGE, H.J. and SEAL, M., 1983, Type dependent variations in the carbon isotopic composition of diamonds (abst.): Terra cognita, v. 3, p. 125. Authors at Planet. Sci. Unit, Dept. Earth Sci., Univ. Cambridge, Cambridge CB2 3EQ, UK.

A survey of the carbon isotopic composition in spectral type II diamonds reveals a variation in $\delta^{13}C$(PDB) from -33‰ to -0.5‰ which is equivalent to the entire range previously reported for uncharacterized diamonds. In contrast, spectral type I diamonds (which comprise 99% of all diamonds recovered commercially and hence must correspond to the great majority of diamonds in a random sample) display a considerably more restricted $\delta^{13}C$ range from -11‰ to -6‰. The range in carbon isotopic composition of type I and type II diamonds corresponds to the isotopic variation in diamonds which are characterized by peridotite and eclogite suites of inclusions (Sobolev et al., 1979). The distribtuion of $\delta^{13}C$ values in type II is not gaussian and peaks are observed around -31‰, -16‰ and -5‰. Deviations in $\delta^{13}C$ from the mode of all reported analyses (-6‰, Deines, 1980) may imply that in addition to primordial mantle carbon, recycled crustal material may also be involved in diamond formation. The observed pattern of preferred $\delta^{13}C$ values within the spectral type II sample may reflect the distinctive isotopic signatures of various carbon reservoirs of crustal origin. (Authors' abstract)

MATTHEWS, Alan, GOLDSMITH, J.R. and CLAYTON, R.N., 1983a, On the mechanisms and kinetics of oxygen isotope exchange in quartz and feldspars at elevated temperatures and pressures: Geol. Soc. Am. Bull, v. 94, p. 396-412.

MATTHEWS, Alan, GOLDSMITH, J.R. and CLAYTON, R.N., 1983b, Oxygen isotope fractionation between zoisite and water: Geochimica Cosmo. Acta, v. 47, p. 645-654.

MATUZENKO, M.Yu., L'VOV, S.N. and ZAREMBO, V.I., 1982, Model calculations on the standard thermodynamic functions for the formation of polyatomic ions in aqueous solution at 298-623 K: Geokhimiya, 1982, no. 5, p. 720-725 (in Russian; translated in Geochem. Int'l., v. 19, no. 3, p. 81-87, 1983).

MATUZENKO, M.Yu., YEGOROV, V.Ya., ZAREMBO, V.I. and PUCHKOV, L.V., 1982, Thermodynamic parameters of aqueous solutions of alkali carbonates at 298-573 K: Geokhimiya, 1982, no. 3, p. 381-386 (in Russian; translated in Geochem. Int'l., v. 19, no. 2, p. 49-56, 1983).

MATYASH, I.V., BRIK, A.B., GALIY, S.A., ZATSIKHA, B.V., DERSKIY, L.S. and LARIKOV, A.L., 1983, Electron paramagnetic resonance of the CH_3 radical in quartz of mercury ore deposits of Transcarpathians: Geokhimiya, no. 6, p. 916-919 (in Russian). Authors at Inst. Geochem. and Physics of Minerals, Kiev, Ukraine.

EPR signals are attributable to CH_3 in quartz structure; it was found that CH_3 in methane in fluid inclusions is not detectable by this method. (A.K.)

MAYNARD, J.B., 1983, Sedimentary ore deposits: Geochemistry of sedimentary ore deposits: New York, Springer-Verlag, 305 pp.

Contains numerous citations to fluid inclusion studies. (E.R.)

MAZE, W.B., 1983, Jurassic La Quinta Formation in the Sierra de Perija, northwestern Venezuela; geology, tectonic environment, paleomagnetic data, and copper mineralization on red beds and volcanics: Ph.D. dissertation, Princeton Univ., Princeton, NJ, 371 pp.

Indexed under Fluid Inclusions. (E.R.)

MEDFORD, G.A., MAXWELL, R.J. and ARMSTRONG, R.L., 1983, $^{87}Sr/^{86}Sr$ ratio measurements on sulfides; carbonates, and fluid inclusions from Pine Point, Northwest Territories, Canada: an $^{87}Sr/^{86}Sr$ ratio increase accompanying the mineralizing process: Econ. Geol., v. 78, p. 1375-1378. First author at Cominco Ltd., Explor. Res. Lab., 1486 East Pender St., Vancouver, British Columbia V5L 1V8, Canada.

$^{87}Sr/^{86}Sr$ ratio measurements on dolomite, fluid inclusions in dolomite, and calcite from Pine Point reveal that crystallization of fine-grained, early diagenetic dolomite and later (but premineralization) coarse dolomite (Presqu'ile facies) has occurred in Sr iosotope equilibrium with Devonian seawater ($^{87}Sr/^{86}Sr$ = 0.7082). Vein dolomites associated with mineralization show more variable and radiogenic ratios that are only exceeded by ratios found in calcite which crystallized in the final stages of mineralization. An increase in $^{87}Sr/^{86}Sr$ ratios with progressive mineralization has previously been noted in Mississippi Valley-type Pb-Zn deposits by Kessen et al. (1981). This observation can be explained by extraction of radiogenic Sr from silicates in metal source sediments by mineralizing brines. (Authors' abstract)

MEDINA, J.A., MORANTE, Margarita and LEGUEY, Santiago, 1983, Natural etch pits in beryl related with the structure: Bull. Minéral., v. 106, p. 293-297. Authors at Dept. Geol. & Geochem., Univ. Autónoma de Madrid, Faculty of Sci., Madrid, 34, Spain.

The etch pits in beryl crystals of diverse natural origin are studied in this work. The study was done on a beryl found in Minas Geraes (Brazil) which present inclusions and etch pits with a pseudopyramidal shape and hexagonal base. Small emerald crystals found in Muzo and Yacopi (Columbia) which show a great amount of corrosion were also studied.

The technique employed in the initial stage was the observation through binocular and polarized light microscopy. Subsequently, we used a scanning electron microscope. We have established in this work a relationship between the various etch pits which appear on the basal, prismatic and pyramidal faces and the structural disposition of the atoms of the Al-O-Be chains on those surfaces. (Authors' abstract)

MEINERT, L.D. and HAWKSWORTH, M.A., 1983, Fluid inclusion composition and temperature evolution in a zoned skarn system, Groundhog mine, New Mexico (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 642. Authors at Geol. Dept., Washington State Univ., Pullman, WA 99164.

Extremely detailed underground mapping and sampling studies of the Groundhog skarn system in the Central Mining District, New Mexico have established systematic mineralogical and compositional zonation patterns in two directions: 1) along the 2km strike length of the system and 2) across the 1-8m skarn thickness from granodiorite porphyry to marble. As summarized by Meinert (1982), silicate skarn mineralogy varies from predominant garnet to pyroxene to bustamite along strike from NE to SW and from dike contact to the marble front. Fluid inclusions are present in all three mineral phases, with pyroxene being the most abundant mineral studied. Homogenization temperatures of primary fluid inclusions vary from a high of 400°C in the furthest NE sample to a low of 205°C 2km to the SW in distal skarn, for a maximum hydrothermal temperature gradient of 100°C/km. At a given location along strike, average homogenization temperatures in silicate minerals decline about 50°C across the skarn thickness (1-8m) from dike to marble. Limited fluid inclusion salinity determinations suggest a significant salinity decrease from NE to SW. Many skarn samples from the NE zone contain visible halite daughter minerals (too small to visibly homogenize); requiring salinities >26 wt % NaCl equivalent. Samples from the Middle and SW skarn zones yielded last melting temperatures of -6.2 and -2.6°C, respectively, for equivalent NaCl wt % of 12.7 and 4.9%. Manganese content of individual mineral phases such as pyroxene increases from NE to SW in the skarn system and, in a given location, towards the marble contact. Electron microprobe analyses of host pyroxene adjacent to previously measured fluid inclusions suggests an inverse correlation between formation temperature and johannsenite content in agreement with experimental evidence. (Authors' abstract)

MEISSNER, H.P. and MANNING, M.P., 1983, Prediction of solubilities and activity coefficients in sodium-potassium-magnesium chloride brines, in Chemical Engineering Thermodynamics, S.A. Newman, ed.: Ann Arbor, Ann Arbor Sci., p. 339-348.

MELENEVSKIY, V.N. and NIKITINA, Ye.I., 1981, Gas evolution from natural quartz: Izvestiya, no. 9, p. 81-91 (in Russian; translated in Int'l. Geol. Review, v. 25, no. 1, p. 30-38, 1983).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 137, 1981. (E.R.)

MEL'NIKOV, B.D., 1983, Use of thermobarometry for finding of gold-sulfide mineralization occurring in black shale formation: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 2, p. 124-126 (in Russian). Author at PGO "Aerogeologiya," USSR.

Studies of pyrite from black shale formation (location not given) revealed two groups of this mineral: decrepitation passive (average Au content in pyrite of 62 samples equal $1.34 \times 10^{-6}\%$) and decrepitation active (av. Au content of 118 samples equal $30.58 \times 10^{-6}\%$). (A.K.)

MELSON, W.G., 1983, Monitoring the 1980-1982 eruptions of Mount St. Helens: compositions and abundances of glass: Science, v. 221, no. 4618, p. 1387-1391. Author at Dept. Min. Sci., Smithsonian Inst., Washington, DC 20560.

The Mount St. Helens eruptive sequence of 1980 through 1982 reflects the tapping of successively less water-rich, more highly crystallized, and more viscous, highly phyric dacitic magmas. These changes reflect both syn- and preeruption processes. The decreasing water content points to a continued decline in the volume and intensity of explosive pyroclastic activity. This decreasing water content appears to be composed of a long-term trend established during a long period of repose (about 130 years) imposed on short-term trends established during short periods (about 7 to 100 days) of repose between eruptions in the present eruptive cycle. The last two eruptive cycles of this volcano, the T (A.D. 1800) and W cycles (about A.D. 1500), exhibited similar trends. These changes are inferred from a combination of petrographic, bulk chemical, and electron- and ion-microprobe analyses of matrix and melt-inclusion glasses. (Author's abstract)

MENZIES, Martin, 1983, Mantle metasomatism and mantle enrichment as discrete events in ultramafic xenoliths (abst.): Geol. Soc. Newsletter, v. 12, no. 1, p. 29.

Rare gas, isotope and trace element geochemistry of mantle xenoliths reveal the presence of MORB-type mantle below several continents. Mantle depletion (1-3 AE) is evident as sparse light REE depleted peridotites ($\Sigma_{Nd} = +8$ $\Sigma_{Sr} = -32$). Mantle enrichment (>0.5 AE), caused by ingress of CO_2-H_2O fluids, chemically modifies this residua without significant petrographic change and produces light REE enriched peridotites ($\Sigma_{Nd} > -2.0$ $\Sigma_{Sr} < +17$). Recent mantle metasomatic effects (<0.2 AE) occur adjacent to vein apophyses or metasomatic aureoles around mantle conduits of basanite. Local chemical and isotopic heterogeneities are therefore a consequence of volcanism. (Author's abstract)

METRICH, Nicole, 1983, Chemical variations of calcic clinopyroxenes as an indicator of various petrological processes in a magma chamber (from the example of some pumices in Phlegrean Fields, Campany, Italy): Bull. Minéral., v. 106, p. 353-364 (in French; English abstract). Author at ER 45 du CNRS, Lab. Pétrologie, Univ. Paris Sud, 91405 Orsay, France.

Diopside and salite occur together in latitic and trachytic pumices in Phlegrean Fields. Optical and chemical studies by electron microprobe (Camebax) on clinopyroxenes, and optical thermometry on the two phase inclusions (glass + gas) (which can be used to get a minimal crystallization of the host mineral) present in these crystals show that: 1) diopside crystallized from a trachybasaltic melt 1155°C ± 10°C; 2) cognate diopsidic pyroxene exists either as phenocrysts in a latitic and trachytic pumices, or as core of salite in latitic pumice; 3) inversed zoning and oscillatory zoning (with diopsidic and salitic compositions) occur in these salites; 4) minimal crystallization temperatures measured on the melt inclusions are: 1020°C ± 10°C and 1040°C ± 10°C for more ferriferous salite in trachyte. These variations can be correlated with compositional variations of the phenocrysts; and 5) melt inclusions of some apatite included in the pyroxene of trachyte show the same temperature 1020°C ± 10°C.

The results suggest the coexistence of different cogenetic magmas at different differentiation degrees. The observed compositional change from trachybasaltic and trachytic melts is consistent with a fractional crystallization process with removal of diopside and olivine in the first step then salite, plagioclase, magnetite and a more and more important role of sanidine in the most evolved liquids. These hypotheses are in agreement with the magma chamber model proposed by Armienti et al. (in press). (Author's abstract)

MEYER, J.W., 1980, Alteration and mineralization of the Grasshopper prospect, Beaverhead County, Montana: M.S. thesis, The Univ. Arizona, Tucson, AZ, 91 pp.

The Grasshopper prospect is a remarkably well zoned "porphyry"-type hydrothermal alteration and mineralization system in a fine-grained, probably shallowly emplaced, circular dacite porphyry stock which is K-Ar dated at 73.4 ± 3.5 m.y. and has not previously been recognized as an intrusion.

Alteration of the stock consists of nearly concentric zones ranging from the outside-inward from chlorite to chlorite-epidote to sericite-quartz-pyrite, and finally to biotite-magnetite-sericite. Within the two innermost alteration zones there is a centerward decrease in pyrite, sericite, and clay, and increase in silica and limonite stockworks, biotite, and magnetite. Copper, molybdenum, gold, and silver values show a clear increase toward the center of the alteration system, whereas zinc occurs mainly in intermediate alteration zones. A shallow, thin, moderately well developed supergene enriched copper blanket exists in the center of the sericite-quartz-pyrite alteration zone.

While being within the range of variation seen in "porphyry" occurrences, the Grasshopper prospect is somewhat distinctive in its near lack of orthoclase, abundance of magnetite, and presence of precious metals in the centermost alteration zone. Exploration potential exists for molybdenum, primary and supergene copper, and by-product or co-product gold and silver. (Author's abstract)

MICHARD, G., MICHARD, A., ALBAREDGE, F., MINSTER, J.F. and CHARLOU, J.L., 1983, Chemistry of solutions from the 13° north EPR hydrothermal site (abst.): IUGG, XVIII General Assembly, Program and Abstracts, v. 2, p. 818. First author at Univ. Paris 7, France. See next abstract. (E.R.)

MICHARD, G., MICHARD, A., CHARLOU, J.L., ALBAREDE, F. and MINSTER, J.F., 1983, Chemistry and $^{87}Sr/^{86}Sr$ ratios in solutions from the 13° North EPR hydrothermal site (abst.): Terra cognita, v. 3, p. 169. First author at Univ. Paris 7, CRPG, Vandoeuvre, France.

Ten samples were recoverd by the CYANA submersible from two groups of hydrothermal vents located 2600 m deep along the EPR at 13°N. The maximum 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 (HTC) and low (LTC) temperature component may be observed. The water chemistry of the HTC slightly differs for several elements at the two sites. This HTC is deprived of SO_4, Mg and U and is greatly enriched in most other species. Maximum concentrations are (in units per kg): 0.72 M (Cl), 1.1 mM (Br), 0.55 M (Na), 29 mM (K), 14 μM (Rb), 54 mM (Ca), 170 μM (Sr), 1.3 mM (Mn), 2 mM (Fe), 15 μM (Al), 22 mM (Si). For many elements, the magnitude of the anomaly relative to sea water does not compare with the results obtained from the Galapagos or EPR 21°N. The enrichment of cations relative to sea water is likely related to the huge Cl excess through charge balance. The Br/Cl ratio is close to the sea water ratio. However, it is not clear whether the Cl excess is due to gas release or basalt hydration (formation of amphibole or chlorite). P-T dependence of SiO_2 solubility suggests interaction occurring at a depth in excess of 1 km below the sea floor. Mixing lines of $^{87}Sr/^{86}Sr$ vs. Mg/Sr or 1/Sr demonstrate a different behavior of Sr between the two sites. The HTC have a nearly identical $^{87}Sr/^{86}Sr$ ratio of 0.7041 while its value in the LTC's differs significantly. The associated glassy basalts contain 120-150 ppm of Sr with a $^{87}Sr/^{86}Sr$ ratio of 0.70257. From these values, a water/rock ratio of about 5 may be inferred which differs from the 1.5 value obtained at 21°N. The discrepancy is attributed to either different residence times of the water in the system or a different configuration of the conduits. Surprisingly, most mixing lines do not perfectly identify the LTC with sea water. This suggests that the diluting solutions are waters residing within the subsurface plumbing system, with which incipient chemical exchanges are operative. (Authors' abstract)

MILLEDGE, H.J., MENDELSSOHN, M.J., SEAL, M., ROUSE, J.E., SWART, P.K. and PILLINGER, C.T., 1983, Carbon isotopic variation in spectral type II diamonds: Nature, v. 303, p. 791-792. First author at Crystal. Unit, Dept. Geol., Univ. College London, London WC1E 6BT, UK.

The carbon isotope composition of most diamonds measured so far falls within a fairly restricted range from -5 to -9‰. On the other hand, the type II diamonds studied here show $\delta^{13}C$ values (-0.5 to -31.9‰) extending over almost the entire range of carbon isotope values previously quoted for diamonds. We suggest here that these data are related to variations in the nature of the carbon reservoir source and associated inclusion suites. (Authors' abstract)

MILLER, M.F. and SHEPHERD, T.J., 1983, Fluid inclusion gas analysis by mass spectrometry: experimental considerations and data interpretation (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 43. Authors at Inst. Geol. Sci., 64 Gray's Inn Rd., London WC1X 8NG, UK.

A facility for the routine analysis for fluid inclusion gases by a combination of cryogenic separation techniques and mass spectrometry will be described. The gases may be released either by crushing or decrepitation, depending upon the nature of the inclusions and their host mineral. Although primarily devised for the analysis of H_2O, CO_2, CH_4, N_2, H_2, Ar and O_2, the technique may readily be extended to include sulphur species and other trace components. System control and data handling is facilitated by use of an on-line microcomputer. Some of the factors which influence the reliability of data generated by this approach will be discussed, with particular reference to Si-OH bonds, carbonate decomposition and gas disequilibria. Mention will also be made of attempts to use gas equilibrium programs as an aid to data interpretation and the prediction of P-T environments at the time of fluid trapping. (Authors' abstract)

MILLERO, F.J., 1983, The P-V-T properties of brines, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyō, Gakujutsu Bunken Fukyu-Kai, p. 111-128. Author at Rosenstiel Sch. Marine & Atmospheric Sci., Univ. Miami, Miami, FL 33149, USA.

High pressure sound speed measurements on the same systems to 1000 bars have been used to determine an equation of state for these electrolytes. We presently are extending these studies to 100°C and plan experiments to 200°C in the future. Our preliminary results on NaCl solutions will be discussed. We also will review some of our recent work on natural brines (Red Sea waters, Dead Sea waters and Orca Basin waters). (Author's abstract)

MINČEVA-STEFANOVA, Jordanka and VESELINOV, Ilia, 1983, Morphology and genesis of negative crystals in sphalerite from the Kenan Dere deposit, Central Rhodope Mountains: Geochem. Mineral. Petrol., Bulgarian Acad. Sci., v. 14, 1981, p. 65-71.

Scanning electron microscopy and reflection goniometry were used to study the morphology of densely spaced negative crystals with very well developed faces and complex combinations of forms. They represent the vacuoles of primary fluid inclusions in the cleiophane core of large, up to 10 cm, sphalerite crystals formed at high temperature (from 350 to 300°C) and high Eh of the medium - the total iron content in them is low and zonally distributed, and, according to earlier special studies, the core does not contain isomorphous iron. The core occupies 2/3 to 3/4 of the volume of the crystals. Its habit is cubic-pseudooctahedral with the characteristic presence of d{110}.

The habit of the negative crystals is rhombododecahedral-pseudooctahedral with the characteristic presence of a{100}. Subordinate forms are e{210}, -p$\{2\bar{2}1\}$, -n$\{2\bar{1}1\}$, p{221} and n{211}, and a considerable number of nonpersistent forms of the types {hk0}. {hhl}, {hkk} and {hkl} are rare forms, the latter three predominating in the negative octants. The isometric appearance of the negative crystals is emphasized by the rounded edges and corners of the main habit combination due to the presence of the subordinate simple forms.

The sculptures on the faces of the individual simple forms are determined primarily by the hemihedry of structure - the negative forms have smooth and flat to slightly curved faces, while the positive forms show stepped faces in the [110] zones. Against the background of this phenomenon there are additional sculptures formed as the result of three different growth mechanisms: subparallel or regular fine twinnings in the enclosing crystal. The subparallel twinnings occur as a strip of subparallel individuals in one of the symmetry planes of the positive octant, the individual crystals being outlined by microdomes[microzones?] developed transversely to [110]. The third mechanism is the same for all negative crystals. It is connected with the position of the gaseous bubbles which was the same in all vacuoles and which determined in their upper parts a hindered, skeletal development of their faces. The different conditions of face development in the two halves of the vacuoles is expressed in the different extent of face growth of one and the same form around G(4i). The different sculptures, determined by these mechanisms, and particularly the different width and height of the steps, as well as the different roundness of the faces, explain the considerable number of rare, but nonpersistent even in a single octant forms, which have been identified by goniometry.

The enclosing part of the sphalerite crystals grew under equilibrium conditions, and more precisely, the core crystallized at high temperatures from solutions of low supersaturation containing [a] gaseous phase (slow crystallization)[sic]. At separate stages during their growth the gaseous phase was intensively released, which resulted in an intense corrosion of the faces of the growing crystal. The corroded surfaces (there are preserved relics of them) easily trapped the gaseous bubbles together with some of the fluid from which the crystal grew.

The face development of the vacuoles took place under conditions analogous to that around the growing crystal, which in the isolated small volumes, from 1 to 500 µm in diameter, were analogous to the conditions of formation of the equilibrium form. The gaseous bubbles with their positions in the vacuoles played an unfavorable role in the development of the equilibrium form. Only those parts which were in contact with the fluid show good faces. An additional redistribution of the deposited ZnS with a tendency towards equilibrium form development is extremely rare. (Authors' summary)

MIRONOVA, G.D., ZOTOV, A.V. and GUL'KO, N.I., 1983, Experimental determination of the orpiment solubility in acidic solutions at 25-150°C: Geokhimiya, no. 12, p. 1762-1768 (in Russian).

MIZUTANI, Yoshihiko, 1983, Deuterium fractionation between water vapor and hydrogen gas in fumarolic gases: Geochem. J., v. 17, p. 161-164. Author at Dept. Earth Sci., Faculty of Sci., Toyama Univ., Toyama 930, Japan.

The fumarolic condensate and hydrogen gas samples collected from the Showashinzan, Nasudake, Yakedake and Kuju-Ioyama volcanoes, Japan, have been analyzed for the D/H ratio. A comparison between temperatures for isotopic equilibrium and measured outlet temperatures indicates that in high temperature fumarolic gases the deuterium exchange reaction between water vapor and hydrogen gas is rapid enough to readjust the equilibrium to the outlet temperature of fumaroles. For low temperature fumarolic gases, however, the isotopic temperature refers to equilibrium conditions deep in the fumarole. (Author's abstract)

MONTGOMERY, J.G., 1983, A theoretical and geochemical study of graphite genesis in the eastern Adirondacks (abst.): 10th Ann. Vermont Geol. Soc. Spring Meeting, Middlebury, VT, April 30, 1983, The Green Mountain Geol., v. 10, no. 1, p. 11. Author at Middlebury Coll., Dept. Geol., Middlebury, VT.

The graphitic quartzofeldspathic pyroxene gneiss has a homogeneous mineralogy with biotites and feldspars of composition Mg_{82} and An_{36} to An_{46} respectively. Two generations of graphite are observed with strong foliations and many fluid inclusions. The lowest lithologic unit, unit 5, is a garnet-biotite-sillimanite gneiss. The sillimanite has been pseudomorphically replaced by muscovite.

Pressure and temperature values are difficult to compute in the Adirondacks. Biotite and pyroxene geothermometers were used to calculate temperatures of 803-950°C. These geothermometers generally give values that are known to be too high; therefore, a more reasonable temperature of 700°C was estimated to calculate a pressure of 11.9 kb. This pressure value is also high considering the presence of sillimanite. My calculated values, 803-950°C and 11.9 kb at 700°C, represent an upper limit for these rock types. A more reasonable pressure and temperature would be around 700°C and 7 kb.

Modeling of fluid composition in the C-O-H-N-S system was used to determine CO_2, H_2O, CO, CH_4, N_2, H_2S, H_2, O_2 and S_2 concentrations at 700°C and 7 kb with an 80% C-O-H fluid species. The composition was dominantly CO_2 with significant amounts of CO, NH_4, SO_4, and H_2S depending upon the acidity of the fluid. No significant amounts of CH_4, N_2, and H_2O were present. This contradicts Hoering and Hart (1964) and Salotti and others (1971), who inferred that graphite resulted from methane dissociation. (From the author's abstract)

MOORE, D.E., MORROW, C.A. and BYERLEE, J.D., 1983, Chemical reactions accompanying fluid flow through granite held in a temperature gradient: Geochim. Cosmochim. Acta, v. 47, p. 445-454.

MOORE, G.R., 1983, A chemical and isotopic study of fluid inclusions from the northern Pennine orefield: Ph.D. thesis, Univ. Durham, 1980, Inst. Mining & Metallurgy Transactions Applied Earth Sci., Sec. B, v. 92, p. B51-B52.

The study was undertaken to investigate the origin of the mineralizing fluids and mechanisms of ore deposition, with particular reference to the fluorite-barite mineral zonation.

Fluid inclusions in fluorite, barite and quartz provided the principal material for analysis. Quantitative measurement of the inclusion gases, including water, was carried out by decrepitation (thermal rupture) under vacuum. The decrepitated material was subsequently leached with deionized water and the leachate was analyzed for Na, K, Ca, Sr, Mg, Cu, Zn, Fe and Mn by flame photometry and atomic absorption spectrometry and for Cl, F and Br by pyrohydrolysis and neutron activation analysis. Hydrogen isotope analysis of the inclusion fluids showed a greater depletion in deuterium for barite than for fluorite and quartz. The work was complemented by oxygen and strontium isotope studies.

It is concluded that the mineralizing fluids originated from sediments in the deep basins to the north, south and east of the Alston Block. During compaction of the sediments the pore fluids underwent filtration, producing two chemically and isotopically distinct fluids. The filtered high-level SO_4-rich fluid migrated laterally, but the residual fluid at depth mixed with dehydration water released during montmorillonite-illite conversion to produce a Ca-Na-Cl brine rich in metals. This deeper component, similar in chemistry to the fluorite-quartz inclusion fluids, migrated upwards through the cupolas of the Weardale granite in response to tectonic readjustment in the basement and anomalous high heat flow in the region. Deposition of fluorite and quartz was caused by cooling and slight pH changes in the fluids. In contrast, barite deposition was controlled by mixing of the two fluids. Chemical analysis and solubility data support the proposed mechanisms of mineral deposition. (Author's abstract)

See also Moore, 1980, Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 167. (E.R.)

MOORE, P.B., 1983, Accessory phases in nepheline syenites: toward a holistic picture (abst.): Abstracts Volume, '83 MSA Symposium on Alkaline Complexes, Wausau, Wisconsin, Sept. 16-18, 1983 (unpaginated). Author at Dept. Geophys. Sci., The Univ. Chicago, Chicago, IL 60637.

I submit a model where the majority of accessory phases in nepheline syenites can be chemically derived, both structurally and paragenetically, from three postulated parent phases: "Keilhauite," the yttrium-lanthanide-bearing titanite, $Ca(TiO)(SiO_4)$; nepheline itself, $KNa_3(AlSiO_4)_4$ and villiaumite, NaF. In this model, accessory phases are treated as retrograde hydrothermal-metasomatic products, and display to an uncanny degree "imprints" of the parent phases as structural fragments. The fluxes F^-, $(OH)^-$, $(BO_4)^{5-}$ and $(PO_4)^{3-}$ appear to selectively digest and reconstitute these phases. (From the author's abstract)

MOROGAN, Viorica and MARTIN, R.F., 1983, Partial melting of fenitic assemblages in the Oldoinyo Lengai carbonatitic volcano, Tanzania (abst.): Abstracts Volume, '83 MSA Symposium on Alkaline Complexes, Wausau, Wisconsin, Sept. 16-18, 1983 (unpaginated). Authors at Dept. Geol. Sci., McGill Univ., 3450 University St., Montreal, Quebec H3A 2A7, Canada.

We describe here the progressive changes in granitic and gabbroic basement xenoliths that have been caught up in alkali carbonatitic magma in the Oldoinyo Lengai volcano, Gregory rift, Tanzania. (From the authors' abstract)

MORSE, S.A., and COACHMAN, L.K., 1983, Ocean chemistry during glacial time--a comment: Geochim. Cosmochim. Acta, v. 47, p. 1539-1540. First author at Dept. Geol./Geography, Univ. Massachusetts, Amherst, MA 01003.

The detection and measurement of CO_2 in air bubbles entrapped in ice originated with Per F. Scholander in 1954, predating the studies referred to in Broecker (1982), Geochim. Cosmochim. Acta, 46, 1689-1706. (Authors' abstract)

MOTORINA, I.V. and YASHCHENKO, N.Ya., 1981, Physicochemical conditions of formation of quartz basalt and quartz rhyodacite in the Bayanaul district, central Kazakhstan: Dokl. Akad. Nauk SSSR, v. 261, no. 4, p. 961-965 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 261, p. 130-133, 1983). Authors at Inst. Geol. & Geophy., Siberian Div., USSR Acad. Sci., Novosibirsk, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 140-141. (E.R.)

MOZHAROVA, T.V., ZOZULYA, A.F., MARKEL', S.A. and TSURKO, N.G., 1983, Studies of $Ca(OH)_2$ solubility in aqueous solutions of sodium and calcium chlorides at 30, 50 and 100°C: Zhurn. Neorg. Khimii, v. 28, no. 9, p. 2389-2393 (in Russian). Authors at Sci.-Research and Projecting Inst. of Basic Chemistry, Khar'kov, Ukraine.

The paper bears data on crystal phases in equilibrium with solutions that may help in identification of dms in certain types of fluid inclusions. (A.K.)

MULLIS, J., 1983a Evolution and migration of the fluids in the central Alps during the retrograde metamorphism (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 44. Author at Inst. de Mineral. et Petrographie, Pérolles - 1700 Fribourg, Suisse.

The early fluid composition in quartz crystals of the Swiss Alps changes with increasing metamorphism. Four fluid fields are defined: the higher hydrocarbon field (non-metamorphic zone), the methane field (low grade anchizone), the water field (high grade anchizone and epizone) and the CO_2-field (mesozone). Within these fluid fields, fluid composition changes during decreasing temperature and pressure by:

1. Rock-fluid interaction: Rock-fluid interaction is more or less everywhere realized and will be discussed by Mullis, Dubessy, Kosztolanyi and Poty (in this symposium).

2. Fluid migration: This phenomenon can be proved by the presence of fluids that do not follow the general evolution of retrograde metamorphism.

3. Fluid unmixing: Fluid unmixing is often observed in metasediments, and less frequently in granitic rocks. Unmixed fluids usually tend to migrate.

The explanation of fluid migration and unmixing is as suggested:

1. The increase of the fluid pressure relative to the behavior of the lithostatic pressure: Assuming that the cooling rate becomes smaller than the rate of erosion of the alpine body, geothermal gradients tend to increase during the retrograde alpine metamorphism. As pressure is a function of the temperature and concentration of a fluid, fluids will migrate by diffusion or "flow" during rapid erosion.

2. Rock fracturing: Rock fracturing produces a local pressure drop and, at low temperature conditions, an unmixing of the aqueous solutions saturated by CO_2, CH_4 and N_2. Fractured rocks easily give way to fluid flow. (Author's abstract)

MULLIS, J., 1983b, Transported metamorphism of the external parts of the central Alps, shown by fluid inclusions (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 45. Author at Inst. de Mineral. et Petrographie, Pérolles - 1700 Fribourg, Suisse.

Fluid inclusions in quartz crystals from alpine fissures display in their composition a narrow relationship to the metamorphic zones.

The fluids in the non-metamorphic zone are characterized by the presence of >1 mole % of higher hydrocarbons, whereas the low grade anchizone is characterized by the presence of >1 mole % methane and <1 mole % of higher hydrocarbons. In the high grade anchizone and in the epizone, water is predominant. The evolution of fluids in sedimentary rocks from higher hydrocarbons (non-metamorphic zone) to water (epizone) is a function of increasing temperature and pressure during prograde metamorphism. The distribution of these fluids can be demonstrated in different cross-sections through the Alps, but examples from the Western part of the Swiss Helvetic and Prealpine nappes will here be discussed.

Three points of view are of interest: 1) Evolution of fluids from the Northern to the Southern part of the Wildhorn nappe. 2) Evolution of fluids from the West to the East of the Helvetic and Prealpine nappes. 3) Transported metamorphism: Fluids formed at higher metamorphic grade are found above fluids formed at lower metamorphic grade: the Morcles nappe contains water and lies above the parautochthonous flysch which contains methane. The Niesen nappe containing water is found above the Wildhorn nappe which contains methane; the "nappe supérieure des Préalpes" with methane is found above the "Préalpes médianes plastiques" containing higher hydrocarbons than methane.

We conclude that both metamorphism and zonal evolution of fluids took place before the nappes arrived at their actual place, in the external domain. The general composition of these fluids was kept more or less constant at least until they were trapped as fluid inclusions in quartz crystals, which grew at a final stage of nappe transport and during uplift of the alpine body. (Author's abstract)

MULLIS, Josef, 1983c, Inclusions in quartz from the Swiss Alps and their mineralogical-geological significance: Bull. Soc. Frib. Sc. Nat., v. 72, no. 1/2, p. 5-19 (in German; English abstract). Author at Inst. Mineral. und Petrographie, 1700 Freiburg, FRG.

Quartz crystals from alpine fissures crystallized during compression and uplift movements of the Alps. Solid, liquid and gaseous inclusions in quartz record its growth history and that of the mineral paragenesis crystallized simultaneously in the alpine fissures. Inclusions often give information about late alpine tectonic movements. During trapping, fluid composition in the rocks is considered to be equal to that found in fluid inclusions of quartz crystals. Following the increasing path of regional metamorphism from the NW to the SE of the Swiss Alps four fluid fields have been differentiated: the field of higher hydrocarbons, the methane-field, the water-field and the field of carbonic gas. Minimum Pt-conditions delimitating the methane-field are: ⩾200°C at ⩾1200 bar resp. ⩾270°C at ⩾1700 bar.

Tectonic movements and regional and temporary variations in fluid composition influenced significantly the growth conditions of quartz, crystallizing in consequence under different form combinations and habitus, such as prismatic quartz, fibre quartz, skeletal quartz, Tessin habitus quartz, etc. (Author's abstract)

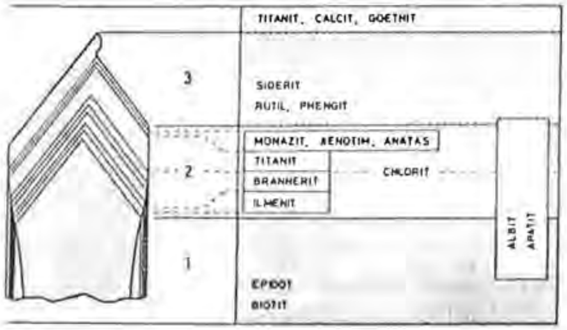


Fig. 9. Growth of quartz in correlation with the succession of the mineral paragenesis and the fluids, represented on a smoky quartz-fissure from the Zinggenstock.

Table 2. Approximate fluid composition of quartz crystals from the Zinggenstock (in mol.%, salt-content in NaCl equiv.).

Generation	H_2O	CO_2	NaCl
1	97.1	0.7	2.2
2 früh	96.7	0.7	2.6
3 früh	93.8	3.3	2.9

MYASNIKOV, V.P., MITRONOV, A.P., KOCHERGIN, N.A. and DIL'MAN, V.V., 1983, Structure of streams in a thick bubble layer without liquid flow: Dokl. Akad. Nauk SSSR, v. 269, no. 4, p. 827-830 (in Russian). Authors at State Sci.-Research and Projecting Inst. of Methanol, Components of Engine Fuels and Products of Organic Synthesis, Sverodonetsk, USSR.

The paper presents the behavior of gas (air) bubbles in liquid depending on their number and size; pertinent to heterogeneous mineral-forming media. (A.K.)

MYERS, L.L., 1983, Geochemistry of the Crandon massive sulfide deposit, Wisconsin: sulfur isotope and fluid inclusion data: M.S. thesis, Univ. Wisconsin-Madison, Madison, WI.

The Crandon deposit is one of four known volcanogenic massive sulfide bodies in the Proterozoic metavolcanic belt of northern Wisconsin. This deposit is a tabular, roughly conformable body within a sequence of tuff, volcanic breccia, argillite, chert, and dolomite. Ore metals are Zn and Cu, with lesser amounts of Pb, Ag, and Au. Sulfur isotopes and fluid inclusions have been analyzed from Crandon deposit core in an attempt to determine the sources of ore fluid components as well as physicochemical parameters of ore deposition. The sulfur isotope values of 82 sulfide mineral separates cluster near zero per mil with a 3 per mil range. This isotope distribution matches sulfur isotope patterns from other Precambrian massive sulfide deposits in the Canadian Shield and indicates a magmatic sulfur source for the ores. Fluid inclusions in zoned quartz crystals reveal the presence of two primary fluids in the ore mineralization stages. The major fluid is a 10 wt% $NaCl-H_2O$ solution. These inclusions homogenize near 200°C. The second fluid is a 3-6 wt% $NaCl-H_2O-CO_2$ mixture. Observations of Crandon fluid inclusions, plus data from experimental studies, suggest that the two fluids in Crandon ore stage minerals may have been part of the same homogeneous ore fluid at one time. The origin of the carbon dioxide in the ore fluid is unknown. (Author's abstract)

MYSEN, B.O., 1983a, The structure of silicate melts: Ann. Rev. Earth Planet. Sci., v. 11, p. 75-97. Author at Geophy. Lab., Carnegie Inst. Washington, Washington, DC 20008.

A review, including the behavior of H_2O and CO_2 in melts. (E.R.)

MYSEN, B.O., 1983b, Rare earth element partitioning between (H_2O+CO_2) vapor and upper mantle minerals: Experimental data bearing on the conditions of formation of alkali basalt and kimberlite: Neues Jahrbuch Miner. Abh., Stuttgart, v. 146, no. 1, p. 41-65. Author at Geophy. Lab., Carnegie Inst. Washington, Washington, DC 20008.

Rare earth element partition coefficients between (H_2O + CO_2) vapor and diopside have been determined as a function of temperature (900°-1100°C), pressure (20-30 kbar), and $CO_2/(CO_2 + H_2O)$. The coefficient increases with increasing pressure, with decreasing temperature, and with increasing $H_2O/(H_2O + CO_2)$. Under all conditions studied, the value is greater than 1. Its pressure and temperature dependence becomes more pronounced with increasing $H_2O/(H_2O + CO_2)$ of the vapor. (From the author's abstract)

NASEDKIN, V.V., 1983, Petrology of water-bearing volcanic glasses, essential ways of their further studies and practical use, p. 76-81, in Problems of petrology, mineralogy and ore genesis: "Nauka," Moscow, 224 pp., 900 copies printed, price 3 rbls. 70 kopecks (in Russian).

Perlites from N-E of Far East of Soviet Union bear minute inclusions filled by concentrated NaCl and KCl solutions. Similar inclusions were found in obsidian outcropping 35 km to the north from Erevan, part of them with CO_2. (Abstract by A.K.)

NASEDKIN, V.V., BOYARSKAYA, R.V., GARAEV, A.M. and FROLOVA, K.Ye., 1983, Microinhomogeneity of iridescent obsidian from the deposit Dzhraber from data of electron microscopy: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 8, p. 101-111 (in Russian). Authors at IGEM, Moscow, USSR.

The paper bears description of inclusions in obsidian and statement that P, S, Cl, Ca, Fe, K, Na, Al and Si are present in them. (A.K.)

NASLUND, H.R., 1983, The effect of oxygen fugacity on liquid immiscibility in iron-bearing silicate melts: Am. J. Sci., v. 283, p. 1034-1059.

NAUMOV, V.B., CLOCCHIATTI, R., KOVALENKO, V.I., SOLOVOVA, I.L. and MALOV, V.S., 1983, Composition of biotite, potassium feldspar and melt in equilibrium with them from the data of studies of inclusions in quartz from ongorhyolite: Doklady Akad. Nauk SSSR, v. 270, no. 6, p. 1450-1452 (in Russian). First author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The studied Lower Cretaceous ongorhyolites occur in the region Durben-Dort-Ula (Central Mongolia). They contain phenocrysts of acid plagioclase, K-spar, quartz and very rare biotite, apatite and magnetite in a glassy or microcrystalline matrix (87-90%). P inclusions in quartz have dimensions from 3 to 75 µm and are filled by glass, G and several crystals (biotite, feldspars and magnetite). Biotite in inclusions is close to siderophyllite, very poor in Mg and rich in Mn (up to 3.08 wt.%, electron microprobe analysis). Homogenized and subsequently quenched inclusions bear silicate glass, G bubble and LH_2O solution, homogenizing with G either in L or G phase at 370-385°C; this indicates that H_2O content in melt equals 2.0-2.5 wt.% and PH_2O 0.8-1.4 kbar. By determinations with use the MOLE [Raman] spectrometer, other gases are absent (CO_2 <0.01, CH_4 <0.002, N_2 ≤0.01, H_2S <0.005 g per cm^3). The paper presents evaluation of Fe^{2+}/Fe^{3+} in biotite from inclusion and crystallochemical formula of this biotite. In 10 inclusions biotite occupies 1.1 ± 0.3 vol.%; its melting begins at 720-790°C, complete homogenization T 760-820°C. Inclusions that do not bear biotite have higher Th 850-1180°C. K-spar in inclusions is poor in Na (microprobe determinations), but the remaining melt (before homogenization run) in inclusion bears approximately the same concentrations Na_2O and K_2O. The paper presents microprobe analyses of remnant glass in inclusions and glass after inclusion homogenization. (Abstract by A.K.)

NAUMOV, V.B., IVANOVA, G.F. and SHAPENKO, V.V., 1983, Genetic aspects of rare-metal ore formation, in Genetic models of endogeneous ore formations: "Nauka" Pub. House, Siberian Branch, v. 2, p. 48-56 (in Russian).

Specific peculiarities of formation of rare metal ores are discussed in the paper. On the basis of fluid inclusion studies, T and P were determined (470-200°C, most frequently 400-250°C, 2.3-0.1 kbar, most frequently 1.5-0.5 kbar). From melt inclusions in minerals of acid effusives, granites and pegmatites, the water concentrations and PH_2O in melt were determined (0.1-13.9 wt.%, 0.1-6.1 kbar). For explanation of genetic connection of processes of magmatic crystallization with formation of rare metal ores, a number of indicator elements (Ta, Nb, Sc, Y , Yb, Ge) were studied in granites of various geochemical types and in minerals of ore formations. All data on peculiarities of T and P changes in the system: magmatic melt-hydrothermal solution, are generalized. (Authors' abstract translated by A.K.; see Translations).

NAUMOV, V.B. and KOVALENKO, V.I., 1981, Water concentration and pressure in silicic magma, as shown by study of inclusions in minerals: Dokl. Akad. Nauk SSSR, v. 261, p. 1412-1420 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 261, p. 149-151, 1983). First author at Inst. Geochem. & Anal. Chem., USSR Acad. Sci., Moscow, USSR.

Sixteen samples of quartz and topaz from silicic magmas containing liquid water in primary melt inclusions were studied to estimate wt% H_2O (0.1 to 13.9). Most H_2O-rich values were 2-8%. (E.R.)

NAUMOV, V.B., KOVALENKO, V.I. and KOSUKHIN, O.N., 1982, Crystallization parameters for ongonite magma, as determined from melt inclusions: Akad. Nauk SSSR, Dokl., v. 267, no. 2, p. 435-437 (in Russian).

Twenty samples of various ongonite or ongonite-related rocks were studied; Th 540-1200°C (mostly 700-900); Te 430-720°C; H_2O 0.2-10%.(E.R.)

NAUMOV, V.B., RUB, M.G. and RODNOV, Yu.N., 1983, Conditions of formation of ore-bearing (Sn, Ag) volcanic-plutonic formations (data of melt inclusion studies): Dokl. Akad. Nauk SSSR, v. 268, no. 2, p. 406-409 (in Russian). Authors at Inst. Geol. Ore Deposits, Petrography, Mineralogy and Geochemistry of Acad. Sci., Moscow, USSR.

The studies were performed on samples from Okhotsk-Chukotha volcanic belt. Quartz from rhyolites and comagmatic granites bear following types of inclusions: 1) 80-85% of transparent glass + 12-13% of G + solid phase in G bubble or near it; 2) partly recrystallized glass inclusions bearing G and magmatic water. Contents of inclusion type 1 begins to melt at 780-820°C, Th 1150-1220°C. Contents of inclusion type 2 starts its melting 720-730°C, Th 1000-1100°C, H_2O concentration in melt 0.4 molar %, pH_2O 170 bar. Cogmagmatic granites bear silicate dms + glass + G inclusions with Th 760-1020°C, water concentration in melt 1.7 to 7.0 molar %, PH_2O 0.3 to 3.6 kbar. High Th of inclusions in rhyolites ("dry" type) prove the deep conditions of initial crystallization of acid melts. (Abstract by A.K.)

NAUMOV, V.B. and SHAPENKO, V.V., 1983, Methane in hydrothermal solutions forming ore deposits of tin and tungsten: Geokhimiya, no. 9, p. 1335-1341 (in Russian; English abstract). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The paper presents the first study of methane in high-T [inclusions] (250-400°C). Two methods were used: cryometry and Raman spectroscopy. Most measurements were made in cassiterite from tin-tungsten deposit Svetkoe (Chukotka, USSR). L phase of the studied inclusions freezes at -34 to -45°C (metastable freezing), gas clathrates melt at T >0°C, up to +15°C. Analyses of Raman spectroscopy (four inclusions, analyses made in Nancy, France) yielded gas compositions (in vol. %): CH_4 32.8-62.3, C_2H_6 0.0, CO_2 12.3-48.0, N_2 9.4-31.4, H_2 0.0, H_2S 0.0, T of hydrate dissolution 11.5-15.0, Th 324-334°C. In one inclusion L CH_4 appeared at -95°C and homogenized at -92°C, methane density 0.062 g/cm^3, calculated CH_4 content in hydrothermal fluid 24.2 g/kg. Fluorite from Svetkoe bears H_2O + CH_4 inclusions with Th 285°C, T of clathrate melting (Tcm) 10.1°C; quartz (Svetloe) - H_2O + CH_4 filling, Th 264-362°C, Tcm -2.5 to +9.6°C; cassiterite (Iul'tin) - H_2O + CH_4 + CO_2 filling, Th 317-347°C, Tcm 8.5-17.8°C; quartz (Iul'tin) - H_2O + CO_2 filling, Th 340°C, Tcm 9.6°C; quartz (Vostok-2) - H_2O + CH_4 + CO_2 filling, Th 355°C, Tcm 18.0°C; scheelite (Vostok-2) - H_2O + CH_4 + CO_2 and H_2O + CO_2 fillings, Th 300-320°C, Tcm 8.5-10.5°C; quartz (Lermontovskoe) - H_2O - CH_4 fillings, Th 335-348°C, Tcm 5.5-10.5°C; topaz (Baga-Gazryn, Mongolia) - H_2O + CH_4 fillings, Th 381-383°C, Tcm 6.1-8.0°C; cassiterite (Horni Slavko, CSSR) - H_2O + CH_4 fillings, Th 352°C, Tcm 9.8°C. Pressures of CH_4 were in the range 20 to 200 bars. The above data prove that CH_4 is present in high-T tin- and tungsten-ore-forming fluids in amounts similar to CO_2. (Abstract by A.K.)

NESBITT, B.E., LONGSTAFFE, F.J., MUEHLENBACH, Karlis and SHAW, David, 1983, Oxygen isotopic evidence on the origin of the Sullivan massive sulfides (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A50. First author at Dept. Geol., Univ. Alberta, Edmonton, Alberta T6G 2E3, Canada.

Results of $\delta^{18}O$ analyses of whole rock samples of country rocks, units immediately adjoining ore, alteration zones, as well as the <2 μm size-fraction of rocks hosting the ore have been combined with information on geochemistry of hydrothermal alteration to produce a genetic model for the Sullivan deposit. The results indicate that the deposit was formed from 2 or possibly 3 fluids which varied from early, low temperature, relatively dilute fluids to later, higher temperature, more saline brines. Oxygen isotopic analyses of whole rock samples produced the following results: country rocks, 11.4 ± 2.0; units adjoining ore, 12.6 ± 1.2; tourmalinite zone, 11.9 ± 0.5; albite-chlorite zone, range 3.9 to 8.5; footwall quartz-sericite rocks, 12.3 ± 0.5. The <2 μm size-fractions of country rocks and units hosting ore have $\delta^{18}O$ values of 9.8 ± 0.6 and

10.7 ± 1.5, respectively. Unlike results of similar work on the Jason deposit, Yukon, there is no systematic decrease in $\delta^{18}O$ in the fine grained fractions. The results from whole rock analyses indicate that only during the albite-chlorite alteration event was there a significant shift in $\delta^{18}O$ values. The lack of a difference between results for the tourmalinite zone and those for the country rocks is due either to a lack of isotopic exchange during alteration or the production of values during alteration which are coincident to those of the country rocks. The first alternative is favored since deposition of boron generally occurs at low temperatures at which there would be little ^{18}O-^{16}O exchange. The proposed genetic model for Sullivan consists of early, B-rich, sub-100°C fluids venting through collapse breccias underlying the Sullivan basin. Subsequently, slightly hotter (100 - 150°C?) brines rose through the same conduit and deposited Fe-Pb-Zn sulfides on the sea floor. Later, hotter (>250°C?) saline brines altered the B-rich zone, the ore, and the hanging wall sediments forming the albite-chlorite zone. (Authors' abstract)

NEWMAN, N.A., 1979, Mineralization at Mount Owen, central Nelson [New Zealand]: M.S. thesis, Univ. Canterbury, Christ Church 1, New Zealand.

The Lower Paleozoic sequence at Mt. Owen, Nelson, hosts gold and base metal mineralization. The succession comprises the Wangapeka Formation (a black shale and sandstone unit), the underlying Arthur Marble Formation, which in turn rests on a metamorphosed and hydrothermally altered sequence of quartzite, dolomite, and black shales, informally defined here as the Owen Formation. The succession dips steeply westward, away from the adjacent intrusive batholith of Cretaceous Separation Point Granite. Tectonic deformation, metamorphism, and hydrothermal alteration are related to two principal controls: (a) granite intrusion, and (b) confinement of fluid processes beneath the marble.

Study of the disseminated sulphide minerals in the sedimentary rocks shows that whereas the sequence within and above the marble contains only crystalline pyrite, the more altered Owen Fromation contains a complex suite of minerals, exhibiting the paragenesis: pyrite → pyrrhotite → marcasite → pyrite.

Base metal ores form both replacement and infilling bodies within, and near, the marble, and comprise argentiferous galena, sphalerite, and minor chalcopyrite; in one deposit a silver-rich tetrahedrite occurs, together with more complex minerals of the fahlore group. Gold is substantially confined to quartz-carbonate veins in the Owen Formation, where it occurs in a hypogene assemblage of marcasite, pyrite, and quartz, which represents late stage deposition. Some gold, which is highly argentiferous, occurs partly in idiomorphic form and is considered to be hypogene; supergene gold is also present. An earlier report of native bismuth appears to be based on the misidentification of native lead.

Mineralization extended over a wide range of generally declining temperatures and changing fluid composition; precise reconstruction of physico-chemical conditions is difficult due to the effects of retrograde overprinting, and the lack of equilibrium data for the sulphide, carbonate, and silicate systems examined. A study of fluid inclusions provides some precise data on the hydrothermal system; evidence for the existence of a CO_2-saturated fluid during mineral deposition permits the use of filling temperatures without correction for sealing pressure. The measurement of both CO_2 content and salinity for one inclusion permits complete P-T-X evaluation of the local fluid system at the time of sealing: $XCO_2 = 15$ wt.%, XNaCl - 9.3 wt.%, T = 312°C, P = 790 b.

All data are combined in an interpretative model for the mineralization, in which a fluid is produced by intrusion-induced dewatering and dehydration of sediments, and the mobilization and transport of ore metals is promoted by decarbonation and desulphurization reactions. Structural control by the impermeable marble produces an up-dip, non-recirculatory fluid flow, resulting in intensified alteration and mineralization in the upper Owen Formation. (Author's abstract)

NEWTON, R.C. and HANSEN, E.C., 1983, Flow of fluids in granulite metamorphism: evidence from south Indian charnockites (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 653. Authors at Dept. Geophy. Sci., Univ. Chicago, Chicago, IL 60637.

Evidence for large-scale fluid migration during granulite metamorphism of South Indian gneisses includes 1) extensive metasomatism, especially the removal of H_2O, 2) coarse recrystallization and deformation concentrated in zones, 3) structural evidence of hydraulic guiding of fluids, 4) fluid samples preserved in healed microfractures of crystals, and 5) grain boundary microveinlets of chlorite and carbonate.

The approximate character of granulite-forming fluids can be deduced from the mineralogy. To form the charnockite assemblage orthopyroxene + K-feldspar, experimental petrology requires $X(H_2O)(max) \approx 0.25$ at 6-8 kbar and ~750°C. Dense CO_2-rich fluid inclusions in healed quartz and feldspar microfractures in transitional South Indian granulites occasionally show ~20 volume % H_2O, and CO_2 equation of state geobarometry gives pressures compatible with mineral geobarometry.

Outcrop patterns of arrested charnockitization show that shear and other deformation aided access of low-$P(H_2O)$ fluids. Thin charnockite seams coalesced to form extensive granulite regions. Concommitant deformation gave rise to banded gneisses. The highest grade regions in southern India are often pervasively sheared, with most fluid inclusions ruptured. Continuous CO_2 streaming may have dried and embrittled rocks in spite of rising temperatures, so that fewer fluids were trapped by crystal overgrowth at the highest grade conditions. Late weak hydrous retrogression commonly emplaced chlorite microveinlets.

For metamorphic time scales $>10^5$ yr, fluid fluxes required to dehydrate large portions of the crust are $\sim 10^{-10}$ m/s. Such fluxes require permeabilities no higher than normal for crystalline rocks. (Authors' abstract)

NICKELSEN, R.P., 1983, Ambient temperatures during the Alleghany orogeny, in Guidebook 48th Ann. Field Conf. Penn. Geol., Dept. Environ. Res., Bureau of Topographic & Geologic Survey, Harrisburg, PA, p. 64-66.

Fluid inclusions provide an opportunity to estimate the temperatures of emplacement and sample the compositions of precipitating fluids in veins of the region. The veins were emplaced during one or more stages of the Alleghany orogeny, thus making it feasible to estimate ambient temperatures during the orogeny. Recently techniques for estimating ambient pressures have been developed, using fluid inclusions filled with methane or mixtures of methane, carbon dioxide and other hydrocarbons.

The most consistent and complete fluid-inclusion information was collected by Bajak (1981, and unpublished manuscript) from fluorite in calcite-dolomite veins of three quarries in the Lower Devonian Keyser Limestone at the southwestern border of the Anthracite Region. Her Th measurements were from veins formed during structural stages II through V of the Alleghany Orogeny. No trend of changing Th was noted. The CAI conodont color index has been determined from all three quarries. Briefly, Th for 285 aqueous inclusions ranged from 67° to 109°C and Tm ice ranged between -23.8°C and -17.7°C. Assuming an overlying stratigraphic column 7.7 km and pressure correction ranging from 1.3 kb to 1.7 kb the temperature of filling (T_{ff})(sic) of these fluid inclusions were estimated to range from 192°C to 260°C. The CAI index for the three quarries was 3 to 4 suggesting temperatures of heating of 110 to 300°C, in fairly good agreement with the fluid-inclusion data. (From the author's text)

NIKOL'SKIY, N.S., 1981, Modeling equilibrium compositions of multicomponent fluid phases (as in the system H-O-C) and their importance in magmatic activity: Dokl. Akad. Nauk SSSR, v. 257, p. 983-988 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 257, p. 134-138, 1983).

NITZSCHE, H.-M. and STRAUCH, G., L983, Investigation of gas-fluid-inclusions in fluorite and quartz: ZfI-Mitteilungen (papers of the Central Inst. Isotope and Radiation Res. of the Acad. Sci. of the GDR), v. 76, p. 213-231 (in German). Authors at Central Inst. Isotope & Radiation Res., 7050 Leipzig, Permoserstrasse 15, GDR.

Fluid inclusions in samples of 10 fluorites and 6 quartzes from the tin deposit Ehrenfriedersdorf (Erzgebirge) were analyzed by isotopic ($\delta^{13}C$-values of CO_2) and by volumetric methods. The results were presented and discussed. (Abstract by R. Thomas)

NOBLE, S.R., SPOONER, E.T.C. and HARRIS, F.R., 1983, The Logtung W (scheelite)-Mo deposit, S. Yukon: an example of large tonnage, low grade, porphyry-style, stockwork and sheeted vein mineralization (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A51. First author at Dept. Geol., Univ. Toronto, Ontario M5S 1A1, Canada.

Logtung is a sub-economic W-Mo deposit (162 x 10^6 tonnes, 0.13% WO_3, 0.05% MoS_2) centered around a complex felsic dyke system on the north flank of the Cretaceous Logtung monzogranite stock. Host metasediments (mainly biotite-quartzite and diopside calc-silicate rocks) were subjected to three periods of contact metamorphism. A sporadic scheelite-bearing skarn (0 to 9 m thick) is present along parts of the stock contact but does not contribute greatly to total tungsten content of the deposit.

W-Mo mineralization is hosted in four superposed vein systems. (1) Early porphyry-type quartz-molybdoscheelite veins occur along the north and west flanks of the stock, comprising background W mineralization. These early veins are cut by (2) porphyry-type quartz-pyrite-scheelite veins, with prominent hornblende-epidote-pyrite selvages, which are proximal to and coeval with early felsic dykes. (3) Porphyry-type quartz-molybdenite veins largely post-date quartz-pyrite-scheelite veins, forming a discrete sytem within and surrounding the dykes. (4) Late polymetallic sheeted veins are locally important and occupy parallel faults and joints over a 3.5 x 1 km area centered on the felsic dykes. Sheeted veins adjacent to the dykes contribute significantly to overall W grades. Primary aqueous and carbonic fluid inclusions in the sheeted veins homogenized mainly between 180°C and 250°C, contain ~4.5 equivalent weight percent NaCl and minor $CaCl_2$.

W and Mo grades are controlled by the degree of vein system superposition. The superposed vein systems form an irregular dome- to tabular-shaped body, rather than discrete Climax-type stacked ore shells. (Authors' abstract)

NORDSTROM, D.K., 1983a, Preliminary data on the geochemical characteristics of groundwater at Stripa: Proc. of OECD/NEA workshop on Geological Disposal of Radioactive Waste, in situ Experiments in Granite, 25-27 Oct., 1982, Stockholm, Sweden, p. 143-153. Author at U.S. Geol. Survey, MS-21, 345 Middlefield Road, Menlo Park, CA 94025.

The deep granitic groundwaters at Stripa are characterized by decreasing alkalinity, increasing pH and increasing salinity (dominantly Na, Ca, Cl and SO_4) with depth. Futhermore, Ca/Mg, Br/Cl and Ca/Cl weight ratios are anomalously high, whereas Mg/Cl and Na/Ca are anomalously low compared to seawater. New evidence from fluid inclusion leaching of V1 and V2 drillcores suggests that the salinity may be derived from salts or brines contained in the Stripa granite and associated metamorphic rocks (leptite). This evidence imples that continued increases in salinity can be expected at greater depths, especially if the hydraulic conductivity remains low or decreases further. (Author's abstract)

NORDSTROM, D.K., 1983b, Chemical data, <u>in</u> Geochemical and isotope characterization of the Stripa groundwaters - Progress report: Stripa Project Rept. 83-01, p. 106-115.

See previous abstract. (E.R.)

NORMAN, D.I., 1983a Gases in epithermal Ag-Au ore fluids (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 654. Author at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Gases in fluid inclusions from ten Ag-Au epithermal deposits have been analyzed. The principal inclusion gases in all the deposits are $C_nH_nN_n$, H_2S, N_2, and CO_2. Gases are 0.5 to 10 wt.% of the inclusion fluids with gas contents >5% common from samples in which boiling was occurring during mineralization. Gold-rich ores have H_2S>1% and the amount of combined $C_nH_nN_n$ and H_2S in some ore fluids is >Cl content.

Nitrated hydrocarbons and N_2 are typical of oil field brines and imply interactions of the Ag-Au mineralizing fluids with sedimentary rock. Inclusion gases from two epithermal deposits in volcanic rocks, mineralized at ~300°C, with <u>no</u> Ag-Au or sulfides were analyzed and showed no organics or H_2S. This suggests that organic-rich, sedimentary rock is an important factor in Ag-Au mineralizing, epithermal systems.

The genetic role of organics and/or sedimentary rock in Ag-Au mineralizing fluids is not clear. Perhaps organic-rich sedimentary rock is the principal reductant in epithermal systems.

The data suggest Au transportation by bisulfide complexes and effervescence and condensation of $C_nH_nN_n$, H_2S, CO_2, and N_2 in "boiling zones." (Author's abstract)

NORMAN, D.I., 1983b Nitrogen and hydrocarbon gases in fluid inclusions as indicators that ore solutions had a sedimentary-water component (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A51. Author at Dept. Geosci., New Mexico Inst. Mining & Tech., Socorro, NM 87801, USA.

Gases in fluid inclusions, which were trapped during diagenesis of Permian evaporites, are CO_2 with high amounts of N_2 and organics of many atomic masses (C_nH_n) plus $\sim 10^{-3}$ M H_2S. The organics are most probably fragments of organic acids and the N_2 has, in part, a biologic origin.

Similar fluid inclusions gases, high in N_2 and C_nH, have been measured in minerals from the Hansonburg mine, NM (a Mississippi Valley-type deposit); Bunker Hill mine, Coeur d'Alene district, and the Bushman mine, Botsawana. The inclusion gases in these ore deposits indicate, by their similarity to the Permian evaporite inclusion gases, that the solutions which mineralized these deposits were primarily sedimentary formation waters. This conclusion is supported by inclusion fluids with >10% salinity and the lack, or at most poor, association of mineralization with magmatism.

Oil in inclusion fluids, and bitumen among ore minerals, has been used to indicate a sedimentary-water component in Mississippi Valley-type deposits. This study suggests that high N_2 and complex hydrocarbons in fluid inclusions waters can also be used to identify waters from sediments in past ore-depositing solutions. (Author's abstract)

NORMAN, D.I., BAZRAFSHAN, K. and EGGLESTON, T.L., 1983, Mineralizatin of the Luis Lopez epithermal manganese deposits in light of fluid inclusion and geologic studies: New Mexico Geol. Soc. 34th Annual Field Conf., Socorro Region II, Oct. 13-15, 1983, Guidebook-New Mexico Geol. Soc. 34, p. 247-251. Authors at Dept. Geosci., New Mexico Inst. Min. & Technol., Socorro, NM.

Six major occurrences of Mn mineralization in the area were studied by fluid inclusion methods and the paragenesis determined. Th values ranged from ~400 to ~100°C. (E.R.)

NORMAN, D.I. and LANDIS, G.P., 1983, Source of mineralizing components in hydrothermal ore fluids as evidenced by $^{87}Sr/^{86}Sr$ and stable isotope data from the Pasto Bueno deposit, Peru: Econ. Geol., v. 78, p. 451-465. First author at Geosci. Dept., New Mexico Inst. Mining & Tech., Socorro, NM 87801.

Strontium isotope systematics of fluid inclusion water, strontium-rich minerals, and rocks define probable sources of solutes in the mineralizing fluids for the well-studied Pasto Bueno deposit. The ore consists of wolframite, tetrahedrite, and base metal sulfides in quartz veins spatially associated with a 10-m.y.-old quartz monzonite stock which has an $^{87}Sr/^{86}Sr$ of between 0.7056 and 0.7074 and which has intruded a Jurassic shale and a Cretaceous quartzite that have $^{87}Sr/^{86}Sr = 0.7169$ and 0.7158, respectively. The $^{87}Sr/^{86}Sr$ of fluid inclusion waters in the host minerals quartz, wolframite, pyrite, and sphalerite, and of the minerals rhodochrosite and fluorite, range from 0.7058 to 0.7239 with $Rb/Sr \leqslant 0.027$. Previous geologic, fluid inclusion, and stable isotope studies clearly indicated the presence of magmatic and meteoric water during mineralization, and possibly a third, evolved water. The strontium isotope data indicate that the variation in $^{87}Sr/^{86}Sr$ of ore fluids is related to the mixing of source reservoirs; lower ratios compare with the host Tertiary intrusions and higher values relate to the Mesozoic country rocks or possibly to the Paleozoic-Precambrian basement. Systematic variations between Sr and stable iostopes preclude the likelihood of selective leaching of radiogenic strontium to produce the higher ratios. These variations do not correlate with the associated wall rocks of veins. The independent variables δD and $^{87}Sr/^{86}Sr$ clearly indicate the following: (1) that delineation of the three recognized waters involved in the mineralization process is possible; (2) that wolframite was deposited from magma-derived tungsten in solution when a large (30-50%) meteoric water influx caused precipitation by a concurrent drop in fluid temperature, a decrease in salinity, and an increase in pH and fO_2 of the fluid; (3) that sulfide mineralization was from mixed derivation ore fluids, even though a magmatic source of sulfur (and possibly base metal) is indicated; and (4) that fluorite exclusively is related to fluids deriving both water and solutes from the stock. (Authors' abstract)

NORRIS, J.R., 1981, Fracturing, alteration, and mineralization in Oxide pit, Silver Bell mine, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 72 pp.

The results of field measurement of density, orientation, and vein fillings for mesoscopic veins and veinlets and laboratory study of fluid inclusions are presented for the porphyry copper deposit in the Oxide pit of the Silver Bell mine.

Alteration is variably manifested depending on rock type and consists of pervasive, selectively pervasive, and vein-controlled assemblages. Fluid inclusion homogenization temperatures up to 460 and 416°C were observed for quartz-molybdenite and quartz-pyrite-sericite veins, respectively. Evidence of boiling in quartz-pyrite-sericite veins allows a pressure determination of 270 bars which, together with depth-of-burial estimates, suggests about 1.1 km of cover.

The fracture density of different vein types in the Oxide pit is variable both between and within rock units. Fracture density appears to increase from west to east in the pit. The Oxide pit is characterized by steeply-dipping fractures which changed successively in orientation as the hydrothermal system developed. Early veins display a suborthogonal fracture pattern with east-northeast to northeast and northwest to north-northwest orientations. Later veins exhibit orientations which progress from northeast to northwest strikes as one moves from east to west in the pit. (Author's abstract)

NORTON, J.J., 1983, Sequence of mineral assemblages in differentiated granitic pegmatites: Econ. Geol., v. 78, p. 854-874. Author at U.S. Geol. Survey, Box 25046, Mail Stop 930, Fed. Center, Denver, CO 80225.

The sequence of mineral assemblages from the outer to the inner parts of zoned pegmatites recognized by Cameron et al. in 1949 needs revision to incorporate later observations. The revised sequence presented here is (1) plagioclase, quartz, muscovite, (2) plagioclase, quartz, (3) quartz, perthite, plagioclase, (4) perthite, quartz, (5) quartz, plagioclase, perthite, spodumene (or petalite), amblygonite, (6) quartz, spodumene (or petalite), (7) quartz, microcline or perthite, (8) quartz, and (9) lepidolite or lithian mica, plagioclase, quartz, microcline. Assemblages 3 and 5 are subdivided to show vertical changes in perthite abundance. Petalite is added as an alternative to spodumene in assemblages 5 and 6 because it is now known to be a primary lithium mineral in some pegmatites. Assemblage 9 corresponds to two of the former assemblages that are essentially the same except in the lithium content of the mica. It has been shifted to the last position in the sequence, following the monomineralic quartz assemblage, because sizable concordant quartz bodies are in the outer parts of some pegmatites and all large lithian mica zones are in the centers.

The earlier sequence does not adequately fit the geology of the Bikita pegmatite, Zimbabwe, and the Tanco pegmatite, Manitoba, which are the two largest known highly differentiated pegmatites. The revised sequence has been tested on these pegmatites and several others of similar structure and lithology. The result was a rather good fit, but the test brought out a few aberrations. Monomineralic quartz units occur not only as cores but also as large concordant bodies in outer zones. The structural centers of pegmatites can have both quartz and lepidolite zones, and either one can be the core and the other an intermediate zone. Large pollucite bodies that have been called zones or replacement units are all in or adjacent to zones of assemblage 5; they seem best interpreted as merely concentrations of a single mineral within a zone.

Zoned pegmatites are interpretable as crystallizing from the contact inward from hydrous magma. As the relatively anhydrous crystalline phases were precipitated, aqueous fluid was continuously exsolved from the magma, and it participated in the crystallizing processes as it moved, mostly upward, into wall rock. Evolution in the composition and behavior of the aqueous phase seems to be a cause of much of the differentiation of pegmatites. By carrying alkalis into wall rocks, the aqueous phase led to the peraluminous composition of muscovite-rich outer zones. It carried K upward to cause a vertical increase in the abundance of K-feldspar in assemblages 3and 5. Assemblage 3, which constitutes a very large part of many pegmatites, is essentially granitic in bulk composition. The difference between it and assemblage 5, which also forms large units, is that Li has been concentrated in the magma until spodumene or petalite is precipitated.

In assemblages 4, 6, and 7, only two minerals are abundant, but they probably crystallized, from aqueous fluid as well as magma, at the same time as coexisting minerals in nearby zones. Monomineralic quartz units reflect an increase in the Si content of the aqueous fluid at low temperatures, and accumulations of aluminosilicates at the margins of some quartz cores imply a response to lowered solubility of these constituents. Lepidolite, though prominent at some of these core margins, is most abundant in cores rich in alkali aluminosilicates that probably crystallized largely from a magmalike residue of the pegmatitic magma. This too exsolved aqueous fluid, but its solute consisted largely of alkalis and aluminum that were deposited in the core and in replacement units cutting outer zones. Other reactions in solidified pegmatite were too localized to affect the sequence of major mineral assemblages. (Author's abstract)

NOVGORODOVA, M.I. and VLASOVA, Y.V., 1983, Water and CO_2 in gold-bearing quartz using infrared spectroscopy data: Trudy - Akad. Nauk SSSR, Miner. Muzey im A.E. Fersmana, v. 31, p. 90-97 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

NOWAKOWSKI, Antoni and KOZŁOWSKI, Andrzej, 1983, Genesis and crystallization conditions of albite in pegmatites of the Karkonosze and Strzegom granites: Archiwum Mineral., v. 39, part 1, p. 5-16 (in Polish; English abstract). Authors at Inst. Geochem., Min. and Petr., Warsaw Univ., Poland.

Albite varieties: white, bluish and colorless transparent (cleavelandite) from granite pegmatites in the Karkonosze and Strzegom massifs, are structurally ordered and their composition is almost pure albite An_0. On the basis of the rhombic section (RS) attitude it was found that white albite forms pseudomorphs after oligoclase O/D. That conclusion is confirmed by oligoclase relics preserved in white albite.

Pegmatitic paragenesis consisting of quartz, microcline and primary plagioclase (oligoclase) formed from pneumatolytic and next from hydrothermal solutions at 580-400°C; this conclusion was made on the basis of fluid inclusion studies in quartz. Probably under similar conditions the bluish albite crystallized, but rather close to the lower temperature limit. Cleavelandite, finishing albitization of oligoclase, probably formed at 330-130°C. Typical composition of solution for this temperature range is as follows, in wt.%: Na - 3.9, K - 1.2, Li - 0.1, Mg - 0.03, Ca - 0.5, Fe - 0.05, Al - 0.4, Cl - 8.8, HCO_3 - 1.0, F - 0.1, SO_4 - 0.01.

Solution concentrations varied from 13.0 to 25.5 wt.% NaCl equiv. (determined by the inclusion freezing method), and pressure may be evaluated in the ranges 50-80 MPa. (From the authors' abstract and summary)

NYDAM, M.A., RYE, D.M., SO, C.-S. and SHELTON, K.L., 1983, A petrologic and stable isotopic study of the Ulsan iron-tungsten mine, Republic of Korea (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 654. First author at Dept. Geol. & Geophy., Yale Univ., P.O. Box 6666, New Haven, CT 06511.

The Ulsan Fe-W mine is a chimney-shaped skarn deposit occurring in limestone along the contact between a Tertiary granite and Cretaceous sedimentary and volcanic rocks. Skarn occurs in the nose and along one limb of a doubly-plunging anticline 500 m from the granite contact. Skarn formation was localized by fluid flow along bedding-plane fractures in the host-rock limestone. Petrologic studies indicate two stages of skarn formation: 1) an initial stage characterized by the formation of salite, grandite, and magnetite; 2) a retrograde stage characterized by actinolite, chlorite, biotite, calcite, magnetite, quartz, sulfides, and scheelite. Scheelite is also associated with late-stage calcite veins cutting skarn, and forms a W-rich zone near the skarn/limestone contact. Fluid inclusion studies indicate a temperature range of 225 to 400°C for both stages of skarn formation at pressures less than 0.7 kb.

C and O isotope compositions of host-rock and late-stage vein calcite have the following ranges: $\delta^{13}C$, -9.9 to 3.7‰; $\delta^{18}O$, 8.5 to 21.9‰. A continuous trend of wall-rock and vein calcite data on a $\delta^{13}C$ versus $\delta^{18}O$ diagram suggest isotopic alteration of the calcites by a single fluid with increasing water:rock ratios. The petrologic and isotopic data suggest mineral zoning in the deposit was a result of spatial differences of the $X(CO_2)$ of the skarn-forming fluid: development of large salite- and grandite-rich skarn zones on the southern edge of the deposit reflect low $X(CO_2)$ values (.01-.03); absence of salite- and grandite-rich zones on the northern edge reflect higher $X(CO_2)$ values (.05-.1). The $\delta^{34}S$ values of sulfides in late-stage calcite veins range from -1.7 to 2.3‰ and indicate an igneous source of sulfur. (Authors' abstract)

OBERHEUSER, Gert, KATHREIN, Hendrik, DEMORTIER, Guy, GONSKA, Horst and FREUND, Friedemann, 1983: Carbon in olivine single crystals analyzed by the $^{12}C(d,p)^{13}C$ method and by photoelectron spectroscopy: Geochim. Cosmochim. Acta, v. 47, p. 1117-1129. First author at Mineral. Inst. and Lehrstuhl Theoretische Chemie, Univ., D 5000 Köln 41, FRG.

Carbon subsurface concentration profiles in olivine single crystals from San Carlos, Arizona, and the Sergebet Island, Red Sea, containing total carbon between 60-180 wt.-ppm, were analyzed by means of the $^{12}C(d,p)^{13}C$ nuclear reaction and by X-ray induced photoelectron spectroscopy (XPS) in combination with acid etching and with Ar^+ ion sputtering respectively, between 200-930 K. The (d,p) analysis reveals equilibrium subsurface C profiles extending 1-2 μm or more into the bulk. Their steepness is a function of temperature. Typical mean C concentrations at 300 K in the resolvable layers, 0-0.6, 0.6-1.2, and 1.2-1.8 μm, are 1.8, and 0.6 wt.%,(sic) corresponding to enrichment factors over the mean bulk C concentration of the order of 100, 40 and 30 respectively. In the topmost atomic layers analyzed by XPS the carbon is enriched by a factor of the order of 1000, decreasing with increasing temperature. The results suggest that the carbon is in a truly dissolved state and highly mobile, subject to a reversible subsurface segregation. (From the authors' abstract)

O'BRIENT, J.D., 1983, Silver stockwork mineralization and associated wall rock alteration at Creede, Colorado (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 655.

OGLOBLINA, A.I., RUDENKO, A.P., KULAKOVA, I.I., FLOROVSKAYA, V.N., RAMENSKAYA, M.Ye. and BOTKUNOV, A.I., 1983, Peculiarities of composition of polycyclic aromatic hydrocarbons in kimberlites: Doklady Akad. Nauk SSSR, v. 272, no. 4, p. 964-967 (in Russian). First author at State Univ., Moscow, USSR.

Hydrocarbons, extracted by n-hexane at room temperature from ground kimberlites of three Yakutian pipes, contained from 0.03 to 173.5×10^3 μg of polycyclic aromatic hydrocarbons per kg of rock. By luminescent spectral analysis, hydrocarbons of the following groups were determined quantitatively: napthalene, benzofluorene, phenantrene, chrysene, pyrene, 3,4-benzopyrene. (A.K.)

OHMOTO, Hiroshi and SKINNER, B.J., eds., 1983, The Kuroko and related volcanogenic massive sulfide deposits: Econ. Geol. Monograph 5.

Includes many papers of pertinence. These are abstracted in this issue. (E.R.)

OHMOTO, H., DRUMMOND, S.E., ELDRIDGE, C.S., PISUTHA-ARNOND, V. and BARTON, P.B., Jr., 1983, Chemical processes of formation of Kuroko-type deposits (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29 Sept. 3. 1983, Misasa, Japan, p. 373-375. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

In contrast to the most widely accepted depositional model for Kuroko-type deposits, our studies from ore textures using doubly-polished thin sections and from a reconstructed thermal history based on fluid inclusion and O isotope analyses, suggest that most massive sulfide ores accumulated on the seafloor during the waxing stage of hydrothermal activity largely through two processes: (1) interaction of hot (T - ~200°C to ~300°C) ore-forming fluids with cold seawater; and (2) interactions of increasingly hotter (T up to ~350°C) fluids with minerals that formed earlier in the deposits. The former process appears to have resulted in the precipitation of fine-grained (<10 μm) "primitive" ores composed largely of black ore assemblages, while the latter process metasomatically transformed the "primitive" ores to coarse-grained black ore, to chalcopyrite-rich yellow ore and finally to pyrite-rich ore. (From the authors' abstract)

OHMOTO, H., MIZUKAMI, M., ELDRIDGE, C.S., PISUTHA-ARNOND, V. and GREEN, G.R., 1983, Origin of fluids and hydrology in the Kuroko ore-forming systems (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 376-378. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

O and H isotopic compositions and the major element chemistry of the Kuroko ore-forming fluids were estimated from: (a) freezing T measurements of fluid inclusions; (b) analyses of inclusion fluids extracted in vacuo; and (c) analyses of gangue minerals in the ore. There exists a positive correlation between the temperature and the $\delta^{18}O$ values of fluids: ~-8 to ~0‰ for fluids of T = ~100° to ~200°C (i.e., very early and very late stages of an ore-forming activity) and +1 ± 2‰ for fluids of T = ~250° to ~350°C (i.e., main sulfide stage). This trend in $\delta^{18}O$, the ranges in the δD and major element concentrations in the fluids, the trends in the isotopic and chemical compositions of the footwall rocks with respect to the alteration zone and the observed paragenetic sequence of alteration minerals, all can be explained by a model of continuous interactions during the diagenetic through hydrothermal stages between pore fluids (seawater) and volcanic rocks within a thermally intensifying system. Neither magmatic nor meteoric water is needed. (From the authors' abstract)

ORKAN, N.I. and VOIGHT, Barry, 1983, Fracture geometry and vein mineral paleothermometry-barometry from fluid inclusions, Valley and Ridge province, Pennsylvania (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 656. Authors at Dept. Geosci., Pennsylvania State Univ., University Park, PA 16802.

Fractures in the central Pennsylvania Valley and Ridge cluster in several characteristic sets. Cross-strike extension fractures intersect regional fold axes at high angles, maintain systematic orientations over large areas of the Valley and Ridge and adjacent Allegheny Plateau, and commonly indicate pre-fold stress orientations. Superposed cross-strike fractures of differing trends are interpreted in terms of stress reorientations. Strike fractures, typically younger than cross-strike fractures, formed in the stress fields influencing folding.

Conditions of fracture fm. were inferred from fluid inclusions in fracture vein minerals. Inclusions typically show variable amounts of CH_4, rendering invalid their simple interpretation as H_2O-NaCl systems. CH_4-rich and H_2O-rich inclusion pairs in individual samples were used to estimate paleotemperature, T and fluid pressure, P. For example, at Bear Valley strip mine (Western Middle Coal Field), CH_4-rich inclusions (85 mole % CH_4, 15 mole % CO_2) were used to infer T, P of 205°C, 1150 bars. Taking lithostatic pressure as maximum limit to P implies a minimum overburden of 5 km and maximum paleogeothermal gradient of 37°C/km. In general, T progressively increased with stage of Alleghenian deformation. The Susquehanna River marks approximately the boundary of a T jump, with rocks to the east exhibiting significantly higher T values. (Authors' abstract)

ORLOV, A.M., ANIKINA, V.I. and BELASHCHENKO, D.K., 1983, Migration of molten inclusions of phases of the Ge-Ga system in single-crystal germanium: Izv. Akad. Nauk SSR Neorganicheskie Materialy, v. 19, no. 8, p. 1111-1113.

ORLOVA, G.P., RYABCHIKOV, I.D. and VOLCHENKOVA, V.A., 1983, Silver partition between granite melt and fluid: Geol. Rudn. Mestorozhd., v. 25, no. 3, p. 91-94 (in Russian). Authors at IGEM, Moscow, USSR.

The experiments were made at T 650-750 and 960°C, P 1.5×10^5 Pa, fluid consisted of H_2O, and solutions of NaCl + KCl (1 and 4 M, equal amounts of KCl and NaCl). (A.K.)

OSPANOV, Kh.K., 1983, The basis of solubility sequence of beryllium minerals: Zhurn. Neorg. Khimii, v. 28, no. 2, p. 324-328 (in Russian). Author at Kazakh State Univ., Alma Ata, USSR.

On the basis of Gibbs energy values the sequence of solubility is presented in the following group of minerals: danalite, genthelvite, helvite, bertrandite, euclase, bavenite, barylite, phenakite, beryl and chrysoberyl, in the solvents: aqueous solutions of HCl, Cl_2 and K_2F_2. May be helpful for dm identification. (A.K.)

OSTROVSKIY, I.A., 1983, Impossibility of temperature minimum on three-phase curve in the projection of binary system like silicate-water: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 7, p. 116-117 (in Russian). Author at IGEM, Moscow, USSR.

The author rejects the possibility of T minimum on three-phase curve of equilibrium silicate + vapor = melt. (A.K.)

OTT, L.E., 1983, Geology and ore localization at the Northumberland gold mine Nye Co., Nevada: M.S. thesis, Montana Coll. of Mineral Sci. and Tech., Butte, MT, 52 pp.

Indexed under Fluid Inclusions. (E.R.)

OTTO, J.W. and WYLLIE, P.J., 1983, The origin of carbonatites modelled in the system $CaO-MgO-SiO_2-CO_2-H_2O$ at 2 kbar (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 656. First author at Dept. Geophys. Sci., Univ. Chicago, 5734 S. Ellis Ave., Chicago, IL 60637.

Crystallization paths can be traced for the evolution of silicate melts to carbonatitic liquids. (From the authors' abstract)

OUDIN, E. and CONSTANTINOU, G., 1983, Hydrothermal chimneys in the East Pacific Rise and Cyprus (abst.): Terra Cognita, v. 3, p. 169-170. Authors at B.R.G.M., Dept. M.G.A., B.P. 6009, 45060 Orléans, France.

A comparison between the East-Pacific Rise present-day massive sulphide deposits and the fossil deposits associated with the Troodos ophiolite complex in Cyprus, is presented here. Chimney wall fragments have been identified in Cyprus ore. They exhibit similar texture, composition and zonations to those observed in some high-temperature inner chimney walls collected near 21°N on the East-Pacific Rise. These present-day chimneys build at the interface between the hot (up to 350°C) hydrothermal fluid discharging on the ocean floor and the cold (2°C seawater). The outer anhydrite wall present in the active chimneys (i.e., from which the hydrothermal fluids escape) in the East-Pacific Rise rapidly dissolves when the hydrothermal activity ceases down and is therefore not observed in Cyprus chimney wall fragments. These chimney wall fragments are partly oxidized, which seems to indicate that they have been submitted to submarine alteration prior to being cemented in a fine pyritic groundmass. The comparison between the present-day and fossil deposits is also based on the similarity of the mineral association. Fe-Cu-Zn sulphides are the predominant species although their relative abundance vary from one deposit to the other. Unstable phases such as pyrrhotite, chalcopyrrhotite ($CuFe_2S_3$, cubic), wurtzite and anhydrite are characteristic of present-day deposits as well as the presence of anomalous iron-rich and zinc-bearing chalcopyrite. Chalcopyrrhotite and anhydrite are absent in Cyprus ore. Chalcopyrrhotite is most probably completely replaced by chalcopyrite in Cyprus deposits. The presence of gypsum in the same deposits may be indicative of the anhydrite former existence. Pyrrhotite is very scarce in Cyprus, but wurtzite has been identified and is locally abundant. The reequilibration during geological times of the anomalous chalcopyrite not observed in Cyprus ore is discussed. The presence in both present-day and fossil deposits of rare minerals such as jordanite, valleriite and idaite observed in trace-quantities is considered to be very significant. (Authors' abstract)

OVCHINNIKOV, L.N., KOZLOV, Ye.D. and RAFAL'SKIY, R.P., 1982, The solubility of stibnite in chloride solutions at elevated temperatures: Geokhimiya, 1982, no. 9, p. 1290-1297 (in Russian; translated in Geochem. Int'l., v. 19, no. 5, p. 56-63, 1983).

OZIMA, Minoru and ZASHU, Shigeo, 1983, Primitive helium in diamonds: Science, v. 219, p. 1067-1068. Authors at Geophys. Inst., Univ. Tokyo, Tokyo 113, Japan.

Thirteen diamond stones from various unspecified mines in South Africa were analyzed for the isotopic ratio of helium-3 and helium-4. Values of the ratio ranged from less than 10^{-7} to $(3.2 \pm 0.25) \times 10^{-4}$. The latter value is higher than the primordial helium-3/helium-4 ratio in meteorites and close to the ratio for solar-type helium. Such extremely high values may represent primitive helium that evolved very little (that is, showed very little increase in radiogenic helium-4) since the formation of the earth. (Authors' abstract)

OZIMA, M. and ZASHU, S., 1983b, He, Ar isotopes and K-Ar ages of diamonds (abst.): Papers presented to the 8th Symp. on Antarctic Meteorites, Tokyo, 17-19 February 1983, Nat'l. Inst. Polar Research, Tokyo, p. 78.

See previous item.

OZIMA, M., ZASHU, S. and NITOH, O., 1983, $^3He/^4He$ ratio, noble gas abundance and K-Ar dating of diamonds--an attempt to search for the records of early terrestrial history: Geochim. Cosmochim. Acta, v. 47, p. 2217-2224.

PANICHI, C., CELATI, R., NOTO, P., SQUARCI, P., TAFFI L. and TONGIORGI, E., 1983, Oxygen and hydrogen isotope studies of the Larderello (Italy) geothermal system: Proc. of Symp., Isotope Techniques in Groundwater Hydrology, Vol. II, Int'l. Atomic Energy Agency, 11-15 March, 1974, Vienna, Italy, p. 3-28.

PANINA, L.I., 1983, Formation of melts high in potassium and alumina: Geol. i Geofiz., no. 4, p. 34-41 (in Russian; English abstract). Author at Inst. Geol. and Geophysics, Novosibirsk, USSR.

Chemical compositions of residual glasses in partially crystallized melt inclusions from pyroxenes of different alkaline (including leucite-bearing) basaltoids and gabbroids were studied by electron microprobe. It was shown that the glasses have compositions similar to the composition of natural potassium- and alumina-rich rocks found in the Synnyr and Sakun massifs. Both are characterized also by high contents of silica and sodium and very low contents of Mg, Ca and Fe. They differ from original leucite basaltoids in having a high K/Na ratio combined with high Fe/Mg ratio rather than in the Mg/Fe ratio alone. The conclusion is that appearance of potassium- and alumina-rich melts is caused by complete fractionation of the original alkaline basalt magmas under conditions comparable to closed systems. (Author's abstract)

PANINA, L.I., SHCHERBAKOVA, M.Ya. and ISTOMIN, V.Ye., 1983, Certain peculiarities of crystallization of ultrapotassic rocks of the Synnyr pluton (studies of electron paramagnetic resonance spectra): Geol. i Geofiz., no. 12, p. 112-116 (in Russian; English abstract). Authors at Inst. Geol. and Geophysics, Novosibirsk, USSR.

Early nepheline yielded Th of melt inclusions 1100-1000°C, late nepheline and K-spar <900°C. (A.K.)

PANKOV, V.Yu. and OLEYNIKOV, B.V., 1983, Native copper and zinc in products of early crystallization of magmas of the Great Fissure Tolbachik Eruption: Doklady Akad. Nauk SSSR, v. 270, no. 6, p. 1467-1470 (in Russian). Authors at Inst. Geol. of Yakutan Division of Acad. Sci., Yakutsk, USSR.

Melt inclusions in lapilli-crystals of plagioclase An_{78}-An_{54} - from Tolbachik (Kamchatka, USSR) bear pure Cu, sometimes in association with titanomagnetite (containing 6.47% Al_2O_3, 3.98% MgO, 1.45% Cr_2O_3), and native alloy Cu + Zn (61.2% and 39.0, respectively). Th of melt inclusions equals 1305-1120°C, being higher than T of melting of Cu (1083°C), Zn (419.5°C) and natural Zn + Cu alloy (902°C). Analyses performed by electron microprobe method. (A.K.)

PANNO, S.V., HARBOTTLE, Garman, SAYRE, E.V. and HOOD, W.C., 1983, Genetic implications of halide enrichment near a Mississippi Valley-type ore deposit: Econ. Geol., v. 78, p. 150-156. First author at Chem. Dept., Brookhaven Nat'l. Lab., Upton, NY.

Analysis of host dolomite adjacent to the Buick lead-zinc-copper deposit, Viburnum Trend, southeast Missouri, by instrumental neutron activation (INAA) and X-ray fluorescence (XRF) has revealed large and distinct primary wall-rock enrichments of bromine and chlorine, respectively. The halide enrichment extends up to 250 ft from the deposit and is found in close association with trace element enrichments. The presence of the Br and Cl enrichment zone is strong additional evidence that the ore-forming solutions of the Viburnum Trend were metal-rich NaCl brines.

The Br/Cl ratios of the dolomite samples also display an asymptotic decrease with distance from the deposit. Their ratios range from 0.0094 to 0.0080 for samples within the adjacent to the deposit and from 0.0035 to 0.0030 for samples over 750 ft from the deposit. The relatively high Br/Cl ratios near the deposit reflect those of the ore-forming solutions whereas the lower ratios farther from the deposit, which are close to that of normal seawater (0.0035), reflect those of the solution present during the formation of the host rock.

The Br/Cl ratios of the whole-rock samples from within and near the deposit and from the water soluble leachate from these rocks reveal that the ore-forming solutions were enriched in Br relative to seawater. These solutions were extremely saline (4.0 to 5.0 molal chloride, as determined by others) and had a calculated Br content ranging from 1,100 to 1,300 ppm. The elevated Br/Cl ratios of the rock samples and their soluble fractions indicate that the ore-forming solutions were initially formed from the evaporation of seawater past the point of halite precipitation. This implies that the ore-forming solutions of the Buick mine and Viburnum Trend deposits evolved from bitterns which formed contemporaneously with an evaporite sequence. These bitterns subsequently underwent mixing with less saline waters prior to or during ore mineralization. (Authors' abstract)

PANOV, B.S., 1982, New data on mineralogy of Donets Basin: Mineralog. Zhurnal., v. 4, no. 6, p. 54-62 (in Russian; English abstract). Author at Donets Polytechnical Inst., Ukraine.

Salt rocks in Donbass bear authigenic minerals: dawsonite, tunisite, galena, sphalerite, wurtzite, pyrite, molybdenite, scapolite, muscovite, albite, microcline, sphene, tourmaline, that formed at (Th) 450-50°C, P $6\cdot10^7$ - $3\cdot10^6$ Pa. (A.K.)

PARTSEVSKII, A.I. and SILENKO, T.M., 1983, Temperature conditions for the formation of tin ore mineralization of the Omsukchan and Iul'tin regions: Strukt. Mineral. Zon. Olovorudn. Mestorozhd. Sev.-Vostoka SSSR Vopr. Lokal'nogo Prognoza, p. 52-66 (in Russian).

The Sn deposits in the Iul'tin region belong to the cassiterite-quartz formation, whereas those in the Omsukchan region are classified in the cassiterite-silicate formation. The temp. of ore formation were estd. from Th of fluid inclusions in quartz and cassiterite. In the Iul'tin deposit multiphase inclusions give Th 340-355° in quartz and 420-460° in cassiterite, in lower horizons the resp. values of Th are 290-320 and 315-340°. For the Svetdoe deposit, Th is 290-320° and for other deposits 320-360°. The temp. range of formation of the quartz-tourmaline-cassiterite productive assocn. in deposits of the Omsuchan region was 315-550°. (C.A. 102: 28733q)

PASSCHIER, C.W., 1983, Fluid inclusions associated with the generation of pseudotachylyte and ultramylonite in the French Pyrenees (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 49. Author at Dept. Geol., Univ. College of Swansea, Swansea SA2 8PP, UK.

In the Saint Barthélemy Massif, French Pyrenees, narrow ultramylonite and pseudotachylyte bands were generated in a major low-angle ductile shear zone at the end of a retrogressive mylonitic event. The deformation is probably of Variscan age and affected Variscan and older gneiss and granodiorite. 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 1.7-3.4 kbar and 450-550°C as a response to hardening. 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., 1983a Adaptation of SGE-USGS heating-freezing stage for operation down to -196°C: Econ. Geol., v. 78, p. 164-169. Author at Dept. Earth & Planet. Sci. and McDonnell Center for the Space Sci., Washington Univ., Box 1169, St. Louis, MO 63130.

A modification of the earlier version is described permitting entry of LN_2 directly into the stage (more recent versions of this stage already have this capability). (E.R.)

PASTERIS, J.D., 1983b, Adaptation of SGE-USGS heating-freezing stage for operation down to -196°C - a reply: Econ. Geol., v. 78, p. 164-169. Author at Dept. Earth & Planet. Sci., Washington Univ., St. Louis, MO 63130.

A reply to Smith, 1983 (this issue). (E.R.)

PASTERIS, J.D., PATEL, R., BERGMAN, S.C. and ADAR, F., 1983, Comparative spectroscopy and microthermometry on fluid inclusions in a mantle xenolith (abst.): EOS, v. 64, p. 340. First author at Dept. Earth & Plan. Sci. and McDonnell Center for Space Sci., Washington Univ., Box 1169, St. Louis, MO 63130.

Abundant, CO_2-rich fluid inclusions in an olivine grain were analyzed by microthermometry (2 separate labs: Bergman, Pasteris), Fourier-transform infrared spectroscopy (FTIRS: Patel), and laser Raman spectroscopy (LRS: Adar). The olivine is from a harzburgite xenolith in a Late Cenozoic alkali basalt of the Lunar Crater Volcanic Field, Nevada (Bergman, 1982). The analytical goal of the present study is to estimate the sensitivity of the 3 techniques, whereas the petrologic goal is to identify the minor components in trapped, probable mantle fluids. Both sets of microthermometry data show melting temperatures near the triple point of pure CO_2, i.e. -56.6°C. Bergman and Pasteris recorded temperatures between -56.4 and -57.4°C. This suggests the presence of small amounts of another volatile with a triple point below that of CO_2, e.g. CO, CH_4, N_2. FTIRS on the same sample required simultaneous analysis of all inclusions within a cylindrical volume of 75 μm diameter through the entire grain. A strong absorption peak for CO_2 was detected at ~2340 cm^{-1} and a weak peak for CH_4 (C-H stretch) at ~2920 cm^{-1}. Quantification is difficult, but up to ~25 mole % CH_4 may be present. A laser Raman microprobe (Ramanor U-1000) analyzed several individual inclusions in the same region of the olivine, but reproducible Raman shifts were detected only for CO_2. CH_4 may not be distributed homogeneously among the inclusions. In addition, CH_4 partitions strongly into the vapor over the liquid in 2-phase inclusions. Further analysis is in progress, particularly on 1-phase inclusions and on the vapor in 2-phase inclusions. (Authors' abstract)

PATERSON, C.J., 1983, Controls on hydrothermal scheelite ore deposition in metamorphic belts (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A53. Author at Dept. Geol., South Dakota Sch. Mines & Technology, Rapid City, SD 57701.

In many metamorphic belts, tungsten, usually as scheelite, is found in minor amounts in association with gold in hydrothermal veins.

In Otago, New Zealand, gold-quartz lodes with minor scheelite occur in many districts which are randomly distributed through greenschist facies rocks, whereas scheelite-rich lodes are best developed at Glenorchy in psammitic rocks (with intercalated pelites) within the pumpellyite-actinolite facies but close to the boundary with greenschist facies rocks. The scheelite-quartz lodes formed at 280-350°C, about 80°C lower than the temperature of metamorphism of the host rocks. Oxygen isotope data have been interpreted as indicating an ore-forming fluid of metamorphic origin.

Hydrothermal alteration is limited to a zone 2 m wide with intense sericitization of albite, and chloritization of epidote and pumpellyite nearest the lode. The breakdown of actinolite and relict hornblende to chlorite-calcite-sphene assemblages represents marginal alteration, and was observed only in psammitic wall rocks. The pelitic schists were originally devoid of amphiboles. The altered wall rocks are depleted in Ca and Sr, but enriched in K, H_2O, CO_2, W, and As relative to background schist.

These data suggest that the hydrothermal fluid transported tungsten from deeper in the metamorphic pile. Interaction between this fluid and psammitic wall rocks of pumpellyite-actinolite facies grade resulted in breakdown of amphiboles, epidote, and pumpellyite, thus releasing calcium ions which combined with tungstate ions to form scheelite.

Wall-rock alteration was the dominant control on scheelite ore deposition, and this type of mineralization, if truly metamorphic in origin, should be found in suitable host rocks of low metamorphic grade elsewhere in the world. (Author's abstract)

PATIL, R.R., CHOUBEY, V.M. and SHARMA, K.K., 1983, Fluid inclusion studies on fluorite from Chumathang, Ladakh Himalaya: J. Geol. Soc. India, v. 24, p. 311-313. Authors at Wadia Inst. Himalayan Geol., Dehra Dun 248 001.

Study indicates low salinity and moderate density for the ore forming fluids responsible for the fluorite. Th (120°C to 150°C) in different colored fluorites indicate that the mineralization is of epithermal type. (Authors' abstract)

PAVLISHIN, V.I., MEL'NIKOV, V.S., KUL'CHETSKAYA, A.A. and GALIY, S.A., 1982, Ideas of Academician Ye.K. Lazarenko and their development in modern mineralogy: Mineralog. Zhurnal, v. 4, no. 6, p. 7-19 (in Russian; English abstract). Authors at Inst. Geochem. and Physics of Minerals of Acad. Sci. of Ukrainian SSR, Kiev.

The paper bears Lazarenko's opinions (positive) about various aspects of fluid inclusion studies. (A.K.)

PAVLOV, A.V., BOBOKHOV, A.S., PSHENICHNYUK, V.S. and KHAYRETDINOV, I.A., 1983, Genetic significance of inclusions in quartz phenocrysts of acid volcanites: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 6, p. 36-42 (in Russian). Authors at Inst. of Geol. of Bashkir Division of Acad. Sci., Ufa, USSR.

Quartz phenocrysts from acid volcanites of the S. Urals bears melt, crystal and gas-liquid inclusions. Results of X-ray emission microanalysis of surface of melt inclusions show that unaltered melt filling occurs only in P melt inclusions, completely isolated from metasomatic alteration by host mineral. Laser microspectral analysis of P inclusions of solidified melts proved that composition of such inclusions correlates sufficiently well with petrochemical properties of the studied volcanic rock complex. Thus, such data may be used for more detailed petrochemical characteristics of rocks altered allochemically. (Authors' conclusions, translated by A.K.)

PEACOR, D.R., KELLY, W.C. and BLAKE, D.F., 1983, Growth strain, optical anisotropy and fluid entrapment in fluorite (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 660. Authors at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

Natural, tectonically undeformed crystals of fluorite commonly display distinct patterns of optical anisotropy when viewed under crossed polars in moderately thick (1 mm) polished plates. Intensity of the birefringence is proportional to dislocation densities which can be related to areas of high local stress during initial crystal growth as, for example, in proximity to a foreign substrate or to foreign solid inclusions. These relationships are documented on varied scales of optical, scanning electron and transmission electron microscopy. High voltage electron microscopy confirms the high density of dislocations and other defects in the birefringent regions and their absence in isotropic regions. Electron beam-induced damage structures were produced in all fluorite examined due presumably to "vacancy ordering," but independent of optical anisotropy. Microscopic fracturing between domains of differential growth stress provided sites for entrapment of "pseudosecondary" fluid inclusions. In fluorites examined, "primary" fluid inclusions are confined to regions of high dislocation densities either because these were areas preferentially etched at times of fluid undersaturation in fluorite or were areas where imperfect growth favored nutrient fluid entrapment. The observed birefringence in fluorite can be helpful in analyzing the history of crystal growth and fluid entrapment in this mineral. (Authors' abstract)

PECHER, A. and BOULLIER, A.M., 1983, Re-equilibration of fluid inclusions under high confining pressure (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 50. First author at C.R.P.G., B.P. 20, F54501 - Vandoeuvre les Nancy, France.

Samples from a single synthetic quartz crystal, containing fluid inclusions, have been heated under high confining pressure (P_c = 200 MPa) in a gas appparatus. The nominal temperature was such that P_c was either higher or lower than the fluid pressure in the inclusion (T = 435°C, P_i-P_c = +75 MPa, or T = 350°C, P_i-P_c = -75 MPa).

Comparison of the homogenization temperatures Th of the fluid inclusions before and after the runs evidences strong density variations, together with drastic shape modifications. Two re-equilibration processes are observed and discussed: 1) rapid and nearly complete re-equilibration by brittle failure (sealing of the decrepitation cracks, sample A1, figure 1); and 2) progressive re-equilibration, Th appearing in first approximation a linear function of log of the duration (figure 2). (Authors' abstract)

Continued next page.

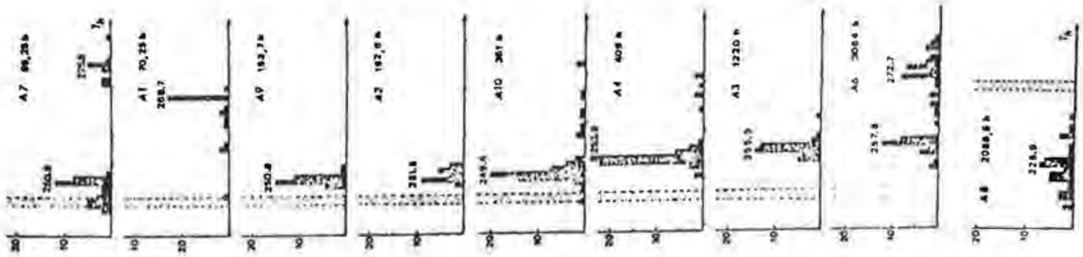


Figure 1 - Histograms of Th, classes of 1°C. Left side: $P_i<P_c$; right side: $P_i>P_c$; grey band: Th before experiments.

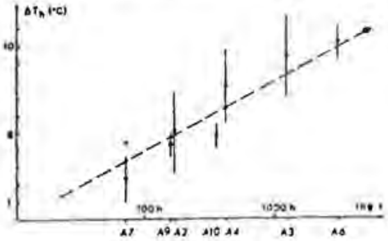


Figure 2 - Variation of Th with the duration of the experiments (for $P_i>P_c$); x-axis = logarithmic scale.

PERCHUK, L.L., 1983a Methods of thermometry and barometry in geology: Piroda (Moscow), 1983, no. 7, p. 88-97 (in Russian).

A review. (E.R.)

PERCHUK, L.L., 1983b Pressure dependence of liquidus temperatures of basalts in dry systems: Doklady Akad. Nauk SSSR, v. 271, no. 3, p. 702-705 (in Russian). Author at Inst. of Exper. Mineralogy, Chernogolovka near Moscow, USSR.

Experiments were performed under P 1 atm, ~5, 10, 20, 30 and 50 kbar; T of liquidi ranged from 1195 to 1415°C. (A.K.)

PERCHUK, L.L. and RYABCHIKOV, I.D., 1983, Experimental modeling of some hydrothermal reactions in kimberlitic magma at 12.5 kbar, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 258-279.

PERCIVAL, J.B. and KATSUBE, T.J., 1983, Scanning electron microscopy of microcavities in crystalline rocks and its application in the study of fluid and ion migration (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A54. First author at Atomic Energy of Canada Ltd., c/o Geol. Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A 0E8, Canada.

The concept of isolating the high level nuclear fuel waste effectively and permanently by its burial in deep and stable geologic formations is currently being assessed by the Canadian Nuclear Fuel Waste Management Program and by similar programs in other countries. Though the rock mass around the subsurface disposal vault will provide a natural barrier between the waste and the biosphere, the potential migration of radionuclides dissolved from the waste is the long time concern.

Radionuclide migration, via advection and diffusion, is controlled by the pore structure of the rock. Pore structure can be defined in terms of size, distribution, shape and interconnectivity of pores. These features, commonly on the micrometer scale, can be observed in thin sections with the aid of the scanning electron microscope.

Pores are equidimensional, irregularly-shaped cavities whereas cracks, providing connections between pores, are cavities whose length is at lest ten times the width. Pores may be isolated, or located along cracks or at their terminations. Cracks are classified in terms of location (inter-, intra-, or transgranular), integrity (healed, sealed, or open) and morphology (straight, anastomosing, or tortuous). Measurement of these pore structure parameters will eventually provide constraints for models of radionuclide migration through "unfractured" rocks. (Authors' abstract)

PERTHUISOT, Vincent and GUILHAUMOU, Nicole, 1983, The Triassic diapirs of the Vocontian domain: diapiric and hydrothermal phases in the perialpine domain: Bull. Soc. Géol. France, Ser. 7, vo. 25, no. 3, p. 397-410 (in French). First author at E.N.S. Lab. Géol., 46 rue d'Ulm, 75230 Paris Cedex 05, France.

Fluid inclusions found in certain new phases which have high CO_2 contents allow one to further define P-T conditions. These data indicate an especially high geothermal gradient which can be correlated with regional events. The analyses of the gases (CO_2, N_2) allows one to deduce the influx of gases at the moment of the crystallization of these new phases. (From the authors' abstract)

PETROVSKIY, V.A., SILAYEV, V.I., BOBROV, V.A., KUZNETSOV, V.P., FILIPPOV, V.N. and KUCHER, M.I., 1983, Indications of heterogeneity of mineral-forming fluids in the properties of calcite crystals, in Minerals and mineral complexes of the northeastern European USSR, M.V. Fishman and N.P. Yushkin, N.P., eds., p. 71-78 (in Russian).

Values for $\delta^{13}C$ are shown to differ in various zones of zoned calcite crystals and in the fluid inclusions. (E.R.)

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). Authors at Vakhrushev Mining Inst., Sverdlovsk, USSR.

Td given for associated quartz ranged from 160-620°C. (E.R.)

PHILLIPS, G.N. and GROVES, D.I., 1983, The nature of Archaean gold-bearing fluids as deduced from gold deposits of western Australia: J. Geol. Soc. Australia, v. 30, p. 25-39. Authors at Dept. Geol., The Univ. Western Australia, Nedlands, WA 6009.

Archaean gold deposits of Australia are most abundant in 2.8 ± 0.1 Ga granitoid-greenstone terrains, where they form both vein-type and disseminated occurrences. Two-thirds of total gold production has come from metamorphic (early, peak or late) vein deposits within host rocks of metabasaltic composition and of greenschist to lower amphibolite facies grade.

Wallrock alteration, isotopic readjustment and fluid inclusion data help to characterize the nature and importance of hydrothermal fluids in the generation of the vein-type deposits. Although fluid access is controlled by major structures and more locally by permeable zones (e.g., hydraulically-fractured country-rocks), gold deposition is a result of fluid-wallrock interacton within a suitable temperature range. Mineralizing temperatures at least as high as 400°C (e.g., Mt. Charlotte, Kalgoorlie) and slightly alkaline, reducing, H_2O-CO_2-rich fluids of low salinity, derived from lower in the sequence, are inferred. In this type of solution, gold transport is more likely as reduced sulphur complexes than as either gold bicarbonate or gold chloride complexes, based on both theoretical predictions and natural occurrences. Considering the associated nature of most species in the above temperature range, $HAu(HS)_2$ complexes are considered to be the most likely gold-transporting agent. Such transport can explain the strong enrichment of gold relative to copper, silver and zinc, and can account for high antimony, arsenic, tungsten, mercury and boron with gold, the variety of host rock chemical environments seen at different deposits, and the close spatial association of pyrite alteration and gold.

The important broad-scale controls of gold accumulation in Archaean terrains are still speculative. Greenstone belts are an integral part of any model and may provide sources of gold and hydrothermal fluids (H_2O-CO_2). They also provide suitable combinations of timing of structural and metamorphic events and suitable host rocks for ore deposition. Host rocks of tholeiitic composition are widespread and particularly favorable for gold deposition, whereas disseminated deposits in banded iron formation appear to be more common in older ($\geq$3.0 Ga) Archaean terrains. The less auriferous nature of some c. 3.5 Ga terrains (e.g., Pilbara) may reflect different early Archaean magmatism with lower total gold, a sequence of tectonometamorphic events unfavorable for major gold deposit formation, or early alteration (e.g., silicification) non-conducive to the later formation of suitable auriferous hydrothermal fluids. (Authors' abstract)

PHILPOTTS, A.R. and DOYLE, C.D., 1983, Effect of magma oxidation state on the extent of silicate liquid immiscibility in a tholeiitic basalt: Am. J. Sci., v. 283, p. 967-986.

PICHAVANT, Michel, 1983, Melt-fluid interaction deduced from studies of silicate-B_2O_3-H_2O systems at 1 kbar: Bull. Minéral., v. 106, p. 201-211. Author at Centre de Recherches Pétrograph. & Géochim., B.P. 20, 54501 Vandoeuvre-lès-Nancy, France.

Boron is an important additive component in the late stage of crystallization of high silica granitic melts. A theoretical discussion of the phase relations in the ternary model system silicate-B_2O_3-H_2O (silicate considered as a single component) is given. The phase relations of the system SiO_2-B_2O_3-H_2O are presented at P = 1 kbar; T = 500°C and compared to the phase relations for the system Qz-Ab-Or-B_2O_3-H_2O at the same pressure. The reduction of the solidus temperature of silicate-H_2O systems and the increase of the silicate solute content of the vapor phase when B is added are considered to be the most important and practical effects. The factors governing the coordination state of B (B^{III} and B^{IV}) in silicate melts are numerous: alkali and aluminium contents, temperature, pressure. There is conflicting evidence whether the boron groups are actually incorporated in the silicate network or occur as segregated units within the melt. (Author's abstract)

PIEKENBROCK, J.R., 1983, The structural and chemical evolution of phyllic alteration at North Silver Bell, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 95 pp.

The geology of the North Silver Bell, Pima County, Arizona, includes a Laramide quartz monzonite porphyry stock and associated dikes intruding a Cretaceous subvolcanic dacite porphyry sill. Alteration consists of an early potassic-propylitic event overprinted by later phyllic and alunite assemblages. Fluid inclusion homogenization temperatures associated with the late potassic to phyllic transition show a retrograde shift from 370°C-430°C to 330°C-390°C. Secondary thermal peaks of 270°C-290°C and 190°C-230°C may represent the late alunite assemblage or thermal gradients associated with mid-Tertiary volcanism. Spatial relationships recognized during mapping show a central core of potassic zone fracturing surrounded by a zone of unfractured, pervasively propylitized dacite porphyry. Peak intensity of phyllic-related fracturing lies outboard from this interface. Fracturing styles recognized between various alteration assemblages suggest early, intrusion-centered and derived potassically altered fractures surrounded by later, regionally influenced phyllic zone fractures. (Author's abstract)

PIGFORD, T.H., 1983, Reply to "Remarks on migration of brine inclusions in salt": Nuclear Tech., v. 63, p. 509-510. Author at Univ. California, Dept. Nuclear Engrg., Berkeley, CA 94720.

A response to criticism of Chou (1983; this volume). (E.R.)

PINEAU, F. and JAVOY, M., 1983, Carbon isotopes and concentrations in mid-oceanic ridge basalts: Earth & Planet. Sci. Letters, v. 62, p. 239-257. Authors at Lab. Geochim. Isot. - LA 196, Univ. Paris VII, 2, place Jussieu, 75251 Paris Cedex 05, France.

In order to estimate carbon fluxes at mid-ocean ridges and carbon isotopic compositions in the convective mantle, we have studied carbon concentrations and isotopic compositions in tholeiitic glasses from the FAMOUS zone (Mid-Atlantic Ridge at 36°N) and East Pacific Rise from 21°N (RITA zone) to 20°S. These samples correspond essentially to the whole spectrum of spreading rates (2-16 cm/yr).

They contain:

- CO_2 vesicles in various quantities (3-220 ppm C) with $\delta^{13}C$ between -4 and -9‰ relative to PDB, in the range of carbonatites and diamonds.
- carbonate carbon (3-100 ppm C) with $\delta^{13}C$ between -2.6 and -20.0‰ relative to PDB.
- dissolved carbon at a concentration of 170 ± 10 ppm under 250 bar pressure with $\delta^{13}C$ from -9 to -21‰ relative to PDB. This dissolved carbon, not contained in large CO_2 vesicles, corresponds to a variety of chemical forms among which [are] part of the above carbonates, microscopic CO_2 bubbles and graphite. The lightest portions of this dissolved carbon are extracted at low temperatures (400-600°C) whereas the CO_2 from the vesicles is extracted near fusion temperature. These features can be explained by outgassing processes in two steps from the source region of the magma: (1) equilibrium outgassing before the second percolation threshold, where micron size bubbles are continuously reequilibrated with the magma; (2) distillation after the second percolation threshold when larger bubbles travel faster than magma concentrations to the surface. The second step may begin at different depths apparently related to the spreading rate, shallower for fast-spreading ridges than for slow-spreading ridges.

In addition to those two steps, late outgassing may proceed after emplacement of the lava onto the seafloor down to the rigid temperature, due to the exothermic character of CO_2 outgassing. This late outgassing may eventually imply inward movements of CO_2 in pillows.

From this outgassing model, we calculate that initial tholeiitic liquids contain 0.2-1% carbon. (Authors' abstract)

PIRES, F.R.M., FREITAS, C.O., PALERMO, N. and SARCIA, M.N.G., 1983, Geology and genesis of topaz deposits from the Ouro Preto district, Minas Gerais (Brazil): Anais do II Simposio de Geologia de Minas Gerais, Belo Horizonte; S.B.R.-Nucleo Minas Gerais, Bol., no. 3, p. 283-296 (in Portuguese; English abstract).

The deposits of imperial topaz from the Ouro Preto district in Minas Gerais state occur in a stratigraphically controlled horizon with outstanding areal distribution. The topaz mineralization has been formed by hydrothermal activity after a short-lived, low temperature, pneumatolytic stage. Filling temperatures of fluid inclusions were in the 260°-280°C range. (Abridged from authors' abstract and text by K. Fuzikawa)

PISTSOV, Yu.P., KARELIN, S.P. and MURATOVA, I.I., 1983, Typical geological conditions of subsurface hydrothermal ore mineralization in East Transbaikalia: Geol. i Geofiz., no. 4, p. 51-57 (in Russian; English abstract). First author at Central Sci.-Research Geol.-Prospecting Inst., Moscow, USSR.

The paper bears some Th values for fluorite (40-240°C) quoted from the literature. (A.K.)

PISUTHA-ARNOND, Visut and OHMOTO, Hiroshi, 1983, Thermal history, and chemical and isotopic compositions of the ore-forming fluids responsible for the Kuroko massive sulfide deposits in the Hokuroku district of Japan: Econ. Geol. Monograph 5, p. 523-558. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Detailed petrographic and fluid inclusion studies of the stockwork siliceous ores from five major Kuroko deposits (Kosaka, Fukazawa, Furutobe, Shakanai, and Matsumine) have revealed an essentially identical sequence of mineralization and thermal history for each deposit: formation of the majority of black ore minerals (sphalerite, galena, pyrite, and minor barite and quartz) during intensifying stages of hydrothermal activity at T = ~200° to 330°C, followed by formation of the majority of yellow ore minerals (chalcopyrite and quartz) during a thermal maximum at T = 330° ± 50°C and minor sphalerite mineralization while the temperatures again decreased to 260° ± 50°C. Despite the change in temperature, salinities of the ore-forming fluids remained fairly constant at about 3.5 to 6 equivalent weight percent NaCl except for occasional values up to around 8 weight percent. Concentrations of elements in the ore-forming fluids, in moles/kg H_2O, as determined by the chemical analyses of fluids extracted from sulfides and quartz, were: Na = 0.60 ± 0.16, K = 0.08 ± 0.05, Ca = 0.06 ± 0.05, Mg = 0.013 ± 0.008, Cl = 0.82 ± 0.32, and C (as CO_2) = 0.20 ± 0.15; and less than 6 ppm each for Cu, Pb, Zn, and Fe.

The range of δD values of the Kuroko fluids, estimated from the analyses of fluids extracted from sulfides and quartz, is between -30 and +15 per mil, a range much larger than the range of -26 to -10 per mil reported by previous investigators. The range of $\delta^{18}O$ values of the Kuroko fluids (-6 to +4‰), estimated from the $\delta^{18}O$ analyses of quartz and the temperature data (this study) and from the $\delta^{18}O$ values of quartz and hematite in the tetsusekiei ores (Tsutsumi and Ohmoto, 1983), is also much larger than that suggested by previous investigators (0 ± 1‰). There is a distinct correlation between the $\delta^{18}O$ values and the temperatures of the Kuroko fluids: fluids of pre- and post-main-stage sulfide mineralization with temperatures less than about 200°C had much lower $\delta^{18}O$ values than those of the main sulfide mineralization at T > 250°C (-2 to +4‰).

Comparison of the isotopic and chemical compositions of the Kuroko fluids with those of pore fluids in the Deep Sea Drilling Project core samples and thermochemical consideration of the stability relationships among alteration minerals have led to a model of continuous interactions during the diagenetic through hydrothermal stages between pore fluids (seawater) and volcanic rocks within a thermally intensifying system. The model explains the following observed characteristics: (1) the ranges of δD, $\delta^{18}O$, and salinity values of the Kuroko fluids; (2) the high H_2O contents and $\delta^{18}O$ values of country rocks around the Kuroko deposits; (3) the correlation between the $\delta^{18}O$ values and fluid temperatures; (4) the concentrations of Na, K, Ca, Mg, and Cl in the fluids; (5) the spatial and temporal relationships among the alteration minerals (zeolite, montmorillonite, transition, and sericite + chlorite assemblages) around the Kuroko deposits; and (6) the Na, K, Ca, Mg, and Cl geochemical halos in the rocks around the Kuroko deposits. Some of the important processes that have caused alteration of the isotopic and chemical compositions of fluids and rocks are thought to be: formation of hydrous minerals (zeolites and smectites) in the country rock and cation exchange reactions between fluids and these minerals during diagenetic stages; formation of calcite in the country rock through reactions between fluids and organic matter during the diagenetic and low-temperature hydrothermal stages; dehydration reactions involving diagenetic minerals; and oxygen isotope exchange reactions between fluids and plagioclase, hydrogen isotope exchange reactions between fluids and smectite, dissolution of plagioclase, and cation exchange reactions between fluids and minerals during high-temperature hydrothermal stages. (Authors' abstract)

PITZER, K.S., 1983, Thermodynamics of electrolyte solutions over the entire miscibility range, in Chemical Engineering Thermodynamics, S.A. Newman, ed.: Ann Arbor, Ann Arbor Sci., p. 309-321.

PITZER, K.S., PEIPER, J.C., PHUTELA, R. and SIMONSON, J.M., 1983, Thermodynamics of high-temperature brines: Lawrence Berkeley Lab. Ann. Rept. 1982, LBL-15500, UC-13, p. 78-80.

A brief review. (E.R.)

PLUMLEE, G.S., HACKBARTH, C.J. and CAMPBELL, A.R., 1983, Applications of infra-red microscopy to ore deposit research (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 662. Authors at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

Mineralogists recognized as early as the 1930's that many "opaque" oxide and sulfide ore minerals are transparent to near-IR radiation. We examined a number of ore minerals in thin section using an IR microscope, and found the following to be transparent to IR wavelengths between .8 and 1.2 microns: molybdenite, tennantite, tetrahedrite, enargite, stibnite, bournonite, polybasite, pyrargyrite, cinnabar, sphalerite, wolframite and chromite.

We observed fluid inclusions in many of these minerals and measured inclusion homogenization temperatures in tennantite and tetrahedrite. The fluid inclusions appear essentially the same as inclusions commonly observed in minerals transparent to visible light. The IR microscope enables the observation of fluid inclusions in many ore minerals, rather than in associated gangue minerals or in the small number of ore minerals transparent to visible light.

Growth banding (seen as alternating light and dark bands) is visible in wolframite, enargite, and tennantite. Electron microprobe analyses indicate that banding in enargite correlates with As and Sb variations; the causes of banding in wolframite and tennantite are not apparent. The banding reveals aspects of crystal morphology not apparent in reflected light, and provides a means for correlating morphology with compositional zoning and fluid inclusion studies. (Authors' abstract)

PODOL'SKIY, A.M., RYABEVA, Ye.G. and five others, 1983a, Stannite and its genesis in tin ore deposits in the East of the USSR. Paper II. Composition and properties of stannite: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 1, p. 42-57 (in Russian). First author at VIMS, Moscow, USSR.

Isostannite from the Khetinskoe deposit crystallized after quartz paragenetic with chlorite; Th of P inclusions in quartz were 480-500°C, S inclusions - 220-240°C. (A.K.)

PODOL'SKIY, A.M., RYABEVA, Ye.G. and five others, 1983b, Isostannite from the Khetinskoe deposit: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 8, p. 64-67 (in Russian). First author at VIMS, Moscow, USSR.

See previous entry. (A.K.)

PODOL'SKIY, A.M., RYABYEVA, Ye.G. and DUBAKINA, L.S., 1982, New variety of pink stannine with composition Cu_3FeSnS_5: Akad. Nauk SSSR Doklady, v. 264, no. 1, p. 182-187 (in Russian). Authors at All-Union Sci.-Res. Inst. of Mineral Raw Material, Moscow, USSR.

Ores of quartz-cassiterite deposit Svetloe in Chukotka formed at 360-100°C, 700-150 bars; stannine-chalcopyrite-löllingite association began to crystallize at 270°C. (A.K.)

POKALOV, V.T. and RUMYANTSEV, V.N., 1983, Problem of genesis of hydrothermal plutonic deposits: Sovetskaya Geologiya, no. 7, p. 28-39 (in Russian). Authors at VIMS, Moscow, USSR.

The paper quotes Th values of several authors. (A.K.)

POKROVSKAYA, I.V. and KOVRIGO, O.A., 1983, Model of formation of polystage volcanogenic polymetal deposit of Rudnyi Altai, in Genetic models of endogeneous ore formations: "Nauka" Pub. House, Siberian Branch, v. 2, p. 112-121 (in Russian).

The Devonian ore mineralization of the Ridder-Sokol'noe deposit yielded the following Th of fluid inclusions: metasomatic pyrite-quartz ore 420-290°C (in quartz), copper sulfide-quartz veins 325-170°C (in quartz), quartz-sphalerite-chalcopyrite veins and nests - 260-185°C (in quartz and dolomite), polymetallic-barite veins - 305-195°C (in quartz) and 360-180 (in barite), galena-pyrite-dolomite-sphalerite (+ barite) lenses and stockwork - 180-110°C (in barite), galena-pyrite-sphalerite-dolomite layers and lenses - 130-70 (in barite), 110-90 (in carbonates), Ag-Au-barite-galena-sphalerite-quartz-barite veins - 180-130°C (in barite, quartz, sphalerite and albite), carbonate-quartz-sulfide veins - 180-130°C (in quartz). (Abstract by 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).

POLETAEV, A.I., KRASNIKOV, A.M. and five others, 1983, Regional position and geology of the copper-porphyry deposit Aktogay: Geol. Rudn. Mestorozhd., v. 25, no. 3, p. 3-16 (in Russian). Authors at Kazakh Sci.-Research Inst. of Mineral Raw Materials, Alma-Ata, Kazakhstan.

The deposit Aktogay is in the NE part of the Upper Paleozoic Balkhash-Iliy volcanic belt. Ore precipitation occurred at (Th) 490-100°C, but essential part of Cu-Mo ores formed at 328-225°C from Ca-K-HCO_3-Cl solutions. (A.K.)

POMÂRLEANU, Vasile and POMÂRLEANU, E.-A., 1983, Fluid inclusions and their significance in the thermobarogeochemistry and genesis of pegmatites in Romania: Anuarul Inst. de Geol. si Geofizica, v. 62, p. 143-149 (in English). First author at Inst. Geol. & Geophy., Lab. Geochem., Jassy.

A synthesis of studies of fluid inclusions in quartz, muscovite, plagioclase, apatite, spodumene, beryl, garnet and tourmaline of the main pegmatite areas in Romania, and data on the temperature, pressure and composition of the solutions from which these minerals have been formed. On the basis of these results and of field observations regarding structural relations between pegmatite bodies and host rocks we have come to the conclusion that the majority of concordant pegmatites have resulted by a tectonic-hydrothermal process. Th = 175-500°C; P of late quartz, using Kalyuzhnyi and Koltun procedure, 925-1500 bars; CO_2/H_2O (mole) 0.055-0.719; salinity ≤35-55 wt.%. (Modified from the authors' text by E.R.)

POREDA, R.J., 1983, Helium, neon, water, and carbon in volcanic rocks and gases: Ph.D. dissertation, Graduate Dept. Scripps Inst. of Oceanography, Univ. California, San Diego.

PORSHNEV, N.V., BONDAREV, V.B. and SAFONOVA, E.N., 1983, Organic compounds of aromatic series in vapor-gas eruptions of Nizhne-Koshelevskoe thermal field (Kamchatha): Doklady Akad. Nauk SSSR, v. 271, no. 4, p. 963-966 (in Russian). Authors at Inst. of Cosmic Studies, Moscow, USSR.

Twenty-one organic compounds were determined quantitatively in the vapor phase of the Nizhne-Koshelevskoe thermal field. (A.K.)

PORTER, E.W., 1983, Petrographic, geochemical and isotopic investigation of the Golden Sunlight deposit, Jefferson County, Montana: Ph.D. dissertation, Indiana Univ., Bloomington, IN, 180 p.

Indexed under Fluid Inclusions. (E.R.)

POSEY, H.H., STEIN, H.J., FULLAGAR, P.D. and KISH, S.A., 1983, Rb-Sr isotopic analyses of Upper Cambrian glauconites, southern Missouri: implications for movement of Mississippi Valley-type ore fluids in the Ozark region: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 166-173. First author at Dept. Geol., Univ. North Carolina, Chapel Hill, NC 27514.

Rubidium and strontium isotopic analyses of southern Missouri, Bonneterre Formation glauconites collected well outside areas of known economic sulfide mineralization yield model ages from 350 to 400 m.y. These ages are 20 to 30 percent younger than their enclosing Upper Cambrian strata and may represent loss of radiogenic strontium due to 1) diagenetic processes, 2) uplift of the Ozark region during Middle Ordovician time, 3) interaction with mineralizing fluids, or 4) a combination of the preceding three factors. Stratigraphic variation in model ages suggests incomplete homogenization of Sr isotopes with an external reservoir and/or less complete loss of radiogenic Sr within higher parts of the stratigraphic section. A minmum age of 350 m.y. (late Devonian to early Carboniferous) for the passage of any hot, mineralization-related fluid through the Bonneterre Formation in southern Missouri is suggested. Therefore, southeast Missouri mineralization is temporally unrelated to Tri-State mineralization (Kansas, Missouri, and Oklahoma) which is hosted in younger Mississippian to Pennsylvanian age rocks. (Authors' abstract)

POWELL, R., 1983a, Fluids and melting under upper amphibolite facies conditions: J. Geol. Soc. London, v. 140, p. 629-633.

Internal buffering paths on temperature-water activity diagrams for the pelitic model system:

$$NaAlO_2 - KAlO_2 - CaAl_2O_4 - Al_2SiO_5 - SiO_2 - H_2O$$

give rise to sequences of assemblages which correspond to those observed in upper amphibolite facies terranes. In particular, the persistence of the assemblage quartz-aklali feldspar-plagioclase-muscovite-sillimanite across a zone and the rapidly changing composition of plagioclase across this zone can be accounted for in a natural way. (Authors' abstract)

POWELL, R., 1983b, Processes in granulite-facies metamorphism, in M.P. Atherton and C.D. Gribble, eds., Migmatites, Melting and Metamorphism: Cheshire, U.K., Shiva Pub. Ltd., p. 127-139.

Granulite-facies rocks are characterized by relatively high temperatures (often also high pressures) and low $a(H_2O)$ of formation, by having relatively anhydrous low variance assemblages, and by showing various geochemical depletions in comparison to possible equivalent amphibolite-facies rocks. The contrasting effects of internal and external buffering which have been used profitably for understanding lower grade metamorphism are here applied to understanding granulite-facies metamorphism. Under internal buffering, the conclusion that partial melting occurs during the formation of granulite-facies rocks seems inescapable for many rock compositions. Internal buffering along dehydration reactions leads to relatively high a(H_2O) conditions and to intersection with the solidus at relatively low temperatures, even for fluid-absent rocks. With further increase of temperature, melting occurs in steps as each phase reacts out in favor of the liquid, internal buffering along melting reactions occurring which reduces a(H_2O). Low variance assemblages should be important in rocks produced by internal buffering in contrast to those in rocks produced by external buffering. The high proportion of assemblages in granulite-facies rocks which appear to buffer a(H_2O), particularly if a silicate liquid was once present, sugests that internal buffering was a dominant process during granulite-facies metamorphism. Consequently many granulite-facies rocks may be residues from parital melting. These ideas are illustrated using a simple model for metabasic rocks. (Author's abstract)

PRICE, L.C., WENGER, L.M., GING, Tom and BLOUNT, C.W., 1983, Solubility of crude oil in methane as a function of pressure and temperature: Org. Geochem., v. 4, no. 3/4, p. 201-221. First author at U.S. Geol. Survey, Denver Fed. Center, Denver, CO 80225, USA.

The solubility of a 44° API (0.806 sp. gr.) whole crude oil has been measured in methane with water present in temperatures of 50 to 250°C and pressures of 740 to 14,852 psi, as have the solubilities of two high molecular weight petroleum distillation fractions at temperatures of 50 to 250°C and pressures of 4482 to 25,266 psi. Both increases in pressure and temperature increase the solubility of crude oil and petroleum distillation fractions in methane, the effect of pressure being greater than that of temperature. Unexpectedly high solubility levels (0.5-1.5 grams of oil per liter of methane - at laboratory temperature and pressure) were measured at moderate conditions (50-200°C and 5076-14,504 psi). Similar results were found for the petroleum distillation fractions, one of which was the highest molecular weight material of petroleum (material boiling above 255°C at 6 microns pressure). Unexpectedly mild conditions (100°C and 15,200 psi; 200°C and 7513 psi) resulted in cosolubility of crude oil and methane. Under these conditions, samples of the gas-rich phase gave solubility values of 4 to 5 g/l, or greater.

Qualitative analyses of the crude-oil solute samples showed that at low pressure and temperature equilibration conditions, the solute condensate would be enriched in C_5-C_{15} range hydrocarbons and in saturated hydrocarbons in the C_{15+} fraction. With increases in temperature and especially pressure, these tendencies were reversed, and the solute condensate became identical to the starting crude oil.

The data of this study, compared to that of previous studies, shows that methane, with water present, has a much greater carrying capacity for crude oil than in dry systems. The presence of water also drastically lowers the temperature and pressure conditions required for cosolubility.

The data of this and/or previous studies demonstrate that the addition of carbon dioxide, ethane, propane, or butane to methane also has a strong positive effect on crude oil solubility, as does the presence of fine grained rocks.

The n-paraffin distributions (as well as the overall composition) of the solute condensates are controlled by the temperature and pressure of solution and exsolution, as well as by the composition of the original starting material. It appears quite possible that primary migration by gaseous solution could "strip" a source rock of crude-oil like components leaving behind a bitumen totally unlike the migrated crude oil. The data of this study demonstrate [that] previous criticisms of primary petroleum migration by gas solution (that primary migration by gaseous solution cannot occur because methane cannot dissolve sufficient volumes of crude oil or cannot dissolve the highest molecular weight components of petroleum (tars and asphaltenes)), are invalid. (Authors' abstract)

PRICE, P.E. and KYLE, J.R., 1983a, Metallic sulfide deposits in Gulf Coast salt dome cap rocks, in Transactions, Gulf Coast Assoc. Geol. Soc., v. 33, p. 189-193.

PRICE, P.E. and KYLE, J.R., 1983b, Origin of metallic sulfide deposits in Gulf Coast salt dome cap rocks (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 665.

PRICE, P.E., KYLE, J.R. and WESSEL, G.R., 1983, Salt dome related zinc-lead deposits: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 558-571.

PRIPACHKIN, V.A., 1983a, Flammable gases from deep levels of the Yukspor apatite-nepheline deposit (Khibiny): Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 1, p. 85-91 (in Russian). Author at Geol. Inst. of Kola Division of Acad. Sci., Apatity, USSR.

Gas content in rocks of the Yukspor deposit ranges from 0.1 to 1.2 m^3 per 1 m^3 of rock. Samples (over 1500) for studies were taken from the depth 40-510 m. Gases were released by grinding under vacuum in ball mills. The concentrations obtained (in cm^3 per kg of rock) varied in the following ranges: He $9x10^{-5}$-0.05, H_2 0.15-1.46, CH_4 0.03-32.70, C_2H_6 0.001-3.14, C_3H_6 $2x10^{-4}$-0.045, C_3H_8 $2x10^{-4}$-0.36, iso-C_4H_{10} $3x10^{-5}$-0.03, n-C_4H_{10} $6x10^{-5}$-0.07, αC_4H_8 $8x10^{-5}$-0.002, ΣC_4H_8 $8x10^{-4}$-0.003[sic.], iso-C_5H_{12} 0.003-0.007, n-C_5H_{12} 0.002-0.003, CO and CO_2 not found. The paper discusses also spatial distribution of gas concentrations in the deposit. (Abstract by A.K.)

PRIPACHKIN, V.A., 1983b, Gases in carbonatites of Khibiny alkaline massif: Doklady Akad. Nauk SSSR, v. 272, no. 2, p. 473-475 (in Russian). Author at Geol. Inst. of Acad. Sci., Apatity, USSR.

Gases from carbonatites accompanying nepheline syenite-ijolite-urtite Khibiny massif were released by milling of rock in vacuum ball mill and analyzed by gas chromatography. The following gas contents were found (in cm^3 per kg of rock) in varieties of carbonatites (c.): Khibiny - calcite c. He 6.4, H_2 2.2, CH_4 0.8, hydrocarbons C_2-C_5 0.012, CO 0.00008, CO_2 3.3; Mn-calcite c. He 0.03, H_2 1.7, CH_4 0.5, hydrocarbons C_2-C_5 0.020, CO 0.011, CO_2 10.9; oligonite c. He 0.009, H_2 7.6, CH_4 0.9, hydrocarbons C_2-C_5 0.0080, CO 0.00002, CO_2 6.0; siderite c. He 0.01, H_2 2.9, CH_4 0.2, hydrocarbons C_2-C_5 0.0005, CO 0.021, CO_2 4.6; Kovdor - calcite c. He 0.06, H_2 0.07, CH_4 0.3, hydrocarbons C_2-C_5 0.002, CO 0.0002, CO_2 0.03; calcite-dolomite c. He 0.02, H_2 0.09, CH_4 0.04, hydrocarbons C_2-C_5 0.00008, CO 0.002, CO_2 0.6; dolomite c. He 0.004, H_2 0.2, CH_4 0.04, hydrocarbons C_2-C_5 0.00009, CO 0.006, CO_2 0.6; Sebl'yavr massif - calcite c. He 0.004, H_2 0.7, CH_4 0.01, hydrocarbons C_2-C_5 0.0002, CO 0.0004, CO_2 0.00;

Ozernaya varaka - calcite c. He 0.08, H_2 0.2, CH_4 0.2, hydrocarbons C_2-C_5 0.0003, CO 0.04, CO_2 20.5; Lesnaya varaka - dolomite c. He 0.004, H_2 0.4, CH_4 1.0, hydrocarbons C_2-C_5 0.004, CO 0.0008, CO_2 4.5. (Abstract by A.K.)

PROKIN, VA.A., YAROSH, P.Ya. and NASEDKIN, A.P., 1983, Stages of formation and alteration of copper-pyrite deposits in the Urals: Dokl. Akad. Nauk SSSR, v. 269, no. 3, p. 687-690 (in Russian). First author at Inst. Geol. and Geochem. of Ural Sci. Center, Sverdlovsk, USSR.

Syngenetic layered ores in tuffites with framboidal pyrite yielded Th 130-150°C, epigenetic ores replacing wall rocks - 250-330°C. (A.K.)

PROKOFE'V, V.Yu., 1983, Thermobarogeochemistry and aspects of genesis of ores of the Maleev pyrite-polymetallic deposit (Rudnyi Altai): Deposited Doc., VINITI 6796-83, p. 36-41 (in Russian). Author at Geol. Fak., Mosk. Gos. Univ., Moscow, USSR.

The Maleev pyrite-polymetallic ore deposit in the Zyryanovsk field is localized in Givetian sandstones and mudstones and in Eifelian volcanogenic-sedimentary rocks. Four stages of ore mineralization in the stratiform orebodies are recognized: (1) tremolite-calcite, (2) pyrite-sericite-quartz, (3) polymetallic, and (4) quartz-calcite-sulfide stages. The 3 major ore-mineral parageneses are quartz-pyrite-sericite, polymetallic ores, and quartz-barite-calcite. Gas-liq. inclusions show Th 145-290, 120-250, and <60-145°, resp., for the 3 parageneses; the crystn. temp. in each case was 235-380°, 180-330°, and <60-225°. Pressure during ore localization was const. (900 atm). (C.A. 102: 9894b)

PROKOPTSEV, N.G., L982, Genetic significance of circular structures of ore formations in magmatic rocks (from results of studies of deep-sea lavas): Akad. Nauk SSSR Doklady, v. 265, no. 1, p. 154-157 (in Russian). Author at Southern Division of Inst. of Oceanology of Acad. Sci. USSR, Gelendzhik, USSR.

Variations of P, T and possibly volatile content cause the segregation of melt with formation of silicate and oxide immiscible melts; pertinent to immiscibility in melt inclusions. (A.K.)

PUCHKOV, Ye.V., 1983, Systematics of copper-porphyry deposits of Kazakhstan: Sovetskaya Geologiya, no. 12, p. 39-45 (in Russian). Author at Kazakh Inst. of Mineral Raw Materials, Alma-Ata, Kazakhstan.

At the Kazakh copper-porphyry deposits Th of inclusions in minerals of the commercial ore stages range from 300-350°C for the subsurface Sokurkoy subtype through 330-430°C for the deeper Kounrad subtype to 420-520°C for the deep Aktogay subtype. G/L inclusions, opened by decrepitation at T 100-500°C, bear the following portion of air argon in total argon content (in %, mean value in parentheses, ^{36}Ar determinations): Sokurkoy 87.0-96.0 (91.8), Kounrad 58.7-99.8 (85.7), Aktogay 32.6-100 (73.04). (Abstract by A.K.)

PUCHKOV, Ye.V., LAGUNOV, R.M., MATVETTS, M.A., SHCHERBOV, D.P., LISITSINA, D.N. and IVANKOVA, A.I., 1983, Role of organic matter in formation of the stratiform lead-zinc deposits: Doklady Akad. Nauk SSSR, v. 270, no. 6, p. 1438-1441 (in Russian). Authors at Kazakh Sci.-Reserach Inst. of Mineral Raw Materials, Alma-Ata, USSR.

The paper presents contents of various kinds of organic matter (bitumoids, phenols, organic acids and humic substances) in Zn-Pb ores and concentrations of Cu and Zn in organic matter. (A.K.)

PUCHKOV, Ye.V., ROD'KIN, B.P. and NAYDENOV, B.M., 1983, Lead-porphyry deposits of Kazakhstan: Doklady Akad. Nauk SSSR, v. 271, no. 6, p. 1451-1454 (in Russian). Authors at Kazakh Sci.-Research Inst. of Mineral Raw Materials, Alma-Ata, Kazakhstan.

Lead mineralization at the Alaygyr, connected with berezites, occurs in quartz, quartz-albite and quartz-barite-calcite veinlets formed at 260-400°C. (A.K.)

PUGIN, V.A. and KHITAROV, N.I., 1982, Geochemistry of various elements in liquation of basalt magmas: Geokhimiya, no. 1, p. 35-46 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 1, p. 35-45, 1983). Authors at Inst. Geochem. & Anal. Chem., Acad. Sci. USSR, Moscow, USSR.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 200. (E.R.)

PUSANOV, L.S., 1983, The genetic types of the Egitinski fluorite deposit: Geolgiya i Geofizika, v. 38, no. 4, p. 131-133 (in Russian; translated in Soviet Geology and Geophysics, v. 24, no. 4, p. 130-132). Author at All-Union Res. Inst. Explor. Geophys., Moscow, USSR.

The author takes exception to inclusion studies of this deposit by Popov (see Fluid Inclusion Research--Proceedings of COFFI, v. 14, 1981, p. 263), in that Popov only studied the concluding stage of fluorite deposition (Th 95-250°C), whereas Pusanov reports that some fluorite at the deposit is magmatic, with melt inclusions (now quartz, carbonate and fluorite[sic]) having Th = 780-850°C. These values are said to be comparable to those from other carbonatite and volcanogenic types of fluorite mineralization. (E.R.)

PUTNAM, B.R., III and NORMAN, D.I., 1983, Genetic model for the Hansonburg Mississippi Valley-type mineralization in New Mexico, based upon fluid-inclusion studies and paleotectonic interpretations: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 526-535. First author at Newmont Exploration Ltd., 44 Briar Ridge Road, Danbury, CT 06810.

The Hansonburg deposits are located on the eastern-most margin of the Rio Grande rift in New Mexico. Field observations of the mineralization indicate ore characteristics which relate to preexisting sedimentary structures within a reef-facies limestone. These bedding irregularities resulted from the deposition of the limestone on a topographic high created by differential uplift along the Capitan lineament. Premineralization development of karst solution-ways within these bedding irregularities created the open-space utilized by the mineralizing fluids.

A series of southeast-trending, high-angle reverse faults are predominant in the district, and cross-cut the east margin of the rift. The reversed displacements and orientation of these faults suggests they are resultant from a component of lateral shearing along the Capitan lineament during rift-opening tectonism.

The ore deposits consist of coarse-grained mineralization occurring primarily as cavity fillings. This open-space mineralization shows a generalized paragenesis of early galena followed closely by barite, fluorite, and quartz. A late barite completely fills some vugs. Numerous ambiguities in the paragenetic sequence were observed, particularly in areas adjacent to the southeast-trending, high-angle reverse faults.

Fluid inclusion homogenization temperatures indicate mineralization took place in the range 130-210°C, with the solutions cooling through the paragenesis. Mineralization from areas nearest to the southeast-trending high-angle faults exhibit the highest homogenization temperatures, suggesting that the faults served as conduits for the ore-forming solutions.

Analyses of the inclusion fluids yield data which are similar to other Mississippi Valley-type deposits, and to present-day formational waters. Measured CO_2 pressures together with the inclusion fluid analyses enabled detailed geochemical modelling of the ore-forming solutions during the mineralization event. Thermodynamic calculations based upon the analyses indicate that the solutions did not change drastically during the course of mineral deposition. The calculations predict both the mineralization and paragenetic sequence observed in the district. Solution-wall rock interaction did not seem to be important; rather, mineralization appears to have resulted from primarily a decrease in temperature (and pressure) of nearly saturated solutions. (Authors' abstract)

PUTNAM, B.R., III, NORMAN, D.I. and SMITH, R.W., 1983, Mississippi Valley-type lead-fluorite-barite deposits of the Hansonburg mining district: New Mexico Geol. Soc. 34th Annual Field Conf., Socorro Region II, Oct. 13-15, 1983, Guidebook-New Mexico Geol. Soc. 34, p. 253-259. First author at Newmont Explor. Ltd., 44 Briar Ridge Rd., Danbury, CT 06180.

The mineralization of the Hansonburg deposit was studied in detail in order to obtain sufficient data to form a coherent genetic model for a Mississippi Valley-type deposit. The study consisted of microthermometry and microanalysis of fluid inclusions from minerals in paragenetic sequence from several deposits in the Hansonburg district. Thermodynamic calculations based upon the analyses yielded pH, fO_2, and fS_2 of the mineralizing solutions. These, coupled with field observations, were used in modeling the genesis of the deposit. (From the authors' Introduction)

PUZANOV, L.S., 1983a Magmatic fluorite mineralization of the Central Aldan: Sovetskaya Geologiya, no. 2, p. 47-56 (in Russian).

Mesozoic intrusive activity of alkaline magmas in Central Aldan occurred from Triassic through Lower Cretaceous. Fluorite mineralization connected with these intrusions was found in more than 80 places in the region. Three genetic types of fluorite mineralization were distinguished: 1) magmatic, 2) hydrothermal-pneumatolytic and 3) hydrothermal. Alkaline hornblende of nepheline syenites from Ryabinovoe bears solidified droplets of fluorite[sic]. Accessory fluorite contains polyphase inclusions with up to 85 vol. % solids, 5-10% of L and ~10% of G, Th 650-850°C. Solidified droplets of melt ± G occur as individuals and as aggregates of few to several micrometers size, consisting of fluorite, carbonate, quartz glass [sic, A.K.] and quartz. Polyphase inclusions are especially numerous in the deposits Samodumovskoe and Bespardonnyĭ. Two groups of such inclusions were distinguished: the earlier ones bear G 5-15 vol. %, L up to 25 vol. % and solids 70-90 vol. %, Th 800-870°C; the later ones bear L and G CO_2 + H_2S 20-60 vol. %, solids (carbonate, halite, sylvite, ore minerals) 30-40 vol. %. L phase freezes at -68°C, Th 730-820°C. Fluorite contains also "melt-pneumatolytic" (G + solids) inclusions, Th 500 to >740°C. (Abstract by A.K.)

PUZANOV, L.S., 1983b Genetic type of the Egita fluorite deposit: Geol. i Geofiz., no. 4, p. 131-133 (in Russian; English abstract). Author at VIMS, Moscow, USSR.

The paper is a discussion of a paper by V.D. Popov (Fluid Inclusion Research--Proceedings of COFFI, 1981, v. 14, p. 263) concerning the genesis of the Egita fluorite deposit in W. Transbakalia. Popov's investigations yielding Th 135-250°C are evaluated as pertinent only to the final stage of the deposit origin. Summarizing his previous works (literature bears nine items by Puzanov alone), Puzanov distinguishes fluorite formed during the following stages (inclusion data in parentheses): magmatic stage (fluorite bears inclusions - solidified melt of quartz, carbonate and fluorite composition, trapped quartz and apatite crystals, crystals + 10 vol.% of G, melt + 5% of G, crystals + 40 to 80% of G, polyphase G + LH_2O + salts, representative Th 780-850°C); pneumatolytic stage (G or G + 5-10% LH_2O); hydrothermal stage (G + LH_2O ± dms, Th 100-350°C). (Abstract by A.K.)

PYATENKO, I.K., EGOROVA, N.F., ZIL'BERMAN, A.M. and CHERNYSHEVA, Ye.M., 1983, Possible role of immiscibility in genesis of the melanocratic members of the basalt series (on the example of Middle Urals complex): Doklady Akad. Nauk SSSR, v. 273, no. 2, p. 441-444 (in Russian). First author at Inst. Mineral., Geochem. and Crystallochem. of Rare Elements, Moscow, USSR.

The melanocratic rocks of the Middle Urals might form due to active degassing probably stimulating immiscibility in intermediate magmatic chambers. (A.K.)

PYTKOWICZ, R.M., ed., 1983, Equilibria, nonequilibria, and natural waters, Vol. I (351 pp.) and II (353 pp.): John Wiley & Sons, New York.

A thorough review of the fundamentals of the chemistry, geology, oceanography, and thermodynamics of waters, including kinetics, complexes, geochemistry of trace elements, and gas-water interactions. (E.R.)

QIAN, Yaqian and ZHUANG, Longchi, 1983, The application of metallic zinc to the determination of deuterium content in natural water and fluid inclusions: Bull. Yichang Inst. Geol. Mineral Resources Chinese Acad. Geol. Sci., Ser. 8, no. 7, p. 115-121 (in Chinese; English abstract).

In the determination with this method metallic zinc is used as a reductor and charcoal as an absorbent. The δD value of hydrogen collected from natural water and fluid inclusions was determined by a V.G. Micromass 602-D mass-spectrometer.

In the course of measurement a test was made on temperature and time needed for the reduction of water with metallic zinc and on the absorbability of hydrogen with charcoal.

The precision of this method is ±1% . It is consistent with the method of water reduction with metallic uranium.

This method is furnished with the following advantages:

1. Being able to avoid the radioactive pollution by uranium.
2. The quantity of a sample can be reduced for all hydrogen gas will be absorbed by charcoal.
3. Since the metallic zinc does not absorb hydrogen, the sample tubes with zinc and hydrogen can be attached directly to the mass-spectrometer for hydrogen isotope analysis. (Authors' abstract)

QUI, X.L., 1983, High density CO_2 fluid inclusions in peridotitic nodules in some alkali-basalts from the east of China (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 55. Author at ER 45 du CNRS Lab. de Pétrogr. et Volcanol., Univ. Paris Sud, Bat. 504, 91405 Orsay, France.

Fluid inclusions of highly compressed, generally liquified, pure CO_2 and nearly pure CO_2, usually with glass and daughter minerals (clinopyroxene), were found in the minerals (olivine, clinopyroxene, orthopyroxene) of lherzolite nodules associated with alkali-basalts from the east of China

(Luhe, Jiangsu and the north of Zhang jia-kou, Hebei). Large numbers of these inclusions are secondary in origin, trapped during the healing of fractures. But some of the inclusions appear to be "primary" (or "nearly"), that is, they occur as isolated inclusions or in random groups rather than on a fracture surface and are therefore most likely to contain fluids actually entrapped at the time of formation of the nodule.

Over 70 fluid inclusions were examined using a petrographic microscope with a CHAIXMECA heating and cooling stage (600°C to -180°C). The homogenization temperatures, melting temperatures and densities calculated for each inclusion as well as data on sizes, morphologies, modes of occurrence and number of phases present at room temperature are reported. The "primary" ("early") inclusions contain pure CO_2. Most secondary inclusions contain nearly pure CO_2 and, in some cases, a small amount of N_2. The CO_2 fluid densities range from 0.26 to 1.03 gm/cm^3 (secondary inclusions) and from 1.05 to 1.14 gm/cm^3 ("primary" or "nearly" inclusions).

The homogenization temperatures of the melt inclusions with CO_2, observed on a petrographic microscope equipped with a Leitz 1350 heating stage, were 1260°-1300°C. Assuming a temperature of entrapment of 1260°C, this implies confining pressures of more than 13 kilobars at the time of entrapment of the densest inclusions. The presence of glass in many of inclusions, whose composition obtained by microprobe analysis is approximately alkali-basalt, implies the coexistence at depth of CO_2, as the major volatile species, with a melt phase. (Author's abstract)

RAFAL'SKIY, R.P., 1982, The solubilities of zinc, lead, and silver sulfides in hydrothermal solutions: Geokhimiya, no. 12, p. 1780-1797 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 5, p. 152-169 1983).

RAFAL'SKIY, R.P., MEDVEDEVA, L.S., PRISYAGINA, N.I. and ALEKSEEV, V.A., 1983, Reaction of sulfur with water at elevated temperatures: Geokhimiya, no. 5, p. 665-676 (in Russian; English abstract). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

Sulfur-water reaction experimental studies at 150-300°C proved that reaction products are mainly H_2S and HSO_4, but at 350°C a significant amount of H_2SO_3 also forms. (A.K.)

RAI, C.S., SHARMA, S.K., MUENOW, D.W., MATSON, D.W. and BYERS, C.D., 1983, Temperature dependence of CO_2 solubility in high pressure quenched glasses of diopside composition: Geochimica Cosmo. Acta, v. 47, p. 953-958. First author at Amoco Production Co., Box 591, Tulsa, OK 74102.

The temperature dependence of carbon dioxide solubility in glasses of diopside composition, quenched from 20 kbar, has been investigated using a combination of high-temperature mass spectrometry and Raman spectroscopy.

CO_2-charged diopside glasses were synthesized in a piston-cylinder apparatus. Because of diffusion of hydrogen through the platinum capsules, significant amounts of H_2O, CH_4 and CO were detected along with CO_2 in the diopside glasses. All three carbon species show a bimodal release pattern in the mass pyrograms. The CO_2 solubility shows a linear and negative temperature dependence. We do not observe any maxima in the solubility curve as was reported previously (Mysen and Virgo, 1980a).

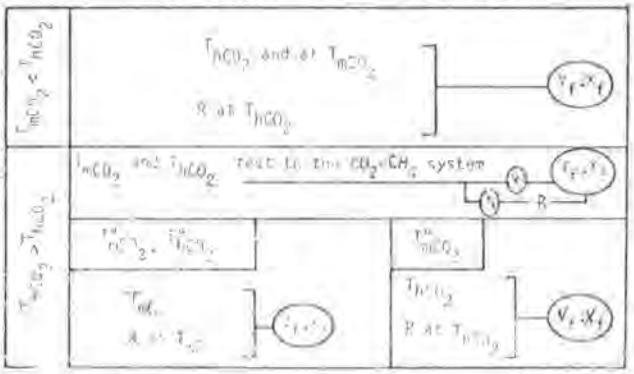
None of the additional bands observed in Raman spectra of CO_2-charged diopside glasses compared to those in the spectrum of diopside glass can be assigned to molecular CO_2. These bands are caused by CO_3^{2-} ions and indicate that the physical solubility of molecular carbon dioxide is negligible. The bimodal release pattern, observed for CO_2 in the mass pyrograms, is consistent with the Raman data which strongly suggests that

CO_3^{2-} ions are present in at least two distinct sites in the glass. (Authors' abstract)

RAMBOZ, C., 1983a Reconstitution from fluid inclusion studies of the bulk composition of fossil hydrothermal fluids in the C-O-H-N-S system (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 51. Author at C.R.P.G., B.P. 20, 54501 Vandoeuvre Cedex, France.

FI studies allow the analysis of intracrystalline fluids in the space of microthermometric variables. It provides the basis to identify geologically significant inclusion fluids, therefore to reconstitute PVTX conditions of fossil fluid circulation. Calculations of the bulk VX of volatile-rich aqueous inclusions from low temperature microthermometric data are based on the implicit assumption that the aqueous and the non-aqueous part of fluid inclusions behave as independent subsystems below room temperature. The formation on cooling of gas hydrate stable below and/or above T_{mI} totally or partly invalidates this assumption. A methodology is proposed to determine from microthermometric measurements the VX of the two parts of complex FI, although they chemically react together below room temperature. (1) An accurate determination of the salinity of separate complex inclusions would require an interpretative model for both T_{mI}-T_{mC}. Presently one can only estimate the average salt content of a population of complex inclusions by extrapolating their T_{mC} to a melting point interpretable in terms of salinity, i.e., referring to the lowering of the upper quadruple point with increasing NaCl content in the system H_2O-CO_2-NaCl. (2) Both microthermometric and Raman spectrometric data are necessary to interpret $T°_{mCO2}$ and/or $T°_{hCO2}$ in terms of VX of the non-aqueous part of complex FI (V_f, X_f below), provided that equations of state are available to interpret phase transitions in the system CO_2-CH_4-N_2-H_2S ... (Author's abstract)

INTERPRETATIVE SCHEME FOR THE VX OF THE NON-AQUEOUS PART



FI = fluid inclusion; T° (T) phase transition in the presence (in the absence) of clathrate; T_{mI} (T_{mC}; T_{mCO2}) = melting point of ice (of clathrate, of CO_2); T_{hCO2}: homogenization temperature of the non-aqueous part; R = Raman spectrometric analysis of the composition of the non-aqueous part; Y = yes; N = no.

RAMBOZ, Claire, 1983b Application of V-X projections to the quantitative interpretation of heterogeneous trapping from fluid inclusion study (abst.): Terra cognita, v. 3, p. 164. Author at CRPG (CNRS) B.P. 20, 54501 Vandoeuvre Cedex, France.

On a V-X plane, the bulk molar volume (V) and composition (X) of mechanical mixtures of two fluids at equilibrium at given P and T plot on a straight line defined by the bulk V and X of the two pure end-members. This property simply derives from the lever rule, visualized on T-X and P-X projections. This representation applies to the bulk V and X of inclusion fluids resulting from heterogeneous trapping of two immiscible fluids. It imposes a strong correlation on the variations of their Th with composition and, therefore, severely constrain the identification of heterogeneous trapping from fluid inclusion study. Besides, the vapor generated because of immiscibility is seldom observed in crystals and/or easily analyzed by microthermometry. It bulk V and X can still be calculated provided that the bulk V and X of the pure liquid and of one mixture are known from fluid inclusion study[sic] (Author's abstract)

RANKIN, A.H. and ALDERTON, D.H.M., 1983, Fluid inclusion petrography of SW England granites and its potential in mineral exploration: Mineral. Deposita, v. 18, p. 335-347. First author at Dept. Geol, Imperial College, London, England.

Fluid inclusions in granite quartz from SW England provide a record of the complex and protracted hydrothermal history of this important metallogenic province. Regional variations in terms of the different types of inclusions can be correlated on an inter-pluton scale with both the texture of the host granite and the extent to which it is mineralized. On an intra-granite scale those areas where mineralization is particularly pronounced show a higher overall inclusion abundnce than areas where little or no mineralization is known to occur. The types of fluid inclusion most commonly related to Sn-W-Cu mineralization are halite-free, moderate temperature inclusions. Inclusions containing visible CO_2 at room temperature are restricted to two localities in SW England. Both of these contain stockwork/vein-swarm tungsten mineralization. These regional 'fluid inclusion anomalies' show that fluid inclusion petrography using a simple petrographic microscope has potential application in the field of mineral exploration. (Authors' abstract)

RANKIN, A.H., HART, D. and JONES, E., 1983, Variations in fluid geochemistry related to granite-hosted tin mineralization at Mt. Misery, Australia: (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 2. Authors at Dept. of Geol., Imperial College, London, England.

The Mt. Misery Sn-prospect of N. Queensland is dominated by a N-S ridge comprising a Sn-mineralized, albitized zone in granite up to 15 m wide. As part of a general study of fluid inclusion compositions from mineralized granites of Eastern Australia (with the support and collaboration of Dr. J. Angus, Goldfields Exploration Pty.), fluid inclusions in quartz from the mineralized zone and in granite up to 1 km away from the zone were analyzed using the ICP-decrepitation technique. The Na:K atomic ratio varied from about 0.1 increasing to 0.3 within a few tens of meters of the strongest mineralization. The Fe:Na and Ca:Na ratios, though lower than might be expected, show more marked variations decreasing gradually over a few hundred meters distance out into the mineralized granite. The cause of these variations is discussed in the light of the steam aureole concept first formulated by Yermakov (1966). (Authors' abstract)

RATKIN, V.V. and MALAKHOV, V.V., 1983, Stages and type of connection with volcanism in hydrothermal-sedimentary ore genesis: Geol. Rudn. Mestorozhd., v. 25, no. 4, p. 102-107 (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. of the USSR, Vladivostok.

Minerals from the skarn-polymetal deposits of the Dal'negorsk group (Primor'ye, USSR) yielded the following salt and gas composition in fluid inclusions (in g-equiv. per 1 kg of H_2O): hedenbergite, pre-ore stage (Th = 350°C) Na 0.33, K 0.04, NH_4 0.15, Mg 0.01, Ca not found, Fe not found, F 0.004, Cl 0.13, HCO_3 0.10, total S 0.15, N_2 0.17, CH_4 0.01, CO 0.08, CO_2 1.61, H_2S not found; galena, ore stage (?Td = 220°C) Na 15.75, K 0.82, NH_4 5.91, Mg 1.78, Ca 1.72, Fe 0.06, F 1.27, Cl 9.52, HCO_3 11.25, total S 3.64, N_2 1.88, CH_4 not found, CO 0.56, CO_2 2.24, H_2S 0.05. (A.K.)

RAUSCHKOLB, M.H., 1983, The geology of the Northwest orebody, Twin Buttes mine, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 179 pp.

The Northwest orebody, located in Pima County, Arizona, is a large tonnage skarn containing copper, silver, and molybdenum mineralization. The orebody is separated from the main orebodies of the Twin Buttes mine by the Twin Buttes fault. Sulfide mineralization and silicate alteration are systematically zoned along a westerly trend away from the fault and from a central intrusive complex.

Original host rock chemistry was the major control on the silicate and sulfide mineralogy of the skarns. The highest grade ore occurs in a garnet-diopside alteration zone within beds of altered limestone and dolomite. Lower grade ores formed in calc-silicate siltstones, quartzites and granitic rocks. The skarns exhibit a complex history of sequential veining and replacement. The alteration can be subdivided into an early thermal event, followed by three stages of hydrothermal alteration. The first stage of hydrothermal alteration is characterized by the formation of anhydrous Ca-Mg-Fe-Al silicates, predominantly garnet and diopside. Stage II is a period of sulfide mineralization. The copper sulfides were deposited when copper in the hydrothermal solutions reacted with Fe^{+++}-rich garnet to form chalcopyrite. Mineralization continued during Stage III as increasingly pyritic sulfide mineralization was deposited with hydrous silicate minerals, predominantly epidote and actinolite.

Several points of evidence show that the mineralization in the Northwest orebody is related to the intrusive activity at the center of the Twin Buttes mine area and not to either the pre-mineral Ruby Star Granodiorite or to a buried intrusive at depth. (Author's abstract)

RAYNOLDS, M.V., 1983, Geochemistry of fluids in the Cerro Colorado porphyry copper deposit, Panama: Ph.D. dissertation, Harvard Univ., Cambridge, MA.

The Cerro Colorado porphyry copper deposit in western Panama is one of the youngest (5.9 Ma) porphyry copper deposits known. Hypogene mineralization consists of pyrite, chalcopyrite, minor bornite and molybdenite. Sulfide ore occurs in the altered Rio Escopeta granodiorite as well as the older (17 Ma) andesitic country rocks into which the granodiorite was intruded.

The temporal and spatial changes in the chemical and physical characteristics of hydrothermal fluids associated with alteration and mineralization are reflected in changes in vein mineralogy and fluid inclusion type. The purpose of this study is to examine such changes and to correlate changes with episodes of alteration and sulfide mineralization. The chronological sequence of vein formation as determined by this study is: barren quartz (A veins); quartz + sulfide (B veins); quartz + sericite (C veins); quartz + sericite + sulfide (D veins); massive sulfide (E veins); late stage gypsum and/or carbonate (secondary veins). Fluid inclusions in vein quartz and quartz phenocrysts fall into three broad categories: 1. high salinity, high K/Na (HSA, HS, HSU, HSC, HSP inclusions); 2. high salinity, low K/Na (H, HC, HP inclusions); 3. low salinity, low K/Na (L and V inclusions). The high K/Na fluids appear to be early, as they are found only in quartz phenocrysts. The high salinity low K/Na fluids were associated with vein formation, as they are found in vein quartz as well as in fracture planes in quartz phenocrysts. The low salinity fluids, which commonly show evidence of boiling, appear to be mostly secondary inclusions in phenocrysts and vein quartz.

Th in all inclusion types range from about 250° to 450°C. Hydrogen isotope equilibration temperatures for fluid inclusion water-sericite pairs range from 400° to 600°C. A large pressure correction of Th is therefore necessary.

Estimates of inclusion trapping depth through use of salinity and boiling temperature of L and V inclusions, a method developed by Haas (1971), suggest the Rio Escopeta granodiorite intruded within about 5km of the surface.

Filling pressures range from close to hydrostatic (about 300 bars at 5km) for inclusions which homogenize by vapor bubble disappearance to lithostatic (1300 bars at 5km) for inclusions which homogenize by halite dissolution. Fluctuations in pressure from lithostatic to hydrostatic are associated with vein formation and mineralization. (Author's abstract)

RAZ, Urs, 1983, Thermal and volumetric measurements on quartz and other substances at pressures up to 6 kbars and temperatures up to 700°C: Ph.D. dissertation, Swiss Fed. Inst. Technology Zurich, Zurich, Switzerland, 91 pp.

Thermal and volumetric properties of several solid and liquid phases were measured simultaneously at hydrostatic pressure up to 6 kbar and temperatures up to 700°C. A computer-controlled high-pressure thermal analysis (TA) was developed to study the phase relations of low/high quartz, low/middle/high tridymite, dry melting of AgCl and the melting of three ice polymorphs (ice I, III, V). Another method, called pressure analysis (PA), was used to determine the volume change of first order reactions as function of pressure. This method was applied to the the low/high quartz transition, the melting of AgCl and the melting of ice I. A new high pressure dilatometer was tested and applied to study the pressure-volume-temperature relationships of minerals. The change in length was measured as a function of temperature and pressure for quartz, magnetite, β-brass and a natural garnet. The transition of low/high quartz is considered as a first order phase change with a pressure independent latent heat of 354 ± 33 J and a ΔV of 0.11 ± 0.01 cm^3. The reaction hysteresis is 1.5°C and 50 bars and the slope of the transition line (dT/dP) is 26.6 ± 0.3 K/kbar. The PVT-data of quartz were expressed as an equation of state $V = V(P,T)$ and the Pippard-relations were applied as a useful test. The relation between structure, soft mode frequency and volume properties was shown by an order parameter within the theory of Landau. Heat capacities (Cp and Cv) were calculated by a combined Debyke-Einstein model, using spectroscopic data and the experimental equation of state. Related thermal properties, the change in the entropy S, enthalpy H and Gibbs free energy G of quartz, were calculated and compared with experimental data. A Grueneisen-parameter and the pressure dependence of Cp were calculated by use of the equation of state. (Author's abstract)

REED, M.H., 1982, Calculation of multicomponent chemical equilibria and reaction processes in systems involving minerals, gases and an aqueous phase: Geochimica Cosmo. Acta, v. 46, p. 513-528. Author at Dept. Geol., Univ. Oregon, Eugene, OR 97403, USA.

The compositional characteristics of many geochemical systems which involve the interaction of natural aqueous solutions with minerals and gases are conveniently described using the following thermodynamic components: Cl^-, $SO_4^=$, HS^-, $CO_3^=$, H^+, Na^+, K^+, Ca^{++}, Mg^{++}, Fe^{++}, Zn^{++}, Cu^+, Al^{+++}, SiO_2 and H_2O. A set of mass balance and mass action equations equal in number to the number of components plus the number of saturated minerals (and gases) is defined for a specified temperature, pressure and bulk composition. The mass balance equations include terms for minerals, gases and the molalities of aqueous complexes and dissociated species. This set of non-linear equations can be solved with the aid of a computer using a Newton-Raphson technique. The calculation takes account of aqueous ion complexing, oxidation-reduction equlibria, activity coefficients, non-unit water activity and solid solutions. The use of H^+, $SO_4^=$, HS^- and H_2O as components allows straightforward treatment of processes involving oxidation-reduction, evaporation, boiling and changes of total aqueous H^+ due to hydrolysis, mineral reaction or temperature change. One product of this approach is a technique for calculating pH at high temperature from measurement of pH at room temperature.

By linking a series of discrete overall heterogeneous equlibrium calculations in which incremental changes of bulk composition, temperature or pressure are made, dynamic geochemical processes can be modeled. Example calculations for two such processes are given. These are the heating of seawater from 25° to 300°C and the isothermal irreversible reaction of rhyolite with an aqueous solution at 250°C. (Author's abstract)

REED, M.H., 1983, Seawater-basalt reaction and the origin of greenstones and related ore deposits: Econ. Gol., v. 78, p. 466-485. Author at Dept. Geol., Univ. Oregon, Eugene, OR 97403.

Massive sulfide deposits of copper, zinc, and iron and associated stringer deposits are consistently located on or above mafic volcanic rocks which accumulated in a marine environment and are altered at least to greenschist metamorphic grade. One possible source of the hydrothermal solutions that produced such mineralization is seawater modified and enriched in metals by reaction with basalt. This hypothesis is tested by multicomponent equilibrium calculations of the reaction of seawater with tholeiitic basalt at 300°C, followed by calculation of the effects of cooling the resultant solution to 25°C and mixing it with seawater.

The calculations show that it is possible that seawater-basalt reaction followed by cooling and seawater mixing of the resultant solutions can lead to ore deposition. (From the author's abstract)

REINTHAL, C.A.A., 1983, A stable isotope, petrographic, and fluid inclusion investigation of the Pioche mining district, Nevada: M.S. thesis, Univ. Wisconsin, Madison, WI, 166 pp.

REX, R.W., 1983a The Imperial Valley California, origin of the brines of (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 670. Author at Republic Geothermal, Inc., 11823 E. Slauson Ave., Santa Fe Springs, CA 90670.

The Imperial Valley appears to contain six types of subsurface brines. Type VI is the unmetamorphosed underflow of brackish water entering the valley from the Gila and Colorado River drainage systems. Type V is local precipitation runoff originating from marine air precipitation, concentrated by evaporation, and enriched with sodium leached out of weathered rocks and bicarbonate from atmospheric carbon dioxide. Type IV brine is fossil lake water from past equivalents to Lake Cahuilla where the flow of Colorado River flooded the delta creating a lake that drained to the Gulf. Cerro Prieto appears to be a mixture of Type IV and V waters. The Heber and East Mesa fields appear to be mainly Type IV waters. Type III waters are hypersaline brines significantly modified by blending with Type IV waters. Type II brines are also mixed brines probably of III and I types. Type II brines however, have had time to equilibrate against their host rocks and show strong chemical coherence with striking covariance of sodium depletion, potassium gain, and manganese gain with chlorinity. Lead and zinc are covariant with each other but not with chlorinity.

Type II brines also show variable salinity with covarying temperature and salinity in near balance to produce nearly uniform density. South Brawley, Westmorland, Salton Sea, and probably North Brawley and East Brawley geothermal fields are Type II brines. Type I brines are hypothesized to be compositionally uniform convectively mixed hotter brines underlying Type II brines at depth. Type 0 brines, also hypothetical, are thought to be near saturated cold sodium chloride brines originating at a density of 1.20 within the salina of the old Salton Sink and descending along fracture networks to feed the spreading rift fractures with a source for the hypersaline brine. The evidence for this original brine is the preservation of Cl/Br ratios of over 20,000 in the deep brines of the Salton Sea well Fee No. 1. (Author's abstract)

REX, R.W., 1983b, The origin of the brines of the Imperial Valley, California: Geothermal Res. Council, Transactions, v. 7, p. 321-324. Author at Republic Geothermal, Inc.

The hypersaline brines of the Imperial Valley of California show evidence of having originated from dissolution of halite deposited in the salina of the Salton Sink from ancestral Lake Cahuilla and its precursors. This hypersaline brine has undergone rock interaction producing loss of sodium to the rocks (sodium depletion) with transfer of potassium, calcium, and numerous heavy metals to the brine. The blending of the brines with overlying fossil lake waters and desert runoff gives rise to variations in the hypersaline brines which are also effected by thermal metamorphism including sulfate reduction, magnesium fixation, and organic matter oxidation. (Author's abstract) See previous item.

REYF, F.G. and ISHKOV, Yu.M., 1983, First results of the direct determination of concentration of ore-forming elements in magmatic distillates of tungsten-bearing intrusion: Dokl. Akad. Nauk SSSR, v. 269, no. 3, p. 725-728 (in Russian). Authors at Geol. Inst. of Buryatian Division of Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

Magmatic quartz from the Mariktikan and Soktuy massifs bears P inclusions of brines magmatically distilled from silicate melt. By laser microanalysis of such inclusions the following concentrations of metals in inclusion brines in g/ℓ (and in G/L inclusions from ore paragenesis of the Dzhida W ore field) were found (in inclusions of volume about 10^{-10} - 10^{-11} ℓ [i.e., 10^{-7} - 10^{-8} g]; detection limits in 10^{-12} g:W 2000-500, Mn 5-0.8, Fe 13-10, Sn 200(?)-50(?) [question marks are from the authors]: Mariktikan W 21, Mn 144, Fe 98, Sn not found, Soktuy W (>133[sic, A.K.]) to 45, Mn 0.3, Fe 18 to 75, Sn not found to ≥0.9, Dzhida W 52, Mn 76 to not found, Fe not found, Sn not found above the detection limit. The numbers of inclusions studied were: Mariktikan 1, Soktuy 2, Dzhida 2. (Abstract by A.K.)

REYNOLDS, T.J., 1980, Variations in hydrothermal fluid characteristics through time at the Santa Rita porphyry copper deposit, New Mexico: M.S. thesis, The Univ. Arizona, Tucson, AZ, 52 pp.

A fluid inclusion study was designed to trace through time the variations of thermal and gross chemical characteristics of hydrothermal fluids responsible for a specific sequence of alteration-mineralization assemblages at the Santa Rita porphyry copper deposit. Results of over 1,700 fluid inclusion measurements indicate the earliest fluid was a high-temperature (>775°C), hypersaline (about 16-34 molal NaCl ± KCl eq.) brine associated with a barren quartz + orthoclase + biotite + apatite vein. This was followed by a cooler (about 260-500°C) but still highly saline (about 10-20 molal NaCl eq.) fluid associated with a quartz + orthoclase + biotite vein assemblage, which evolved to the coolest (about 240-400°C) high salinity (about 8-16 molal NaCl eq.) solutions associated with quartz + orthoclase deposition in the Whim Hill breccia pipe and characterized by much lower Na/K atomic ratios (about 1.0) than the other groups of high-salinity fluids (about 2.8). In addition to halite, sylvite, and anhydrite, chalcopyrite, magnetite, hematite, potassium feldspar, and mica (muscovite?) have been tentatively identified as daughter products in all generations of hypersaline fluid inclusions, using scanning electron microscopy and observable physical properties. A later, lower temperature (260-360°C), low-salinity (<3 molal NaCl eq.) fluid is associated with two alteration assemblages: a quartz + sericite + pyrite assemblage dominant in zones peripheral to chlorite + orthoclase + sulfides + clay assemblages which bear the hypogene copper mineralization at the Santa Rita deposit. (Author's abstract)

RICHARDSON, C.J. and CANN, J.R., 1983, Anatomy of fossil high temperature hydrothermal systems in the Troodos ophiolite, Cyprus (abst.): Mineralog. Soc. (G.B.) Bull., no. 61, p. 3. Authors at Univ. of Newcastle.

Beneath the massive sulphide ores of the Troodos ophiolite lie narrow vertical pipes of quartz-rich argillized basalt, surrounded by envelopes of propylitic alteration. About 1 km down more diffuse zones of argillic and propylitic alteration with abundant epidote appear. These in turn give way to zones at the base of the sheeted dykes in which epidosites are abundant, where the fluids pick up heat from the magma chamber, and metals from the rocks. Comparison of rock chemistry and black smoker fluids shows that the interaction is complex, and in particular that the exchange of Mg for Ca in the fluids is not a simple single stage process. (Authors' abstract)

RICHARDSON, C.K. and RYE, R.O., 1983, The chemical and thermal evolution of fluids in the Cave-in-Rock district, Illinois: stable-isotope systematics (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 670. First author at Dept. Earth Sci., Iowa State Univ., Ames, IA 50011.

The isotopic composition was determined for fluid-inclusion waters and crystals of fluorite, quartz, sphalerite, calcite, and barite from the Deardorff mine, Cave-in-Rock, Ill. The $\delta^{18}O$ values of zoned quartz crystals vary from 18.9 to 20.5‰; calcites have $\delta^{18}O$ values between 18.9 and 24.2‰; and barite yields a value of 20.4‰. The isotopic variation across crystals of either calcite or quartz is easily accounted for by the variation in temperature of the fluid as measured by fluid-inclusion homogenization temperatures. However, the calculated $\delta^{18}O(H_2O)$ for fluids in equilibrium with the $\delta^{18}O$ bearing minerals ranges from 0.8 to 9.2‰ with a trend to larger values in later stages. δD values of -24±4‰ were measured on water extracted from fluid inclusions in fluorite; values of -32±1‰ were measured on water from sphalerite; values of -30±5‰ were measured on water from quartz and a value of -30‰ was measured on water from main-stage calcite. These water values are nearly identical to values for formation water from the Illinois Basin. The $\delta^{13}C$ values for calcite decrease significantly from the center to the exterior of the crystals. The low $\delta^{13}C$ values in the exterior of the crystals correlate well with an observed increase in the amount of organic debris trapped in the crystal, suggesting the addition of some methane-derived CO_2. The $\delta^{34}S$ values of sphalerite (5.6 to 9.0‰) and barite (70.5 to 73.8‰) are consistent with a source solution evolved from sea water sulfate. The data suggest that the main-stage fluids underwent isotopic evolution, but were derived from a single source reservoir. Late-stage calcite fluids have a $\delta D(H_2O)$ values of -50±4‰ and show input of water from another source. (Authors' abstract)

Some late barite crystals shows a range of $\delta^{34}S$ values from 55 to 102‰ for core to edge (personal comm., C.K. Richardson). (E.R.)

RICKARD, David, 1983, Precipitation and mixing mechanisms in Laisvall-type sandstone lead-zinc deposits: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 449-458. Author at Ore Res. Group, Geol. Inst., Stockholms Univ., S-106 91 Stockholm, Sweden.

Laisvall-type sandstone lead-zinc deposits are defined primarily as the galena-sphalerite-calcite-fluorite-barite impregnations which occur in late Precambrian and Cambrian sandstones along the eastern border of the Caledonides in Scandinavia. They are genetically closely related to carbonate-hosted lead deposits, particularly of the Viburnum Trend type. However, their genetic connections with other sandstone lead deposits, such as Largentière, are at present unclear.

The Laisvall-type deposits are characterized by a simple mineralogy but complex paragenesis, with several stages of deposition and dissolution of the minerals. These stages may be correlated with fluid inclusion homogenization and melting temperatures, which indicate precipitation from two end-member solutions, at 150-200°C and with ca 25 equivalent wt. % NaCl, and at 50-120°C and with 15 equivalent wt. % NaCl respectively. A plot of relative time, based on paragenetic observations, against formation temperature reveals a fluctuating thermal environment for the Laisvall deposit itself. This is consistent with an interpretation calling upon different precipitation mechanisms for different minerals. Calcite precipitated on warming and dissolved on cooling, whereas the sulfides, fluorite and, possibly, barite precipitated mainly during the cooling stage of a temperature cycle.

Geochemical data from the Vassbo and Guttusjö deposits have revealed further aspects of the precipitation process. In particular, carbon and oxygen isotope data from the ore calcites show that the ore carbonate derived from the oxidation of organic carbon, probably hydrocarbons, which was mixed with local groundwater carbonate cement. The detection of carboxylic acids in the ore calcite, tends to confirm this oxidation process. Spatial relationships together with sulfur isotopic data on sulfide and sulfate sulfur, suggest that the oxidant in this reaction was sulfate and that sulfide was a product.

The solutions involved in the formation of the Laisvall-type ores therefore appear to have been a hot, saline, metalliferous brine and local, cooler, less saline waters closely associated with hydrocarbon accumulations. Sulfide was generated in situ through interaction between these fluids.

The fluid inclusion data can be used to compute the fluid densities, and this shows that the brine was always denser than the local solutions. This meant that mixing by turbulent convection was prohibited, and double-diffusive convection occurred. That is, the cooler solution was warmed before mass transfer through chemical diffusion occurred. This initial heating caused the primary precipitation of calcite, which was enhanced by CO_2 production; mixing and consequent cooling led to the precipitation of sulfides. Repetition of the process occurred through either tectonic pumping or climatic variations or both.

The model explains the localization of the ores as well as their typical form and mineralogical paragenesis. The data are not consistent with groundwater or synsedimentary hypotheses, and inclusion-mineral relationships demonstrate that the fluid inclusions have not been reset by some subsequent process. The observations also concur with thermodynamic and mass balance calculations, which suggest that two solutions were involved in the formation of Laisvall-type deposits and that precipitation occurred by mixing. (Author's abstract)

RIMSTIDT, J.D. and COLE, D.R., 1983, Geothermal mineralization I: The mechanism of formation of the Beowawe, Nevada, siliceous sinter deposit: Am. J. Sci., v. 283, p. 861-875. First author at Dept. Geol. Sci., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061.

The siliceous sinter deposit at Beowawe, Nev., has a volume of 7.71 x 10^7 m^3 and contains 1.28 x 10^{11} kg silica. This silica precipitated from geothermal solutions that welled-up along the Malpais Fault, a graben bounding fault. Sinter formation involved three steps: (1) Geothermal solutions saturated with quartz in the reservoir moved to the surface where they cooled and became supersaturated with amorphous silica. (2) Amorphous silica particles nucleated (heterogeneously) to produce a colloidal suspension. (3) The amorphous silica particles agglomerated and were cemented together by amorphous silica precipitating in the embayments between the particles. At least 5.58 x 10^{14} kg of geothermal solution must have been produced over time to account for the mass of silica in the Beowawe Deposit. This fluid would have carried at least 4.95 x 10^{17} kJ of heat to the surface. (Authors' abstract)

ROBERT, F., HALBOUT, J., JAVOY, M., DIMON, B. and MERLIVAT, L., 1983, The D/H ratio and petrological types of chondrites: Meteoritics, v. 18, no. 4, p. 387-388. First author at Lab. Géochimie des Isotopes Stables, Univ. Paris VII, Tour 54-64, l'étage, 2 place Jussieu 75251 Paris Cedex 05, France.

Pyrolysis of ordinary chondrites (Parnallee LL3, Bremervoerde H3, Hedjaz L3, Tieschitz H3, St. Severin LL6, Olivenza LL5, Guarena H6) indicates that the deuterium rich phase is widespread among these meteorites in various proportions: a typical bimodal release of hydrogen for temperatures between 500 and 900°C (cf. HF-HCl residues from C.Cs) is observed in several samples with δD's ranging from -50 to +450‰. At 370-395°C, a large amount of low δD hydrogen with minimum δD's of -290‰, is released. The low δD end member has a mean calculated δD of -430 ± 110‰ with some values down to -600‰. The whole hydrogen is concentrated in the finest particles of types 5 and 6 chondrites, separated by decantation in acetone. This mineralogical fraction has been shown to be in thermodynamical disequilibrium with the rest of the rock. This is in agreement with the hydrogen release temperatures (370-390°C) which are far below the estimated metamorphic temperatures.

A precise correlation between the maximum measured δD's in meteorites and their mean δD's is interpreted as a progressive mixing between two hydrogen components. Acid residues from Orgueil (Cl) and deuterium-rich LL3 meteorites fit precisely this correlation. The D/H variations in meteorites are governed by the relative proportion of these two components. In addition, an approximate correlation between ^{36}Ar content and the D/H value is observed for all the studied meteorites as well as for the Earth and Venus atmospheres. (Authors' abstract)

ROBERTS, D.E., 1983, Metasomatism and the formation of greisen in Grainsgill, Cumbria, England: Geol. J., v. 18, p. 43-52. Author at Dept. Geol., Univ. Bristol, Queen's Bldg., Bristol BS8 1TR, UK.

A section of hornfelsed Skiddaw Slate adjacent to the margin of the Grainsgill Greisen is described and chemical analyses of the various rock types presented. The results confirm that hydrothermal fluids liberated

K and Na from the granite to produce the greisen. This gave rise to K metasomatism of the adjacent hornfels and to retrogressive metamorphism over a radius of 200 m from the intrusion. Na leached from the hornfels near the intrusion and that liberated during the formation of the greisen are probably the sources of the Na in the brines recorded in fluid inclusions within the nearby quartz-tungsten veins. (Author's abstract)

ROBINSON, B.W., 1983, The GeoSEM: a scanning electron microscope optimized for mineralogy: CSIRO Div. of Mineralogy Res. Review 1983, p. 234-237.

Modifications to an existing scanning electron microscope (SEM), based on ideas proposed by V.N.E. Robinson, have made it more useful for mineralogy than normal commercial SEMs. The acronym GeoSEM has been adopted for a geologically oriented SEM. The capacity of this instrument to reveal compositional variations even on relatively rough surfaces is demonstrated and the instrument has proved invaluable in quite diverse applications. This experience has led to a concept for an instrument, custom-designed for mineralogy, combining the essential features of GeoSEM with desirable features of modern commercial SEMs. (Modified from author's abstract)

ROEDDER, Edwin, 1983a, Diurnal periodicity in NaCl precipitation in Permian salt basins (abst.): U.S. Geol. Survey Prof. Paper 1375, p. 139.

Core samples of bedded Permian salt from the Palo Duro basin of Texas exhibit periodic fluid inclusion textures that appear to be related to diurnal cycles rather than to annual cycles, as is frequently reported in the literature of bedded salt deposits. The sodium chloride crystals, approximately 1 cm in length, apparently grew vertically from the bottom of a very shallow sea. Each day's solar evaporation at the water surface produced denser supersaturated brines which convected downward and caused a rapid growth of 0.40 to 0.85 mm thick layer of NaCl on the salt crystals. These rapidly growing layers trapped numerous inclusions containing brine. A small amount of residual supersaturation at nightfall caused a very thin layer of clear inclusion-free salt to form. The next day the process was repeated, yielding finely banded crystals of sodium chloride. The process is of more than academic interest, for it proceeds only in very shallow waters. There is considerable interest in estimating the water depths during Permian salt deposition; any data on these depths can help in reconstructing the paleogeography of these salt basins. (Author's abstract)

ROEDDER, Edwin, 1983b, Fluid inclusions in salt, in U.S. Geol. Survey Research in Radioactive Waste Disposal--Fiscal Year 1981: U.S. Geol. Survey Water Resources Investigations Rept. 83-4105, p. 62-64.

A brief review of past activities in this area, mostly already abstracted in earlier volumes of Fluid Inclusion Research--Proceedings of COFFI. (E.R.)

ROEDDER, Edwin, 1983c, Geobarometry of ultramafic xenoliths from Loihi Seamount, Hawaii, on the basis of CO_2 inclusions in olivine: Earth & Planet. Sci. Letters, v. 66, p. 369-379. Author at National Center, Stop 959, U.S. Geol. Survey, Reston, VA 22092, USA.

Abundant fluid inclusions in olivine of dunite xenoliths (~1-3 cm) in basalt dredged from the young Loihi Seamount, 30 km southeast of Hawaii, are evidence for three coexisting immiscible fluid phases--silicate melt (now glass), sulfide melt (now solid), and dense supercritical CO_2 (now liquid + gas)--during growth and later fracturing of some of these olivine crystals. Some olivine xenocrysts, probably from disaggregation of xenoliths, contain similar inclusions.

Most of the inclusions (2-10 μm) are on secondary planes, trapped during healing of fractures after the original crystal growth. Some such planes end abruptly within single crystals and are termed pseudosecondary, because they formed during the growth of the host olivine crystals. The "vapor" bubble in a few large (20-60 μm), isolated, and hence primary, silicate melt inclusions is too large to be the result of simple differential shrinkage. Under correct viewing conditions, these bubbles are seen to consist of CO_2 liquid and gas, with an aggregate $\rho = \sim 0.5-0.75$ g cm^{-3}, and represent trapped globules of dense supercritical CO_2 (i.e., incipient "vesiculation" at depth). Some spinel crystals enclosed within olivine have attached CO_2 blebs. Spherical sulfide blebs having widely variable volume ratios to CO_2 and silicate glass are found in both primary and pseudosecondary inclusions, demonstrating that an immiscible sulfide melt was also present.

Assuming olivine growth at ~1200°C and hydrostatic pressure from a liquid lava column, extrapolation of CO_2 P-V-T data indicates that the primary inclusions were trapped at ~220-470 MPa (2200-4700 bars), or ~8-17 km depth in basalt magma of $\rho = 2.7$ g cm^{-3}. Because the temperature cannot change much during the rise to eruption, the range of CO_2 densities reveals the change in pressure from that during original olivine growth to later deformation and rise to eruption on the sea floor. The presence of numerous decrepitated inclusions indicates that the inclusion sample studied is biased by the loss of higher-density inclusions and suggests that some part of these olivine xenoliths formed at greater depths. (Author's abstract)

ROEDDER, E., 1983d Discussion of "A re-assessment of phase equilibria involving two liquids in the system K_2O-Al_2O_3-FeO-SiO_2," by G.M. Biggar: Contrib. Mineral. Petrol., v. 82, p. 284-290. Author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092, USA.

A discussion and correction of errors made in a paper by Biggar (1983, this volume). (E.R.)

ROEDDER, Edwin, BELKIN, H.E. and LU, Huanzhang, 1983, The paradox of aqueous inclusions in a chondritic meteorite from Jilin, China (abst.): U.S. Geol. Survey Prof. Paper 1375, p. 143.

For abstract on this and related work, see Adar et al. (1982), Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 2. (E.R.)

ROMASHKIN, Y.N., 1983, Topomineralogy of the Amderma fluorite-bearing region, in Minerals and mineral complexes of the northeastern European USSR, M.V. Fishman and N.P. Yushkin, N.P., eds., p. 7-13 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

ROMBERGER, S.B., 1983, Transport and deposition of gold in hydrothermal systems at temperatures up to 250°C with geologic implication (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A59. Author at Dept. Geol., Colorado Sch. Mines, Golden, CO 80401, USA.

Processes responsible for the transport and deposition of gold in hydrothermal systems are evaluated using available solubility and thermodynamic data. The relative importance of aqueous gold complexes is considered in terms of pH, oxygen fugacity, and concentration of complexing agents. When these results are considered along with hydrothermal alteration and mineral assemblages observed in gold deposits, the following conclusions can be made: 1) gold bisulfide complexes are important in near neutral reducing solutions; 2) if gold were transported as bisulfide complexes, oxidation, dilution, pH changes, and/or precipitation of base metal sulfides result in gold deposition; 3) gold chloride complexes are important under low pH oxidizing conditions when chloride activity is high; 4) importance of chloride complexes increases with temperature; 5) if gold were transported as chloride complexes, deposition would occur with increase pH, reduction, dilution and/or cooling. For solutions in equilibrium with pyrite and argillic alteration mineral assemblages adequate quantities of gold can be transported only as bisulfide complexes at temperatures up to 250°C. Associated alteration assemblages in gold ores are consistent with a depositional model involving oxidation and pH increase. These changes could occur during solution boiling and/or loss of volatiles through effervescence. (Author's abstract)

RONA, P.A., BOSTROM, Kurt, LAUBIER, Lucien and SMITH, Kenneth L., Jr., 1983, Hydrothermal processes at seafloor spreading centers: Plenum Press, New York, ~800 pp. First author at NOAA, Atlantic Oceanographic & Meteorlogical Labs., Miami, FL.

Contains discussions of geologic setting, hydrothermal convection, basalt-seawater interaction, geochemistry of fluids and gases, etc. (E.R.)

ROSENBAUER, R.J., BISCHOFF, J.L. and RADTKE, A.S., 1983, Hydrothermal alteration of graywacke and basalt by 4 molal NaCl: Econ. Geol., v. 78, p. 1701-1710. First author at U.S. Geol. Survey, 345 Middlefield Rd., Mail Stop 99, Menlo Park, CA 94025.

Graywacke and basalt were reacted with a pure 4 m NaCl brine in separate experiments at 350°C and 500 bars at a rock/fluid ratio of 1/10. Illite, dolomite, and quartz, amounting to 67 percent of the original graywacke, were quantitatively converted to albite and smectite. In the process, the rock gained Na and released Ca, K, heavy metals, and CO_2 to solution. The concentrations of metals in solution are less than in similar experiments with natural brine but greater than in seawater after reaction with graywacke. Metal mobilization depends primarily on acidity which was produced by Na metasomatism and by dedolomitization.

In sharp contrast, reaction of 4 m NaCl with basalt produced only minor alteration in which some smectite and little albite formed. No significant acidity was produced nor did metals become mobilized.

Production of acidity during albitization depends entirely on the phase being altered. The albitization of graywacke produces H^+ whereas the albitization of basalt apparently consumes H^+.

All experiments to date that have reacted basalt with seawater, natural brine, and fully saturated NaCl over a variety of conditions have been unsuccessful in producing a spilite alteration assemblage. (Authors' abstract)

ROSSMAN, G.R. and AINES, R.D., 1983, The water content of mantle garnets (abst): EOS, Transactions, Am. Geophy. Union, v. 64, no. 45, p. 903.

ROUSE, J.E., 1982, Terrestrial brines in the development of sabkha-type evaporites (abst.): Terra Cognita, v. 2, p. 80. Author at Inst. Geol. Sci., 64 - 78 Grays Inn Road, London WC1X 8NG, England.

Previous isotopic work on the carbonate phases of the marine sabkha-facies evaporites of Abu Dhabi has enabled the likely field of carbonate values to be defined as being in a field between +1.5 and 3.5 $\delta^{13}C$ and +1 and +5 $\delta^{18}O$. Values reported here for carbonates precipitating in a truly continental environment from terrestrial groundwaters lie entirely along a line extending from -1.5 to +2 $\delta^{13}C$ and +5.5 to +1.0 $\delta^{18}O$, the lowest values corresponding to brines precipitating only carbonate, middle values carbonate and gypsum and the highest values anhydrite. This 'evaporation' trend line is interpreted as representing the loss of $\delta^{18}O$ light water and light $\delta^{13}C$ CO_2 from the brines during evaporation. The slope of this line is modified by the dissolution of existing carbonates. Hence, it may be possible to use isotopic values of carbonates from evaporitic sequences to demonstrate brine source especially in those cases where $\delta^{34}S$ measurement on the sulphates proves inconclusive.

This argument is shown to be useful in interpreting brine sources in the Keuper Marl evaporites of the Midlands, U.K., where a clear division exists between carbonates of marine source and those of terrestrial source. The division occurs at about +1 $\delta^{13}C$, +1 $\delta^{18}O$ and also separates evaporites containing neoformed clay minerals of two different series corresonding to marine brines and evaporated continental brines.

A study of carbonate isotopic values in Miocene sabkha cycles from Abu Dhabi is reported. $\delta^{13}C$ carbonate composition falls by 3-5 during each gypsum depositing cycle and is shown to correlate well with increasing neogene clay content further indicating the continentality of these evaporites. In two cycles where no change in $\delta^{13}C$ value occurs, there is also no increase in clay mineralogy suggesting a marine origin for these cycles. Late stage dolomitization has evened out the $\delta^{18}O$ record and only some cycles show a small depression in oxygen value.

These data further emphasize the relevance of solution and redeposition processes by deep groundwaters in remobilization and diagenesis of the more soluble mineral species. (Author's abstract)

ROWAN, L.P., BETHKE, P.M. and BODNAR, R.J., 1983, Stretching of fluid inclusions in fluorite at confining pressures up to one kilobar (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 674. First author at U.S. Geol. Survey, P.O. Box 25046, Denver Fed. Center, Denver, CO 80225.

The validity of fluid inclusion geothermometry is in part based on the assumption that the inclusion volume has remained constant since trapping. This is valid for most inclusions, but two types of inclusion deformation have been recognized: 1) "leakage" which involves loss of some of the inclusion fluid and is generally characterized by visible fractures extending out from the inclusion, and 2) "stretching" which is generally not accompanied by visible evidence of the deformation in the surrounding crystal, and occurs without fluid loss from the inclusion.

Stretching results when the pressure inside the inclusion (P_{in}) exceeds the external pressure (P_{ex}) by an amount greater than the strength of the crystal. The P_{in} required to initiate stretching expressed as a function of inclusion volume (V) and P_{ex} has been experimentally determined for secondary inclusions in fluorite as: $P_{in} = 178P_{ex} - .7\mathrm{Log}V + 1019$ (P_{in}, P_{ex}:bars; V:μ^3). Thus the smaller the inclusion or the higher the external pressure, the less likely an inclusion is to stretch. The volume relationship provides a means of identifying groups of stretched inclusions. P_{in} and V are calculated from the P-V-T-X properties of the inclusion fluid and P_{ex} ($\leqslant$1 kb) is externally controlled by means of a cold seal bomb and hydrothermal apparatus.

The most probable stretching mechanisms are microfracturing (brittle failure), and propagation of dislocations (plastic failure). The initial gradual changes in inclusion volume with heating (e.g., 1%/23°) are interpreted as plastic deformation. This is followed by partial decrepitation as a form of brittle failure. Inclusions in harder minerals require a greater P_{in} to cause decrepitation (slope of curve is 110 atm/mohs unit), as well as to initiate stretching (plastic deformation). (Authors' abstract)

ROYZENMAN, F.M., VALYASHKO, L.M., KARSKIY, B.Ye. and ZORIN, B.I., 1983, Certain general regularities of formation of coarse-crystalline ores in deposits of muscovite, phlogopite and pollucite: Dokl. Akad. Nauk SSSR, v. 269, no. 6, p. 1441-1444 (in Russian). Authors at Moscow Geol.-Prosp. Inst., Moscow, USSR.

Minerals from deposits of muscovite, phlogopite and pollucite (pegmatites) were studied by the decrepitation method. All the studied parageneses were submitted to intensive recrystallization that is marked by high decrepitation activity at 100-320°C. 200 samples were studied, with determination of the released G components. Concentration of CO_2 (moles) per kg of H_2O ranges from 1.1 to 59.1. From the performed studies the authors conclude that for formation of rich pegmatitic ore bodies it is necessary that a large and sufficiently closed geological "trap" has been formed causing the filtration of $CO_2 + H_2O$ solutions in a cooling system. (Abstract by A.K.)

RUB, M.G., PAVLOV, V.A., KHETCHIKOV, L.N. and DOROGOVIN, V.I., 1983, Melt and gas-liquid inclusions in quartz of ore-bearing (Ag, Sn) volcanic-plutonic associations of the East of the USSR: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 8, p. 76-81 (in Russian). First author at IGEM, Moscow, USSR.

The studied rocks are in NE USSR (location not given). Lower Cretaceous volcanic-plutonic association rhyolite-quartz syenite has high K_2O content (up to 8%), as well as F (0.1%) and Cl 0.04%, rare alkalis, SiO_2 and Mn; Ag ores associate with this rock complex. Lower and Upper Cretaceous gabbro-diorite-andesite association is connected also with tuff formation. Upper Cretaceous rhyolite-granite has chemical features similar to Lower Cretaceous rhyolites and syenites, but upper limits are lower. Sn-Ag and Ag-polymetal ores are associated with rhyolites and granites. Lower and Upper Cretaceous rhyolites bear melt inclusions 15-20 µm in size, filled by G, glass and silicates, Th ~900°C; such inclusions frequently bear halite, sylvite and magnetite. In the second region--Primor'ye--the volcanic complex consists of rhyolites, ignimbrites and sanidine granite-porphyries bearing 74-76% SiO_2, to 5.9% K_2O, FeO, MgO to 0.2%, CaO to 0.45%. Glass inclusions in rhyolites have Th 865 ± 10°C, in granite porphyries and sanidine rhyolites - 910-980°C. In G bubble in inclusions in sanidine rhyolite quartz a condensate freezes at -58 ± 5°C, indicating that CO_2 is an important volatile component. S G/L inclusions are rare; G/L inclusions in veins homogenize at 205-315°C. (Abstract by A.K.)

RUDNICK, R.L., ASHWAL, L.D. and HENRY, D.J., 1983, Metamorphic fluids and uplift-erosion history of a portion of the Kapuskasing structural zone, Ontario, as deduced from fluid inclusions, in Workshop on A Cross Section of Archean Crust, L.D. Ashwal and K.D. Card, eds.: Lunar and Planetary Inst. Tech. Rept. 83-03, p. 76-80. First author at Res. School of Earth Sci., Aust. Nat. Univ., Canberra, Australia.

Fluid inclusions [CO_2, H_2O and CO_2-H_2O] can be used to determine the compositional evolution of fluids present in high grade metamorphic rocks (Touret, 1979) along with the general P-T path followed by the rocks during uplift and erosion (Hollister et al., 1979). In this context, samples of high-grade gneisses from the Kapuskasing structural zone (KSZ, Fig. 1) of eastern Ontario were studied in an attempt to define the composition of synand post-metamorphic fluids and help constrain the uplift and erosion history of the KSZ. Recent work by Percival (1980), Percival and Card (1983) and Percival and Krogh (1983) shows that the KSZ represents lower crustal granulites that form the lower portion of an oblique cross-section through the Archean crust, which was up-faulted along a northeast-striking thrust fault. The present fluid inclusion study places constraints upon the P-T path which the KSZ followed during uplift and erosion. (Authors' Introduction)

RUIZ, J., 1983, Geology and geochemistry of fluorite ore deposits and associated rocks in northern Mexico: Unpub. Ph.D. thesis, Univ. Michigan, 202 pp.

Th values range from 80-220 (Las Cuevas-El Realito); 185-225 (Navidad); and 195-230 (Rodeo). (E.R.)

RUMBLE, D., 1983, Combining field and laboratory studies to obtain fluid/rock ratios of metamorphic rocks (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 676.

RUMBLE, D. and SPEAR, F.S., 1983a Comparison of $^{18}O/^{16}O$ and chemical equilibration of oxides and silicates in regional metamorphism (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 676. First author at Geophy. Lab., 2801 Upton St., NW, Washington, DC 20008.

Samples were collected at cm intervals across a 7 m outcrop in E. Vermont of kyanite-staurolite grade rocks (P = 6Kb, T = 535°C) interlayered in the sequence muscovite schist, calc-silicate, biotite schist, garnetiferous quartzite, and amphibolite. Outcrop widths of muscovite schist and amphibolite are 100's of times greater than the thin-bedded rocks: calc-silicate (discontinuous lenses, 2 cm thick), biotite schist (10 cm) and quartzite (25 cm). Analyses of mineral separates of quartz show $\delta^{18}O$ values are uniform throughout the muscovite schist but vary by 1‰, or more, between 1 cm thick hand specimens collected in mutual contact from the thin-bedded rocks. Microprobe analyses of ilmenite show uniform $FeTiO_3$ and $MnTiO_3$ values throughout the muscovite schist and amphibolite but variations of 40 mol % over distances of 1 cm in the thin bedded rocks. Local equilibration of $^{18}O/^{16}O$ is suggested by the observed constancy of fractionation between quartz and magnetite despite differences in whole rock $\delta^{18}O$. Chemical equilibration is suggested by systematic partitioning of cations between adjacent minerals. Ambient fO_2 differed by 1-2 orders of magnitude between rock types. These results show $^{18}O/^{16}O$ and chemical equilibration occurred during metamorphism on a spatial scale determined by the thickness of sedimentary beds. In contrast, recent work on the Beaver Brook fossil locality (Am. J. Sci. 282, 886) shows that in more permeable rocks fluid flow may enlarge the domain of isotopic equlibration beyond the thickness of sedimentary beds whereas chemical equilibration remains constrained to sedimentary beds by the buffer capacity of mineral assemblages. (Authors' abstract)

RUMBLE, Douglas, III and SPEAR, F.S., 1983b Oxygen-isotope equilibration and permeability enhancement during regional metamorphism: J. Geol. Soc. London, v. 140, p. 619-628.

The degree to which oxygen-isotope equilibrium has been attained between the minerals of different, contiguous rock layers during metamorphism is correlated with evidence of enhanced permeability. Quartz separated from various rock layers of naturally occurring 'diffusion couples' has uniform values of $\delta^{18}O$ where rocks have either (1) experienced intense devolatilization reactions, or (2) been severely fractured. Quartz from interlayered rock types lacking evidence of enhanced permeability differs by 1-2‰ over distances as small as 1 cm. These results suggest that intergranular diffusion through static pore fluid is not an efficacious process for exchanging oxygen isotopes between different rock types. Infiltrating pore fluid, however, can serve as a medium of isotope exchange over distances greater than bedding thickness where rocks are sufficiently permeable for fluid flow to occur. (Authors' abstract)

RUVALCABA-RUIZ, Delfino, 1983a Geology, alteration, and fluid inclusions of the Santa Elena and Santo Nino veins in Fresnillo, Mexico (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 277. Author at Dept. Earth Res., Colorado State Univ., Fort Collins, CO 80523.

The Fresnillo mine in north-central Mexico consists of sulfide veins, skarn sulfide mantos, and disseminated sulfides. The deposits form part of a precious and base metal province in the region, where they are associated with, or related to Triassic-Tertiary sedimentary rocks and calc-alkaline volcanics and epizonal plutons.

Ore mineralization at Fresnillo is related to a quartz monzonitic stock. Major structures trend NW-SE and E-W. Two silver-rich veins of the latter system were discovered recently; these veins, Santa Elena and Santo Nino, extend along strike for more than 500 m and 1 km, respectively with average grades in excess of 500 grams silver per metric ton. Ore minerals include pyrargyrite, acanthite, and minor amounts of other silver compounds and base metal sulfides.

Hydrothermal alteration-mineralization occurred in three main events: an early stage caused K-SiO$_2$ alteration close to and within the fissures and propylitization on the wall rock. The second event brought about the precipitation of ore minerals in the veins and the formation of narrow halos of argillic-phyllic alteration in the host rocks. Barren calcite was deposited during the late mineralizing episode. Heating studies of fluid inclusions indicate the bulk of the ore formed at 220-245°C from fluids whose salinity varied from 0.1 to 1.3 equivalent weight percent NaCl. Sulfur isotope analysis suggest a magmatic origin for the sulfur of the economic deposits. (Author's abstract)

RUVALCABA, D.C., 1983b Fluid inclusions and hydrothermal alteration of silver-rich veins at Fresnillo, Mexico (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A60. Author at Dept. Earth Resources, Colorado State Univ., Ft. Collins, CO 80523, USA.

See previous item.

RYABCHIKOV, I.D., 1983a Hydrothermal reactions in the earth's mantle, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tokyo, Gakujutsu Bunken Fukyu-Kai, p. 244-257. Author at Inst. Geol. of Ore Deposits, Petrogr., Mineral., & Geochem. (IGEM), Moscow, USSR.

Recent studies of mineral-fluid interaction at high temperatures and pressures above 10 kb revealed high solubilities of rock-forming minerals in fluid under P-T conditions of the upper mantle. It indicates to the possibility of effective mass transfer by dense gas in the deep-seated zones of the earth. (From the author's abstract)

RYABCHIKOV, I.D., 1983b Mobilization of materials by fluids in the Earth's crust and upper mantle, p. 189-195, in Problems of petrology, mineralogy and ore genesis: "Nauka," Moscow, 224 pp., 900 copies printed, price 3 rbls. 70 kopecks (in Russian).

The paper presents a photograph of an olivine crystal [synthetic] with inclusions of water fluid ($\sim$50% of silicate by weight) in equilibrium with olivine at 1100°C and 3 x 10^6 kPa. (A.K.)

RYABCHIKOV, I.D., 1983, Oxidation-reduction equilibria in the upper mantle: Dokl. Akad. Nauk SSSR, v. 268, no. 3, p. 703-706 (in Russian).

RYABCHIKOV, I.D., ORLOVA, G.P., KOVALENKO, V.I. CHAPOROV, D.Ja., SOLOVOVA, I.P. and MURAVITSKAYA, G.N., 1983, An experimental study of interaction between a fluid and micaceous spinel lherzolite at high temperatures and pressures: Izvestiya Akad. Nauk SSSR Geol., no. 2, p. 38-46 (in Russian).

RYADCHIKOV, A.P., NEKRASOV, I.Ya. and ZUYEV, A.P., 1983, Inversion of ligand shells of Sn(II) in sulfide-chloride complexing: Dokl. Akad. Nauk SSSR, v. 270, no. 4, p. 970-975 (in Russian).

RYE, D.M. and SHELTON, K.L., 1983, A stable isotopic study of the Homestake gold mine: an example of a lower Proterozoic submarine hydrothermal vent system (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A60. Authors at Dept. Geol. & Geophys., Yale Univ., P.O. Box 6666, New Haven, CT 06511.

A detailed sulfur, carbon, and oxygen isotopic study was performed on a single orebody within the Homestake gold mine. Sulfur isotopic analyses were obtained for sulfides from composite drill core samples stratigraphically above, below, and within the gold-bearing Homestake Formation in major gold-mineralized and barren areas. The δ^{34}S values of units below the Homestake Formation range from 3.1 to 20.0‰; above the Homestake Formation, from -11.2 to 13.7‰; within the Homestake Formation, from 2.3 to 10.8‰. Contours of δ^{34}S values follow gold ore trends within the Homestake Formation with all of the ore falling between the 4.0 and 9.0‰ contours. Analysis of detailed drill holes suggests gold-rich regions of the Homestake Formation have nearly constant δ^{34}S values near 7.0‰, whereas gold-poor regions have a large variability of δ^{34}S values.

The δ^{13}C and δ^{18}O values of Fe-carbonates above, below, and within the Homestake Formation range from -11.3 to -7.6‰ and 12.3 to 16.6‰, respectively. Contours of isotopic values show haloes depleted in both ^{13}C and ^{18}O along the major axis of gold mineralization.

We suggest that data from non-mineralized horizons and unmineralized regions within the Homestake Formation reflect normal marine and diagenetic conditions, with sulfides produced in a system dominated by low-temperature bacteriogenic processes. Local gold-rich areas, characterized by constant δ^{34}S values near 7.0‰ and isotopically depleted carbon and oxygen isotopic haloes, represent submarine hot spring systems that vented along specific fracture systems. (Authors' abstract)

RYE, R.O., HALL, W.E., CUNNINGHAM, C.G., CZAMANSKE, G.K., AFIFI, A.M. and STACEY, J.S., 1983, Preliminary mineralogic, fluid inclusion, and stable isotope study of the Mahd adh Dhahab gold mine, Kingdom of Saudi Arabia: U.S. Geol. Survey Open File Report 83-291, 26 pp. Authors at U.S. Geol. Survey, Denver, CO.

The Mahd adh Dhahab mine, located about 280 km northeast of Jiddah, Kingdom of Saudi Arabia, has yielded more than 2 million ounces of gold from periodic production during the past 3,000 years. A new orebody on the southern side of the ancient workings, known as the South orebody, is being developed by Gold Fields-Mahd adh Dhahab Limited. A suite of samples was collected from the newly exposed orebody for preliminary mineralogic, stable isotope, fluid inclusion, and geochemical studies.

The Mahd adh Dhahab deposit is in the carapace of a Proterozoic epizonal rhyolite stock that domed pyroclastic and metasedimentary rocks of the Proterozoic Halaban group. Ore of gold, silver, copper, zinc, tellurium, and lead is associated with north-trending, steeply dipping quartz veins in a zone 1,000 m long and 400 m wide. The veins include an assemblage of quartz-chlorite-pyrite-hematite-chalcopyrite-sphalerite-precious metals, which is similar to the mineral assemblage at the epithermal deposit at Creede, Colorado.

The primary ore contains abundant chalcopyrite, sphalerite, and pyrite in addition to a complex precious metal assemblage. Gold and silver occur principally as minute grains of telluride minerals disseminated in quartz-chlorite-hematite and as inclusions in chalcopyrite and sphalerite. Telluride minerals include petzite, hessite, and sylvanite. Free gold is present but not abundant.

All of the vein-quartz samples contained abundant, minute inclusions of both low-density, vapor-rich fluids and liquid-rich fluids. Primary fluid inclusions yielded homogenization temperatures of from 110° to 238°C. Preliminary light-stable isotope studies of the sulfide minerals and quartz showed that all of the $\delta^{34}S$ values are between 1.2 and 6.3 per mil, which is a typical range for hydrothermal sulfide minerals that derive their sulfur from an igneous source. The data suggest that the sulfide sulfur isotope geochemistry was controlled by exchange with a large sulfur isotope reservoir at depth.

The $\delta^{18}O$ values of all stages of vein quartz in the South orebody range between 8.5 and 11.1 per mil. This range is similar to that for quartz from the North orebody and indicates that the hydrothermal system consisted of dominantly exchanged meteoric water, which was uniform in temperature and $\delta^{18}O$ content throughout the area during the entire period of mineralization.

Lead isotope analyses of two galena samples indicate that the lead in the South orebody is less radiogenic than that from the North orebody and confirm that the lead was derived from oceanic crust approximately 700 Ma ago. (Authors' abstract)

SAFRONOV, A.F. and NIKISHOV, K.N., 1982, Fluid regime of the upper mantle and mineral associations in diamonds: Dokl. Akad. Nauk SSSR, v. 262, no. 4, p. 961-964 (in Russian, translated in Dokl. Acad. Sci. USSR, v. 262, p. 174-177, 1983).

Abstracted in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 221. (E.R.)

SAMSON, I.M. and RUSSELL, M.J., 1983, Silvermines base-metal-baryte deposits, Ireland: Trans. Instn. Min. Metall., Sect. B, Appl. Earth Sci., v. 92, p. B67-B71. Authors at Dept. Applied Geol., Univ. Strathclyde, Glasgow, Scotland.

The Silvermines Pb-Zn-$BaSO_4$ orebodies consist of a large exhalative sedimentary deposit with a relatively undisturbed system of feeder veins below it. This deposit and other exhalative sediment-hosted orebodies have in the past been considered as an exhalative sub-group of the Mississippi Valley type, produced by basin dewatering. Th of fluid inclusions as high as 260°C refute this hypothesis at Silvermines, where adjacent basin aquifers were only 200 or so meters deep. The deposit was produced when a hot hydrothermal fluid that carried base metals rose from depth up the Silvermines fault system and encountered a cooler, nearer-surface fluid. Mineral deposition was caused, principally, by cooling due to mixing of the two fluids--a deduction from the negative correlation of Th with salinity in the inclusion fluids. The end members are a 250°C, 12 wt% fluid and a lower-temperature, highly saline (25 wt%) fluid. The latter fluid was probably derived from a brine pool. Rare vapor-rich inclusions and low-salinity (condensate) inclusions indicate that, on occasion, the solutions boiled. (Authors' abstract)

SANDER, W. and HERBERT, H.-J., 1983, NaCl-crystallization at the $MgCl_2$/NaCl-brine boundary - a possible natural barrier (abst.): Min. Soc. Bull., no. 60, p. 6. Authors at Gesellschaft fur Strahlenund Umweltforschung, Inst. für Tieflagerung, Braunschweig, West Germany.

Concentration-conductivity-temperature- and flow-logs from sixteen brine-filled shafts in northern Germany have shown that the brines in all former potash salt mines exhibit a very sharp stratification; at the bottom a high $MgCl_2$-rich brine, ± saturated with regard to halite, carnallite, kieserite and sylvite with a density of 1.29-1.30 g/cm^3, and above an NaCl-saturated brine with densities between 1.20 and 1.24 g/cm^3, and at the top a ± saline groundwater. Laboratory experiments have shown that at the $MgCl_2$-brine/NaCl-brine boundary both solutions become oversaturated with regard to NaCl due to diffusion processes in both directions. NaCl therefore crystallizes from the solutions and forms a salt plug in the boundary region, which considerably reduces further diffusion. For this experiment the natural conditions in the measured shafts have been used. This applies both to the concentrations of the brines and to the temperatures. Therefore it is concluded that the observed effects also take place in shafts, i.e., in the scale 1:1. The backfilling material plays a two-fold role in this process: (a) it has a crystalllization-nucleus function, and (b) a supporting function for the NaCl-crystals. The results of this and other experiments show: (i) the density boundaries in the brine bodies act as barriers against transport of matter; (ii) at the $MgCl_2$-brine/NaCl-brine boundary an additional barrier in the form of a halite plug grows independently; and (iii) the diffusion processes which generate the halite plug will also close cracks generated by tectonic or mechanical events within the plug. (Authors' abstract)

SANGSTER, D.F., ed., 1983, Short course in sediment-hosted stratiform lead-zinc deposits: Mineralogical Assoc. of Canada, May 1983, Victoria, Canada, 309 pp.

SANTOSH, M. and NAIR, N.G.K., 1983, Granite-molybdenite association in Kerala in relation to taphrogenic metallogeny: Proc. Indian Acad. Sci. (Earth Planet. Sci.), v. 92, no. 3, p. 297-310. Authors at Centre for Earth Sci. Studies, P.B. No. 2235, Trivandrum 695 010, India.

Two molybdenite-bearing granites from the Kerala region, namely, the Chengannoor and the Ambalavayal granites, are discussed here in terms of their salient geochemical characters. The geochemistry of the host rocks indicates a peraluminous, calc-alkaline to alkali-calcic nature and the element levels show good fit with the proposed 'finger-prints' for granite-molybdenite systems. Fluid inclusion studies suggest that Mo was probably partitioned in vapor phase, which subsequently combined with available sulphur. Regional distribution of molybdenite strongly favors the view of a molybdenum province in the southern part of the Indian shield. Associations of rare metal mineralization with the rift-controlled acid magmatic phase in the Kerala region are suggestive of a late Precambrian-Early Palaeozoic taphrogenic metallogeny. (Authors' abstract)

Inclusions contain high CO_2, and rarely NaCl. (E.R.)

SAUNIAC, S. and TOURET, J., 1983, Petrology and fluid inclusions of a quartz-kyanite segregation in the main thrust zone of the Himalayas: Lithos, v. 16, p. 35-45. First author at Lab. Géol. Struc. Appli., Univ. Sci. Techniques du Languedoc, 34060 Montpellier Cedex, France.

Fluid inclusion data are compared to P-T estimates from coexisting minerals in a quartz-kyanite segregation and in the surrounding garnet-bearing micaschist. Mineral assemblages, notably plagioclase-garnet-kyanite-quartz, record a retromorphic evolution from 550-600°C, 7-8 kb to 450-500°C 3-4 kb. The density of the early fluid in the segregation (H_2O + 9 to 15 mole % CO_2) is compatible with this last set of values; it suggests a continuity of the evolution in the metamorphic rock and in the segregation and an early separation of the segregation during postmetamorphic uplift. (Authors' abstract)

SAVINOV, Ye.N., SAIDKHANOV, S.S., PARMON, V.N. and ZAMARAEV, K.I., 1983, Mechanism of hydrogen release from acid water solutions of double reduced 12-silicotungstic acid: Doklady Akad. Nauk SSSR, v. 272, no. 4, p. 916-919 (in Russian). Authors at Inst. of Katalysis of Siberian Branch of Acad. Sci., Novosibirsk, USSR.

Experiments made in solutions of 10^{-4} to 1 N H_2SO_4 plus $5x10^{-4}$ M $H_4[SiW_{12}O_{40}]$ showed release of hydrogen; this occurs also for solutions of other heteropolyacids. (A.K.)

SAYEGH, S.G., NAJMAN, J. and HLAVACEK, B., 1983, Phase behavior of pembina cardium stock-tank oil/methane/carbon dioxide/sulfur dioxide mixtures at 45°C and 13.8 MPa, in Chemical Engineering Thermodynamics, S.A. Newman, ed.: Ann Arbor, Ann Arbor Sci., p. 59-73.

SCHMIDT, S.Th. and AMSTUTZ, G.C., 1983, Mineralogical investigations of strata-bound Pb-Zn-Ba occurrences in the Triassic of the Central Alps (Switzerland), in Mineral Deposits of the Alps and of the Alpine Epoch in Europe, H.-J. Schneider, ed.: Berlin, Springer-Verlag, p. 117-127. Authors at Min.-Petrog. Inst. Univ. Heidelberg, Im Neuenheimer Feld 236, D-6900 Heidelberg, FRG.

Pb-Zn-Ba occurrences in Triassic metasediments of the southern zone of sediments (südliche Sedimenthülle) of the Gotthard Massive in Central Switzerland were studied in the Passo del Lucomagno-Passo della Greina area. The Triassic sequence constitutes the initial phase of the Mesozoic transgression. The ore minerals (sulfides, barite, and fluorite) are located at the base of this sequence in quartzites and dolomitic marbles. Their geometric distribution is conformable with the bedding, and they occur as disseminations, lenses, and porphyroblasts. The regional epimetamorphism, consisting of at least two periods, has affected both simultaneously, the ore minerals and the country rock. Fluid inclusion data reflect the temperature conditions of the regional metamorphism. The ore mineral occurrences are comparable and correlatable with other Triassic strata-bound deposits in the Eastern and the Southern Alps, but also in the Central Alps for example in the Binntal. A synsedimentary origin for the ore minerals of the Passo del Lucomagno-Passo della Greina area is suggested. (Authors' abstract)

SCHOPF, J.W., ed., 1983, Earth's earliest biosphere: its origin and evolution: Princeton Univ. Press, Princeton, NJ, 543 pp.

SCHREYER, W., 1983, Metamorphism and fluid inclusions in the basement of the Vredefort Dome, South Africa: guidelines to the origin of the structure: J. Petr., v. 24, part 1, p 26-47. Author at Inst. Min., Ruhr Univ., Bochum, West Germany.

See Schreyer and Medenbach, 1981, Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 184, 1981. (E.R.)

SCHWARCZ, H. and YONGE, C., 1983, Isotopic composition of paleowaters as inferred from speleothem and its fluid inclusions: Paleoclimates & Paleowaters: A Collection of Environ. Isotope Studies, Proc. Adv. Group Mtg., Int'l. Atomic Energy Agency, 25-28 November 1980, Vienna, p. 115-133. Authors at Dept. Geol., McMaster Univ., Hamilton, Ontario, Canada.

Speleothem precipitated in the deep interior of karstic caves is commonly found to have been deposited in isotopic equilibrium with the water from which it was precipitated. The temperature of deposition can in such cases be determined from the oxygen isotopic fractionation between the calcite and the water. For this purpose the composition of the water can be determined from analyses of the water trapped as fluid inclusions in the stalagmites, flowstones and other speleothems. However, because of the possibility of isotopic exchange between the calcite and the oxygen of the water, D/H ratios of the inclusions have been used to infer the original $^{18}O/^{16}O$ ratio, assuming a relation between oxygen and hydrogen isotope ratios comparable to that existing at present in both meteoric precipitation and drip waters in caves. Some shift in the position of the meteoric water line is inferred to have occurred during glacial periods, however, as shown by measurements of ice cores from Antarctica. If account is taken of this shift, then paleotemperatures for Wisconsin stage speleothems are found to be consistent with their ages relative to the time scale of the glacial stage. Variations in δD of meteoric paleowaters can be directly inferred from fluid inclusion data; using the uranium series dates on the host speleothem, it is possible to reconstruct the history of the isotopic composition of rain and snow at a site over the past 300,000 years. During the last two glacial stages in North America, precipitation was on the average about 12‰ lighter than its modern value at each site. (Authors' abstract)

SELIN, A.A., VIGDOROVICH, V.N. and KHANIN, V.A., 1983, Evaluation of crystal stability at the contact with a nonequilibrium liquid phase: Doklady Akad. Nauk SSSR, v. 271, no. 5, p. 1174-1178 (in Russian). Authors at Inst. of Electronic Technique, Moscow, USSR.

The paper presents a method of calculation an evaluation of solid phase stability with respect to a melt contacting three phases, formed by elements of the IIIrd and Vth groups of the periodic system. (A.K.)

SELVERSTONE, Jane and STERN, C.R., 1983, Petrochemistry and recrystallization history of granulite xenoliths from the Pali-Aike volcanic field, Chile: Am. Min., v. 68, p. 1102-1112. First author at Dept. Earth & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

The P-T conditions indicated by petrochemistry are consistent with P-T values previously determined from different generations of fluid inclusions entrapped in both granoblastic matrix and symplectite phases. The xenoliths are interpreted as fragments of a gabbroic pluton which exists at a depth of approximately 20 km in the crust. This is consistent with suggestions that mafic igneous rocks comprise a large portion of the lower continental crust. Capture of the xenoliths in the host basalt must have resulted in extensive heating, but the petrologic evidence of this event is restricted to heterogeneously distributed high temperature oxidation effects. (From the authors' abstract)

SENGERS, J.M.H.L., KAMGAR-PARSI, B., BALFOUR, F.W. and SENGERS, J.V., 1983, Thermodynamic properties of steam in the critical region: J. Phys. Chem. Ref. Data, v. 12, no. 1, p. 1-28.

SERDOBINTSEVA, V.V., KALININ, D.V. and SHARAPOV, V.N., 1983, Kinetics of the reaction of hedenbergite and hydrothermal hydrogen sulfide solutions: Geol. i Geofizika, v. 24, no. 12, p. 77-82 (in Russian; translated in Soviet Geol. & Geophys., v. 24, no. 12, p. 67-72).

The kinetics of the reaction of hedenbergite and hydrogen sulfide solutions were studied in a closed system in the temperature range of 150-300°C and a PH_2O = 50.6 MPa. The results give an idea of the order of velocities for the reactions of replacement of iron-bearing silicates by sulfides in the investigated range of temperatures and pressure, which is usual for thermal systems of zones of active volcanism. (Authors' abstract)

SERDYUCHENKO, D.P., 1981, Volatile components of pyroxene structure: Dokl. Akad. Nauk SSSR, v. 259, p. 462-466 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 259, p. 163-166, 1983). Author at Inst. Min., Geochem. & Crystal Chem. of Rare Elements, Moscow, USSR.

Many pyroxene analyses show significant quantities of H_2O (0.1-0.5 wt.%) and more rarely, F (0.3-0.7 %), which cannot always be ascribed to inclusions and lattice defects. (E.R.)

SEVRYUKOV, N.N., ANTONIU, N.K. and DOLGANTSEV, V.P., 1983, The system $NaBr-NaHCO_3-H_2O$ at 50°C: Zhurn. Neorg. Khimii, v. 28, no. 6, p. 1615-1616 (in Russian). Authors at Univ. of Friendship of Nations, Moscow, USSR.

The paper presents the solubility isotherm of $NaHCO_3$ and $NaBr \cdot 2H_2O$. (A.K.)

SEWARD, T.M., 1983, A u.v. spectrophotometric study of Pb(II) chloride complexes in aqueous solutions up to 300°C, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tōkyo, Gakujutsu Bunken Fukyu-Kai, p. 135-144.

SHABO, Z.V., ALEKSELYEVA, N.I., MAMCHUR, G.P. and MANZHAR, N.I., 1982, Organic compounds of the Slavyansk ore show and their association with endogenic mineral formation: Geol. Rudnykh. Mestorozhdeniy, no. 5, p. 63-73 (in Russian; translated in Int'l. Geol. Review, v. 25, no. 3, 1983, p. 299-308). Authors at Inst. Geol. & Geochem. of Fossil Fuels, L'vov.

The elemental nature and chemical constituents in organic material in ore deposits is compared with fluid inclusion data. (E.R.)

SHAPENKO, V.V., RODIONOVA, L.N. and SHAPENKO, G.A., 1983, Genesis of cassiterite-wolframite deposits of the Central Sikhote-Alin': Doklady Akad. Nauk SSSR, v. 272, no. 2, p. 453-456 (in Russian). First author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Ore region is a dome structure with Bikino-Malinovskiy cryptobatholith in the center. Studies were performed for two cassiterite-wolframite deposits of the quartz-vein-greisen formation: Zabytoe and Tigrinoe. Mineral associations of the deposit Zabytoe yielded following Th and Tm of ice (in °C): quartz-topaz-wolframite association 380 to 315, -7.0 to -4.0 (quartz), 363 to 342, -7.0 to -4.0 (topaz), 355 to 315 (fluorite); quartz-sulfide association 235 to 180, -3.0 to -1.0 (quartz). The same values for the deposit Tigrinoe are in the ranges: quartz-topaz-mica association 360 to 310, -4.0 (quartz), 395 to 360, -3.0 to -2.0 (topaz), 367 (cassiterite), 130 to 120, -1.0 (fluorite); quartz cassiterite-wolframite association: 355 to 290, -4.0 to -2.0 (quartz), 355, -4 (cassiterite), 126 to 120 (fluorite); pyrrhotite-chalcopyrite 370 to 180 (quartz), stannite-sphalerite 337 to 315, -2.0 (quartz). Quartz from granite porphyry of the stock Zabytoe bears melt inclusions with Th 785-800°C, with LH_2O + G phase that homogenize in L at 190-205°C, hence water content in melt equals about 6-7 wt.%, PH_2O 5-6. Augite from dikes of olivine basalt porphyrites bears S inclusions of pure CO_2 (triple point at -56.6°C), Th -18.5°C (density 1.02 g per cm^2, P at 1200°C 8.5 kbar, depth of trapping ~30 km). (Abstract by A.K.)

SHARKOV, E.V., 1983, Liquation-kinetic stratification in thin basite bodies: Izvestiya Akad. Nauk SSSR Geol., no. 2, p. 14-24 (in Russian).

SHARKOV, Ye.V., 1983a, Problem of petrologic role of liquation in magmatic processes: Geokhimiya, no. 10, p. 1399-1412 (in Russian; English abstract). Author at Inst. Geol. Rudn. Mest., Petrogr., Mineralogy and Geochem. of Acad. Sci. USSR, Moscow, USSR.

The paper discusses the following topics: mechanism of formation of intrusive bodies, main peculiarities of sulfide-silicate immiscibility in intrusives, and possible petrologic role of immiscibility in silicate melts. (A.K.)

SHARKOV, Ye.V., 1983b, Immiscibility-kinetic layering in thin bodies of basites: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 2, p. 14-24 (in Russian). Author at IGEM, Moscow, USSR.

Immiscibility in the Monchetundra and Zlatogorskiy massifs of micronorites and gabbro-norites is described. (A.K.)

SHCHERBA, G.N., LAUMULIN, T.M., KUDRYASHOV, A.V., SENCHILO, N.P., KORMUSHIN, V.A. and MASGUTOV, R.V., 1983, Geological-genetic models of main types of endogeneous rare metal deposits of Kazakhstan, in Genetic models of endogeneous ore formations: "Nauka" Pub. House, Siberian Branch, v. 2, p. 3-14 (in Russian).

The paper bears fluid inclusion data (Th, P, ionic composition) from literature on the following deposits: Losevka (Ta, Nb, Zr), Belaya Gora (Ta, Sn, rare alkalis), E. Kounrad (Mo in quartz veins and greisens), Akchatau-Karaoba (W, Mo, Sn, Bi etc.), Cherdoyak (Sn, W), Katpar (W), Verkhnee Kayrakty (W) and Shagliya (Mo). (A.K.)

SHCHERBAKOV, Yu.G. and ROSLYAKOVA, N.V., 1983, Genetic model of hydrothermal ore formation on the example of gold ore deposits, in Genetic models of endogeneous ore formations: "Nauka" Pub. House, Siberian Branch, v. 2, p. 132-139 (in Russian).

The paper bears numerous fluid inclusion data (Th, solution composition, etc.) essentially quoted from literature. (A.K.)

SHCHERBAN', I.P. and SHUN'KO, V.V., 1983, Chlorite-orthoclase near-ore metasomatites in uranium deposits: Geol. Rudn. Mestorozhd., v. 25, no. 3, p. 43-54 (in Russian). Authors at Inst. Geochem. and Physics of Minerals of Acad. Sci. of Ukrainian SSR, Kiev, Ukraine.

Calcite from metasomatites of internal zone bears P inclusions with Th 120-250°C, S and PS inclusions with Th <100 or <120°C and S inclusions with Th 70-80°C. (A.K.)

SHELTON, K.L., 1983, Composition and origin of ore-forming fluids in a carbonate-hosted porphyry copper and skarn deposit: a fluid inclusion and stable isotope study of Mines Gaspé, Quebec: Econ. Geol., v. 78, no. 3, p. 387-421. Author at Dept. Geol. & Geophys., Yale Univ., P.O. Box 6666, New Haven, CT 06511.

Essentially the published equivalent of doctoral thesis abstracted in Fluid Inclusion Research--Proceedings of COFFI, v. 15, 1982. (E.R.)

SHELTON, K.L., RYE, D.M. and SO, C.-S., 1983, A stable isotopic and fluid inclusion study of the Weolag W-Mo deposit, Republic of China (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 685. First author at Dept. Geol., Univ. Missouri-Columbia, Columbia, MO 65201.

The Weolag W-Mo deposits are composed of three main sets of quartz veins associated with the Cretaceous Weolagsan granite which intruded carbonate-rich wall rocks, metamorphosing them to calc-silicate rocks. Fluid inclusion data suggest molybdenite, wolframite, and scheelite were deposited between 380 and 220°C from fluids with salinities between 3.7 and 11.1 wt.% eq. NaCl at pressures below 180 bars. Late-stage carbonates and fluorite were deposited between 190 and 150°C. The δD values of fluid inclusion waters suggest W and Mo minerals were deposited from fluids with magmatic isotopic signatures, whereas δD values of fluid inclusions and $\delta^{18}O$ values of late-stage calcites suggest meteoric water dominated fluids below 190°C. The $\delta^{34}S$ values of molybdenite, pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena range from 3.0 to 7.6‰. The $\delta^{34}S(H_2O)$ values calculated for these minerals suggest an igneous source of sulfur with a $\delta^{34}S(\Sigma S)$ value near 3.0‰. The range of $\delta^{34}S$ values for individual minerals is consistent with the range expected due to pH shifts when a fluid in equilibrium with a granite encounters carbonate-bearing wall rocks.

Petrographic studies and C and O isotopic analyses of wall rocks suggest an early pervasive flow of water-rich fluids uniformly through non-mineralized regions during metamorphism, but channeled fluid flow within structurally controlled aquifers and fracture systems during metamorphism and ore deposition in mineralized regions. The overall hydrothermal system was characterized by low water:rock ratios, but local areas with channeled fluid flow and W-Mo mineralization were characterized by high water:rock ratios. (Authors' abstract)

SHEMYAKINA, N.M., 1983, Specific type of low-temperature iron-magnesium metasomatites: Doklady Akad. Nauk SSSR, v. 272, no. 1, p. 193-196 (in Russian). Author at All-Union Sci.-Research Geol. Inst., Leningrad, USSR.

Chlorite metasomatites in a tectonic zone of Baltic Shield yielded Td ≤240°C. (A.K.)

SHIEH, Y.-N., LAN, C.-Y. and HUANG, T.-C., 1983, Stable isotope studies of drill core samples and silica minerals from Tatun geothermal area, Taiwan (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 686.

SHIKAZONO, Naotatsu, 1983, Mineralogical and fluid inclusion studies of rock alterations in Seigoshi gold-silver mining district, western part of Izu peninsula, Japan (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 441-443. Author at Geol. Inst., Faculty of Sci., Univ. Tokyo, Bunkyo-ku, Hongo, Tokyo 113, Japan.

Fluid inclusions in quartz from Type 1 (propylitic) and Type 2 (argillic) alterations were studied. Fluid inclusions from the epidote-prehnite-K feldspar-chlorite zone are liquid-dominated with Th of 220°C to 260°C. Th for the zeolite zone are variable, in the range of 240°C to 350°C. This wide range suggests the boiling of the fluids responsible for the zeolite zone. Liquid/vapor ratio of the fluid inclusions for Type 2 is generally variable and sometimes fluid inclusions with very low liquid/vapor ratio are found together with the fluid inclusions with high liquid/vapor ratio; Th of this type is from 220°C to 420°C. This wide range implies that the liquid/vapor separation existed commonly during the formation of highly silicified zone and alunite zone.

Probable ranges of gaseous fugacities such as fS_2, fO_2, fCO_2 and

fH_2S and pH for each type of alteration have been estimated based on the alteration mineral assemblage, filling temperature data and thermochemical calculations. (From the author's abstract)

SHIKAZONO, Naotatsu and HOLLAND, H.D., 1983, The partitioning of strontium between anhydrite and aqueous solutions from 150° to 250°C: Econ. Geol. Monograph 5, p. 320-328. First author at Geol. Inst., Univ. Tokyo, Bunkyo-ku, Hongo, Tokyo 113, Japan.

The partitioning of strontium between anhydrite and mixtures of seawater with NaCl solutions has been studied experimentally. Anhydrite was precipitated by heating mixtures of seawater and NaCl solutions to temperatures between 150° and 250°C. It was found that the partition coefficient of Sr in this system depends less on the NaCl concentration, temperature, and precipitation rate than on the degree of supersaturation of the solutions with respect to anhydrite and/or the morphology of the precipitated anhydrite crystals. Acicular anhydrite was precipitated from solutions with a relatively high degree of supersaturation; rectangular anhydrite was precipitated from solutions with low degrees of supersaturation. The partition coefficient of Sr between solutions and rectangular anhydrite at 150°, 200°, and 250°C is 0.35 ± 0.05, 0.24 ± 0.05, and 0.27 ± 0.05, respectively. (Authors' abstract)

SHIKAZONO, Naotatsu, HOLLAND, H.D. and QUIRK, R.F., 1983, Anhydrite in Kuroko deposits: mode of occurrence and depositional mechanisms: Econ. Geol. Monograph 5, p. 329-344. First author at Geol. Inst., Univ. Tokyo, Bunkyo-ku, Hongo, Tokyo 113, Japan.

In the Kuroko deposits of Japan anhydrite is very abundant in sekko ore, which underlies the strata-bound sulfide ores. Anhydrite in sekko ore is usually nodular. The diameters of the anhydrite nodules vary with stratigraphic position and range from a few millimeters to several meters. The pyroclastic rocks in sekko ore horizons have undergone intense hydrothermal alteration. Pyroclastic rocks contianing large amounts of anhydrite are altered to Mg chlorite. Pyroclastic rocks containing sericite and sericite-montmorillonite mixed layer clay minerals generally contain small amounts of anhydrite. The strontium content of the sekko anhydrite ranges from about 200 to 2,000 ppm and tends to increase both stratigraphically upward and according to nodule size. The filling temperature of fluid inclusions in the anhydrites ranges from ca. 240° to 340°C.

The mode of occurrence, texture, Sr content, nature of the contained fluid inclusions, and isotopic composition of Sr, S, and O in anhydrite together with the mineralogy of the sekko ore suggest that anhydrite deposition was probably related to subsurface mixing of fluids. (Authors' abstract)

SHILOBREEVA, S.N., KADIK, A.A. and LUKANIN, O.A., 1983, Volatile loss of magmas of ocean floor as reflection of volatile regime in the magma formation zone: Geokhimiya, no. 9, p. 1257-1274 (in Russian; English abstract). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The paper presents regularities of volatile loss by H_2O- and CO_2-bearing magmas, contents of H_2O and CO_2 in quench products of magmatic effusions on the ocean floor, possible ratios $CO_2/(CO_2 + H_2O)$ and H_2O contents in magmatic melts under deep conditions, composition of fluid phase of magmas, and possible relation between H_2O and CO_2 in the zone of magma formation. (A.K.)

SHINKAREV, N.F. and GRIGOR'EVA, L.V., 1983, Transport of deep-seated substance and ore-forming fluids: Zapiski Vses. Mineralog. Obshch., v.

112, no. 1, p. 28-41 (in Russian). First author at Leningrad Univ., USSR.

The paper presents discussion on the following topics: sources of volatile components in mantle and generation of magmas, conditions of separation of fluids from magmas and evolution of post-magmatic fluids. (A.K.)

SHISHAKOVA, L.N., PAL'MOVA, L.G. and BITSOEV, K.B., 1983, Use of thermobarogeochemical methods in the study of a gold-silver deposit: Tr. Tsentr. N.-i. Geol.-razved. In-t Tsv. i Blagorod. Met., no. 178, p. 16-24 (in Russian). From Ref. Zh, Geol. 1984, Abstr. No. 8V228.

SHKODZINSKIY, V.S. and TRUNILINA, V.A., 1983, Types of magma crystallization: Geokhimiya, no. 6, p. 798-808 (in Russian). Authors at Geol. Inst., Yakutsk, USSR.

Petrological reconstructions, including separation of water and carbon dioxide from magmas. (A.K.)

SHMULOVICH, K.I., 1983, Activity - component concentration ratios in water supercritical solutions, in Proc. First Int'l. Symp. on Hydrothermal Reactions, S. Somiya, ed.: Tōkyo, Gakujutsu Bunken Fukyu-Kai, p. 203-215.

SHMULOVICH, K.I. and KOTOVA, P.P., 1982, Mineral equilibria in a hot H_2O-CO_2-electrolyte fluid: Geokhimiya, no. 10, p. 1440-1453 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 5, p. 146-160, 1983).

SHMULOVICH, K.I., TERESHCHENKO, Ye.N. and KALINICHEV, A.G., 1982, The equation of state and isochors for nonpolar gases up to 2000 K and 10 GPa: Geokhimiya, no. 11, p. 1598-1613 (in Russian; English abstract; translated in Geochem. Int'l., v. 19, no. 5, p. 49-64, 1983). Authors at Inst. Exper. Mineral., Acad. Sci. USSR, Chernogolovka and Odessa Refrigeration-Industry Tech. Inst.

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 15, p. 231. (E.R.)

SHUMLYANSKIY, V.A., 1983, Kimmeridgian fluorite-bearing ore formations of Ukraine: Geol. Rudn. Mestorozhd., v. 25, no. 6, p. 91-97 (in Russian). Author at Inst. Geochem. and Physics of Minerals, Kiev, Ukraine.

Fluorite yielded the following Th (in °C): Podole zone 270-250, 170-110 (calcite 125-105, 86, 60-40, sphalerite 130, barite 60); Voznesenskaya zone 120-110 (calcite 155-120); Pokrovo-Kireevskoe field 280-220, 190-180 (quartz 220-190, calcite 80-50); Slavlyanskoe field 210 (quartz 265-245, 144-120, calcite 260-240, 190-180, 160-120, 120-60, sphalerite 170, cinnabar 150-120, celestite 80); Valury-Markovskaya zone - (calcite 200-180, 160, 120-80). (A.K.)

SHVARTSMAN, L.A., PETROVA, Ye.F., BOGOLYUBSKIY, S.D., MALKIN, V.I. and AFANAS'YEVA, S.A., 1983, Adsorption of hydrogen sulfide on steel: Dokl. Akad. Nauk SSSR, v. 268, no. 2, p. 381-384 (in Russian). Authors at Central Sci.-Research Inst. of Black Metallurgy, Moscow, USSR.

By use of the isotope ^{35}S it was found that adsorption of H_2S on the surface of stainless steel depends on the average grain size; pertinent to opening of inclusions for analysis of gases by ball milling method. (A.K.)

SHVEDENKOV, G.Yu., SHVEDENKOVA, S.V., DASHEVSKIY, Yu.A. and KALININ, D.V., 1983, Phase equilibria in the system muscovite-paragonite-alkali feldspars-H_2O-CO_2: Geol. i Geofiz., no. 1, p. 80-86 (in Russian; English abstract). Authors at Inst. Geol. and Geophysics, Novosibirsk, USSR.

Experimental data for total P = 100 MPa, T 382-621°C, CO_2 content to 0.6 of total volatiles. (A.K.)

SIDOROV, A.A. and VOLKOV, A.V., 1982, On antimonite mineralization of gold ore deposits: Akad. Nauk SSSR, Dokl., v. 266, p. 433-435 (in Russian).

Includes Th values for 8 areas in part from the literature. (E.R.)

SIMAKOV, S.K., 1983, Formation of carbon in mantle fluid during reaction of nitrogen with methane: Dokl. AN SSSR, v. 268, no. 1, p. 206-210 (in Russian). Authors at All-Union Sci.-Research Geol. Inst., Leningrad, USSR.

The paper presents mechanisms of diamond and graphite formation at 800-1400 K, pressure 10-50 kbar, from gas phase. (A.K.)

SIMMONS, Gene and CARUSO, Lou, 1983, Uranium-bearing microcracks: evidence of fluid-rock interactions (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 688. Authors at Dept. Earth & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

Typical observations of sealed microcracks (MC) from several granites: (1) U-bearing MC intersect primary uraniferous minerals. (2) Minerals that seal MCs occur also as (or with) alteration products of plagioclase and mafic minerals. (3) Mafic minerals within 2 cm of MCs wider than 50 μm have been altered and enriched in U. (4) MCs apparently isolated from primary uraniferous minerals often contain U. (5) U-bearing carbonate minerals are ubiquitous crack-sealing phases.

We conclude that: (A) Open microcracks before becoming sealed were the pathways for fluids that interacted with the granites. (B) The fluids leached U from primary uraniferous minerals, effected alteration, and redistributed U locally. (C) The fluids contained CO_2, F, Ca, Fe, U and LREEs. (D) Fluid-rock interaction ceased when microcracks became sealed. (Authors' abstract)

SIMMONS, S.F. and SAWKINS, F.J., 1983, Mineralogic and fluid inclusion studies of the Washington Cu-Mo-W-bearing breccia pipe, Sonora, Mexico: Econ. Geol., v. 78, p. 521-526. Authors at Dept. Geol. & Geophys., Univ. Minnesota, Minneapolis, MN 55455.

Chalcopyrite, molybdenite, and scheelite mineralization within the Washington breccia are spatially and temporally related to phyllic and potassic alteration. Fluid inclusions indicate that fluids responsible for mineral deposition are characterized by a wide range of temperatures, 500° to 250°C, and a bimodal distribution of salinity of approximately 10 equivalent weight percent NaCl and 35 equivalent weight percent NaCl. The pressure regime during mineral deposition fluctuated between 80 and 220 bars and suggests that alternating hydrostatic-lithostatic heads, or throttling, occurred at approximately 1 km depth. Boiling of fluids may in part be responsible for mineral deposition and coincide with decreasing temperatures and possible increasing pH. Hydrothermal explosions along the Bolivar fault were primarily responsible for the formation of the Washington breccia and may have been aided by faulting, hydrofracture, and chemical brecciation. Fluid inclusion data compare favorably with data from other breccia pipes and are similar to intermediate and lower temperatures and salinities observed in porphyry copper deposits. (From the authors' summary)

SIMONEIT, B.R.T., 1983, Organic matter maturation and petroleum genesis:-geothermal versus hydrothermal: Geothermal Resources Council, Spec. Rept. No. 13, p. 215-241.

ŚLÓSARZ, Jadwiga and KARWOWSKI, Łukasz, 1983, Physico-chemical conditions of polymetallic mineralization in the Paleozoic formations of the Myszkow region (NE border zone of the Upper Silesian coal basin): Archiwum Mineral., v. 39, part 1, p. 93-108 (in Polish; English abstract). First author at Geol. Inst., Upper Silesian Branch, Poland.

A polymetallic mineralization associated with the Variscan magmatism occurs within the igneous rocks of type of porphyry and granitoid in the Myszków region. Basing on the investigations of fluidal inclusions it can be stated that the early mineralization involved highly concentrated hot brines (440°C) at pressure of about 80 MPa. Further evolution of the mineral-forming solutions formed several paragenetic assemblages of molybdenum-copper and polymetallic mineralization. Zoning of the mineralization as well as its physico-chemical conditions of origin and close relation with the magmatism prove that this mineralization is associated with the formation of Cu porphyry deposits. (Authors' abstract)

SMITH, N.G., KYLE, J.R. and MAGARA, Kinji, 1983, Geophysical log documentation of fluid migration from compacting shales: a mineralization model from the Devonian strata of the Pine Point area, Canada: Econ. Geol., v. 78, p. 1364-1374.

SMITH, R.C., 1983, Adaptation of SGE-USGS heating-freezing stage for operation down to -196°C - a discussion: Econ. Geol., v. 78, p. 1528-1529. Author at S.G.E., Inc., Dept. Geosci., Univ. Arizona, Tucson, AZ 85721.

A discussion of Pasteris, 1983a (see this issue), and particularly of the temperature readout precision and accuracy. See Pasteris, 1983b, for reply. (E.R.)

SMITH, S.P. and KENNEDY, B.M., 1983, The solubility of noble gases in water and in NaCl brine: Geochim. Cosmochim. Acta, v. 47, p. 503-515.

SMITH, T.J., CLOKE, P.L. and KESLER, S.E., 1983a Evaluation of fluid inclusion gas contents as indicators of conditions of formation (P, T, fO_2) of ore bodies (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 690. First author at St Joe Am. Corp., 7880 12th Ave. South, Minneapolis, MN 55420.

In most cases fluid inclusion homogenization T's provide only minimum estimates of entrapment T. This problem is greatest for inclusions in high T-high P deposits, such as greenstone gold deposits (Porcupine, Ont.; Mother Lode, CA), for which P corrections are probably very large. We have evaluated the potential of equilibrium calculations based on analyzed gas contents for these deposits to indicate conditions of formation (T, P, fO_2). Fluid inclusions from greenstone gold deposits were decrepitated at 550°C and gases analyzed chromatographically; results correlate well with optical measurements of phase volumes in inclusions and CO_2 solubility. At equilibrium at known P and T fugacities of any three of H_2O, CH_4, CO_2, and CO will fix fH_2 and fO_2. At a given P lines for any two reactions will intersect in T-fH_2 space. We estimated fugacities after Kerrick and Jacobs using the modified Redlich-Kwong (MRK) equation. Parameters of CO, N_2, and H_2 were taken the same as for CH_4, or the MRK "a" parameter was scaled using van der Waal's "a" parameters. In all cases T at intersection points falls 100-150°C higher than is geologically reasonable and varies little with P(tot) from 300 to 2000 bars. Calculated $P(H_2)$ at reasonable T for the analyzed C/O ratio implies H_2 leakage and formation of most CO by reaction among remaining components. Even at 2 kb the calculated $P(H_2)$ was less than 10 bars, showing that in all cases H_2 was a minor constituent in the ore forming fluid. (Authors' abstract)

SMITH, T.J., CLOKE, P.L. and KESLER, S.E., 1983, Geochemistry of fluid inclusions from Archean and Phanerozoic gold deposits (abst.): Proc. 29th Annual Inst. Lake Superior Geol., p. 41. Authors at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

Fluid inclusions from various Archean and Phanerozoic gold deposits in metamorphic terrains were examined using a specially designed gas chromatographic analytical system and conventional heating/freezing techniques. The inclusion analyses indicate that, in most cases, the fluids are H_2O-CO_2 or H_2O-CH_4-CO_2 mixtures, with trace amounts of CO and N_2. Heating and freezing measurements indicate the presence of low salinity (<2 equiv. wt.% NaCl), H_2O-CO_2 and H_2O-CH_4-CO_2 fluid inclusions, confirming our analyses. Homogenization of the inclusions occurred at temperatures of 220°C to 380°C. Temperature and $f(O_2)$ determinations were made by plotting reaction lines on $a(O_2)$-temperature diagrams utilizing a recently developed equation of state for supercritical H_2O-CO_2-CH_4 fluids. Our results indicate that the fluids obtained equilibrium at temperatures of 340°C to 500°C and $f(O_2)$'s near the QFM buffer. Isochores, also calculated from the equation of state, indicate high pressures of 2000 to 4000 bars. (Authors' abstract)

SNEE, L.W., SUTTTER, J.F. and KELLY, W.C., 1983, Mineralization history of the Panasqueira, Portugal, tin-tungsten deposit by high-precision 40Ar/39Ar age-spectrum dating of muscovites (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 691. First author at U.S. Geol. Survey, Reston, VA 22092.

A complex thermal and mineralization history for the tin-tungsten deposit in Panasqueira, Portugal, has been determined by high-precision 40Ar/39Ar age-spectrum dating of 13 vein and greisen muscovites. Plateau ages range from 296.3±0.8 to 291.6±0.9 Ma (1σ), requiring a minimum duration of 3 Ma for muscovite precipitation in this deposit. Plateau ages are related to location in the deposit and directly date episodes within the oxide-silicate (OSS) and main sulfide (MSS) stages as defined by Kelly and Rye (Econ. Geology, v. 74, 1979). Two distinct episodes within the OSS occurred at 296.3±0.9 Ma (2 samples) and 292.8±0.9 Ma (2 samples). The younger OSS episode did not reset Ar ages of the older OSS event, though occasionally both are represented in the same specimens. Two episodes also occurred during the MSS - one at 295.8±0.7 Ma (1 sample), the other at 294.1±0.6 Ma (4 samples). The older episode of MSS is generally spatially associated with the older episode of OSS, and the younger MSS with the younger OSS. Muscovites from greisen and altered silica cap in the known cupola area yield a plateau age of 292.1±0.3 Ma (4 samples), indistinguishable from the younger episode of OSS. Small amounts of 40Ar loss superposed on all 13 spectra reflect effects of at least one later, potentially long-lived thermal episode whose temperature did not exceed that of muscovite Ar-retention (320±40°C). This event, likely the pyrrhotite alteration stage (230-360°C or lower; Kelly and Rye, ibid.), occurred between 274 and 291 Ma based on low-temperature steps of Ar age-spectra. These initial high-precision Ar dates call for a long-lived hydrothermal system in which heat and fluid circulation were probably associated with different intrusive centers through time. (Authors' abstract)

SO, C.-S. and SHELTON, K.L., 1983, A sulfur isotopic and fluid inclusion study of the Cu-W-bearing tourmaline breccia pipe, Ilkwang mine, Republic of Korea: Econ. Geol., v. 78, p. 326-332. First author at Dept. Geol., Korea Univ., Seoul, Republic of Korea.

P inclusions in quartz, tourmaline, and scheelite showed Th 305-435°C, Tm -3.0 to -8.2; evidence of boiling was found. These results are generally similar to those found at other breccia pipe deposits. (E.R.)

SO, C.-S., RYE, D.M. and SHELTON, K.L., 1983, Carbon, hydrogen, oxygen and sulfur isotope and fluid inclusion study of the Weolag tungsten-molybdenum deposit, Republic of Korea: fluid histories of metamorphic and ore-forming events: Econ. Geol., v. 78, p. 1551-1573. First author at Dept. Geol., Korea Univ., Seoul, Korea.

The Weolag tungsten-molybdenum mine is located in the Hwanggangri mineralized area within the Ogcheon metamorphic belt of the southern Korean peninsula. The Weolag tungsten-molybdenum deposits are composed of three main sets of parallel fissure-filling quartz veins that are associated with the Weolagsan granite of Cretaceous age which intruded the surrounding carbonate-rich country rocks, metamorphosing them to calc-silicate rocks. Data from fluid inclusions suggest that molybdenite, wolframite, and scheelite were deposited at temperatures between 380° and 220°C from fluids with salinities between 3.7 and 11.1 equivalent wt percent NaCl at pressures below 180 bars. Late-stage carbonates and fluorite were deposited at temperatures between 190° and 150°C. The hydrogen isotope compositions of fluid inclusion waters suggest that tungsten and molybdenum were deposited from fluids dominated by water with a magmatic isotopic signature. The δD values of fluid inclusions and $\delta^{18}O$ values late-stage calcites suggest that meteoric water dominated the Weolag hydrothermal fluids at temperatures below 190°C. The $\delta^{34}S$ values of sulfides within the mine have the following ranges and values: molybdenite, 3.0 to 5.7 per mil; pyrite, 4.5 to 7.6 per mil; pyrrhotite, 4.8 to 5.1 per mil; chalcopyrite, 4.8 per mil; sphalerite, 4.9 to 5.5 per mil; and galena, 3.9 per mil. The $\delta^{34}S(H_2S)$ values calculated for these minerals are consistent with an igneous source of sulfur with a $\delta^{34}S(\Sigma S)$ value near 3.0 per mil. The range of $\delta^{34}S$ values for the individual minerals is consistent with the range expected owing to pH shifts when a hydrothermal fluid in equilibrium with a granite encounters carbonate-bearing wall rocks.

Comparison of results from petrographic studies and carbon and oxygen isotope analyses of carbonate-bearing wall rocks from parts of the districts with tungsten-molybdenum mineralization to parts without mineralization suggests different patterns of hydrothermal fluid flow.

An early, pervasive flow of water-rich fluids which took place uniformly throughout the carbonate rocks during metamorphism is suggested for nonmineralized regions. Channeled fluid flow within structurally controlled aquifers and fracture systems during metamorphism (high water to rock ratios) is suggested for mineralized regions. Later, ore fluids followed these same restricted pathways while depositing ore minerals. Carbon and oxygen isotope analyses of late-stage vein calcites suggest that their oxygen isotope compositions were controlled by exchange of hydrothermal fluids with a large reservoir of igneous rock (low to variable water to rock ratios). The geochemical and isotope data obtained in this study suggest that the overall hydrothermal system at Weolag was characterized by low water to rock ratios, but local areas with channeled fluid flow associated with tungsten-molybdenum mineralization were characterized by high water to rock ratios. (Authors' abstract)

SO, C.-S., SHELTON, K.L. and RYE, D.M., 1983, Geologic, sulfur isotopic, and fluid inclusion study of the Ssang Jeon tungsten mine, Republic of Korea: Econ. Geol., v. 78, p. 157-163. First author at Dept. Geol. & Geophys., Yale Univ., P.O. Box 6666, New Haven, CT 06511.

The Ssang Jeon tungsten mine is a fissure-filling quartz, vein-type deposit within a pegmatite developed along the contact between a granitic gneiss and a hornblende schist. There is no nearby intrusive igneous rock associated with the deposit, although an association with regional Mesozoic volcanism has been suggested.

The major ore minerals are wolframite, scheelite, and arsenopyrite with accessory pyrite, chalcopyrite, and rare bornite.

All fluid inclusions are water-rich and low salinity with 10-25 vol. % vapor. No daughter minerals were observed. Crushing tests suggest that CO_2 is not present in significant concentrations in the inclusion fluids. All of the inclusions homogenize to the liquid phase. The presence of recognizable primary fluid inclusions suggests that the ore vein did not experience a metamorphic event similar to the host schists and gneisses.

Th values (uncorrected for pressure): P inclusions in blue quartz 186-300°C; in white quartz 185-248°; in purple fluorite 186-212°C. No systematic spatial or temporal variations were seen; the mode was ~200°. S inclusions in quartz and fluorite have Th 110-160°C. Salinities 1.4-9.3 wt. % NaCl, with no significant mode seen.

These data, plus isotopic data on S(igneous) and H(meteoric), are compared with other W deposits, and show that the deposit is a hydrothermal quartz vein, not a pegmatite. (E.R.)

SO, C.-S., SHELTON, K.L., SEIDEMANN, D.E. and SKINNER, B.J., 1983, The Dae Hwa tungsten-molybdenum mine, Republic of Korea: a geochemical study: Econ. Geol., v. 78, p. 920-930. First author at Dept. Geol., Korea Univ., Seoul, Korea.

The Dae Hwa W-Mo mine is located approximately 75 km southeast of Seoul within the Precambrian metamorphic belt of the southern Korean peninsula. The Dae Hwa W-Mo deposit is composed of numerous fissure-filling quartz veins contained within Precambrian granitic gneiss adjacent to a contact with a granitic stock of Mesozoic age. K-Ar dates of 88 ± 2 m.y. for biotite from granitic gneiss <25 m from the granitic contact and for muscovite from a W-Mo-bearing ore vein suggest that both tungsten and molybdenum mineralization were contemporaneous with emplacement of the granite and are a direct result of igneous activity. Sulfur isotopic compositions of sulfide minerals from Dae Hwa range from $\delta^{34}S$ values of 2.4 to 4.4 per mil and suggest that the source of sulfur in the deposit was dominantly an igneous source. Carbon and oxygen isotopic analyses of late-stage calcites and dolomites suggest that the Dae Hwa hydrothermal system was dominated by meteoric fluids at temperatures below 240°C. Evidence from fluid inclusions suggests that deposition of molybdenite, wolframite, and scheelite occurred during a period of declining temperatures from 390° to 200°C. Salinities of mineralizing fluids ranged from 2.6 to 14.4 equiv. wt.% NaCl. Evidence from inclusions also suggests a range of pressures from about 100 to 350 bars. This range is consistent with a depth of mineralization near 1,250 m under pressure conditions that alternated between hydrostatic and lithostatic.

Color zoning in large scheelite crystals for which Dae Hwa is famous can be correlated among scheelites within the mine. Fluid inclusion Th and salinities display a general decrease from the central zone toward the edge of the scheelite crystals. The temperature ranges of each zone are consistent from crystal to crystal, but fluid salinities are not. The color zoning of the scheelite crystals is likely due to small changes of the fO_2 of the hydrothermal fluids which are reflected in different oxidation states of trace elements in each of the scheelite zones.

The geochemical data from the Dae Hwa mine are similar to those from other Korean hydrothermal tungsten deposits. These similarities suggest that hydrothermal tungsten deposits in Korea are genetically related to shallow granitic volcanism of Cretaceous age. (Authors' abstract)

SOBOLEV, Alexandre, CLOCCHIATTI, Robert and DHAMELINCOURT, Paul, 1983, Petrology--variations of the temperature, melt composition and water pressure during olivine crystallization in oceanitic rocks from the Piton Fournaise volcano (Réunion Island, 1966 eruption): C.R. Acad. Sci. Paris, Ser. II, v. 296, p. 275-280 (in French).

An optical thermometry study of melt inclusions trapped in olivine phenocrysts obtained from the Piton Fournaise volcano shows that these minerals crystallized in the temperature range of 1240 to 1195°C ± 10°C with a simultaneous change of the melt composition (MgO content from 9 to 7.6% wt.). It is also noticed that the observed rise of Th with the duration of experiments and the simultaneous oxidation of the melt can be inferred as direct signs of water existence in the basaltic system. Water occurrence in the CO_2 bearing coexisting fluid and melt inclusions was proved using a Raman laser microprobe. The spectra were obtained at a temperature near the critical point of H_2O and the $p(H_2O)/p(CO_2)$ ratio was measured. (Authors' abstract)

SOBOLEV, A.V., TSAMERYAN, O.P., ZAKARIADZE, G.S. and SHCHERBOVSKIY, A.Ya., 1983, Compositions and crystallization conditions of melts of volcanic ophiolite complex in Little Caucasus from data of melt inclusion studies: Doklady Akad. Nauk SSSR, v. 272, no. 2, p. 464-468 (in Russian). Authors at Inst. of Geochem. and Anal. Chem., Moscow, USSR.

Rocks of pillow-lava flows, consisting of basalts in Sevano-Akerin zone and metadiabases and andesite-basalts in Veda zone, bear phenocrysts of plagioclase, clinopyroxene and olivine in plagioclase, clinopyroxene, amphibole, olivine, biotite, nepheline, glass and ore mineral matrix. Phenocrysts contain P melt inclusions of 20-40 µm in size, with Th 1110-1210°C (Sevano-Akerin zone) and 1160-1220°C (Veda zone) ± 5°C. Homogenized melt inclusions were analyzed by electron microprobe method. Inclusions in clinopyroxenes have compositions of central and periphery ocean tholeiites, rocks of boninite-marianite sequence and alkaline basalt. From decrepitation of melt inclusions in Ti-augite at 1200°C pressure of "dry" melt is about 5 kbar. Formation of volcanic complex of ophiolite zones appeared from magmas of the Earth zones: mid-ocean ridges, primitive island arcs and zones of ocean and/or continental intracratonic activation. First for paleoocean basin two main types of tholeiite melts were found typical of mid-ocean ridges of the present ocean deeps. The melts reflect complicated history of this basin, from stage of significantly spreading to stage of primitive island arc. (Abstract by A.K.)

SOBOLEV, R.N. and AVILINA, I.V., 1982, Influence of overheating on the duration of magmatic melt crystallization: Vestnik Moskovsk. Univ., Ser. 4, Geologiya, no. 3, p. 25-35 (in Russian).

Considerations on temperatures of intruding magmas, partly with use of reference inclusion data. (A.K.)

SOBOLEV, V.S., PANINA, L.I. and PODGORNIKH, N.M., 1978, Crystallization temperatures of several carbonatite minerals from Siberia, <u>in</u> Proc. of the First Int'l. Symp. on Carbonatites, Pocos de Caldas, MG, Brazil, June 1976, Brazilian Ministry Mines & Energy, p. 215-219.

Mineral thermometric studies of solid and gaseous silicate inclusions from carbonatites of Siberia were carried out. Evidence from the studies favors the crystallization of carbonatite minerals from high temperature salt melt solutions. It was also established that ijolite-melteigite and forsterite-magnetite-apatite rocks originate from silicate magmatic melts at considerably higher temperatures than carbonatites. Therefore, carbonatites are not the source of alkaline magmas and apatite mineralization. The inverse relationship may be more probable. (Authors' abstract)

SOKOLOV, S.V., 1983, Genetic unity of apatite-magnetite ores and carbonatites of alkaline-ultramafic massifs: Geokhimiya, no. 3, p. 438-449 (in Russian, English abstract; translated in Geochem. Int'l., v. 20, no. 2, p. 86-98, 1983). Author at All-Union Sci.-Research Inst. of Mineral Raw Materials, Moscow, USSR.

Minerals of apatite-magnetite ores and carbonatites bear inclusions with the following Th (in °C): Kovdor massif, forsterite (crystallized incs.) 765-900, 740-820; apatite (crystallized incs.) 680-790, 860-890 (G/L + dms) 180-480, P 0.6-2 kbar; Turiy, calcite and apatite (G/L inclusions) 320-380. Td of magnetite, apatite and calcite from Kovdor and Vuorijarvi are in ranges 260-380°C. (A.K.)

SOLOMON, G.C., DILLES, J.H., CRISS, R.E. and TAYLOR, H.P., 1983, $^{18}O/^{16}O$ and D/H characteristics of the Ann-Mason porphyry copper deposit, Yerington, Nevada (abst.): Geol. Soc. Am. Abstracts with Program, v. 15, p. 277. First author at Un. Georgia, Athens, GA 30602.

The 168 m.y. old Ann-Mason porphyry copper deposit was tilted ~90°W, eroded, and is now exposed in plain view as a 5 km-long cross section. Stable isotope and alteration studies suggest that formation waters in the country rocks circulated to a depth of at least 5 km, forming a zone of extensive Na-Ca alteration; this zone is peripheral to and below a central zone of potassic alteration and Cu mineralization that formed from magmatic waters within a porphyry dike swarm above a quartz monzonite cupola. At and above the ore zone, and superimposed on the earlier potassic alteration, is an upwardly expanding zone of pyritic mineralization associated with major albitic (Na), minor sericitic, and flanking propylitic alteration. The main stage is characterized by high-salinity, 280-480+°C fluid inclusions, and the late stage by low-salinity, 180-300°C fluid inclusions. The Yerington batholith has a primary $\delta^{18}O$ whole-rock (WR = +7.0, quartz (Q) = +9.0, and plagioclase (F) = +7.0, with δD biotite (B) = -88. These values were changed by the hydrothermal activity as follows: Potassic: WR = +6.5 to +8.2, δD = -68 to -109 (B); Na-Ca: WR = +5.7 to +6.8, δD = -67 (actinolite); Propylitic: WR = +6.4 to +6.8, δD = -82 to -92 (actinolite); Late Na and sericitic: WR = +9.1 to +10.4, δD = -61 (sericite), -85 (chlorite). The highest $\delta^{18}O$ values occur in the late Na-sericite alteration in the uppermost part of the deposit, associated with low temperatures of alteration and non-equilibrium (reversed) ΔQ-F ^{18}O fractionations as low as -1.0. Contoured $\delta^{18}O$ WR values outline alteration patterns that coincide with inferred hydrothermal flow paths, and could be useful guides to exploration for hidden porphyry copper deposits. (Authors' abstract)

SOLOVOVA, I.P., RYABCHIKOV, I.D., KOVALENKO, V.I. and NAUMOV, V.B., 1982, Inclusions of high-density CO_2 in mantle lherzolites: Akad. Nauk SSSR, Dokl., v. 263, no. 1, p. 179-182 (in Russian; see Translations).

SOMAN, K. and NAIR, N.G.K., 1983 Genesis of chrysoberyl pegmatites of south Kerala, India, and its relation to the tectonic evolution of the region: Trans. Instn. Min. Metall., Sec. B, Appl. Earth Sci., v. 92, p. B154-B159. Authors at Center for Earth Sci. Studies, Trivandrum, India.

In south Kerala, India, chrysoberyl with its varieties,+ sapphire, topaz, zircon and other gemstones are mostly derived from pegmatites, though some also come from the alluvial beds. Chrysoberyl was formed at 440-520°C with $P(H_2O)>4-5$ kb. The formation of chrysoberyl pegmatite possibly took place under granulite-facies P-T conditions towards the closing stage of a major tectono-magmatic event about 445 m.y. ago that affected southwest India, Sri Lanka and Madagascar. The chrysoberyl pegmatites are generally confined to the metapelitic regions, whereas beryl mineralization is more abundant in the pegamtites of charnockitic terrain. The pegmatites give mineral ages of 445-474 m.y. and are younger than those in the Bihar, Rajasthan, Nellore and Mysore belts of India. Mineral ages of zircon and monazite from the beach sands of Chavara, Kerala, could represent granitic intrusion phases and the origin of the placer minerals is attributed to granites and granitic pegmatites. (Authors' abstract)

SOMIYA, Shigeyuki, ed., 1983, Proceedings of the First International Symposium on Hydrothermal Reactions, March 22-26, 1982, Japan: Tokyo, Gakujutsu Bunken Fukyn-Kai, 965 pp.

SOMMER, M.A. and SCHRAMM, L.S., 1983, An analysis of the water concentrations in silicate melt inclusions in quartz phenocrysts from the Bandelier Tuff, Jemez Mountains, New Mexico: Bull. Volcanol., v. 46-3, p. 299-320. First author at Dept. Geol., Florida State Univ., Tallahassee, FL 32306.

We have developed a new direct method for the quantitative measurement of the amounts of volatiles dissolved within silicate melt inclusions in phenocrysts. The method was applied to the determination of water in the Bandelier Tuff of north-central New Mexico. The analytical method utilizes partial pressure capacitance manometer determinations of volatiles separated by fractional freezing subsequent to vacuum heating and decrepitation of quartz phenocrysts containing single phase silicate melt inclusions. Glass concentrations within the phenocrysts were determined by a combination of glass-specific element analysis by electron microprobe and total phenocryst element concentration determinations by atomic absorption-emission spectroscopy. Melt inclusions in quartz phenocrysts of the lower member airfall have an average of 3.99 wt.% water, in the upper member airfall have an average content of 2.11 wt.% water. Melt inclusions in quartz phenocrysts of the lower member ashflow have an average of 0.79 wt.% water. (Authors' abstract)

SØNDERHOLM, Martin and FABRICUS, Johannes, 1983, Fluid-inclusions in calcite cement from fractures from the T-1 well: Report on Geol. Survey of Denmark, Chalk Project, Energiforskningsprojekt - 81, "Oil and gas containing chalk reservoirs in the Danish part of the central Graben", 17 pp. (in English).

It is suggested that the vein calcite in these chalk beds is derived from a mixing of connate pore water and warm brine from dissolved salt beds.

The formation of the fractures and the high temperature of the salt indicates that the salt stock is not in equilibrium with its surroundings, and thus that a renewed diapirism has been active. A possible time for this is the Miocene/Pliocene boundary.

A few inclusions are believed to contain hydrocarbons under pressure. Fluid inclusion work in the future ought to focus upon quartz and other minerals in addition to calcite. (Author's abstract)

SOREY, M.L. and INGEBRITSEN, S.E., 1983, Evolution of liquid-dominated hydrothermal systems with parasitic vapor-dominated zones: Proc. 5th New Zealand Geothermal Workshop, p. 17-22. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

Liquid-dominated hydrothermal systems with parasitic vapor-dominated zones occur in regions of moderate to great topographic relief where upflowing steam and liquid phases separate, with steam rising through a vapor-dominated zone toward areas of steam and steam-heated discharge at relatively high elevations and liquid flowing laterally toward areas of high-chloride spring discharge at relatively low elevations. Numerical simulations of the evolution of such systems demonstrate the hydrogeologic mechanisms responsible for their development, and quantify the factors controlling the corresponding temperature and pressure distributions and the rates of upflow of steam and lateral flow of liquid. (Authors' abstract)

SOTNIKOV, V.I., BERZINA, A.P., NIKITINA, E.I. and KOROLYUK, V.N., 1982, Chlorine and fluorine contents and their distribution in minerals from copper-molybdenum deposits with reference to the peculiarities of mineral-forming process: Proc. XI General Meeting Int'l. Mineral. Assoc., Novosibirsk 4-10 Sept., 1978: Leningrad, Nauka Press, p. 101-108 (in Russian). (Published 1982)

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 11, p. 206, 1978. (E.R.)

SPEAR, F.S. and SELVERSTONE, Jane, 1983, Water exsolution from quartz: Implications for the generation of retrograde metamorphic fluids: Geology, v. 11, p. 82-85. Authors at Center for Geochem., Dept. Earth & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139.

Available data from the literature suggest that the solubility of H_2O in nominally anhydrous minerals such as quartz should increase with increasing metamorphic grade. If this is the case, water should precipitate from the host mineral during cooling and uplift of regionally metamorphosed terranes. Calculations indicate that this mechanism could result in the release of significant quantities of H_2O, which would then be available to participate in retrograde hydration reactions and the formation of fluid inclusions. (Authors' abstract)

SPECHT, D.J., 1983, A new solubility model and its application to the Mississippi Valley lead deposits: M.S. thesis, California State Univ., Hayward, CA, 108 pp.

Indexed under Fluid Inclusions. (E.R.)

SPECZIK, Stanislaw and RYDZEWSKI, Andrzej, 1983, Postmagmatic processes in lower Permian volcanic rocks associated with the Zary pericline south-western Poland: Achiwum Mineral., v. 39, part 1, p. 77-92 (in English). First author at Geol. Faculty of Warsaw Univ., Poland.

The volcanics and associated sedimentary rocks were subjected to postmagmatic alteration processes of varying kinds and intensities. Fluids generated by the crystallizing magma were responsible for extensive autometasomatic alteration. They are in order of decreasing importance: silicification, hematitization, albitization, serpentinization, carbonatization, celadonitization, saussuritization, zeolitization, kaolinitization, and sericitization.

The present petrographic character of the rocks is the result of those processes, while the original rocks are thought to have been basalts and andesites. Epithermal ore minerals such as chalcopyrite, tetrahedrite, sphalerite, galena, bornite, chalcocite, covellite, pyrite, marcasite and hematite and gangue minerals such as quartz, carbonates, and barite are found within the volcanics and the sedimentary rocks adjacent to them. Late-stage epithermal solutions carrying the suite of epithermal were minerals were probably derived from the volcanics. (Authors' abstract).

Th of gas-liquid inclusions in vein quartz range from 120-150°C (but <200°C); quartz of amygdules and phenocrysts homogenize up to 400°C. (E.R.)

SPIRAKIS, C.S., 1983a A possible precipitation mechanism for sulfide minerals in Mississippi Valley-type lead-zinc deposits: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 211-215. Author at U.S. Geol. Survey, MS 916, Box 25046, Federal Center, Denver, CO 80225.

Both experimental and geological evidence suggest that partly oxidized sulfur species may exist as long-lived metastable components of the solutions involved in the genesis of Mississippi Valley-type lead-zinc deposits. Other experiments show that at temperatures relevant to the genesis of these deposits, partly oxidized sulfur species can be reduced by organic matter at a rapid, but not instantaneous, rate. In the case of Mississippi Valley deposits, organic accumulations in the host rocks could have provided the reductant. Wherever the mineralizing solutions encountered organic matter, the partly oxidized sulfur species were reduced to sulfide sulfur. The increase in the activity of sulfide sulfur triggered the precipitation of sulfide minerals. This concept allows sulfur and metals to be transported to the site of mineralization together and it provides a source for the partly oxidized sulfur in pyrite without relying on either sulfate reduction, which is kinetically inhibited at these temperatures, or on sulfide oxidation at sites where oxidizing agents do not appear to have been available. (Author's abstract)

SPIRAKIS, C.S., 1983b Speculation on the roles of sulfur kinetics and metastable sulfur species in convecting meteoric-hydrothermal systems (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 693.

See previous item.

SPULBER, S.D. and RUTHERFORD, M.J., 1983, The origin of rhyolite and plagiogranite in oceanic crust: an experimental study: J. Petr., v. 24, part 1, p. 1-25. Authors at Geol. Sci. Dept., Brown Univ., Providence, RI 02912.

Hydrothermal and anhydrous experiments were conducted on a primitive oceanic tholeiite dredged from the Galapagos Spreading Center (DO8: mg = 0·65, K_2O = 0·06) and on a more evolved oceanic tholeiite from Hawaii (Kilauea: mg = 0·53, K_2O = 0·44) in order to characterize the minerals and residual melts present over the range 10-100 per cent melting. Silicate liquid immiscibility, which occurred in 1 atm DO8 experiments, did not occur in the hydrothermal experiments. (From the authors' abstract)

SROLOVITZ, D.J., PETKOVIC-LUTON, R.A. and LUTON, M.J., 1983, Diffusional relaxation of the dislocation-inclusion repulsion: Philosophical Mag. A, v. 48, no. 5, p. 795-809. Authors at Exxon Res. & Engrg. Co., P.O. Box

45, Linden, NJ 07036, USA.

Deals with elastic interaction between solid inclusions and their matrix during shear. (E.R.)

STANFORD, S.J., 1981, Dating thermal events by fission track annealing, Cerro Prieto geothermal field, Baja California, Mexico: MS thesis, Univ. California, Riverside, CA, 105 pp.

This study is an investigation of the thermal history of the Cerro Prieto geothermal field, where temperatures as high as 350°C have been measured in boreholes penetrating Plio-Pleistocene clastic sediments of the Colorado River delta. The method used was to relate observed temperatures to the fading of spontaneous fission tracks in detrital apatite grains from sandstone drill cuttings. The rate of fading of fission tracks is a function of both temperature and duration of heating. The apparent fission track age of the detrital apatites then, depends both upon the age of their source and upon their thermal history.

Data from laboratory annealing experiments and geologic fading studies were compiled from published sources to produce lines of iso-annealing in time-temperature space for apatite. Fission-track ages were calculated from samples at intervals of increasing depth and temperature in two wells from Cerro Prieto, one with an apparently simple and one with an apparently complex thermal history. The temperature where complete erasure of fission tracks first occurs in well T-366 was found to be between 160° and 180°C. Assuming instantaneous heating to the present temperature and constant temperature thereafter, the annealing data indicate heating has lasted between 10^3 and 10^4 years in this well.

Well M-94 has an apparently complex thermal history. Geothermometers [including fluid inclusion, vitrinite reflectance and oxygen isotope equilibria] in this well indicate temperatures some 50°C to 100°C higher than those measured directly in the borehole. A short, intense thermal event, on the order of 10^1 years in duration, is indicated by the preservation of fission tracks at depths corresponding to paleotemperatures of ~200°C.

A general relationship between rate of heating and temperature of complete annealing of fission tracks in apatite was derived. This permitted corrections of the estimates of heating duration in well T-366 [in which all geothermometers record temperatures similar to the measured temperature] to be made for different rates of heating. Assuming reasonable rates of heating, the maximum duration of heating in this bore is on the order of 10^4 years.

An estimate of the average flow rate through the geothermal system was made using a water-to-rock volume ratio determined by previous light stable isotope studies of hydrothermally altered rocks, along with estimates of reservoir geometry and porosity. Values calculated are between 6 and 60 m/year. The lower estimate is the same order of magnitude as an estimate of the rate of natural recharge by water from the Colorado River. (Author's abstract)

STAROSTIN, V.I., LYCHAKOV, V.A. and GONCHAROVA, T.Ya., 1982, Metamorphic mineral associations in near-ore rocks of the Bulousy deposit of the Rudnyi Altai: Akad. Nauk SSSR Doklady, v. 264, no. 4, p. 933-937 (in Russian). Authors at Moscow State Univ., Moscow, USSR.

Amphibolite quartz-bearing rocks yield Th 500-700°C, P 3-6 kbar; pyrite-polymetallic ores formed at 600-900°C, 5-6 kbar. (A.K.)

STEELE, I.M., 1983, Factors affecting hydrogen determinations by ion microprobe (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p.

696. Author at Dept. Geophy. Sci., The Univ. Chicago, Chicago, IL 60637.

The ability to determine hydrogen in both hydrous and anhydrous minerals is limited by: (1) instrumental hydrogen background; (2) matrix effect on hydrogen ion yield; (3) availability of homogeneous standards. Using an assortment of hydrogen-bearing minerals and glasses we have attempted to quantify these limitations under routine operating conditions of our AEI ion microprobe. Instrumental background can be determined using an assumed H-free sample or by extrapolating a calibration curve to zero-H. The later procedure shows an H-background for H-bearing glasses equivalent to 0.25 wt.% H_2O; higher values (3x) are present with poor vacuum conditions. This determination requires either analyzed samples or synthetic samples with controlled H contents. The background gives a detection level for reasonable counting times of about 0.02 wt.% H_2O.

The yield of H secondary ions varies with matrix composition. For comparison cts/%H_2O for basalt, andesite and rhyolite glass are 2700, 2000, 1670/sec. for a 5 namp focused beam of $^{-}O_{16}$. For hornblende cts/%H_2O are 6700/sec compared to 850/sec for scapolites; within each mineral type a linear relation is present. The wider sensitivity for minerals compared to glasses suggests that structural site of H as well as matrix composition may affect the secondary H yield. These variations require that ion probe determinations of H must be referenced to similar standards.

Both background determination and standard calibration require a suite of analyzed samples, a difficult analytical problem. Analysis of H in synthetic andesite glasses shows better precision than similar data for analyzed natural basaltic and rhyolitic glasses suggesting that the natural samples may not be homogeneous. NASA NAG 9-47. NSF EAR 8206191 (Author's abstract)

STEIN, C.L., 1983, Freezing point depressions and laser Raman spectroscopy of fluid inclusions in halite from the Delaware basin, southeastern New Mexico (abst.): EOS, v. 64, p. 344. Author at Div. 9731, Sandia Nat'l. Labs., Albuquerque, NM 87185.

A suite of samples was selected from core obtained during exploratory drilling for the proposed Waste Isolation Pilot Plant near Carlsbad, NM, under the auspices of the US Dept. of Energy. These samples were composed primarily of halite from the Upper Permian Castile and lower Salado Formations; fluid inclusion content averaged about 0.7-1.0% by volume. A preliminary study of these inclusions showed a wide range of freezing temperatures, apparently unrelated to fluid inclusion type, sedimentary facies, or depth. Very low freezing points (-20°C - -40°C) from both primary and secondary inclusions were often observed in close proximity to anhydrite beds; higher freezing temperatures (-10° - ≥0°C) usually occurred in more massive halite layers. This variation in freezing points may reflect equilibration with a diverse mineralogy.

Laser Raman spectroscopic analyses for SO_4 in inclusion fluids from these samples showed no correlation between SO_4^{--} content and freezing point depression, regardless of inclusion type. The sulfate values were constant through the Castile, a bedded halite-anhydrite sequence, and then decreased markedly in the lower Salado, primarily halite. This trend suggests an overall change in composition that is consistent with the chemical evolution of this basin toward the end of the Permian. This evidence also indicates that the fluid inclusions from at least this portion of the section have not migrated any significant vertical distance since the halite was deposited. (Author's abstract)

STEMPROK, Miroslav and VOLDAN, Jan, 1983, Solubility of molybdenum oxide in granite melts: Věstnik Ustředního ústavu geologického, v. 58, no. 2, p. 79-89.

STENDAL, H. and GHISLER, M., 1983, Stratabound copper sulfide and hydrothermal scheelite, arsenopyrite and base metal mineralization in the Caledonides of East Greenland; a review (abst.): Int'l. Geol. Correlation Program Project 60, Symp. on Stratabound Sulfides of the Appalachian-Caledonian Orogen, Ottawa, Ontario, Canada, Sept. 16-17, 1983, Program and Abstracts, p. 27. Authors at Inst. Gen. Geol., Univ. Copenhagen, KD-1350 Copenhagen K, Denmark.

In the central East Greenland Caledonides numerous stratabound copper mineralizations and hydrothermal mineralizations of arsenic and tungsten occur. The host rocks for the mineralization are metasediments of middle Proterozoic and unmetamorphosed to slightly metamorphosed late Proterozoic sediments (quartzite, shale, limestone), all intruded by Caledonian granites.

Stratabound copper mineralization up to 2 m thick is found at 8 different stratigraphic levels in late Proterozoic shale and quartzite, and extends over a distance of 275 km. The parageneses in the shale are dominated by chalcopyrite-pyrite, bornite-chalcocite, or chalcocite. In the quartzite the sulphide associations are chalcopyrite-pyrite-(pyrrhotite) or chalcopyrite-pyrite-(tetrahedrite). In addition stratabound sulphide-bearing veins occur. The grade of the mineralized zones varies from 0.25-1.5% Cu. The stratabound copper sulphides were probably mainly concentrated by diagenetic processes and show similarities with parts of the Zambian copper belt.

Hydrothermal scheelite and arsenopyrite mineralization is mainly located close to the border zone between the Central Metamorphic Complex and the late Proterozoic sediments.

Three main types of scheelite mineralization occur: 1) a skarn type, 2) a vein type and 3) a breccia type. The skarn type is hosted by marble, schist, and calc-silicate rocks. The tungsten content varies from 0.1-1% W with enrichment of the elements Be, Bi, F, Li, and Sn. Scheelite-mineralization in quartz veins yields 0.1% W associated with enhanced contents of As, Be, Bi, Fi, Li, Pb, and Sn. The skarn and vein types are closely related to Caledonian granitic intrusions. The scheelite (± stibnite) mineralized breccia type is found in fault zones probably connected with a granite. These occurrences contain 0.8-3% W and up to 2.4% Sb and represent at the moment the only mineral deposits of potential economic interest in the area.

The arsenopyrite mineralization is regionally widespread. Mineralized quartz veins occur in both quartzitic and semipelitic sediments, whereas mineralized fracture zones are restricted to semipelitic quartzite. Arsenopyrite is also found in pegmatites and in greisen. The arsenopyrite mineralization is often associated with scheelite, galena, pyrrhotite, chalcopyrite, sphalerite and traces of gold and silver.

The distribution of the elements in the scheelite and arsenopyrite mineralization indicates a zonation around the Caledonian granites. In general, elements as Be, Bi, F, Li, and Sn are concentrated within 1-2 km from the contact. At a greater distance up to 7 km the metals Bi, Co, Cu, Pb, and Zn are typical. Fluid inclusions of the veins show homogenization temperatures of boiling carbon dioxide-bearing water of moderate salinity at 225-260°C and a pressure of approximately 1 Kb. (Authors' abstract)

STEPANOV, S.N., PIPOVA, Z.M. and NARSEEV, A.V., 1983, Interpretation of thermobarogeochemical data during construction of a model of the evolution of a mineral-forming solution: Vestn. Akad. Nauk Kaz. SSSR, 1983, no. 12, p. 45-48 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

STIEHL, G., HAENDEL, D. and GUNTHER, U., 1983, Isotopic variations of nitrogen in granite and mica schist of contact zones of intrusives in the middle Erzgebirge (abst.): ZfI-Mitteilungen (papers of the Central Inst. of Isotope and Radiation Research of the Acad. Sci. GDR), v. 80, p. 133 (in German).

STONELEY, Robert, 1983, Fibrous calcite veins, overpressures, and primary oil migration: AAPG Bull., v. 67, p. 1427-1428. Author at Dept. Geol., Royal Sch. Mines, Imperial College Sci. & Tech., Prince Consort Rd., London SW7 2BP, England.

The fibrous calcite veins, found parallel to the bedding of certain shales, may have been formed during burial as a consequence of overpressuring. Their presence could even be indicative of former overpressures. This suggestion, if it can be upheld, carries implications for theories of primary oil migration. (Author's abstract)

STRAUCH, G., KAMPF, H., THOMAS, R., GEISLER, M., HAASE, G. and STIEHL, G., 1983, Isotopic geochemical, thermobarogeochemical and elemental geochemical investigations of a hydrothermal fluorite mineralization from the southern part of the GDR (abst.): ZfI-Mitteilungen (papers of the Central Inst. of Isotope and Radiation Research of the Acad. Sci. GDR), v. 80, p. 40-41 (in German). First author at Central Inst. Isotope & Radiation Research, 7050 Leipzig, Permoserstrasse 15, GDR.

A late- to postvariscan hydrothermal fluorite mineralization in the southern part of the GDR was the subject of a complex investigation with isotopic geochemical, thermobarogeochemical and elemental geochemical methods. (Abstract by R. Thomas)

STRNAD, Z. and McMILLAN, P.W., 1983, Metastable two-liquid tie lines in the soda-lime-silica system: Phys. & Chem. of Glasses, v. 24, no. 3, p. 57-64.

STUDEMEISTER, P.A., 1983, The origin of mercury deposits in the California coast ranges (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A66. Author at Geol. Dept., Univ. Ottawa, Ottawa, Ontario, Canada K1N 6N5.

Mercury deposits in western California are in or near the Coast Ranges thrust fault that separates two Mesozoic groups of rocks. The Franciscan Assemblage is a metamorphosed melange with serpentine and the structurally overlying Great Valley Sequence is a layered series of mudstone, sandstone, plus conglomerate resting on oceanic crust. Volcanic and sedimentary rocks of Cenozoic age sparsely cover the Mesozoic basement of the Coast Ranges. Cinnabar with quartz, dolomite, magnesite, zeolite, and kaolinite fills fractures traversing the margin of serpentine bodies or the younger series of volcanic and sedimentary rocks. Accessories with cinnabar are pyrite, marcasite, metacinnabar, stibnite, native mercury, and bituminous matter. The base metal-forming minerals are scarce and native gold is reported in a few deposits. Fluid inclusions and hot springs suggest cinnabar concentrated from hot fluids with <5000 ppm chlorine at $T<250$°C and $P<0.2$ kb. The major producer in the Coast Ranges was the New Almaden mine with 30×10^6 kg Hg.

Compaction and volatilization of the Franciscan Assemblage along the sole of the Coast Ranges thrust generated hot CO_2-H_2O fluids bearing mercury. These fluids migrated upward along the thrust fault and conjugate fractures, cooled and reacted with wallrocks to precipitate cinnabar, quartz, and dolomite. Gold may be associated with cinnabar deposits because the base metals are scarce and the fluids were of low salinity, features common to lode gold deposits. (Author's abstract)

STUEBER, A.M. and PUSHKAR, Paul, 1983, Application of strontium isotopes to origin of Smackover brines and diagenetic phases, southern Arkansas (abst.): Abstracts AAPG Ann. Conv., Dallas 1983, p. 166.

SUGISAKI, Ryuichi, IDO, Masahiko, TAKEDA, Hiroshi, ISOBE, Yumiko, HAYASHI, Yoshimitsu, NAKAMURA, Noriaki, SATAKE, Hiroshi and MIZUTANI, Yoshihiko, 1983, Origin of hydrogen and carbon dioxide in fault gases and its relation to fault activity: The J. Geol., v. 91, no. 3, p. 239-258.

SUKHANOV, M.K., RACHKOV, V.S. and SONYUSHKIN, V.Ye., 1983, Anorthosites of the Anabar Shield: Izvestia Akad. Nauk SSSR, Ser. Geol., no. 6, p. 29-42 (in Russian). First author at IGEM, Moscow, USSR.

Anorthosites spatially connected with rocks metamorphosed under conditions of amphibolite facies bear in plagioclase the following gas components (in ml per g): H_2O 0.60, CO_2 0.08, CO 0.04, CH_4 traces, H_2 0.09, N_2 0.10; same for metaanorthosites (with amphibole) H_2O 1.76, CO_2 0.97, CO 0.28, CH_4 traces, H_2 0.10, N_2 0.1; adjacent granulites - H_2O 0.76, CO_2 0.07, CO 0.05, CH_4 0.006, H_2 0.10, N_2 0.03. Determinations were made by high-T chromatography (Letnikov's method - gas release by calcination of sample at 800-900°C). (Abstract by A.K.)

SUSTAVOV, O.A., 1983, Submicroscopic gas-liquid inclusions in ore-bearing quartz from Yakutia: Doklady Akad. Nauk SSSR, v. 271, no. 3, p. 691-694 (in Russian). Author at the Mining Institute, Sverdlovsk, USSR.

In N. and E. Yakutia the Upper Triassic and Lower Permian [the sequence suggests here a possible misprint for Upper Permian and Lower Triassic, A.K.] sandstone-shale beds contain mineralization of gold-quartz sulfide-poor and gold-antimonite types. Milky-white vein quartz is the main barren mineral and it bears very abundant G/L inclusions. Most inclusions have dimensions <1 μm, filling of rare larger inclusions was recognized to be LH_2O + G or LCO_2 + LH_2O + G with Th 280-350°C in L phase. Due to presence of very small inclusions, the light transmission coefficient for quartz does not exceed 1-3%. Decrepitation activity is very low and after heating at 800°C for several hours most inclusions remain unopened. IR spectra of quartz contain intensive absorption bands of water and weak bands of CO_2. Density of quartz is about 0.015 g per cm^3 lower than of pure quartz, that means that 1 cm^3 of quartz contains 10^{10} inclusions of dia. 0.2 μm. The paper presents also the frequency of occurrence of quartz bearing submicroscopic inclusions in various types of deposits. (Abstract by A.K.)

SUTTER, J.F., HARTUNG, J.B. and KELLY, W.C., 1983, Laser probe $^{40}Ar/^{39}Ar$ dating of individual muscovite grains from the tin-tungsten mineralization at Panasqueira, Portugal (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 702. First author at U.S. Geol. Survey, Reston, VA 22092.

A laser-probe mass spectrometer for $^{40}Ar/^{39}Ar$ dating has recently been made operational at the U.S. Geological Survey, Reston, Va. This microanalytical technique involves focusing a pulsed laser beam onto a sample contained in a vacuum chamber attached to a mass spectrometer. Argon in the neutron-irradiated sample is released by heating with the laser pulse and its isotopic composition is measured to yield an $^{40}Ar/^{39}Ar$ age.

Individual muscovite grains (conventional $^{40}Ar/^{39}Ar$ total fusion age of 290 Ma) from a greisen in the tin-tungsten mineralized zone at Panasqueira, Portugal, yield the following laser $^{40}Ar/^{39}Ar$ ages: 320 Ma (about 1.5 μg of muscovite melted); 298 Ma (about 4 μg); 287 Ma (about 6 μg); 289 Ma (about 11 μg). These results show that precise ages can be measured on as little as 5-10 μg of muscovite.

The diameter of the area melted by a single pulse of the laser beam (spot size) can be varied by focusing the beam through a microscope. Spot location can be controlled to about 10 μm using the current system. Based on potassium content and age, a suitable number of spots must be melted to produce a measurable quantity of argon for the age determination. Laser $^{40}Ar/^{39}Ar$ ages of single mica grains measured in situ can aid greatly in understanding the chronology of many mineralized zones where micas are present but are not separable mineral phases in quantitites needed for conventional age dating (10^4 to 10^5 μg of pure mineral). In addition, in situ dating of superimposed growths of mica in single specimens could help in establishing the minimum duration of various stages of a complex mineralization event. (Authors' abstract)

SVEINBJORNSDOTTIR, A.E., 1983, Water-rock interaction in Krafla and Reykjanes geothermal systems, Iceland (abst.): J. Geol. Soc. London, v. 140, p. 549-550.

SVERJENSKY, D.A., 1983, Chemistry of water-rock interactions in the aquifers of sedimentary carbonate and sandstone-hosted base-metal sulfide ore deposits (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 703.

SVISERO, D.P., 1978, Chemical composition, origin and geological significance of mineral inclusions in diamonds from Brazil: Assoc. Professorship thesis, The Univ. Sao Paulo, Brazil, 165 pp. (in Portuguese).

The author mentions the existence of descriptions of fluid inclusions since last century and refers to the determinations of gaseous fluids with C, H, N, and O (mainly H_2O and CO_2) from diamonds fractured in vacuum. He presents several S.E.M. micrographs showing cavities which were supposedly filled with those fluids. (Abridged from the text by K. Fuzikawa)

SWART, P.K., PILLINGER, C.T., MILLEDGE, H.J. and SEAL, M., 1983, Carbon isotopic variation within individual diamonds: Nature, v. 303, p. 793-795. First author at Lab. for Comparitive Sedimentology, Univ. Miami, Fisher Island Station, Miami Beach, FL 33139, USA.

Various regions of type I diamonds have been analyzed to determine intra-specimen variation in carbon isotopic abundance. We report here that generally, although not in all cases, a trend was observed from the center to the exterior. The cores of some samples were isotopically light (enriched in ^{12}C) whereas the edges became progressively heavier. For the specimen showing the greatest spread of $\delta^{13}C$ values, the range observed covered almost 4‰ from -11.01 to -7.32‰. Such changes could be interpreted according to one or a combination of fractionation processes. Since diamonds exhibit a wide range of $\delta^{13}C$ values (+2.7 to -34.4‰) and many specimens show evidence of heterogeneity, we have looked for isotopic differences between areas in individual diamonds which might reasonably be expected to have been formed in different conditions. The small scale of such internal structures in diamond requires the accurate excision of selected volumes. Such a requirement can now be met by controlled laser dissection. As a preliminary to realizing the full potential of such an approach, we have examined the exteriors and core of coated diamonds, as representing one of the most conspicuous instances in which two distinct epochs of diamond genesis might be involved. (Authors' abstract)

TAGUCHI, Sachihiro and HAYASHI, Masao, 1983a Fluid inclusion study in some geothermal fields of Kyushu, Japan (extended abstract): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 459-462. Authors at Res. Inst. Industrial Sci., Kyushu Univ. 86, Kasuga, Fukuoka 816, Japan.

Homogenization temperatures of fluid inclusions have been measured on quartz, amorphous silica, anhydrite, and calcite from the very active Hatchobaru geothermal field and the less active Kirishima geothermal field, Kyushu, Japan. They are both of water-dominated. Th at Hatchobaru are in narrow ranges at each depth, while those at Kirishima have wide ranges probably due to the cooling of the system. This paper discusses the thermal structure and the thermal history of the very active and less active geothermal fields. (From the text)

TAGUCHI, Sachihiro and HAYASHI, Masao, 1983b Past and present subsurface thermal structures of the Kirishima geothermal area, Japan: Geother. Resources Council, Transactions, v. 7, p. 199-203. Authors at Research Inst. of Industrial Sci., Kyushu Univ. 86, Kauga, Fukuoka 816, Japan.

The homogenization temperature of fluid inclusions has been measured on hydrothermal quartz, anhydrite and calcite found in cores and cuttings from the Kirishima geothermal area, Japan. The results show that the homogenization temperatures have a wide range at each depth, usually 45 to 100°C for the inclusions from the North Kirishima geothermal field, and 20 to 45°C for those from the West Kirishima geothermal field. The distribution of homogenization temperatures suggests that the Kirishima geothermal area has cooled down to some extent, and the cooling degree in the North Kirishima field is larger than that of the West Kirishima field. The cooling began to progress from the margin of Kirishima Volcano, and seems to have been controlled also by fault systems in the area. (Authors' abstract)

TAKAMATSU, Nobuki, IMAHASHIM Masayuki, SHIMODAIRA, Kyoko and KAMIYA, Hiroshi, 1983, The dissolution of lithium minerals in salt solutions: Implication for the lithium content of saline waters: Geochem. J., v. 17, p. 153-160. First author at Dept. Chem., Toho Univ., Miyama, Funabashi, Chiba 274, Japan.

Lithium minerals, petalite ($Li[AlSi_4O_{10}]$) and lepidolite ($K_2(Li, Al)_{5-6}[Si_{6-7}Al_{2-1}O_{20}](OH, F)_4$), were reacted with seawater and NaCl solutions for 240 hours at 150 to 250°C and with a water/mineral ratio of 25 by weight, to clarify the role of dissolved salts on the enrichment of lithium in natural saline waters such as coastal thermal waters and fossil seawaters. Lithium leaching from the minerals was enhanced with increasing salt concentration and temperature. It was proved from the experiments using various salt solutions that NaCl solution and seawater are effective for the leaching of lithium from rocks and that even the altered seawaters containing low magnesium have the ability to extract lithium from rocks. This investigation suggests that the non-volcanic saline waters of high lithium content (e.g. fossil seawater) can be produced by a long term seawater-rock interaction at relatively low temperature without a contribution from the so-called "magmatic emanation." (Authors' abstract)

TAKENOUCHI, Sukune, 1983a Fluid inclusion study of the Nansatsu-type deposits, Southern Kyushu: Mining Geol. (Japan), v. 33, no. 4, p. 237-245 (in Japanese with English abstract; see Translations).

TAKENOUCHI, Sukune, 1983b Fluid inclusion study of hot spring-type gold deposits and geothermal areas (abst.): Fourth Int'l. Symp. on Water-Rock Interaction, Aug. 29-Sept. 3, 1983, Misasa, Japan, p. 468-471. Author at Dept. Mineral Dev. Engrg., Univ. Tokyo, Tokyo 113, Japan.

Fluid inclusions in quartz from gold disseminated siliceous bodies in Southern Kyushu and from a siliceous body in the Doroyu geothermal area in Akita, were studied. These siliceous bodies would have been formed by acid hydrothermal solutions near the surface. Th ranges between 120° and 275°C for the gold deposits in Kyushu, and between 175° and 275°C for the siliceous body in Akita. Fluctuation of fluid pressure is suggested from the occurrence of fluid inclusions and temperature data. (Author's abstract)

TAKENOUCHI, Sukune and ICHIKUNI, Masami, 1982, Analytical studies of fluid inclusions: The J. of the Japanese Assoc. Mineralogists, Petrologists & Economic Geolgists, Spec. Vol. 3, p. 331-340 (in Japanese; English abstract).

Laser microanalysis (LMA) and neutron activation analysis were carried out on fluid inclusions in quartz from several types of ore deposits. LMA method was used in order to check the presence of base metals in polyphase fluid inclusions in quartz from the Taishu Pb-Zn veins, Nagasaki, and the St. Tomas II porphyry copper deposit in the Philippines. Spectra of Cu, Ag, Fe, Ca and Al were detected. Na line was weak in spite of high salinities of these polyphase inclusions. Neutron activation analysis revealed that those quartz samples containing a large number of high-salinity polyphase inclusions gave reasonable values of sodium, potassium and chlorine, and that the samples from tungsten deposits showed high values of potassium and much lower chlorine compared to the alkali content. Presence of carbonate complexes in the ore-forming fluids of tungsten deposits is discussed in connection with the fact that fluid inclusions containing a large amount of CO_2 were occasionally observed in minerals from tungsten deposits. The water content in fluid inclusions was determined, and salinities of aqueous solutions were calculated from the obtained analytical data. Salinities of fluid inclusions in samples from porphyry copper deposits were high, meanwhile those of tungsten deposits were much lower. (Authors' abstract)

TALLANT, D.R. and HIGGINS, K.L., 1983, Materials characterization with macro/micro laser Raman spectroscopy; L.I.A. [Laser Instrum. Assoc.], v. 42, ICALEO [Int'l. Conf. Applied Laser Electro Optics], 1983, p. 12-19. Authors at Sandia Nat'l. Labs., Div. 1823, P.O. Box 5800, Albuquerque, NM 87185.

A slightly more detailed version of material in following item. (E.R.)

TALLANT, D.R., HIGGINS, K.L. and STEIN, C.L., 1983, Raman microscopy through transparent materials: Microbeam Analysis, Ron Gooley, ed.: San Francisco, San Francisco Press, p. 297-300. Authors at Sandia Nat'l. Labs., Albuquerque, NM 87185.

As one example of three, SO_4 ion was determined in brine inclusions in halite from the Delaware Basin, New Mexico, using standard solutions for calibration. SO_4 concentrations varied somewhat with depth, from 4000 to 20000 ppm SO_4. (E.R.)

TALTYKIN, Yu.V., LIPATOV, V.G. and ABLESIMOV, N.Ye., 1983, Supercritical fluids as factors in generation of deep electrical conductivity anomalies: Dokl. Akad. Nauk SSSR, v. 272, no. 4, p. 935-936 (in Russian).

TAYLOR, B.E. and CRAMER, R.S., 1983, Oxygen, hydrogen, and sulfur isotope geochemistry of the Gray Eagle Cu-Zn-Au deposit, Siskiyou Co., California:

fingerprint of a paleohydrothermal system (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A67. Authors at Dept. Geol., Univ. California, Davis, CA 95616.

The Gray Eagle massive sulfide (py+cpy+po+sphal) deposit is hosted by greenschist metamorphosed Jurassic calc-alkaline volcaniclastic and sedimentary rocks of the Galice formation. Isotopic analysis of samples from drill core throughout the deposit permitted construction of the three dimensional record of fluid-rock interaction above and below the sulfide horizon. Although a mineralogically distinct stockwork zone is not observed in the Gray Eagle host rocks, patterns of ^{18}O depletion indicate the presence of a hydrothermal vent area. ^{18}O depletion is more extensive and localized in the *overlying* host rocks, where $\delta^{18}O$ varies from +15.9 to +5.8‰. This pattern of ^{18}O exchange is concentric about the east-central portion of the deposit, recording locally higher water/rock ratios expected in the vent area. These data suggest that (1) the deposit has been overturned, and (2) some hydrothermal activity persisted after sulfide deposition.

δD (whole rock) values from the host rock have a narrow range of -38 to -43‰, essentially reflecting the isotopic composition of chlorite. No gradients in δD were identified, although a slight increase in water content characterizes samples nearer the delineated vent area. The oxygen and hydrogen isotope data indicate that evolved sea water constituted the hydrothermal fluid ($\delta^{18}O$ = 0 to +5‰ and δD = -10 to +10‰, calculated from quartz and chlorite data). Fluid inclusion studies indicate that the hydrothermal fluid reached temperatures of 176 to 358° during sulfide deposition.

The $\delta^{34}S$ values of pyrite from the sulfide horizon vary from 0 to +3.4‰, and are compatible with a reduced (i.e., H_2S dominant) hydrothermal fluid and a dominantly magmatic (leached?) source of sulfur. (Authors' abstract)

TAYLOR, B.E., EICHELBERGER, J.C. and WESTRICH, H.R., 1983, Hydrogen isotope fractionation during degassing of rhyolitic magma (abst.): EOS, v. 64, p. 341-342. First author at Dept. Geol., Univ. California, Davis, CA 95616.

The hydrogen isotope compositions and water contents of fresh obsidian clasts in tephra decrease from -63 to -90‰ δD and 1.93 to 0.41 wt.%, respectively, within eruption sequences for a number of sites studied in California and Oregon. Oxygen isotope compositions do not vary more than 0.3‰ in any one group of samples ($\delta^{18}O$ = +7.4 to +8.1, total range), indicating that the water contents (and δD values) are primary. These isotopic relationships indicate a progressive depletion of the melt in water and deuterium due to exsolution of vapor bubbles and escape of vapor accompanied by isotopic fractionation. The amount of water lost by degassing *prior* to explosive eruption is indicated by the degree of isotopic depletion, and may be modelled as Rayleigh distillation.

Obsidian flows characteristically have *low* water contents (~0.2 wt.%) and δD values (-118 to -131‰). A vertical section through one rhyolite obsidian flow indicates a range of water content from 0.21 ± 0.03 wt.% near the base, to 0.34 ± 0.06 wt.% beneath an upper pumice zone. δD varies upward from -130 to -107‰. By comparison to tephra obsidian clasts and solubility data, flow obsidian represents magma degassed to 1 atm vapor pressure during extrusion and subsequently welded. Variations in H_2O and δD are attributable to variable resorption of D-enriched vapor prior to completion of welding within the flow. (Authors' abstract)

TAYLOR, B.E. and FRIEDRICHSEN, Hans, 1983, Oxygen and hydrogen isotope disequilibria in the Landsverk I pegmatite, Evje, southern Norway: evidence for anomalous hydrothermal fluids: Geologisk Tidsskr., v. 4, p. 199-209. First author at Dept. Geol., Univ. California, Davis, CA 95616, USA.

Oxygen isotope analysis of certain quartz, amazonite feldspar, and epidote from the Landsverk I pegmatite near Evje, southern Norway, indicates extreme local ^{18}O depletion. The $\delta^{18}O$ values of massive, milky white breccia-filling quartz are as light as -7.4‰. Marked oxygen isotope exchange was found for amazonite, but not for fragments of microcline perthite in the breccia. ^{18}O depletion of this magnitude is characteristic of meteoric-hydrothermally altered rocks, and the isotopic composition of the appropriate meteoric water is estimated to have been $\delta^{18}O$ = 16.0‰ and δD = -125‰. However, the δD values of water in only one fluid inclusion sample provide supportive evidence for the presence of meteoric water, and no large-scale hydrothermal alteration systems are as yet known for the area. The oxygen and hydrogen isotope compositions of Precambrian(?) meteoric water may not correspond to the Epstein-Craig equation for present-day waters. ^{18}O depletion by CO_2 exsolution from a late magmatic fluid provides an alternative explanation. (Authors' abstract)

TAYLOR, Mark, 1983, Estimation of inclusion fluid composition in Mississippi Valley-type mineralization from low-temperature phase behavior (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 704. Author at St. Joe Minerals Corp., P.O. Box 500, Viburnum, MO 65566.

The presence of salts other than NaCl in inclusion fluids in Mississippi Valley-type mineralization has been widely recognized by initial, and in cases, final melting temperatures below the binary eutectic (-20.81°C) in the system $NaCl-H_2O$. Evolved connate brines, particularly those with anomalous Pb^{2+} and Zn^{2+}, typically contain $Na^+ > Ca^{2+} > K^+ \simeq Mg^{2+}$. Less common are brines with $Ca^{2+} > Na^+$, as are found in the Michigan Basin.

The relative proportions of major cations in inclusion fluids can be estimated from low temperature phase behavior. The temperature of initial (eutectic) melting indicates the presence of Ca^{2+}(-49.8°C), Mg^{2+}(-33.6°C), or Na^+(-20.8°C). The disappearance of hydrohalite, $NaCl \cdot 2H_2O$ (cotectic melting) provides an estimate of the ratio of divalent to monovalent cations, essentially Ca^{2+}/Na^+.

Substantial ranges in freezing temperature (0° to -41.6°C) have been reported from numerous occurrences of Mississippi Valley-type mineralization. Measurements on samples from the Mascot-Jefferson City zinc district, the Viburnum Trend, and the Bonaparte Basin indicate that substantial variations in Ca^{2+}/Na^+ occur (≈4 - 0.5, by weight). These variations can be interpreted in light of models of brine origin (membrane filtration, dolomitization, dissolution of evaporites) and depositional mechanisms (dilution, fluid mixing). (Author's abstract)

TAYLOR, Mark, KELLY, W.C., KESLER, S.E., McCORMICK, J.E., RASNICK, F.D. and MELLON, W.V., 1983, Relationship of zinc mineralization in east Tennessee to Appalachian orogenic events: Proc. Int'l. Conf. [1982] Mississippi Valley Type Lead-Zinc Deposits, G. Kisvarsanyi et al., eds., Univ. Missouri-Rolla, Rolla, Missouri, p. 271-278. First author at Dept. Geol. Sci., The Univ. Michigan, Ann Arbor, MI 48109.

Sphalerite mineralization in the Mascot-Jefferson City zinc district can be divided into three stages on the basis of crystal deformation and inclusion characteristics. Early stage sphalerite contains very thin, commonly curved polysynthetic deformation twins. Intermediate stage sphalerite is characterized by the development of subordinate deformation twins within larger, straight growth twins. Late stage sphalerite is untwinned, and occurs as coatings on or interstitial fillings among earlier sphalerite aggregates. Undeformed vug-filling crystals were considered to be a fourth stage.

Fluid inclusion homogenization temperatures for the intermediate, late, and vug-filling stages of sphalerite ranged from 88° to 197°C, with a mean of 138°C. The mean freezing temperature was -19.9°C, with observations ranging from -41.6° to -8.6°C. A general inverse correlation between homogenization temperature and freezing point depression exists in fluid inclusions from the majority of the samples.

Deformation twinning in the early and intermediate stages of sphalerite mineralization indicates that ore deposition took place during the Alleghenian orogeny. The basin evolution processes that produced the sphalerite and sparry dolomite mineralization were related to the tectonic events of the Appalachian orogeny. This model suggests that the Appalachian subtype of Mississippi Valley-type deposits are related genetically as well as geographically. (Authors' abstract)

TAYLOR, Mark, KESLER, S.E., CLOKE, P.L. and KELLY, W.C., 1983, Fluid inclusion evidence for fluid mixing, Mascot-Jefferson City zinc district, Tennessee: Econ. Geol., v. 78, p. 1425-1439. First author at St. Joe Minerals Corp., P.O. Box 500, Viburnum, MO 65566.

Paired homogenization and freezing temperatures for fluid inclusions in sphalerite from the Mascot-Jefferson City zinc district exhibit three significant relationships: (1) a general inverse correlation exists between homogenization temperature and salinity, with greater variation of homogenization temperature at lower salinities than higher salinities; (2) in some samples, temperature of formation changes at near-constant salinity; and (3) low-salinity, low to moderate-temperature inclusion fluids are found in sphalerite formed in limestone. Eutectic and cotectic melting temperatures for frozen inclusions indicate that Ca + Mg/Na decreased with decreasing salinity.

No systematic spatial changes in fluid inclusion temperatures (laterally across the district or within a mine, vertically through the stratigraphic section, or with increasing distance from unaltered limestone) were detected. Consideration of possible causes for the widespread inverse correlation indicates that it must have been caused by mixing of two distinct basinal solutions. An evolved basinal brine component was recognized by its characteristic temperature (100° to 120°C), freezing point depression (<-22°C), and apparent Ca + Mg/Na>1. A lower salinity fluid (Tm>-22°C) of more variable temperature, and with apparent Ca + MgNa<1, was inferred to have been present in the host formations and breccias at the time of brine influx. Fluid inclusion, isotope, and trace element data from the major Mississippi Valley-type districts of the southern Appalachians have been interpreted as evidence for multisolution depositional processes. These data must reflect the fundamental chemical requirements for formation of Pb-Zn-Ba-F deposits from metal-bearing basinal brines. (Authors' abstract)

THISSE, Yves, GUENNOC, Pol, POUIT, Georges and NAWAB, Zohair, 1983, The Red Sea: A natural geodynamic and metallogenic laboratory: Episodes, no. 3, p. 3-9.

A review, including fluid inclusion studies. (E.R.)

THISSE, Y., OUDIN, E. and RAMBOZ, C., 1983, Boiling fluids in the Red Sea metalliferous sediments (abst.): Symposium, European Current Research on

Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 52. First author at B.R.G.M. - B.P. 6009 - 45060 Orleans Cedex, France.

The 1027-cm-long core has been recovered from the metalliferous sediments of the Atlantis II deep hydrothermally active south-west basin situated in the Red Sea axial rift zone. The sediment is characterized by the alternation of hematite-rich and sulphide-rich layers. At the base of the core, the sediment is cut by thin veinlets coated with anhydrite associated with talc and minor sulphides such as pyrrhotite, chalcopyrrhotite ($CuFe_2O_3$, cubic) and chalcopyrite. Primary fluid inclusions are abundant and large (50 μm to 100 μm in average). They are often induced during anhydrite growth by the presence of opaque euhedral oxides or sulphide crystals. Homogenization either in the liquid or the vapor phase at the same temperature indicates that the hydrothermal fluid trapped in the inclusions was boiling. Boiling occurred at approximately 340°C and the salinity of the fluid (expressed in equivalent NaCl) was close to saturation at 25°C (~22% equivalent NaCl). However, multiple hydrates are formed during cooling experiments indicating the complex chemical composition of the fluid. Microprobe analyses do not show the presence of dissolved gas in the inclusions. Higher homogenization temperatures coupled with a wide salinity range (from 12 to 22% equivalent NaCl) are the result of heterogeneous trapping above the boiling point. Fracturing of the oceanic crust and the overlying sediments in the rift zone allow the hydrothermal circulation and may create a sufficient drop in pressure to cause boiling. Sulphide deposition in the sediment occurs as a result of chemical and physical changes in the fluid due to boiling. (Authors' abstract)

THOMAS, Rainer, 1982a Results of the thermobarogeochemical investigations of the hydrothermal fluorite-paradoxite-quartz mineralizations of the Erzgebirge and of the SW-Vogtland, in Freiberger Forschungshefte, C 374, p. 63-77 (in German). Author at 9200 Freiberg/Sa., Lomonossowstrasse 14, GDR.

The temperature conditions of the formation of the Late Variscan fluorite-potassium feldspar (adularia)-quartz mineralization (the so-called FPQ- or "paradoxite" - formation, named after paradoxit, the name given by Breithaupt 1830 to adularia) from some Saxonian fluorite occurrences and deposits were studied using thermometric and cryometric measurements of fluid inclusions in fluorite, adularia and quartz.

The following deposits were considered: Fluorite deposits of Schönbrunn, Bösenbrunn and Grüne Tanne (SW-Vogtland), the FPQ-mineralization from Euba and Niederwiesa (near the town Karl-Marx-Stadt), adularia from the wolframite deposit of Pechtelsgrün/Vogtland and the FPQ-mineralization of the tin deposit of Ehrenfriedersdorf in the Central-Erzgebirge.

The FPQ-paragenesis was formed from low concentration fluids at moderate temperatures and low pressures ($\geqslant 110 \cdot 10^5$ Pa), indicated by the inclusion studies. The mean temperature of the minerals fluorite, adularia and quartz is (308 ± 22)°C and the total temperature interval of formation lies between 230 and 392°C as estimated from Th.

The cryometric studies of the inclusion fluids indicated that they are NaCl-type and are of low concentration (2.4 to 5.6% NaCl equivalents). Vapor-rich fluid inclusions, especially in the fluorite from SW-Vogtland, representing trapped steam, coexist with inclusions containing low-salinity fluids, from the boiling of hydrothermal fluids commonly accompanied by change from lithostatic to hydrostatic conditions (rhythmic sequences) during the mineralization. (Abstract by R. Thomas)

Dr. H.A. Stalder has translated Tables 2, 3, and 4 from this paper and they are given below:

Table 2: Results from microthermometric investigations on minerals from the FPQ-paragenesis. Erzgebirge and SW-Vogtland. Primary inclusions.

No.	Mineral	Locality	Th (°C)	n	NaCl Eqiv. %
1.	Cassiterite	Oelsnitz	(382 ± 13)	12	5.0
2.	Sphalerite	Grüne Tanne, K 24 I	(337 ± 16)	10	9.6
3.		Grüne Tanne, K 24 II	(335 ± 15)	15	
4.	Paradoxite	Schönbrunn	(321 ± 14)	12	
5.	Paradoxite	Schönbrunn	(292 ± 5)	9	
6.	Quartz-xl	Bösenbrunn, K 19 b-1	(319 ± 10)	130	4.1
7.	Quartz-xl	Bösenbrunn, K 19 b-2	(280 ± 16)	25	
8.	Quartz-xl	Bösenbrunn, K 19 b-3	(267 ± 14)	35	
9.	Quartz-xl	Bösenbrunn, 120 m-S.	(288 ± 32)	10	
	Fluorite	Bösenbrunn, 120 m-S.	(202 ± 7)	10	
10.	Quartz-xl	Schönbrunn, No. 3 (LAHIRY, 1972)	(320 ± 14)	10	
11.	Gangue quartz	Euba	(320 ± 18)	18	2.6
12.	Quartz-xl	Euba	(303 ± 8)	11	3.4
13.	Paradoxite-x	Euba, Pr. 1	(382 ± 10)	6	
14.	Paradoxite-x	Euba, Pr. 2	(315 ± 18)	12	3.4
15.	Paradoxite-x	Euba, Pr. 3	(305 ± 8)	13	
16.	Fluorite-x	Euba	(252 ± 13)	40	3.4-4.9
17.	Paradoxite-x	Niederwiesa	(298 ± 32)	11	
18.	Sternquartz	Ehrenfriedersdorf (Pr. Sn-120)	(291 ± 8)	25	3.0-3.7
19.	Fluorite-x	Ehrenfriedersdorf (Pr. Sn-120)	(295 ± 10)	20	
20.	Paradoxite-x	Pechtelsgrün/Vogtland	(322 ± 21)	18	

Table 3: Results from the density determinations (average of 10 determinations).

Mineral	Locality	Specific Volume (cm^3/g)	Density (g/cm^3)
Cassiterite	Oelsnitz/Vogtland	1.8	0.56
Sphalerite	Grube "Grüne Tanne"/Vogtland	1.6	0.62
FPQ-Quartz	Bösenbrunn/Vogtland	1.36	0.74
Quartz-xl	Euba	1.34	0.75

Table 4: Physiochemical formation-conditions of FPQ-mineralization (Thomas, 1979/23).

Parameter	FPQ-Mineralization	Parameter	FPQ-Mineralization
Temperature:		fS_2	10^{-8} to $10^{-11} \cdot 10^5$ Pa
range	350 - 250°C		
average value	(308 ± 22)°C	$[H_2S]$	About 10^{-3} Mol/l
Pressure:		pH at 300°C	4.8 - 6.5
lithostatic model	<750 - 300 · 10^5 Pa	$\delta^{18}O$ of mineral-forming solution	+4.2%.
hydrostatic model	>110 · 10^5 Pa		
Density of the mineral-forming solution	(0.74 ± 0.03) g/cm^3	Salinity of the solution	(4.0 ± 1.6) Equiv. % NaCl and max. 1.5 wt.% $NaHCO_3$
Depth	>1350 m	K/Na atomic ratio	(0.15 ± 0.07)
Temperature gradient at the mineralization area	∇T <150°C/1000 m	Main components of the mineral-forming solutions	NaCl, KCl, $NaHCO_3$, H_2S, Ca^{2-} - and F^-; CO_2: 10^{-3} to $10^{1.5} \cdot 10^5$ Pa
fO_2	10^{-30} to $10^{-32} \cdot 10^5$ Pa		

THOMAS, Rainer, 1982b Results of thermobarogeochemical investigations on fluid inclusions in minerals of the postmagmatic tin-tungsten-mineralization of the Erzgebirge: Freiberger Forschungshefte, v. C 370 (85 pp., 91 references, 38 figures, 15 tables) (in German; English abstract courtesy of the author).

The paper presents the results of fluid inclusions research on 90 cassiterite samples and also many other minerals (quartz, topaz, beryl, tourmaline, fluorite, wolframite, zinnwaldite, apatite, triplite, sphalerite, and "paradoxite" (See previous item.)) from the Sn-W mineralization of the Erzgebirge (southern part of the G.D.R.). Four postmagmatic stages of cassiterite formation were found: pegmatitic, >550°C; high-hydrothermal, 470-410°C; pneumatolytic, 390 (± 15)°C; and hydrothermal, 350 to 270°C (see also Thomas, 1979, Fluid Inclusion Research--Proceedings of COFFI, v. 12, p. 189, and Thomas and Bauman, 1980, Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 253-254). The main precipitation of cassiterite (and other minerals) was associated with the high-hydrothermal and the pneumatolytic stages (fig. 10). The high-hydrothermal stage is characterized by the presence of three-phase and polyphase inclusions with halite and sometime sylvite (and other daughter minerals) and two-phase liquid inclusions. All these inclusions homogenize at the same (narrow) range of temperature. The polyphase inclusions homogenize in the temperature range of 450 (± 20)°C either by the disappearance of the bubble or by the dissolution of halite, several times also by the simultaneous disappearance of the bubble and the NaCl-daughter-phase. Many two-phase liquid inclusions homogenize with critical phenomena at 448 (± 13)°C. The coexistence and the simultaneous trapping of the different inclusions are striking indicators of the participation of boiling, high-salinity and high-temperature fluids during the ore formation. The pneumatolytic stage, in general, is characterized by the presence of two-phase fluid inclusions, which homogenize with critical phenomena (boiling) at 397 (± 10)°C.

The presence of boiling inclusion assemblages permitted an accurate calculation of pressure and therefore also the depth at time of mineralization. Fluctuations between hydrostatic and lithostatic pressure conditions can explain the association of the different types of mineral-forming fluids, the large range in pressure (1.3 kbar to 250 bar) and the range in temperature.

Fluid inclusion data combined with the calculated $\delta^{18}O$-values for water in quartz (7.3 ± 2,3‰) and in cassiterite (6.9 ± 0.8‰), based on analysis of quartz and cassiterite allow significant genetic conclusions on the conditions of the mineralization, and suggest that the mineral-forming fluids were dominantly magmatic. Preliminary studies on fluid inclusions of the kb-Formation (polymetalliferous sulphide formation with quartz, pyrite, arsenopyrite, sphalerite, chalcopyrite, tetrahedrite, bornite, chalcocite, stannite, galena) of the Erzgebirge were carried out also. Three temperature stages (mean values) were observed:

- "kiesige" - Fe, S, As - sequence: (383 ± 8)°C
- Zn-Sn-Cu - sequence: (352 ± 19)°C
- Pb - sequence: (303 ± 14)°C

The results were compared and discussed with those of the tin-tungsten-mineralization.

See also Fluid Inclusion Research--Proceedings of COFFI, v. 12, p. 189 (1979) and v. 13, p. 253 (1980). (E.R.)

THOMAS, Rainer and BLANKENBURG, H.-J., 1981, First results from fluid inclusion studies on quartz of agate nodules and balls from basic and acid volcanics: Zeitschr. geol. Wissensch. Berlin, v. 9, no. 6, p. 625-633 (in German).

Investigations with quartz from volcanic agates indicated formation temperatures between 370 and 420°C resp. The agates themselves probably crystallized in the range >420°C, perhaps even in the high temperature quartz range (zone of honeycomb quartz had been proved for the first time). The genetic conclusions which can be drawn from the stated facts are discussed. (Authors' abstract, translated by H.A. Stalder)

Note by E.R. based on partial translation of text by H.A. Stalder: A wide range of G phase, from 0 to 100 vol.% was found; from this fact it seems possible that the strange Th data are artifacts of heterogeneous trapping (and/or subsequent leakage or necking down), rather than valid formation temperatures, with or without correction for the stated pressures of 210-340 bars (p. 626). (See also Blankenburg et al., 1983, this volume.)

THOMPSON, A.B., 1983, Fluid-absent metamorphism: J. Geol. Soc. London, v. 140, p. 533-547.

Many interpretations of metamorphic parageneses tacitly assume that a free fluid phase was always present during metamorphic equilibration (fluid-present metamorphism), as opposed to the circumstance that, while volatile species are certainly released from minerals during metamorphism, these species may not saturate the grain boundaries to produce free fluid (fluid-absent metamorphism). H_2O-activity has meaning for both fluid-present and fluid-absent metamorphism and may be evaluated if an equilibrium may be written involving H_2O and the temperature and rock-pressure of equlibration are known. PH_2O has only a physical meaning for fluid-present metamorphism.

Although the effects of an aqueous fluid on displacing reactions in P-T space are well known, as are the enhanced kinetic and deformational effects of excess fluid, there is actually little compelling evidence to suggest that the presence of aqueous fluids is common during metamorphism of the middle and lower crust, and the mantle, for the duration of most dynamic processes, including partial melting. Possible exceptions are discontinuous dehydration reactions which affect large compositional ranges of metamorphic rock over narrow pressure-temperature intervals and which could locally produce a free liquid if production rate exceeds escape rate.

Evidence from stable isotopes and fluid inclusions obviously points to the accumulation of free aqueous fluid in definite locations for limited duration, but cannot, unfortunately, be used as evidence for generalized fluid transport during regional or contact metamorphism. Both mineralogical and textural criteria presently used to infer ubiquitous fluid must be examined in terms of crustal volume and duration of dynamic processes to deduce the presence or absence of free fluid. If volatile components ever saturate grain boundaries, then the fluid-phase may only exist locally and perhaps only for short periods of time. Flow of metamorphic fluid may be focused into narrow regimes that could be quite widely spaced. Fluid-present metamorphism should not be considered as typical of whole crust evolution. (Author's abstract)

THOMPSON, J.M., GRUNDER, A.L. and HILDRETH, Wes, 1983, Selected chemical analyses and geothermometry of hot spring waters from the Calabozos caldera, central Chile: Geothermal Resources Council, Transactions, v. 7, p. 331-335.

THOMPSON, J.M., HOWE, S.S. and HALL, W.E., 1983, Chemical analysis of fluid inclusions by ion chromatography: Rocky Mountain [Spectroscopy] Conference, 25th, Denver, Colorado, Aug. 14-17, 1983, Abstracts, p. 108. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

Fluid inclusions in minerals give information about the temperature and salinity of the liquid at the time of mineral deposition provided the inclusions were trapped as the minerals grew. Freezing and heating stage microscopic studies of fluid inclusions yield information on the NaCl equivalent salinity and homogenization temperature of the fluid. The purpose of this study was to assess the use of ion chromatography as a means of chemically analyzing fluid inclusions and to use cation geothermometers to estimate the temperature of the fluid during mineral deposition. Nine mineral samples were studied, including quartz, sphalerite, rhodochrosite, pyrite, and chalcopyrite from the Creede Mine, CO., and quartz from the Climax Mine, CO. Each sample was cut to approximately 1 cm^3, cleaned by constant potential electrolysis at 100 VDC for 36 hours, dried overnight in a vacuum oven at 110°C, and loaded into previously cleaned stainless steel tubes; the tubes were then sealed, evacuated, and crushed. Typically $1\text{-}10\times10^{-6}$ g of water was liberated from the inclusions and the salts leached with three 20 mL aliquots of distilled water while immersed in an ultrasonic bath for 10 minutes. Fluoride, Cl, Br, NO_3, and SO_4 were separated using a Dionex AS3 anion column and Li, Na, NH_4 and K using a Dionex CS1 cation column. Because a HCO_3-CO_3 solution is the eluent, HCO_3 and CO_3 were not determined by this technique. Calcium and Mg were analyzed by atomic absorption spectrometry. Four samples had cation-anion balances within 20 percent; the remainder had poor charge balances. Two of these poorly balanced samples were sulfides that may have oxidized during the electrolysis (excess sulfate was recovered) and one was a carbonate. All samples from Creede have calculated Na-K-Ca temperatures between 250-320°C; calculated Na-K temperatures between 270-350°C; and calculated salinities from 12-37 percent. In comparison, fluid inclusion homogenization temperatures at Creede are between 180-250°C and NaCl equivalent salinities range from 4-12 percent. (Authors' abstract)

THOMPSON, K.F.M., 1983, Origin of natural gas, San Juan basin, New Mexico (abst.): AAPG 1983 Conv., Dallas Geol. Soc., p. 169. Author at ARCO Oil and Gas Co., Dallas, TX .

^{13}C and D/H data are used to trace the origin. (E.R.)

TILLMAN, J.E., 1983, Exploration for reservoirs with fracture-enhanced permeability: Oil & Gas J., p. 165-180. Author at Target Exploration Inc., Ellicott City, MD.

See next item. (E.R.)

TILLMAN, J.E. and BARNES, H.L., 1983, Deciphering fracturing and fluid migration histories in northern Appalachian basin: The Am. Assoc. Petr. Geol. Bull., v. 67, no. 4, p. 692-705. First author at Target Exploration, Inc., 4851 Manor Lane, Ellicott City, MD 21403.

An attempt to decipher the fracturing and fluid migration histories in the northern Appalachian basin on the basis of Th of aqueous fluid inclusions in calcite and quartz. No Tm data are given. (E.R.)

TOMILENKO, A.A. and CHUPIN, V.P., 1983, Thermobarogeochemistry of metamorphic complexes, Yu.A. Dolgov, ed., Transactions of Inst. Geol. and Geophys., v. 524, Siberian Branch of the "Nauka" Publishing House, Novosibirsk, 200 pp., 1000 copies printed, price 2 rbls 30 kopecks (in Russian). Authors at Inst. Geol. and Geophys., Novosibirsk, USSR.

The book bears results of fluid inclusion studies in metamorphic minerals from Aldan Shield, Stanovoy Ridge, SE Altai, Boruss ophiolite belt, Dzhungarian Alatau, Belomor'ye granulites, S. Enisey area and Yakutia. First chapters describe the present state of problem of fluid regime of metamorphism, anatexis and genesis of migmatites and charnockites, methods of evaluation of parameters of metamorphism and anatexis, general information about inclusions in minerals, their diagnostics, methods of thermometry, cryometry, and determinations of qualitative and quantitative composition of inclusions, methods of determination of pressure from inclusions. The systematics of inclusions in metamorphic minerals, vein quartz, migmatites, granites and pegmatites. Metamorphic minerals bear several types of inclusions: liquid one-phase; two-liquids immiscible at room T (one is always LH_2O solution, the second - LCO_2, LN_2, LCH_4 or their mixtures); three or more phases - one or two L, plus one or more crystal phases (sometimes xenogenic). For areas of low-P metamorphism inclusions bear G phase of a mixture of CO_2, N_2 and CH_4 with predominant CO_2 (>50 wt.%). Precipitation of gas cryohydrates on cooling proves the common presence of small amount of water solutions, not discernible under microscope. Veins of certain migmatites and anatectic granites bear inclusions of crystallized silicate melts; more common in migmatites and anatectites are inclusions of melts-solutions - they occur essentially in quartz. Temperatures of metamorphism (Th) are as follows: granulite facies: Upper Aldanian complex, W part of Aldanian Shield 400-820°C, amphibolite facies: Upper Aldarian complex, W part of Aldanian Shield 830-780°C, same area, basin of the Olekma River 790-700°C, Dzhungarian Alatau, Koksuy complex of the Mynchukur block 710-700°C, Upper Altai series, S. Chuy Ridge - about 700°C, Mama River region, Transbaikalia 630 ± 20°C, Chupa region, Karelia <700°C. The pressures obtained from fluid inclusions (from Th, °C, and specific volumes of CO_2 and N_2 in cm^3 per g, data in parentheses) are in ranges (in kbar): eclogites, Yakutia and Zeblitz in GDR, garnet 15 (-195 to -188, 1.244-1.297); granulites, Sutama region in Aldan Shield, sapphirine up to 8.5 (-27 to -25, 0.94-0.95), plagioclase - same, garnet up to 7.5 (-22 to -10, 0.96-1.02), sillimanite, quartz - same; granulites, Chogar complex in Stanovoy Ridge, quartz up to 10-11 (-42 to -27, 0.89-0.94); granulites, Belomor'ye complex of the Pon'gomi River region, garnet, quartz up to 8.5 (-33 to -30, 0.92-0.93); charnockites of the Kana complex in S. Enisey area, quartz, plagioclase up to 8.0 (-24 to -14, 0.95-0.997); granulites of the W. Aldan Shield, garnet, sillimanite, quartz, up to 6.0 (-3 to +5, 1.066-1.12); amphibolite facies rocks in W. Aldan Shield, quartz - same; metamorphic rocks of the S. Chuy Ridge, kyanite up to 8.0 (-190 to -184, 1.281-1.331), andalusite, quartz up to 5.5 (-172 to -160, 1.459-1.662), quartz up to 6.0 (-21 to -13, 0.96-1.0). Gas phase (by analysis of individual inclusions) in inclusions of crystallized melts consist mostly of CO_2 plus N_2<20% by vol., in inclusions of LCO_2 - CO_2 + N_2 and CH_4, <10 vol.% each, except for 7 determinations. Inclusions of "LN_2" may contain up to 78% CH_4, up to 67% vol. CO_2 and may not contain N_2[sic, A.K., from the authors' plot in Fig. 39, p. 174], but essentially they bear up to 65 vol.% of N_2. The book contains data that in significant part were published in earlier papers of the authors of this book, see previous volumes of Fluid Inclusion Research--Proceedings of COFFI. (Abstract by A.K.)

TOULHOAT, P., 1982, Petrography and stable isotope geochemistry (D/H, $^{18}O/^{16}O$, $^{13}C/^{12}C$, $^{34}S/^{32}S$) of the Quérigut skarns - Comparison with the scheelite skarns of the Pyrénées: Thesis, 3°Cyde, Univ. Pierre et Marie Curie, Paris VI, 268 pp (in French).

The author studied an area of grantitic intrusions into limestones and other country rocks in the eastern Pyrénées in an effort to determine why there is no significant mineralization associated with these intrusions, while significant scheelite skarns are associated with similar intrusions elsewhere in the range. Topics addressed in the thesis include:

1. Petrography of the different skarns in the area of the Col de Pailleres. Geochemical interpretations of the chemistry and textures are proposed.

2. Description and interpretation of the various stages of alteration and interaction between the granites and the limestones.

3. Microthermometric analyses of the fluids involved in the mineralizing solutions. The salinity and the proportions of H_2O, CO_2 and CH_4 are shown to be closely correlated with the presence or absence and the nature of mineralization. [No data presented in the author's abstract.]

4. Isotope geochemistry of oxygen, hydrogen, carbon and sulfur, including a comparison with the results from the scheelite deposits of Costabonne and Salau (B. Guy, 1979).

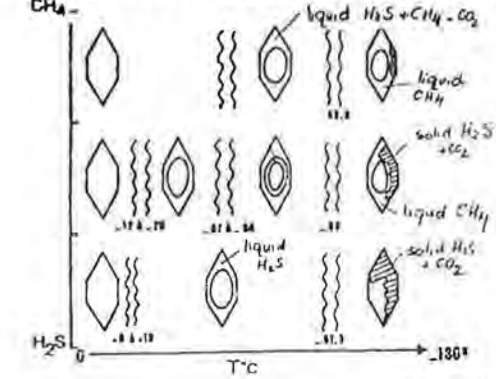
Definitive conclusions on the differences of origin between the mineralized and unmineralized skarns of the Pyrenées are not possible based on this work alone. (Abstract courtesy M.J. Logsdon)

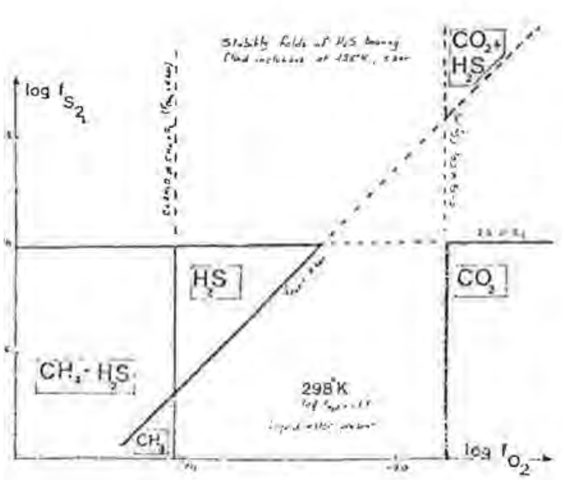
TOURAY, J.C. and GUILHAUMOU, N., 1983, Characterization of H_2S-bearing fluid inclusions (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 53.

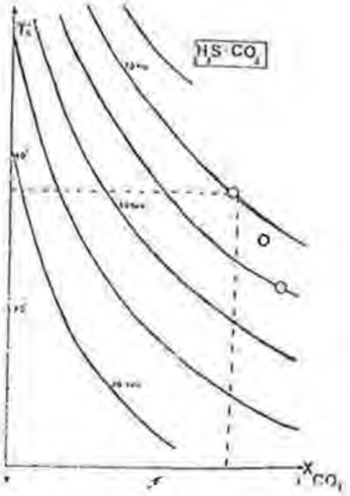
Using Raman microprobe determinations, it is now possible to bridge the bulk chemical composition of gas inclusions to their phase behavior on heating or freezing. H_2S-bearing fluids have been recently described in CO_2-H_2S-H_2O-S (1) and CO_2-CH_4-H_2S-H_2O-C (2) systems.

a) CO_2 + H_2S (+H_2O + S) inclusions: In H_2S-rich - the clathrate H_2S, 5.75 H_2O forms on cooling and decomposes around +27°C; in CO_2-rich - the melting temperature of solid CO_2 is slightly depressed (Tf = -58°C with H_2S = .13), and the clathrate CO_2, 5.75 H_2O decomposes at +6 to +14°C. Partial homogenization occurs usually at tempertures higher than T(crit) CO_2. The corresponding pressure may be derived from figure. Daughter crysals of sulphur are sometimes present.

b) CH_4 + H_2S + CO_2 (+ H_2O +C) inclusions: Three types of phase behavior on freezing are noticed and illustrated by figure, for variable CH_4/H_2S ratios and a nearly constant content of CO_2 (10 to 20%). Solid H_2S melting aroung -98°C is always present at low temperature. From thermochemical calculations, it appears that CO_2 + H_2S inclusions are not stable at room temperature under pressures higher than 1 bar (figure). (Authors' abstract)







TOURAY, J.C., HUBERT, P. and BOURRAT, X., 1981, Geochemical study of the Burc fluorspar vein (analysis of trace lathanides, study of fluid inclusions); comparison with other veins in the Tarn District: DGRST 79-7-1309; avail. CNRS-AR 9223, 22 pp. (in French).

TOURET, J., 1983, Fluid distribution in the lithosphere as indicated by fluid inclusions: Österreich. Mineral. Gesellschaft Mitt., no. 129, p. 31-38 (in English).

A review of the nature and use of fluid inclusion studies, particularly during metamorphism. (E.R.)

TOURET, J. and DIETVORST, P., 1983, Fluid inclusions in high-grade anatectic metamorphites: J. Geol. Soc. London, v. 140, p. 635-649.

Fluid inclusions have been studied, by microthermometry, in metapelites and metabasites which have undergone partial melting in the transition zone from amphibolite to granulite facies. Mobilizates contain far more abundant and larger fluid inclusions than non-mobilized or restite layers, and these inclusions occur as several generations of well-defined and chemically constrasted fluids: carbonic (CO_2 ± CH_4 and hydrocarbon), aqueous (H_2O ± NaCl) and N_2.

A garnet-bearing mobilizate in amphibolite contains 4 generations of relatively pure fluids, most of them trapped after peak metamorphic conditions in the following P-T domains: CO_2 and N_2, P = 2-8 kbar, T = 550-850°C; CH_4, P = 1-2 kbar, T = 400-550°C; H_2O, $P < 1$ kbar, T = 120-400°C. (Authors' summary)

TREIMAN, A.H., 1983, The Oka complex, Quebec: tests of liquid immiscibility (abst.): Abstracts Volume, '83 MSA Symposium on Alkaline Complexes, Wausau, Wisconsin, Sept. 16-18, 1983 (unpaginated). Author at Lunar & Planet. Lab., Univ. Arizona, Tucson, AZ 85721.

Definitive textural evidence of liquid immiscibility, e.g., the presence of a meniscus, is unlikely to have been preserved through plutonic crystallization and cooling. Because the miscibility gap between silicate and carbonate melts widens with decreasing temperature, coexisting melts will exsolve droplets of each other as they cool, and the resultant emulsion texture should appear as ocelli or inclusions of one rock type in the other. Such textures are preserved in the JOMIC pluton on scales of 0.01 mm to meters. However, textures are often ambiguous and should be used in conjunction with chemical evidence to infer liquid immiscibility.

Chemical and physical criteria are consistent with the hypothesis that the silicate and carbonate rocks of the JOMIC pluton, Oka complex, originated as immiscible liquid fractions. The most useful chemical test is comparison of mineral assemblages and compositions, and this test should be applied whenever textural relations suggest the presence of immiscible magmas. (From the author's abstract)

TREMBLY, J.A., 1982, Hydrothermally altered basalts from the Mariana Trough: M.S. thesis, The Univ. Arizona, Tucson, AZ, 42 pp.

Mineralogical and chemical studies were conducted on fresh and altered basalts collected near the axis of spreading of the Mariana Trough, an actively spreading back-arc basin which is part of the Mariana Island Arc system. Alteration of the basalts occurred under seawater-dominant, followed by rock-dominant conditions. Fluid inclusion data indicate that temperatures may have increased during alteration, then retrogressed.

There do not appear to be significant differences between basalt alteration processes in back-arc environments and mid-ocean ridge environments. Although the samples analyzed here have no intrinsic economic value, their study leads to interpretations about processes forming massive sulfide deposits such as those on the island of Cyprus. It is tentatively concluded that massive sulfides are deposited under seawater-dominated conditions while the associated stockwork system is mineralized under rock-dominated conditions. (Author's abstract)

TROSHIN, Yu.P., 1983, Fluid regime of formation of rare-metal plumasite granites of East Transbaikalia: Geol. i Geofiz., no. 11, p. 66-76 (in Russian; English abstract). Authors at Inst. Geochem., Irkutsk, USSR.

Fugacities of O_2, H_2O, HF and HCl were calculated for process of formation of peraluminous granites bearing rare metal mineralization. (A.K.)

TRUESDELL, A.H., MAZOR, Emanuel and NEHRING, N.L., 1983, The origin of thermal fluids at Lassen Volcanic National Park: evidence from noble and reactive gas abundances: Geothermal Resources Council, Transactions, v. 7, p. 343-348.

TRUFANOVA, L.G., 1981, Experimental study of formation of lithium minerals in the system granite-H_2O-LiCl: Dokl. Akad. Nauk SSSR, v. 260, p. 476-480 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 260, p. 164-167, 1983).

TRUSKINOVSKIY, L.M. and SENDEROV, E.E., 1983, Kinetics of isothermal re-crystallization in solution (mathematical model): Geokhimiya, no. 3, p. 450-462 (in Russian; English abstract). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

The paper presents a model applicable, e.g., to recrystallization of pyroclastic material, metamorphic rocks or hydrothermal crystallization in veins with dissolution of wall rocks; the nucleation scheme is pertinent to fluid inclusion formation. (A.K.)

TSUTSUMI, Makoto and OHMOTO, Hiroshi, 1983, A preliminary oxygen isotope study of Tetsusekiei ores associated with the Kuroko deposits in the Hokuroku district, Japan: Econ. Geol. Monograph 5, p. 433-438.

TSVETKOV, A.A., GOVOROV, I.N. and KARPUKHIN, V.Y., 1983, Alkali basalt magmatism on the island of Mauritius, in Magmatic and Metamorphic Rocks of the Ocean Bottom and their Genesis, Bogatikov. O.A., Dmitriyev, Y.I. and Tsvetkov, A.A., eds.: Moscow, Izdat. Nauka, p. 213-233 (in Russian).

Includes Th for some silicate melt inclusions. (E.R.)

TUFAR, W. and PODUFAL, P., 1983, Mineral paragenetic revelations in the barite deposit of Dreislar (Sauerland, Rheinisches Schiefergebirge, West Germany), in Mineral Deposits of the Alps and of the Alpine Epoch in Europe, H.-J. Schneider, ed.: Berlin, Springer-Verlag, p. 335-346. First author at Philipps-Univ. Marburg, Fachbereich Geowissenschaften, Lahnberge, D-3550 Marburg, FRG.

The vein deposit of Dreislar, located in a large fracture zone, is generally regarded as a typical Saxonic, i.e., Alpine in age, mineralization, presumably of Tertiary age. In the Dreislar deposit Lower Carboniferous slates and graywacke slates are mineralized. The veins consist in greatest part of barite, which is subdivided into at least 4 different generations showing the typical Sr-contents of hydrothermal vein mineralizations. Minor and additional mineral constituents of the barite veins are quartz, carbonates and a number of sulfides which are also of special interest. Predominant amongst the sulfides are pyrite, in part associated with marcasite and chalcopyrite. In the paragenetic sequence of the non-ferrous metal sulfides sphalerite and galena are the oldest components; later on copper ore minerals became dominant (locally "inverse cementation," but ascendent in origin). Primary multiphase fluid inclusions of barite show Th of about 70° to 140°C. Chemical analyses of the fluid inclusions from the barites indicate that the mineral-forming solutions were chloride-hydrogen-carbonate solutions of alkali and alkaline-earth metals. (Authors' abstract)

TUGORIK, G.I., ZAIKIN, I.D. and KIRASIROVA, V.I., 1982, The composition of fluid inclusions in platinum minerals from granulitic complexes and some aspects of their genesis: Akad. Nauk SSSR, Dokl., v. 266, no. 3, p. 704-706 (in Russian).

Includes 4 analyses, of the gases evolved in two temperature ranges from two samples, for CO_2, H_2, CO, N_2, CH_4, and H_2O. Water is the largest component in all, with CO_2 generally next. (E.R.)

TUKHTAEV, S. and KUCHAROV, Kh., 1983, Solubility in the system $MgSO_4$-$ZnSO_4$-H_2O at 50°C: Zhurn. Neorg. Khimii, v. 28, no. 7, p. 1831-1833 (in Russian). Authors at Inst. of Chemistry of Acad. Sci. of Uzbek SSR.

The paper presents the solubility isotherm and physical and optical properties of salts precipitating in the system. (A.K.)

TURNER, J.S., HUPPERT, H.E. and SPARKS, S.J., 1983, An experimental investigation of volatile exsolution in evolving magma chambers: J. Volcanol. Geotherm. Res., v. 16, p. 263-277. First author at Res. Sch. Earth Sci., Australian Nat'l. Univ., Canberra 2600, Australia.

Previous laboratory experiments investigating the fluid dynamics of replenished magma chambers have been extended to model effects resulting from the release of gas. Turbulent transfer of heat between a layer of dense, hot and volatile-rich mafic magma overlying cooler more evolved magma can lead to crystallization and exsolution of volatiles in the lower layer. Small gas bubbles can cause the bulk density to decrease to that of the upper layer and thus produce sudden overturning and initiate mixing, followed by further exsolution of gas and explosive eruption. These processes have been modelled in the laboratory using a chemical reaction between sodium or potassium carbonate and nitric acid to release small bubbles of CO_2. We have investigated both the initial overturning produced by gas release in the lower layer, and the subsequent evolution of gas due to intimate mixing of the two layers. The latter experiments, in which the reactants remained isolated in the two layers until overturning occurred, demonstrated unambiguously that the fluxes of chemical components across the interfaces between convecting layers are very slow compared to the flux of heat. This shows that the evolution of layers of magma of different origins and composition can take place nearly independently of each other. The magmas can coexist in the same stratified chamber, until their bulk densities become equal and they mix together. The processes illustrated in these experiments could occur in H_2O-bearing magmas such as in the calcalkaline association and in CO_2-bearing mafic magmas such as in silica undersaturated suites. (Authors' abstract)

TURNER, Kent, Jr., 1983, The determination of the sulfur isotopic signature of an ore-forming fluid from the Sierrita porphyry copper deposit, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 93 pp.

The application of sulfur isotopy to studies on the genesis of porphyry copper deposits requires knowledge of the physio-chemical parameters governing aqueous sulfur distribution accompanied by the isotopic composition of precipitated sulfur-bearing minerals. Detailed study of a single vein from the Sierrita deposit permitted the determination of the parameters: temperature (350°C), pressure (330 bars), salinity (1.14 molal), fO_2 ($10^{-27.5}$), pH (5.8) and sodium, potassium and calcium activities 6.3 x 10^{-2}, 9.8 x 10^{-3}, 1.0 x 10^{-5}, respectively) from which the relative molar distribution of aqueous sulfur was calculated to be 50% sulfide and 50% sulfate. Isotopic analyses of vein sulfides (pyrite = -0.8‰, chalcopyrite = -2.0‰) and sulfates (anhydrite = +8.8‰) indicate a system which is not in isotopic equilibrium. This lack of equilibrium precludes quantitative calculation of the isotopic composition of aqueous sulfur. The concept of systematic disequilibrium may allow interpretation of these results that imply either an igneous or a dual igneous-sedimentary sulfate sulfur source. (Author's abstract)

UJIKE, Osamu, 1983, Geochemistry of Archean quenched immiscible liquids, Noranda, Quebec, Canada; with reference to magmatic liquid structure: J. Japan. Assoc. Min. Petr. Econ. Geol., v. 78, p. 415-427.

UKHANOV, A.V. and DEVIRTS, A.L., 1983, Meteoric origin of water serpentinizing Yakutian kimberlites: Dokl. Akad. Nauk SSSR, v. 268, no. 3, p. 706-709 (in Russian).

ULFF-MØLLER, Finn, 1983, The Kitdlît lens--a terrestrial case of extreme liquid evolution of a complex metal-sulphide melt system from Disko, west Greenland: Meteoritics, v. 18, no. 4, p. 410-411. Author at Dept. Mineral Industry, Tech. Univ., 2800 Lyngby, Denmark.

Recent field work on southern Disko in the West Greenland Basalt Province led to the discovery of a unique 100 kg-sized troilite-iron body (the Kitdlît lens) on a shelf in a dyke [sediment contaminated high-MgO tholeiite, Pedersen (1979)].

The lens was formed from immiscible sulphide and metal liquids with the estimated composition (in wt %),

	Fe	Co	Ni	Cu	C	O	Si	P	S
sulphide:	70.9	0.28	1.83	0.30	0.32	1.45	0.03	0.01	24.7
metal:	92.3	0.50	2.05	0.08	3.2	0.51	0.01	0.16	1.2

which were deposited at 1200°C, $fO_2 \sim 10^{-13}$ and $fS_2 \sim 10^{-5}$-10^{-6}. Solidification took place from about 1160° to 300°C.

In the lower metal-rich half of the lens, formation of iron dendrites preceded crystallization of matrix-forming Fe-Fe_3C eutectic containing minor pockets of Fe-Fe_3C-Fe_3P-FeS eutectic, Fe-FeS eutectic and large oxide grains (altered wüstite?)

In the upper sulphide-rich half of the lens, solidification was complicated by three stages of dendritic growth [two types of two-phase Fe-Fe_3C dendrites and FeS dendrites with finely dispersed chromite(?) needles]. The matrix is quantitatively a Fe-FeS eutectic intergrowth with accessory chromite, wüstite(?), fayalite(?), silicate glass blebs, chalcopyrite, pentlandite, shandite ($Ni_3Pb_2S_2$) and galena plus gas vesicles and minor pockets of troilite-wüstite(?) eutectic. An immiscible Pb-rich liquid exsolved from the sulphide liquid and solidified to compact aggregates of galena, shandite, altaite (PbTe), chalcopyrite, pentlandite, native Pb and others.

The quantitative and textural distribution of large wustite(?) grains in both the metal- and sulphide-rich halves of the lens suggests that an oxy-sulphide liquid (O/S>>1) may coexist with iron, cohenite, metal and sulphide liquids about 1100°C and >250 bars. (Author's abstract)

URAI, J.L., 1983, Deformation of wet salt rocks: Ph.D. dissertation, Univ. Utrecht, 221 pp.

This work deals with two topics. First, - as observations on naturally deformed salt rocks indicate that brine has been present in these during salt metamorphism, and that this brine has strongly effected rheological behavior - the effect of saturated brine on the rheological properties of polycrystalline carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$) and bischofite ($MgCl_2 \cdot 6H_2O$) was investigated. Second, - as salt minerals are good analogues for other rock forming minerals - a fundamental study of microstructural evolution during dynamic recrystallization was carried out.

Most of the experiments on carnallite were performed using starting material obtained from the Asse salt mine in W-Germany. Microstructural analysis of this material (chapter 2) indicates a history involving three processes: grain boundary migration, progressive misorientation of subgrains and mass transfer through the fluid phase. Detailed investigation of hematite inclusions found in the carnallite (which give the carnallite its red color) reveals that these are decorating dislocation networks. This provides strong evidence that the hematite was precipitated after formation of the carnallite.

A variety of deformation experiments were conducted on carnallite and bischofite, at various conditions of confining pressure, fluid contents, strain rates, ambient temperature, grain size, etc. These were then interpreted in terms of deformation mechanisms, creep law equations, grain boundary migration rates, etc. It is argued that the experimentally found flow law for the deformation of wet carnallite and bischofite is applicable to the deformation behavior of these minerals during diapirism. Based on theoretical models of diffusive mass transfer flow, it is argued that at strain rates below those attainable in the laboratory, the weakening effect of water will increase. (From the author's abstract, modified by E.R.)

URUSOVA, M.A. and VALYASHKO, V.M., 1983, Solubility, vapor pressure and thermodynamic properties of solutions in the system $MgCl_2$-H_2O at 300-350°C: Zhurn. Neorg. Khimii, v. 28, no. 7, p. 1845-1849 (in Russian). Authors at Inst. General and Inorg. Chem., Moscow, USSR.

The paper presents isotherms of vapor P of $CaCl_2$ and $MgCl_2$ solutions, phase diagram of the $MgCl_2$-H_2O system at T 0-700°C and osmotic coefficients and coefficients of water activity in $MgCl_2$ solutions at 300 and 350°C. (A.K.)

U.S. DEPARTMENT OF ENERGY, 1983, Interdisciplinary gas hydrate literature bibliography: DOE/METC/83-65 (revised) (DE 84001900), 54 pp.

Of use in any study of hydrates in inclusions. (E.R.)

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). Author at Moscow Mining Inst., Moscow, USSR.

Includes some discussion of the evolution of gases from honeycomb quartz. (E.R.)

USPENSKAYA, A.B., 1983b Influence of gas-liquid inclusions on physical properties of vein quartz of tin ore deposits: Doklady Akad. Nauk SSSR, v. 271, no. 5, p. 1218-1221 (in Russian). Author at Mining Inst., Moscow, USSR.

Studies of elastic properties of quartz were performed at T 20-800°C, and of electric properties at 20-1050°C. The influence of fluid inclusions on these properties is shown. (A.K.)

USTINOV, V.I., GRINENKO, V.A., ALEKSANDROV, S.M. and IVANOVA, T.R., 1983, The isotopic study of boron in the process of formation of ore deposits (abst.): ZfI-Mitteilungen (papers of the Central Inst. of Isotope and Radiation Research of the Acad. Sci. GDR), v. 80, p. 30-31 (in German).

USTINOV, V.I., IVANOVA, T.R. and GRINENKO, V.A., 1983, Mass spectrometric analysis of boron isotopes using $B(OCH_3)_3$ (abst.): ZfI-Mitteilungen (papers of the Central Inst. of Isotope and Radiation Research of the Acad. Sci. GDR), v. 80, p. 134-135 (in German).

UyTANA, V.F., 1983, Physiochemical characteristics during potassic alteration of the porphyry copper deposit at Ajo, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 96 pp.

Potassium metasomatism is a widespread alteration type in porphyry copper deposits and is often spatially associated with hypogene sulfide ore formation. At Ajo, potassic alteration composes the dominant alteration type and is spatially, and to some extent temporally, associated with chalcopyrite and bornite mineralization. Physiochemical conditions prevailing during potassic alteration thus describe a significant portion of the hydrothermal ore-forming process. Studies of fractures, fluid inclusions in quartz, and structural and compositional characteristics of K-feldspar, all in the potassic alteration zone at Ajo, indicate that: fracturing was strongest during potassic alteration and sulfide deposition, pressures were at approximately 650 bars, temperatures started at a minimum of 580°C, continued through 470°C and possibly 280°C, log a_{K+}/a_{H+} changed from 2.6 at 580°C to 3.2 at 470°C, log a_{Na}/a_{H+} changed from 2.7 at 580°C to 3.8 at 470°C, and the ratio a_{K+}/a_{Na+} radically decreased from 0.8 to 0.3 in this temperature range. (Author's abstract)

VAILLANCOURT, Pierre, 1983, Geology and genesis of pyrite-sphalerite-galena concentrations in Proterozoic quartzite at Quartz Lake, Yukon Territory (abst.): Geol. Assoc. Can./Mineral. Assoc. Can. Prog. with Abstracts, v. 8, p. A71. Author at Dept. Geol., Univ. Western Ontario, London, Ontario N6A 5B7, Canada.

Pyrite, sphalerite and galena occur in stratabound massive lenses and disseminations in two zones within Proterozoic quartzite and argillite at Quartz Lake, 70 km northeast of Watson Lake, Yukon Territory. One zone contains 1.1 million tonnes of 8.32% Zn, 4.13% Pb and 61.7 g/tonne Ag and the other has 0.4 million tonnes of 1.72% Zn, 9.34% Pb and 214 g/tonne Ag. The host rock is the middle quartzite of three cyclical successions of quartzite, limestone and argillite flanked by the Mackenzie Platform to the east and the Pelly Cassiar Platform to the west.

Sulphide minerals appear to be in pore spaces and their abundance is a function of permeability and porosity before lithification. Temperatures of homogenization of fluid included in quartz and sphalerite are between 185 and 195°C and ^{18}O of fluid in quartz is 2 to 3‰ suggesting meteoric water modified by interaction with sea water. Radiogenic isotopes of land (sic) are present in the galena, indicating a crustal source.

The interpretation is that metals were leached from the Precambrian basement by downward percolating groundwater which became reduced and heated. This metalliferous fluid migrated to the edge of the continent and precipitated metals as sulphide minerals in pores of semi-consolidated sediment below the sea water-sediment interface upon mixing with sulphate-bearing sea water. The Quartz Lake occurrence is most comparable in nature and genesis to sandstone-hosted lead deposits of the Baltic Shield. It may be a precursor to Phanerozoic sedimentary deposits of the Selwyn Basin. (Author's abstract)

VALETTE, C.-O., 1983, Karsts and fluorite veins in the synclinal stratigraphic horizon of the Morvan: the Argentolle deposit: Ph.D. dissertation, U. d'Orléans, 299 pp. (in French); Documents du BRGM, no. 58-1983.

The Argentolle fluorite deposit is situated in the central part of the Devonian-Dinantian synclinorium of the French Morvan, a few kilometers north of the contact with the Luzy biotite monzogranite.

The Upper Visean country rocks comprise volcanites with calco-alkaline affinities. A typological study of the zircons has revealed an evolution with an aluminous tendency, the early lavas being at the dacitic pole and the late lavas at the rhyodacitic pole.

The various stretching and compression phases affecting the Morvan since the Stephanian have been defined by microtectonic analysis. The Paleozoic compressive phases were responsible for the N 80° E and N 160° E faults which trapped the mineralization. The Argentolle deposit was emplaced along these trends at the Liassic-Middle Jurassic. The N 80° E trending mineralization is of the vein type and is hosted by a microgranite dike. The N 160° E trending mineralization is included in a calcareous lens and presents a Karstic appearance: dissolution cavities may be observed[+] at the junction of the two fault systems the mineralization takes the form of violet quartz-fluorite - hematoidal quartz - yellow fluorite.

Study of the fluid inclusions and the rare earths suggests that the mineralization was deposited during the Liassic in a littoral shelf zone. Hydrothermal solutions of crustal origin, mixed with surface waters of marine origin, circulated in the traps. The relative proportions of these two decreased with the Mesozoic regression. Karstification is still active with a system of alternate dissolution and filling. (Author's abstract)

VALLEY, J.W., 1983, The CO_2 flux in the granulite facies (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 710. Author at Dept. Geol. & Geophy., Univ. Wisconsin, Madison, WI 53706.

Granulite facies gneisses in the Adirondack Mts., N.Y. often contain evidence that fluid conditions were heterogeneous at the peak of metamorphism. Extreme values of $\delta^{18}O$, up to +27.2 (calcite) in marble and down to -1.3 (wollastonite) in skarn, represent premetamorphic values preserved through regional metamorphism by the absence of sufficient fluid exchange for homogenization. Likewise, large gradients in $\delta^{18}O$ across layered lithologies would tend to be removed by exchange (6‰/m in wollastonite skarn; 8‰/20m in non-carbonate metasediments; 15‰/15m at anorthosite/marble contact; 16.9‰/260m at granite/marble contact). When fluid-buffering mineral assemblages are available in nearby rock units CO_2 fugacity also can vary by over 10^2 indicating that buffering capacity has not been exhausted by fluid movement.

Marbles evolve up to 25 wt % CO_2, but may never be penetrated by fluids of external origin if deep crustal fluid movement is channelized along vein systems rather than pervasive. The molar oxygen ratio of (externally derived CO_2)/(rock), CO_2/R, more accurately describes CO_2 movement than "open-" and "closed-system." In well-defined situations, stable isotope analysis yields $CO_2/R \leqslant 0.1$ at Cascade slide, Harrisville and Antwerp and $\leqslant 1.0$ at Weston Mines and Keene. Gradients in fCO_2 also indicate low CO_2/R.

Estimates of CO_2/R may eventually resolve various theories of low fH_2O during granulite formation (charnockitization). If P(fluid) < P(lithostatic) then premetamorphic heterogeneity will be preserved by the absence of fluids. CO_2-flooding, to dilute H_2O, requires $CO_2/R>0.1$ for orthopyroxene growth in many rocks while H_2O removal by rising magmas can proceed at $CO_2/R = 0.0$. The present results are not consistent with processes requiring $CO_2/R>1.0$ in these rocks. (Author's abstract)

VALLEY, J.W., McLELLAND, James, ESSENE, E.J. and LAMB, William, 1983, Metamorphic fluids in the deep crust: evidence from the Adirondacks: Nature, v. 301, p. 226-228.

VAN REENEN, D.D., 1983, Hydration of cordierite and hypersthene and the nature of the opx isograd in the Limpopo belt, South Africa (abst.): Geol. Assoc. Canada; Mineral. Assoc. of Canada; Canadian Geophy. Union; joint annual meeting, Victoria, B.C., Canada, May 11-13, 1983, Geol. Assoc. Canada Program with Abstracts, v. 8, p. A72. Author at Dept. Geol. & Geophys. Sci., Princeton Univ., Princeton, NJ 08544.

Pelitic rocks in the Southern Marginal Zone of the Limpopo belt reveals a complex metamorphic history during an extended period of high-grade metamorphism before 2.5 b.y. Peak metamorphic conditions of T >820°C and P >9.5 kbar were attained during the early prograde stage (M_1) which was followed by retrograde event during slow uplift and subsequent cooling. The early stage (M_2) of this retrograde event was controlled by isothermal (T = ± 820°C) unloading accompanied by the divariant breakdown of garnet ($ga + qz \rightleftharpoons cd + hy$). This reaction records pressures down to 7.2 kbar. The final stage (M_3) of this retrograde event is the hydration of the earlier cordierite and hypersthene; this controlled the present position of the extremely well-defined opx isograd.

Microprobe analyses of orthoamphiboles from the partially hydrated cordierite + hypersthene-bearing granulites along this isograde and from chemically identical, but completely hydrated, rocks south of the isograd revealed the presence of sub-solvus anthophyllite and gedrite coexisting with kyanite, biotite, quartz and plagioclase in the lower-grade rocks. The miscibility gap between anthophyllite and gedrite is clearly illustrated by discontinuities in the A-site occupancy and in the Al^{VI} and Al^{IV} contents. The solvus is wider for coexisting Mg-rich pairs from the isograd as compared with more Fe-rich pairs from chemically identical rocks at lower grade. A chemographic analysis based on these K_2O- and CaO-poor rocks indicates that the isograd was established by a combination of decreasing T (T > 750°C) and increasing PH_2O at constant total P >7 kbar. Preliminary results of a fluid inclusion study showed the presence of H_2O-rich inclusions only in partially or completely hydrated samples, and predominantly CO_2-rich inclusions in the unhydrated samples. (Author's abstract)

VAN WAGONER, N.A., 1983, Critical evaluation of segregation vesicles in mid-ocean ridge basalts as a rock orientation tool: J. Geophys. Research, v. 88, no. B10, p. 8318-8332.

Solidified residual melt forms crescent-shaped partial fillings of vesicles of ~100 μm diameter. (Ed. note - gas inclusions, containing some melt, within single crystals, should behave similarly.) (E.R.)

VARGUNINA, N.P. and ANDRUSENKO, N.I., 1983, Mineralogical-geochemical peculiarities of a polygenic gold-silver deposit: Dokl. Akad. Nauk SSSR, v. 269, no. 2, p. 419-423 (in Russian). First author at Central Sci.-Research Geol.-Prosp. Inst. of Noble Metals, Moscow, USSR.

The deposit (name not given, A.K.) occurs in a volcanic belt in the NE part of the USSR. It developed in early Cretaceous acid effusives, about 1 km above a Late Cretaceous granitoid intrusion. The deposit formed in the following stages: I polymetallic stage with sulfide-chlorite-quartz and adularia-chlorite-quartz with Au and Ag associations; II contact-infiltration skarns of vein type (andradite-grossularite, diopside-hedenbergite, epidote, actinolite, rhodonite, quartz-axinite) with Au-Ag mineralization occurring mostly in quartz-rhodonite veins. Three types of inclusions were found in garnet: G, G>L Th 520-490°C, G<L Th 390-370°C; in axinite G>L Th 490°C, G<L 320°C; in quartz associated with rhodonite Th 420-210°C in L; in epidote Th 390-380°C in L. In endo- and exocontacts of granitoid massif the following varieties of greisens were found: biotite-muscovite-quartz, muscovite-feldspar-quartz, tourmaline-quartz and muscovite-fluorite-quartz, some with garnet and andalusite, all with Cu, Mo, As, Sn and W mineralization. Greisens are high-temperature formations: Th are as follows - in muscovite 510-480°C in G and 380-360 in L, in K-spar 510-500°C in G, in quartz 510-490°C in G, 310-230°C in L, in tourmaline 490°C in G, up to 420°C in L, in fluorite 395-310°C in L (all are P inclusions). Greisen formation finished with late polymetallic mineralization, Th in quartz - 420-310°C, in dark sphalerite - 340-240°C, in cleiophane 290-180°C, in manganocalcite - 320-250°C.

Post-skarn helvite yielded Th 450-280°C. Late hydrothermal activity formed post-ore associations with numerous minerals from which Th were measured for calcite (240-180°C) and gypsum (70-50°C). (Abstract by A.K.)

VELICHKIN, V.I. and VOLOVIKOVA, I.M., 1983, Near-intrusion zoning of ore metasomatites in the Czech massif: Sovetskaya Geologiya, no. 1, p. 76-85 (in Russian). Authors at IGEM, Moscow, USSR.

Skarns formed at 550-430°C, albitites at 410-370°C, greisens at 370-320°C (probably Th, A.K.). (A.K.)

VERETENIKOV, V.M., GORBUNOV, Yu.V., GROSHENKO, A.R., ZHUNKOVA, T.B. and NOVGORODOVA, M.I., 1983, Typomorphic peculiarities of vein quartz of the Kumak ore field (southern Urals): Sovetskaya Geologiya, no. 1, p. 49-54 (in Russian). Authors at IGEM, Moscow, USSR.

The gold ore field Kumak occurs in graben-syncline structure in Devonian volcanic-sedimentary beds and Lower Caraboniferous terrigenous carbonate rocks with intercalations of coal shales. Ore veins occur in carbonate, feldspar, biotite and siliceous metasomatites. Vein quartz yielded Td (two peaks) 270 and 390-400°C, and Th 340-380°C, (340-353°C in L and 372-380°C in G); inclusions with LCO_2 homogenize at 384°C in L phase. Other groups of inclusions homogenized at 252-256, 223-227 and down to 170°C. Veins from the end of formation of metasomatites bear inclusions with Th 340-410°C; strongly recrystallized and deformed quartz from veins 235-280°C. By triple water leachate method, ore quartz bears Cl as main anion, barren quartz - HCO_3, F is subordinate. Ore quartz has very stable Na/K ratio equal 1.7 to 2.0, barren quartz 0.8-1.3. Distributions of Ca and Mg do not show noticeable regularities. Gases consist of CO_2 (especially high content in gold-ore-bearing quartz), CH_4, H_2 and traces of He (in central parts of thick quartz vein). (Abstract by A.K.)

VIDALE, Rosemary, 1983, Pore solution compositions in a pelitic system at high temperatures, pressures, and salinities: Am. J. Sci., v. 283-A, p. 298-313. Author at INC-7, Isotope Geochem., Los Alamos Nat'l. Lab., Los Alamos, NM 87545.

Aqueous solution composition was determined with respect to concentration of KCl, $MgCl_2$, NaCl, and $CaCl_2$, in the system K_2O-MgO-Al_2O_3-SiO_2-H_2O-KCl ± Na_2O ± CaO for the mineral assemblages, albite-muscovite-phlogopite-sanidine-quartz, anorthite-muscovite-phlogopite-sanidine-quartz, and plagioclase-muscovite-phlogopite-sanidine-quartz, at 538° and 587°C, 2 and 4 kb, and 2, 10, and 20 molal total chloride. Approximate expressions were derived from the first two data sets for $[NaCl]a(Sanidine)/[KCl]a(Albite)$, $[KCl]^2/[MgCl_2]$, and $[KCl]^2/[CaCl_2]$, as a function of temperature and pressure for use in transport models. (Author's abstract)

VISHNEVSKIY, S.A., FELD'MAN, V.I. and SHUGUROVA, N.A., 1981, Gases in inclusions in impact glass of the El'gygytgyn astrobleme: Dokl. Adad. Nauk SSSR, v. 261, no. 5, p. 1220-1223 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 261, p. 194-197, 1983). Authors at Inst. Geol. & Geophy., Siberian Div., USSR Acad. Sci., Novosibirsk, USSR.

Includes analyses of 11 samples for CO_2, CO, CH_4, H_2, H_2O, O_2 and N_2 released by bulk heating, and of 18 individual inclusions in glasses, for CO_2, HC, CO, H_2 and N_2. (E.R.)

VLASOV, Yu.G., MILOSHOVA, M.S. and ANTONOV, P.P., 1983, Studies of the system NH_4Cl-NH_4Br-H_2O at 25°C: Zhurn. Neorg. Khimii, v. 28, no. 8, p. 2127-2130 (in Russian). Authors at State Univ., Leningrad, USSR.

The authors show the solubility isotherm, relation between coefficient of common crystallization and composition of crystal phase, water activity in the system, relation between total molar concentration and solution composition, and values of change of free energy ΔG, change of enthalpy ΔH and change of enthropy $T\Delta S$. (A.K.)

VOLKOV, A.V., 1981, Gold-silver mineralization in terrigenous sequences: Geol. i Razvedka, no. 8, p. 50-56 (in Russian; translated in Int'l. Geol. Review, v. 25, no. 8, p. 917-921, 1983).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 220, 1981. (E.R.)

VOLLMER, R., 1983, Earth degassing, mantle metasomatism, and isotopic evolution of the mantle: Geology, v. 11, p. 452-454. Author at Dept. Earth Sci., The Univ., Leeds, LS2 9JT, England.

Excess ^3He in mantle-derived rocks relative to atmospheric abundance shows that degassing of Earth is a continuing process. The importance of chemical changes induced by fluids from the deep mantle on the oceanic and continental lithosphere has been recognized increasingly in recent years. I propose that the parent-daughter element fractionation caused by such fluids dominates the Sr, Nd, and Pb isotope evolution of the mantle in the second half of Earth's history. A simple two-layered mantle model based on such a premise seems to be consistent with the present knowledge of the Sr, Nd, Pb, and He isotopic characteristics of mantle-derived rocks. The model predicts two populations of intraplate oceanic-island volcanism: "primary" fluid-induced volcanism and "secondary" volcanism caused by remelting of ancient metasomatized domains. The model implies a new interpretation of the Nd-Sr isotopic covariations in oceanic basalts. (Author's abstract)

VON DAMM, K.L. and EDMOND, J.M., 1983, Hydrothermal activity in the eastern Pacific and the formation of volcanogenic massive sulphides (abst.): IUGG, XVIII General Assembly, Program and Abstracts, v. 2, p. 811. Authors at Dept. Earth & Planet. Sci., E24-201 MIT, Cambridge, MA 02139, USA.

Ophiolite massive sulphides are forming at several known locations on the East Pacific Rise. Pictures, movies and chemical data from the location at 21°N will be presented. Here the solutions are acid (pH = 3.5) with concentrations of H_2S ranging between (in different fields) 6 and 9 mM, Fe 0.7 and 2.5 mM, Zn and Cu of around 0.1 and 0.01 mM respectively and

Ni below 0.001 mM. The solutions have Cl as the only anion (SO_4 is completely depleted) are strongly enriched in the alkalies and Ba and variably so in Ca. Sr shows small enrichments but is isotopically homogenized with the basalt. Maximum enrichments in ionic strength i.e. Na+Cl are about 8% due to rock hydration by the circulating sea water; however removal of substantial amounts of Na and Cl from the sea water is common.

In Guaymas Basin in the Gulf of California the ridge axis is buried beneath several hundred meters of detrital sediments rich in organic and carbonate carbon. It appears that a 21°N-type solution issuing from the region of the magma chamber reacts with this sediment. The dissolution of planktonic carbonate and the thermal cracking of immature organic carbon results in a solution saturated with calcite at 315°C (pH = 5.5, A_t = 10 meq, PCO_2 = 17 atmos) and containing up to 16 mM of ammonia. Close to quantitative precipitation of the sulphide-forming elements in the sediment pile occurs in consequence. Levels in the 315°C end-member solutions are more than an order of magnitude lower than those at 21°N.

It is likely that the grade and bulk chemistry of the sediment hosted volcanogenic massive sulphides is controlled by the surface biological productivity. A correlation between grade, organic carbon content and abundance of ammonia-rich clays would then be expected. (Authors' abstract)

VORONIN, D.V., NEFEDOVA, Ye.N. and RUDASHEVSKAYA, N.S., 1983, Solution of galena under the influence of electric current: Dokl. Akad. Nauk SSSR, v. 267, no. 2, p. 446-449 (in Russian).

VORTSEPNEV, V.V., GONCHAROV, V.I., EREMIN, R.A. and BABAYTSEV, O.V., 1983, Thermobarogeochemistry of a gold-ore deposit* of sulfide-disseminated type: Geol. Rudn. Mestorozhd., v. 25, no. 4, p. 64-70 (in Russian). Authors at NE Complex Sci.-Research Inst. of the Far-East Sci. Center of Acad. Sci. of the USSR, Magadan, USSR.

The deposit occurs in miogeosynclinal terrigenous beds cut by dikes of acid and intermediate rocks. Th of the melt part of P melt inclusions in quartz of magmatic rocks, bearing crystallized melt + ~20 vol.% of G sticking to trapped apatite crystal occurred at 1200-1300°C. Other inclusions bearing 10-20 vol.% of G + crystallized melt (or glass), have Th 1180-1320°C. S inclusions in magmatic quartz bear: 1) G + LH_2O + halide dms, 2) G + LCO_2 + LH_2O ± dms and 3) G + LH_2O. In 2) the CO_2 content reaches 70% [by vol.? - A.K.]. Variety 1) yielded Th 610-350°C, P 2200-1600 atm; they are accompanied by essentially G (i.e. G>L) inclusions with Th 530-510°C, that proves heterogenization of fluid. Variety 2) yielded Th 440-300°C, P 1600-1400 atm for inclusions filled by G + LH_2O + LCO_2 + dms, 340-280°C and 1150-930 atm for inclusions G + LCO_2 + LH_2O, sometimes Th 340-150°C, P 900-720 atm. Variety 3) yielded Th 340-170°C. In these ranges, for quartz of the rare-metal complex Th 400-220°C and P 1800-1170 atm are typical, for gold-commerical complex Th 330-150°C, P 1400-870 atm. (Abstract by A.K.)

*Name of the deposit not given. (A.K.)

VOZNYAK, D.K., GALABURDA, Yu.A., LEGKOVA, G.V. and KOTVITSKIY, L.F., 1982, Conditions of formation of quartz porphyry from the settlement Rudnya Ososhnya (NW Ukrainian Shield): Mineralog. Zhurnal., v. 4, no. 6, p. 83-94 (in Russian; English abstract). First author at Inst. Geochem. and Physics of Minerals, Kiev, Ukraine.

The Upper Proterozoic quartz porphyry bears 25-30 vol. % of quartz, oligoclase-albite, albite and microcline phenocrysts, and its chemical composition is (wt. %) SiO_2 73.13, TiO_2 0.34, Al_2O_3 13.88, Fe_2O_3 2.62, FeO

2.45, MnO 0.02, MgO 0.34, CaO 0.38, Na_2O 1.45, K_2O 3.60, P_2O_5 0.11, ignition loss 1.18, total 99.51. Quartz bears numerous inclusions: glass, G/L, solid (apatite, zircon, ilmenite). Glass inclusions are P and S, their dimensions are from 0.00n to 0.25 mm. P inclusions formed during A) homogeneous and B) heterogeneous trapping; the inclusions of A) type consist of varieties: 1. glass ± G bubble, glass colorless or brown-yellow, 2. crystallized inclusions with various amounts of mineral phases + G bubble, 3. inclusions of green-gray glass with numerous spherical mineral aggregates, without G phase. Inclusions A1 and A2 homogenize at 1020-1270°C. P inclusions of glass and ore, formed due to melt immiscibility (B) bear up to 95% of ore substance. The latter was trapped in liquid state, and at T of glass softening it becomes liquid and moves toward the lowermost part of inclusions. Th of silicate glass + G 1120 to 1020 ± 15°C, and for inclusions extremely rich in ore substance 970-990°C. S melt inclusions frequently bear various G/melt phase ratios, Th of inclusions of homogeneous trapping 960-980°C. S inclusions of heterogeneous trapping bear CO_2 in G phase of Th 30-30.5°C. Chemical composition of A-type glass inclusion (by electron microprobe) is (in wt. %): SiO_2 77.28, TiO_2 0.16, Al_2O_3 11.66, FeO 2.34, CaO 0.46, MgO 0.06, Na_2O 1.91, K_2O 6.14, total 100.01; glass of B-type inclusion: SiO_2 73.58, TiO_2 0.41, Al_2O_3 11.61, FeO 0.29, CaO 0.10, Na_2O 2.11, K_2O 8.07, total 96.16, and ore substance from the same inclusion (ilmenite) SiO_2 0.22, TiO_2 54.93, FeO 45.72, Na_2O 0.42, K_2O 0.11, total 101.40. Gas composition in individual melt inclusion (by mass spectrometry, vol. %): CO_2 12.9, CO and/or N_2 70.3, CH_4 3.2, H_2O 1.6, H_2 11.7, Ar 0.3. S G/L inclusions have Th 80-160°C, G composition (vol. %) H_2O 40.1, N_2 57.3, CO_2 2.6. The following may be concluded: retrograde magma boiling occurred at 960-980°C, P $>1.2 \cdot 10^8$ Pa. High content of CO_2 and K_2O in glass inclusions and high T may indicate the connection of magmatic melt of the studied porphyry with basic magma. Presence of magmatic ilmenite (ore melt) close in its composition to ilmenite found in the basic rocks of this region may suggest that ore substance was extracted by "porphyry magma" from wall rocks during migration. (Abstract by A.K.)

VOZNYAK, D.K., KVASNITSA, V.N. and KROCHUK, V.M., 1981, Solidified melt inclusions in baddeleyite from carbonatite of the Azov region: Dokl. Akad. Nauk SSSR, v. 259, p. 952-955 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 259, p. 167-170, 1983). Authors at Inst. Geochem. & Phys. of Minerals, Ukrainian Acad. Sci., Kiev, USSR.

Abstracted in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 222, 1981. (E.R.)

WAKATSUCHI, Masaaki, 1983, Brine exclusion process from growing sea ice: Contributions from Inst. Low Temperature Sci., Ser. A, no. 33, p. 29-65. Author at The Inst. of Low Temperature Sci., Japan.

The process of exclusion of brine from growing sea ice, which plays an important role in the polar ocean, was quantitatively studied in the field and laboratory under various conditions. (E.R.)

WAKITA, Hiroshi and SANO, Yuji, 1983, $^3He/^4He$ ratios in CH_4-rich natural gases suggest magmatic origin: Nature, v. 305, p. 792-794. Authors at Lab. for Earthquake Chem., Faculty of Sci., Univ. Tokyo, Bunkyo-ku, Tokyo, Japan.

Natural gas and oil fields, commercially exploited since the 1950s, are distributed in the zonal area facing the Sea of Japan in north-east Japan. We report here measurements of the $^3He/^4He$ ratios in 27 CH_4-rich natural gases obtained from commercial oil and gas wells in the area. We observed extraordinarily high $^3He/^4He$ ratios, up to 8.65×10^{-6}, in gases from wells drilled into deep reservoirs in volcaniclastic rock formations, the so-called 'Green Tuff' (Fig. 1). These values are almost identical to those of volcanic fumaroles in the Japanese Islands. In contrast, gases in shallower sedimentary rock reservoirs have low $^3He/^4He$ ratios with a minimum value of $0.3x10^{-6}$. These low values are similar to those of natural gases originating from biological materials. This suggests that the formation of natural gas reservoirs in the volcaniclastic rock may be attributed to large-scale magmatic activities which occurred in the middle Miocene. (Authors' abstract)

WALCHESSEN, A.A., 1983, The geology and ore deposits of a portion of the Tyndall mining district, Santa Cruz County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 89 pp.

The Tyndall mining district, located in the Santa Rita Mountains, Santa Cruz County, Arizona, has produced 500,000 ounces of silver. Mineralized quartz veins including the Alto Group, the Salero, and the Jefferson veins are hosted by the Jurassic Squaw Gulch Granite, Cretaceous Salero Formation, and Cretaceous Josephine Canyon Diorite. Alteration is limited to regional propylitization. These veins are vertical with a northwest orientation and are composed of quartz, pyrite, tetrahedrite, galena, sphalerite, and chalcopyrite. Three phases of quartz were identified: early barren quartz, ore stage quartz, and late barren quartz. Filling temperatures of 300°C and 240°C for the first and second quartz phases, respectively, were determined by homogenizing fluid inclusions. Geochemical sampling of mine dumps show high silver values, a molybdenum anomaly, and high gold values in the Alto Group veins. Microprobe analyses indicate that silver proxies for copper in tetrahedrite rather than occurring in discrete silver minerals. (Author's abstract)

WALKER, R.N., GULSON, B. and SMITH, J., 1983, The Coxco deposit--a Proterozoic Mississippi Valley-type deposit in the McArthur River district, Northern Territory, Australia: Econ. Geol., v. 78, p. 214-249. First author at Carpentaria Explor. Pty. Ltd., G.P.O. Box 1042, Brisbane, Queensland, Australia.

The Coxco deposit is a Proterozoic strata-bound dolomite-hosted lead-zinc deposit which shows many similarities to Mississippi Valley-type deposits. Solution cavities are now filled in with finely laminated speleothems.

An important constituent of the deeper sections of the karst system are crusts of colloform sphalerite, galena, pyrite, and marcasite (stage I mineralization) which were deposited on the surfaces of the karst-produced solution cavities. The remaining open space in these cavities is filled with detrital sediments and in many instances deposition of mineralization alternated with deposition of the detrital sediments. Textural evidence suggests the rapid dumping of sulfide probably during the mixing of metal-rich and sulfur-rich solutions. The low temperature of sulfide deposition (less than 100°C), the ubiquitous association of the sulfides with organic matter, and the sulfur isotope ratios of the sulfides suggest that the reduced sulfur was produced by sulfate-reducing bacteria within the karst system.

A second stage of mienralization (stage II mineralization) consisting of coarsely crystalline sphalerite, galena, pyrite, and marcasite occurs in veins and as the matrix for dolomite breccias. Matrix for the sulfide is sparry dolomite and rate bitumen. The temperature of sulfide deposition is estimated to be in the range 100° to 170°C based on the sulfur isotope fractionation between sphalerite and galena and homogenization temperatures of fluid inclusions in the sphalerite. The sulfur isotopic ratios of the sulfides, the presence of bitumen, and the dolomite dissolution suggest that reduced sulfur, the precipitation of the sulfides, was suppled by inorganic reduction of sulfate. (From the authors' abstract)

WALTERS, F.H. and KEELEY, D.F., 1983, Analytical Letters, v. 16, no. A11, p. 847-852. Authors at Dept. Chem., Univ. Southwestern Louisiana, Lafayette, LA 70504.

Fluoride ion was determined by means of a fluoride ion selective electrode. The values decrease from 7.8 ppm to a plateau value of 1.6-1.8 ppm. (Authors' abstract)

WALTHER, J., 1983, The system H_2O-CO_2, application of new diagrams in fluid inclusion practice (abst.): Symposium, European Current Research on Fluid Inclusions, April 6-8, 1983, Orleans, France, Program, p. 54. Author at Mineralog. Inst. d. Univ. Kaiserstr 12, D-75 Karlsrühe, RFA.

Demonstration and use of P-T-X-V diagrams in the H_2O-CO_2 system. (No further abstract available)

WALTHER, J. and ALTHAUS, E., 1983a, Fluid inclusions in apatite crystals from carbonatitic rocks form Kaiserstuhl (southwestern Germany) (abst.): Terra cognita, v. 3, p. 146. Authors at Mineralog. Inst. Univ.-Karlsruhe.

Apatites of the Kaiserstuhl-Carbonatite contain an unusual variety of fluid inclusions: cavities with vapor filling, cavities with low salinity solutions (and rather different degrees of filling), cavities with oversaturated solutions and rather different numbers and types of daughter crystals (chlorides, carbonates, sulfates of Na, K dominant) - partly with, partly without two phase CO_2. Many apatites also contain spheroidic calcite and some cavities with bituminous hydrocarbons up to C-24. (Authors' abstract)

WALTHER, J. and ALTHAUS, E., 1983b Fluid inclusions in ultramafic xenoliths of volcanites from southern and western Germany (abst.): Fortschritte der Mineral., v. 6, part 1, p. 217.

Microthermometric investigation of fluid inclusions in olivines and pyroxenes of ultramafic xenoliths (Eifel, Southern Germany, Northern Hesse) revealed that the rock fragments were not closed systems when they were transported by the magmas but were able to exchange their fluids with those exsolved from the melt. Densities varied within wide limits (<0.2 up to 1 g/cm^3), and almost all inclusions contained CO_2 only with no trace of H_2O. This observation is interpreted in the literature as evidence of CO_2 being the prevailing fluid of the upper mantle. Th and densities show, however, that the cavities do not contain fluids incorporated under mantle conditions. It is concluded, that the inclusions were altered during the ascent of the magma; in this process H_2O was dissolved preferably in the melt whereas CO_2 remained in the inclusions. These observations are probably applicable to other localities, too, and hence the hypothesis of a CO_2-rich upper mantle needs some more investigation. (Authors' abstract)

WALTHER, J.V., 1983, Description and interpretation of metasomatic phase relations at high pressures and temperatures: 2. Metasomatic reactions between quartz and dolomite at Campolungo, Switzerland: Am. J. Sci., v. 283-A, p. 459-485. Author at Dept. Geol. Sci., Northwestern Univ., Evanston, IL 60201.

Metasomatic reaction zones consisting of calcite and fluorine-bearing tremolite, phlogopite, and sporadic talc have formed along preexisting hydrothermal quartz veins in dolomite at Campolungo, Switzerland. Measurements of the $MgCO_3$ concentration of calcite in apparent equilibrium with dolomite, combined with observations of fluid inclusion compositions and densities, indicate the metasomatic process took place at ~3.25 kb and 500°C with the introduction of a ~5 wt percent NaCl equivalent aqueous fluid phase. Fluid generated as a result of the metasomatic reactions appears trapped in fluid inclusions along annealed fractures in quartz crystals sub-perpendicular to the reaction front. Most of these inclusions contain CH_4 along with CO_2 and H_2O. Density analysis of the CO_2-rich inclusions shows apparent leakage. The fluid produced, however, appears to be the approximate composition $X(CO_2) = 0.5$, $X(H_2O) = 0.4$, $X(CH_4) = 0.1$. Measured fluorine contents of solid phase assemblages containing phlogopite, tremolite, and talc agree with experimental phase data reported in the literature on fluorine-hydroxyl exchange. Relative abundances of calcite, tremolite, and phlogopite suggest that both calcium and magnesium were conserved between solid phases. Complete equilibrium between all phases was not achieved. Phase relations viewed in the CaO-MgO-SiO_2-HCl-HF-CO_2-H_2O system at 3.25 kb and 500°C are consistent with the observed phase assemblages and suggest talc was stabilized by fluorine within the fluid phase. Analysis of ionic activity diagrams incorporating provisions for solvation of aqueous species indicates that $\log a(H_2O)$ and $\log (a[SiO_2aq]/\sigma[SiO_2aq])$ increase while $\log (a[Mg^{++}]/\sigma[Mg^{++}]a[H^+]^2)$ and $\log (a[Ca^{++}]/(\sigma[Ca^{++}]a[H^+]^2))$ decrease from dolomite to quartz. (Author's abstract)

WALTHER, J.V. and ORVILLE, P.M., 1983, The extraction-quench technique for determination of the thermodynamic properties of solute complexes: application to quartz solubility in fluid mixtures: Am. Mineral., v. 68, p. 731-741. First author at Dept. Geol. Sci., Northwestern Univ., Evanston, IL 60201.

A procedure is outlined that allows determination of the hydration state, charge and chemical stoichiometry, as well as the apparent standard molal Gibbs free energy of formation, of aqueous species from solubility measurements in fluid mixtures. Also described is a hydrothermal apparatus capable of obtaining the necessary solubility data in fluid mixtures. The apparatus was used to determine quartz solubilities in supercritical CO_2-H_2O and Ar-H_2O mixtures. Results of this investigation along with other values reported in the literature are consistent with a stoichiometry of the dominant aqueous silica species of $Si(OH)_4 \cdot 2H_2O$ in the supercritical region of H_2O. Knowledge of the hydration number of aqueous silica was used to predict silica concentrations in CO_2-H_2O mixtures in the system CaO-MgO-SiO_2-HCL-CO_2-H_2O at 2 kbar and 450°C. (Authors' abstract)

WANG, Liankui, ZHU, Weifang, ZHANG, Shaoli and YANG, Wenjin, 1983, The evolution of two petrogeno-mineralization series and Sr isotopic data from granites in south China: Mining Geol., v. 33, no. 5, p. 295-303. Authors at Inst. Geochem., Acad. Sinica, Guiyang, China.

The two series are said to have different "inclusion temperatures," 900-1140°C and 600-680°C. (E.R.)

WANG, Zhifen, 1983, Some problems on the mineralization of tin deposits in Gejiu, Yunnan: Acta Geol. Sinica, v. 57, no. 2, p. 154-163. Author at No. 308 Exploration Team, Southwest Geol. Exploration Co., MMI.

Gejiu large tin deposits are large polymetallic tin-bearing deposits, with cassiterite-sulfide and cassiterite-quartz mineralization (inclusion cassiterite-tourmaline) as the main types. Genetically, the deposits are closely associated with the middle and late Yanshan porphyritic biotite-granite and equigranular biotite-granite. The formation temperature of granite is >800°C. The mineralization may be divided into four stages, namely silicate, oxide, sulfide, and carbonate stages, their formation temperature being 425°C, 238-358°C, 277-386°C and 290-305°C respectively. The major tin mineral is cassiterite, with minor stannite etc. It is considered that the deposits should belong to the pneumato-hydrothermal type owing to the high salinity and great content of CO_2, OH(sic) and H_2S in the fluid inclusions, which indicate the nature of the ore solutions during the ore-forming process.

Based on the data mentioned above, and sulfur and lead isotopic measurements, it is assumed that the Gejiu tin deposits are related to granites which were formed by the anatexis of lower earth's crust and were emplaced to the shallow part of the crust. (From the author's abstract)

WARNER, J.D., 1982, Geology and mineralization of the Blue Rock mine, northeastern Rincon Mountains, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 131 pp.

Mineralization at the Blue Rock mine (Sec. 16, T. 13 S., R. 18 E.) is paragenetically related to the structural evolution of the northeastern Rincon Mountains. This evolution is represented in the study area by a middle Tertiary ductile to brittle continuum of deformation that resulted in the juxtaposition of five lithologically and chronologically distinct domains of rock along low-angle faults. Associated mineralization and alteration progressed from an environment of high-temperature regional and contact metamorphism to one of lower temperatures and localized hydrothermal activity.

Uranium is the most economically important mineralization of the study area. It is probably hydrothermal in origin and was probably precipitated from an oxidizing, CO_2-bearing, neutral to slight acid, 160°C-180°C fluid as a result of adsorption onto hematite within bodies of chloritized breccia. The uranium source is speculative, but may be biotites within the nearby augen gneisses. (Author's abstract)

WARNER, J.L., ASHWAL, L.D., BERGMAN, S.C., GIBSON, E.K., Jr., HENRY, D.J., LEE-BERMAN, Richard, ROEDDER, Edwin and BELKIN, H.E., 1983, Fluid inclusions in stony meteorites: Proc. 13th Lunar & Planet. Sci. Conf., Part 2, J. Geophys. Res., v. 88, Supple., p. A731-A735. First author at Chevron Oil Field Res. Co., La Habra, CA 90631.

We describe fluid inclusions in five stony meteorites: diogenite ALHA 77256 and chondrites Bjurbole (H4), Faith (H5), Holbrook (L4), and Jilin (H5). This brings to seven the number of stony meteorites in which fluid inclusions have been confirmed. The fluid inclusions in diogenite ALHA 77256 display a vapor bubble that decreases in volume from -180°C, the lowest temperature attainable in our microthermometric runs, to homogenization of liquid plus vapor to liquid. Homogenization temperatures are reproducible in each inclusion, and range from 25°C to over 225°C; some vapor plus liquid inclusions remain at 225°C, the highest temperature in our microthermetric experiments. On cooling, the fluid in some inclusions apparently freezes, as indicated by deformation and immobilization of the vapor bubble at low temperatures. However, temperatures of melting are difficult to observe and are not reproducible. Preliminary laser Raman spectroscopy shows symmetric and antisymmetric stretch bands characteristic of H_2O. Microthermometric data suggest that the fluid in diogenite ALHA 77256 is aqueous with a high solute content. Fluid inclusions discovered in four chondrites have similar properties. (Authors' abstract)

WATANABE, Makoto and SAKAI, Hitoshi, 1983, Stable isotope geochemistry of sulfates from the Neogene ore deposits in the Green Tuff region, Japan: Econ. Geol. Monograph 5, p. 282-291. First author at Inst. Geol. & Min., Faculty of Sci., Hiroshima Univ. Hiroshima 730, Japan.

Neogene mineralization throughout the Green Tuff region of Japan, closely related to geosynclinal evolution, is classified mainly into two types: the polymetallic, strata-bound Kuroko-type and hydrothermal vein-type mineralization occurring mostly in submarine volcanogenic sediments of Neogene age. In order to examine their genetic relation, especially the possible origins of their ore fluids, we have analyzed $\delta^{34}S$ and $\delta^{18}O$ values of sulfates in more than 100 samples of barite, anhydrite, and gypsum in the Neogene ore deposits, along with some $\delta^{18}O$ values of quartz and adularia associated with these deposits.

Most of the isotopic compositions of Kuroko sulfates collected mainly in the Kuroko (black) and keiko (siliceous) ore zones fall within a relatively narrow range: 19.5 to 25.5 per mil for $\delta^{34}S$ and 6.4 to 10.9 per mil for $\delta^{18}O$. These compositions, combined with fluid inclusion data, indicate that the ore fluids were predominantly Miocene seawater. In contrast, the hydrothermal vein sulfates are characterized by more scattered distributions of $\delta^{34}S$ (ranging mostly from 16 to 29‰) and $\delta^{18}O$ (mostly 0 to 14‰) values and were deposited from ore fluids of predominantly meteoric origin. The large spread in the isotopic compositions of these sulfates can be attributed to varying degrees of mixing or meteoric waters with other fluids such as modified seawater or connate water.

Barite samples from a single Kuroko deposit, the Ainai-Daikoku deposit, display a tendency for the $\delta^{18}O$ values of sulfates in the keiko zone to be slightly higher than those in the Kuroko zone. No clear trend exists between the $\delta^{34}S$ values from these two zones. (Authors' abstract)

WATANABE, Shuichi, MISHIMA, Kazunobu and MATSUO, Sadao, 1983, Isotopic ratios of carbonaceous materials incorporated in olivine crystals from the Hualalai Volcano, Hawaii - An approach to mantle carbon: Geochem. J., v. 17, p. 95-104. Authors at Dept. Chem., Tokyo Inst. Tech., O-okayama, Meguro-ku, Tokyo 152, Japan.

Carbon dioxide and graphitic carbon in olivine crystals from dunite nodules in the 1801 lava flow of the Hualalai Volcano, Hawaii were extracted by three methods, i.e., the pyrolysis under oxygen atmosphere, the ball-milling and the dissolution with hydrochloric acid. It is concluded that most of CO_2 extracted by the oxidative pyrolysis was derived from fluid inclusions, by comparing the isotopic ratios of CO_2 released by the oxidative pyrolysis and the ball-milling. Graphitic carbon was recoverd from the evaporation residue after olivine crystals were dissolved in hydrochloric acid.

The averaged concentration of CO_2 extracted by the oxidative pyrolysis was 0.87 μmole/g and $\delta^{13}C$ value was -3.2% . These of graphitic carbon were 0.51 μmole/g and -26.9% , respectively. No appreciable amount of hydrogen-bearing species such as H_2, H_2O, CH_4, higher hydrocarbons and H_2S was detected in olivine crystals by both the oxidative pyrolysis and the ball-milling. Assuming all the extracted carbon is present in fluid inclusions in olivine crystals and the disproportionation reaction of CO ($2CO \rightarrow CO_2 + C$) has occurred in inclusions, we conclude that the major carbon-bearing species in the mantle beneath the Hawaiian Islands are CO and CO_2, and the CO/CO_2 ratio is estimated to be about 3 on the basis of the experimental data and that the $\delta^{13}C$ value of the carbon in upper mantle below the Hawaiian Islands is around -12% . Some additional data on Japanese olivines suggest that the $\delta^{13}C$ value of the mantle carbon may not be unique throughout the mantle. (Authors' abstract)

WATKINS, K.P., 1983, Petrogenesis of Dalradian albite porphyroblast schists: J. Geol. Soc. London, v. 140, p. 601-618.

A linear belt of schists within which abundant albite porphyroblasts are developed outcrops over approximately 2000 km^2 of the SW Scottish and NE Irish Dalradian. Other features which characterize these rocks are chloritization, the common occurrence of magnetite and development of quartz segregations. The albite porphyroblast schists occur in the biotite and garnet Barrovian metamorphic zones and occupy the crests of regional F3 antiforms.

Textural, mineralogical and petrological data indicate that retrogression of original (Barrovian) metamorphic assemblages and concomitant hydrogen metasomatism occurred. As a consequence of these reactions pH gradients were induced between quartz-albite and mica-garnet-rich bands in the rocks which resulted in redistribution and recrystallization of albite as porphyroblasts. No input of sodium on a regional scale is necessary to explain porphyroblast growth.

An influx of water was responsible for these processes. It is likely that the water was a product of Barrovian regional metamorphism and accumulated in the crests of F3 antiforms as a result of restricted fluid flow. (Author's summary)

WATSON, G.P. and KERRICH, R., 1983, Macassa mine, Kirkland Lake - production history, geology, gold ore types and hydrothermal regimes, in A.C. Colvine, ed., The Geology of Gold in Ontario: Ontario Geol. Survey Miscellaneous Paper 110, p 56-74. Authors at Dept. Geol., Univ. Western Ontario, London, Canada.

Oxygen isotope abundance in rocks and mineral separates from three ore types suggest the ore was precipiated from hydrothermal fluids of +8 to +9.6‰ $\delta^{18}O$, and at 420 to 490°C. These data are consistent with an initial fluid evolved by dehydration of volcanic and sedimentary rocks during accumulation and burial, which ascended and precipitated in open faults and fractures.

Isotopic data from rocks contained within the major faults suggest the initial fluid regime was followed by downward penetration of oxidizing, sulphate-bearing fluids of probable marine origin, initially at temperatures of <200°C and waning to 50°C or less. A third fluid regime is indicated in a quartz-magnetite-chlorite vein which has mineral pair fractionations corresponding to fluids of -4.0 to -0.5‰ $\delta^{18}O$ and 210 to 260°C. This fluid's isotopic composition is consistent with hydrothermal fluids of meteoric origin.

These three hydrothermal fluid regimes are interpreted to reflect a sequence of crustal compression, relaxation and uplift above sea level during the Archean. (From the authors' abstract)

WEBER, Klaus and AHRENDT, Hans, 1983, Mechanisms of nappe emplacement at the southern margin of the Damara Orogen (Namibia), in M. Etheridge and S. Cox (eds.), Deformation Processes in Tectonics: Tectonophysics, v. 92, p. 253-274. Authors at Geol.-Paläon. Inst., Goldschmidstr. 3, D-3400 Göttingen, FRG.

Recent investigations of the mineral content, fluid inclusions, grain fabric, and deformation lead to the conclusion that continental playa-lake evaporites must be assumed as source rocks of the "Sole Dolomite," a 0-30 m-thick bed at the base of the Naukluft Nappes, containing 35 different minerals with sparitic dolomite, albite, quartz, tourmaline, Mg-riebeckite, talc, and sericite being the main components.

The Sole Dolomite contains numerous rock fragments of granites, granodiorites, gneisses and mica schists with tourmaline and Mg-riebeckite as metasomatic minerals. Fragments of quartz-albitolites, which contain more than 50% vol. of albite, and various amounts of tourmaline and dolomite are very frequent. The Sole Dolomite is extremely rich in fluid inclusions of different, but mostly high salinity. The minerals of the Sole Dolomite display no primary recrystallization and no crystal plastic deformation. No preferred lattice orientation is developed. All deformation found in the Sole Dolomite is of the brittle type.

The Sole Dolomite is interpreted as a discordant intrusion under high pore fluid pressure into the base of a nappe sequence. It may be assumed that before its lithification the water-rich carbonate mush has acted as a lubricant. (From the authors' abstract)

WEI, Jiaxiu, 1983, Characteristics of fluid inclusions and mechanism of mineralization alterations for the volcanic deposits in the Lujiang-Zunyang Basin [China]: Zhongguo Dizhi Kexueyuan Kuangchan Dizhi Yanjiuso Sokan, v. 11, p. 40-55 (in Chinese). Author at Inst. Miner. Deposits, Chin. Acad. Geol. Sci., Beijing, PRC.

A series of known Fe, Cu, and pyrite deposits occur in the Lujiang-Zunyang Basin. The volcanism and hydrothermal activities resulted in intense mineralization alterations which have vertical and lateral zoning characterized by a gradual transition from dark to light color. Microscopic and fluid-inclusion studies showed that the temps. of alteration were 140-620°, salinities were 8-43 wt.%, and pressures were 550-1000 atm. The ascent of juvenile gaseous thermal fluids from depth led to the spread of mineralization from the center outward. Gaseous thermal fluids caused replacement by a combined process of infiltration and diffusion. (C.A. 102: 28751u)

WELHAN, J.A. and CRAIG, H., 1983, Methane and helium in deep Earth gases (abst.): Amer. Chem. Soc. 1983 Ann. Meeting Program, GEOC abst. 14 (unpaginated). Authors at Scripps Inst. Oceanography, La Jolla, CA 92093.

Evidence for primordial helium outgassing from the earth's upper mantle is now well-established and documented by the numerous observations of ^{3}He-enriched gases associated with volcanic and hydrothermal activity, both on the continents and at seafloor spreading centers (H. Craig and J.E. Lupton *in* the Sea, vol. 7, Wiley and Sons, 1981). Only recently has similar information become available for reduced carbon gases in mid-ocean ridge (MOR) hydrothermal systems. Evidence for abiogenic methane in the 350°C hydrothermal fluids at 21°N on the East Pacific Rise includes: a) the association of high concentrations of methane with mantle-derived helium and CO_2; b) the lack of suitable sedimentary organic carbon sources; c) the low C_2^+/CH_4 ratio (0.0007-0.002) and high $^{13}C/^{12}C$ ratios ($\delta^{13}C(CH_4)$ = -15‰ vs PDB); and d) the close similarity of $CH_4/^3He$ ratios in the fluid and in the MOR basalts which are known to be the source of mantle helium and CO_2 for the hydrothermal fluids. The global flux of abiogenic methane due to MOR hydrothermal activity can be calculated from the known flux of ^{3}He and is approximately 60,000 metric tons/year. The present carbon flux (CH_4 plus CO_2) from MOR's could supply about one third of the sedimentary carbon reservoir (oxidized plus reduced carbon) over a 4.5 billion year time span. At present ^{3}He is the sole tracer available for identifying mantle volatiles in continental geological environments. In high-temperature geothermal systems mantle helium is ubiquitous, but methane produced thermocatalytically in the crust probably eclipses any mantle methane component which may be present. However, similar inferences concerning methane in low-temperature, tectonically active environments (e.g.: deep faults) cannot be made at this time, pending further studies of helium and methane in natural gases. (Authors' abstract)

WENGER, L.M., PRICE, L.C., GING, Tom and BLOUNT, C.W., 1983, Solubility of crude oil in methane as function of temperature and pressure (abst.): Am. Assoc. Petrol. Geol., Ann. Convention, Abstracts, p. 180-181. First author at Rice Univ., Houston, TX.

See Price et al., this volume. (E.R.)

WESOLOWSKI, D. and OHMOTO, H., 1983, Oxygen isotope fractionation in the minerals scheelite and powellite from theoretical calculations (abst.): EOS, v. 64, p. 334.

WESTER, Robert and ANDERSON, B.W., 1983, Gems, 4th Ed.: London, Butterworths, 1006 pp.

The subject index contains over 90 entries to "inclusions in gemstones." (E.R.)

WHITE, D.E. and HEROPOULOS, Chris, 1983, Active and fossil hydrothermal-convection systems of the Great Basin: Geothermal Resources Council, Special Rept. No. 13, p. 41-53.

WHITE, J.L., 1980, The development of fractures in the Harris Ranch Quartz Monzonite related to the Sierrita porphyry copper system, Pima County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 38 pp.

Detailed field and laboratory observations of altered fractures in the Harris Ranch Quartz Monzonite lead to a description of the sequential evolution of those altered features. Field observations include the measurement of fracture densities, orientations, and alteration assemblages at 300 stations in the area studied. Vein-filling temperatures are determined from laboratory study of fluid inclusions.

A sequence of four fracture-controlled alteration assemblages result from two periods of hydrothermal activity in the Harris Ranch Quartz Monzonite. The earliest alteration assemblage represents an early hydrothermal event not related to mineralization. The existence of this early event is recognized by the spatial distribution of altered fractures, fluid inclusion temperatures, fracture styles, and the absence of the early assemblage in the Ruby Star Granodiorite. The later three assemblages are products of hydrothermal activity responsible for mineralization at Sierrita. As the Sierrita system matured in the Harris Ranch, the extent and abundance of fractures open to hydrothermal fluid flow decreased, as did the temperature of fluids within those fractures. Regional tectonic activity, pre-existing faults, and the concentrator intrusive all influenced the distribution and orientation of fractures during the evolution of the Sierrita porphyry copper system. (Author's abstract)

WHITNEY, J.A. and STORMER, J.C., Jr., 1983, Igneous sulfides in the Fish Canyon Tuff and the role of sulfur in calc-alkaline magmas: Geology, v. 11, p. 99-102. First author at Dept. Geol., Univ. Georgia, Athens, GA 30602.

Pyrrhotite is a common inclusion in several phenocrystal phases from the Fish Canyon Tuff, a voluminous, homogeneous ash flow erupted from the Central San Juan field. The fugacities of various gaseous species have been calculated using the composition of the pyrrhotite, iron-titanium oxides, and biotite. Sulfur and oxygen fugacities fall very near the sulfur condensation curve, implying that liquid sulfur may have been present in the parent magma. High sulfur fugacities during melt formation can cause high oxygen fugacity in calc-alkaline magmas due to the breakdown of pyrite at high temperatures. During cooling of such magmas, separation of SO_2-rich gases causes a reduction in oxygen fugacity. Significant amounts of sulfur are available during degassing and represent a major source of sulfur for related ore deposits. The ultimate source of the high sulfur and oxygen activities is probably pyrite and magnetite deposited during the waning stages of hydrothermal circulation of active oceanic ridges. Other ash flows and calc-alkalic volcanic rocks should be carefully examined for similar sulfide phases. (Authors' abstract)

WHITTAKER, P.J., 1983, Geology and petrogenesis of chromite and chrome spinel in alpine-type peridotites of the Cache Creek Group, British Columiba: Ph.D. dissertation, Carleton Univ., Ottawa, Ontario, Canada.
Indexed under Fluid Inclusions. (E.R.)

WICKS, F.J., SCHANDL, E.S., OZORAY, Judit and PU, Wan, 1983, Grant 138 - Mineralogy and geochemistry of the chrysotile asbestos deposits of Ontario, in Geoscience Research Grant Program, Summary of Research 1982-1983: Ontario Geol. Survey Miscellaneous Paper 113, p. 193-199. Authors at Dept. Geol., Univ. Toronto, Canada.

Studies of the fluid inclusions in some of the diopsides in the rodingites indicates a fluid composition of almost pure H_2O, with no more than 1% NaCl and temperatures of entrapment of the fluid inclusions of 270°C at 1 kbar pressure or 350°C at 2 kbars pressure. (From the authors' abstract)

WILCOX, R.E., 1983, Refractive index determination using the central focal masking technique with dispersion colors: Am. Mineral., v. 68, p. 1226-1236.

WILKINS, R.W.T., 1983, Fluid inclusion investigations with a laser Raman microprobe (abst.): CSIRO Div. of Mineralogy Research Review 1983, p. 219.

The laser Raman microprobe (MOLE) is a new instrument with considerable potential for certain mineralogical applications. Among these is the non-destructive identification of solid, liquid and gaseous species in fluid inclusions. At present, the only instrument of this type which is dedicated to mineralogical studies is at the Centre de Recherches sur la Geologie de l'Uranium in Nancy, France. As a guest of Dr. B. Poty at this institution during 1981, I collaborated with French workers in studies of the hydrates of Na, Ca, Mg and Fe chlorides, and established that these salts could be readily identified at low temperature when they were present as daughter crystals in fluid inclusions (Dubessy et al., 1982). As a result of this work there is some promise that it will eventually be possible to determine semi-quantitatively the composition of the aqueous phase in individual fluid inclusions.

As quantitative gas analyses on individual fluid inclusions can be obtained with this technique, we examined the possiblity of using these data to distinguish generations of barren and ore veins in an area of tin mineralization (Burlinson et al., 1982). The technique was also applied to a study of the gas compositions of retrograde metamorphic fluids at Broken Hill, N.S.W. A wide range of CO_2-, CH_4- and N_2-rich fluids was identified from the metamorphic rocks of this area. (Author's abstract)

WILKINS, R.W.T. and EWALD, A.H., 1983, Ore fluids of the Aberfoyle tin-tungsten deposit, Tasmania: CSIRO Div. of Mineralogy Research Review, 1983, p. 122-123.

Fluid inclusions in the Aberfoyle tin-tungsten deposit, Tasmania, have erratic variations in composition in contrast with the simple mineralogical zoning in the ores. This could be due to formation of the orebody in a zone of mixing between meteoric and magmatic waters but there is also evidence that the fluid inclusions themselves have been modified by necking down and overheating. (Authors' abstract)

WILKINS, R.W.T., EWALD, A.H. and BIRD, J.R., 1983, Proton irradiation as a tool for the study of growth and deformation features of minerals: CSIRO Div. of Mineralogy Research Review, 1983, p. 215-217.

The irradiation of fluorite and halite with 2.5 MeV protons results in the coloration of many growth and deformation features. Healed fracture surfaces, subgrain boundaries and kink and deformation band boundaries are revealed, and even growth dislocations are decorated. This gives essential information for determining the origin of fluid inclusions in these minerals, and provides a tool for the investigation of the response of fluid inclusions to temperature and stress changes. Similar results were obtained with α-particles. (Authors' abstract)

WILKINS, R.W.T., HLADKY, G. and BURLINSON, K., 1983, The rapid distinction of ore veins and barren veins by fluid inclusion decrepitometry: CSIRO Div. of Mineralogy Research Review 1983, p. 219-221.

The heating of minerals gives rise to acoustic emissions which are related to the fracturing and leaking of fluid inclusions contained in the samples. A record of the frequency of the acoustic emissions as a function of temperature provides a method of distinguishing the locally barren parts of an irregularly mineralized hydrothermal vein system, from barren veins of other origin. (Authors' abstract)

WISZNIEWSKA, Janina, 1983, Origin of tin mineralization of the Izera schists in Kamienickie Range (Sudetes): Archiwum Mineralogiczne, v. 38, no. 2, p. 45-55 (in English). Author at Geol. Inst., Warsaw, Poland.

An attempt at explaining the origin of tin mineralization of the Izera schists in Kamienickie Range (Western Sudetes) has been undertaken. Within the research scope are included mineralogical, petrographical, geochemical and tectonical problems. Mutual original relations between mineralization and tectonics have been established. Moreover several tin bearing zones of various thickness and varying tin content have been found in individual borehole profiles. From the results of investigations of temperature, chemistry of ore-bearing solutions as well as parageneses and mineral associations has been drawn the conclusion of hydrothermal origin of tin mineralization in question. (Author's abstract)

WŁODLYKA, Roman, KARWOWSKI, Łukasz and BZOWSKI, Zbigniew, 1983, Beryl-bearing pegmatite from the environs of Jakuszyce (Karkonosze Mts.): Archiwum Mineral., v. 39, part 1, p. 17-28 (in Polish; English abstract). Authors at Mineral Raw Material Anal. Inst. of the Silesian Univ., Sosnowiec, Poland.

The beryl-bearing pegmatite in the Jakuszyce environs is a vein-shaped body concordant with horizontal fractures of granite. The following minerals were found in the pegmatite: alkali feldspar, plagioclase, quartz, tourmaline, beryl, biotite, muscovite, magnetite and pyrite. The pegmatite-forming process started at temperature estimated about 500°C under pressure about 82 MPa. First crystallized microcline, oligoclase, quartz, magnetite and biotite. Next albitization stage developed at temperature range 400-300°C and pressure decreasing down to 60 MPa, resulting in the albite-muscovite-quartz paragenesis. In the final stage of the pegmatite formation beryl, tourmaline and latest quartz crystallized at temperature decreasing down to about 100°C and pressure 47 MPa. (Authors' abstract)

WOLFSBERG, M., 1983, Relationship between anomalies in the relative abundance of ^{18}O, ^{17}O, ^{16}O and anomalies in the temperature dependence of isotopic fractionation factors (abst.): ZfI-Mitteilungen (papers of the Central Inst. of Isotope and Radiation Research of the Acad. Sci. GDR), v. 80, p. 15 (in German). Author at Univ. California, Chemistry Dept., Irvine, CA 92717, USA.

Equilibrium constants, K^{18} and K^{17}, for isotopic exchange equilibria will be discussed,

$$A^{18} + B^{16} = A^{16} + B^{18} \qquad K^{18} \qquad (1)$$

$$A^{17} + B^{16} = A^{16} + B^{17} \qquad K^{17} \qquad (2)$$

Here, a given ^{16}O atom in A^{16} is replaced by ^{18}O. The statistical mechanical theory of the temperature dependence of such equilibrium constants will be elucidated. Particular attention will be given to anomalies in the temperature dependence, e.g., to situations where the logarithm of the equilibrium constant changes sign as a function of temperature (so-called cross-over phenomenon). It is apparent that such anomalies can lead to anomalies in the fractionation of ^{18}O relative to ^{16}O when compared to the corresponding fractionation of ^{17}O relative to the ^{16}O; these anomalies are manifestations of deviations of $\ln K^{18}/\ln K^{17}$ from the value which is usually found, ~1.9. The possibility that the equilibrium constant anomalies could explain so-called anomalies in the relative abundances of the three oxygen isotopes in nature will be discussed. (Author's abstract)

WOLTER, R. and SCHNEIDER, H.-J., 1983, Saline relics of formation water in the Wettersteinkalk and their genetical connection with the Pb-Zn mineralization, in Mineral Deposits of the Alps and of the Alpine Epoch in Europe, H.-J. Schneider, ed.: Berlin, Springer-Verlag, p. 223-230. Authors at Inst. Angewandt Geol., Freie Univ. Berlin, Wichernstr. 16, D-1000 Berlin 33, FRG.

Small amounts of leachable salts have been observed occasionally in various carbonate rocks hosting Pb-Zn deposits. In order to determine the relation between the saline relics and the Pb-Zn mineralization a systematic analytical research has been carried out in the host rock sequence of the Bleiberg-Kreuth deposit. The contents of leachable (minor) components commonly range between 5 and 5000 ppm.

The components might be derived from four different sources: (1) partial dissolution of host rock minerals (plus gypsum/anhydrite), (2) ions adsorped on clay minerals, (3) fluid inclusions in crystals, and (4) interstitial fluid remnants and salt crystals.

The leachable ion contents differ significantly between mineralized parts and barren host rock. Electrical conductivity of the leaches is correlated with the variation of the geochemical data and can be applied for rapid determination.

The leachable components might be interpreted as saline remnants of migrated formation water or upwelling hot brine which have been trapped during the various stages of diagenesis. (Authors' abstract)

WORONICK, R.E. and LAND, L.S., 1983, Burial cements in Lower Cretaceous Pearsall Formation and Lower Glen Rose Formation, south Texas (abst.): Am. Assoc. Petrol. Geol., Ann. Convention, Abstracts, p. 185.

Lower Cretaceous platform carbonates and shales were buried to depths in excess of 2,000 ft (610 m) by the end of Eocene time, and were locally affected by late-stage cementation. Burial diagenetic cements include ferroan baroque dolomite, ferroan and nonferroan calcite, anhydrite, kaolinite, barytocelestite, galena, and sphalerite. The lack of these minerals in outcrop and their occurrence in fractures are evidence for a subsurface origin.

Carbonate cements are chemically and isotopically zoned; the $FeCO_3$ content in baroque dolomite cement varies by as much as 10 wt. % across a single crystal. Stratigraphic and regional distribution of iron in baroque dolomite indicates that the iron is derived from local sources. Good negative correlation between $\delta^{13}C$ values and iron contents of baroque dolomite suggests the simultaneous reduction of iron oxides and oxidation of organic material.

Some of the late subsurface carbonate cements with extremely depleted $\delta^{18}O$ values precipitated either from hot brine or from isotopically light water; both require the vertical movement of fluid along faults. Galena and sphalerite occur in small amounts in some cores; a single fluid inclusion Th from sphalerite was 20°C (68°F) higher than the present formation T at that depth. Brines moving up faults after albitizing feldspars in more deeply buried formations could be the source of lead and zinc for these minerals. Strontium isotopic ratios for calcite cement in these rocks are similar to ratios for brines from the Stuart City reef trend that are believed to originate deep in the Gulf of Mexico basin. (Authors' abstract)

WRIGHT, I.P., 1983, Carbon isotope analysis at the nanogram level using static mass spectrometry: Ph.D. dissertation, Dept. Earth Sciences, Univ. Cambridge, U.K.

WRIGHT, T.O. and GRAY, D.R., 1983, Structures in the Fort Loudon, Pennsylvania locality of the Ordovician Reedsville formation (abst.): Bermagui '84; Int'l. Conf. on Multiple Deformation and Foliation Development, Bermagui, Australia, Feb. 4-10, 1984; Newsletter of the Specialist Group in Tectonics & Structural Geol., Geol. Soc. Australia, v. 9, p. 154.

Indexed under Fluid Inclusions. (E.R.)

WYLLIE, P.J., HUANG, W.-L., OTTO, Jens and BYRNES, A.P., 1983, Carbonation of peridotites and decarbonation of siliceous dolomites represented in the system $CaO-MgO-SiO_2-CO_2$ to 30 kbar, in M. Friedman and M.N. Toksoz, eds., Continental Tectonics: Structure, Kinematics and Dynamics: Tectonophysics, v. 100, p. 359-388. First author at Div. Geol. & Planet. Sci., California Inst. Tech., Pasadena, CA 91125, USA.

The decarbonation of siliceous dolomite produces rocks including the minerals forsterite, orthopyroxene, and clinopyroxene, characteristic of peridotites. Selected reactions in the system $CaO-MgO-SiO_2-CO_2$ are reviewed, and published data at crustal and mantle pressures are compared with previously unpublished experimental results between 15 and 30 kbar for five reactions: (0) magnesite + clinopyroxene = dolomite + orthopyroxene; (1) magnesite + quartz = enstatite + CO_2; (5) dolomite + orthopyroxene + quartz = clinopyroxene + CO_2; (3) magnesite + enstatite = forsterite + CO_2; (6) dolomite + orthopyroxene = clinopyroxene + forsterite + CO_2. Reactions (0), (1) and (5) meet at an invariant point near 1090°C and 34 kbar. Reactions (3) and (6) represent the carbonation of model harzburgite and lherzolite, respectively. Dolomites in reaction (6) contain more than 70 wt. % $CaCO_3$; at temperatures below the crest of the calcite-dolomite solvus, they are magnesian calcites. Phase relationships for carbonated model peridotites in the presence of H_2O, compared with estimated depths and temperatures of equilibration of xenoliths from the Premier Mine kimberlite, indicate that within limited depth intervals solid magnesite-harzburgite can coexist with partially melted lherzolite. Eruption of kimberlite could transport xenoliths of lherzolite and magnesite-harzburgite. Experiments indicate that the magnesite dissociates within minutes during uprise. This observation is consistent with the proposal of Boyd and Gurney that low-calcium garnets in kimberlites of the Kaapvaal-Rhodesian craton are produced by disruption of magnesite disseminated through depleted harzburgites in the roots of the craton, within the diamond stability field. (Authors' abstract)

YAGNIK, S.K., 1983, Interfacial stability of migrating brine inclusions in alkali halide single crystals supporting a temperature gradient: J. Crystal Growth, v. 62, p. 612-626. Author at Dept. Nuclear Engrg., Iowa State Univ., Ames, IA 50011, USA.

Application of a temperature gradient to a solid containing inclusions exerts a driving force which sets the inclusions in motion towards higher temperatures. Since the inclusions are essentially negative crystals, they retain definite shape with the inclusion walls being low index crystallographic planes of the host solid matrix. The migration speed of these inclusions is known to depend on the kinetics of interfacial crystallization/dissolution, which favors layer-by-layer growth/dissolution. Despite these effects, which tend to keep the inclusion walls stable and straight, interfacial instabilities are occasionally observed in the migrating inclusions. A perturbation method is used to analyze such instabilities at a planar interface growing from solution. The model is applied to the interfaces of the temperature gradient driven brine inclusions in alkali halide single crystals, and the resulting stability criteria are checked against limited available experimental data. (Author's abstract)

YANSHIN, A.L. and ZHARKOV, M.A., eds., 1981, Structure and formation conditions of salt-bearing horizons: "Nauka" Press, Novosibirsk.

Includes several articles dealing with fluid inclusions that have been abstracted in this and earlier volumes. (E.R.)

YARDLEY, B.W.D., 1983, Quartz veins and devolatilization during metamorphism: J. Geol. Soc. London, v. 140, p. 657-663.

Fluid inclusion studies indicate that quartz veins represent pathways of rapid fluid movement in the Connemara Schists, where fluids have passed through contrasting lithologies without reequilibrating. This suggests that fluid flow over distances of tens of meters must have occurred within a matter of hours. It is further suggested that since fluid generation is slow, fluid pressure and permeability may fluctuate during prograde metamorphism, with periodic episodes of hydraulic fracturing and fluid loss after slow increases in fluid pressure. Veining does not always occur during metamorphism and, where veins are absent, fluid loss may have been achieved through enhanced permeability or fine scale pervasive fracturing. Hydraulic fracturing is more likely if deviatoric stresses are large, and an association of veining with belts of more intense deformation is noted. (Author's abstract)

YARDLEY, B.W.D., SHEPHERD, T.J. and BARBER, J.P., 1983, Fluid inclusion studies of high-grade rocks from Connemara, Ireland, in M.P.A. Atherton and C.D. Gribble, eds., Migmatites, Melting and Metamorphism, Cheshire, U.K., Shiva Pub., Ltd., p. 110-126.

Fluid inclusions in quartz veins from upper sillimanite zone metasediments in Connemara show that H_2O, CO_2 and CH_4 fluids were likely to have been present when melting began in the higher grade rocks found immediately to the south. There is some relation between host rock type and fluid inclusion composition, for example, CH_4 is mostly present where the host is graphitic. However, many veins contain 2 or 3 distinct fluid types and it is suggested that this diversity stems from fluid movement across layers along veins. All fluid types were present at the peak of metamorphism. H_2O is the most common fluid and is usually rather pure, with an equivalent salinity typical around 1 molar NaCl. All three main fluid types occur most commonly as rather pure fluids, though mixed fluids are sometimes present. Mass spectrometry has revealed the presence of N_2 in many samples, with a correlation between N_2 and CH_4.

Fluid inclusions from the migmatites are again dominantly H_2O, with CO_2 also present, however, CH_4 is absent. N_2 contents suggest that some CO_2 could result from oxidation of CH_4. It is inferred that virtually all the fluids seen were produced by metamorphism of the Dalradian sedimentary sequence. (Authors' abstract)

YARTER, W.V., 1981, Geology, geochemistry, alteration, and mass transfer in the Sol prospect, a subeconomic porphyry copper-molybdenum deposit, Safford district, Graham County, Arizona: M.S. thesis, The Univ. Arizona, Tucson, AZ, 136 pp.

Element and mineral gains and losses resulting from alteration in the Sol porphyry copper deposit were studied to determine characteristics that distinguish this subeconomic occurrence from productive, or potentially productive, porphyry copper systems. Time-integrated fluxes of components were analyzed along with fracture abundances, paragenetic relationships, and calculated mineral stabilities to determine the most favorable parts of the system for copper-molybdenum mineralization, and to evaluate the efficiency of transport and depositional mechanisms across the system.

Laramide hornblende quartz monzonite porphyry intruded the sedimentary-volcanic pile at Sol but resulted in no significant copper mineralization. A younger hornblende-biotite diorite porphyry intruded the quartz monzonite and volcanic pile under a modified stress field and resulted in significant copper-molybdenum mineralization. Highest copper values were deposited in quartz monzonite and volcanic sediments adjacent to the diorite porphyry. No high copper values were deposited in the diorite porphyry because the activity of $Fe^{=3}$ and $f(O_2)$ were kept high by the presence of magnetite. Low fracture abundance in the diorite did not provide the permeability necessary for circulating hydrothermal fluids to leach and redistribute the 0.06% average copper values present in the upper portions of the stock. Silica, potassium, sulfur, and molybdenum were added to zones of highest estimated permeability regardless of rock type or alteration assemblage. (Author's abstract)

YEFREMOVA, V.P., KUZNETSOV, V.A. and SHUKINA, N.D., 1982, The solubility of α-HgS in hydrosulfide solutions at elevated temperatures: Geokhimiya, 1982, no. 1, p. 71-98 (in Russian; translated in Geochem. Int'l., v. 19, no. 1, p. 55-62, 1983).

YU, Cimei and LU, Huanzhang, 1983, An investigation into the genesis of the Shilu iron deposit with special reference to its fluid inclusions: Geochemistry, v. 2, no. 2, p. 127-141. Authors at Inst. Geochem., Acad. Sinica, China.

The Shilu iron ore deposit is one of the highly economically important rich iron deposits in China. Based on the results of geological field studies, ore composition, and fluid inclusion research, it can be reasonably explained that the genesis of this iron deposit is from marine volcanic sedimentary deposition, followed by regional metamorphism and later hydrothermal fluid replacement. The temperatures of regional metamorphism range from 465° to 536°C, while those of later hydrothermal replacement range from 344° to 396°C. The later hydrothermal fluids seem related to the migmatization of Zhan Xian granite which occurs near the Shilu iron ore deposit. Due to the hydrothermal replacement, the original marine volcanic deposits were replaced and the ore became rich and concentrated. (Authors' abstract)

YU, Zhijun, 1983, Chinese meteorites and the inorganic hypothesis of oil genesis: Program Eighth Symp. on Antartic Meteorites, Tokyo, 17-19 February, 1983, Nat'l. Inst. of Polar Research, Tokyo, p. 87. Author at Beijing Petr. College, No. 12-1215, Beijing, China.

Various hydrocarbons were found in the Jilin chondrite. The formation of these was presumably catalyzed by the olivine and pyroxene. As these minerals make up the Earth's mantle also, an inorganic origin for terrestrial petroleum is put forth. (E.R.)

YUDINTSEV, S.V., FAM TYK, Suan, GRAMENITSKIY, Ye.N. and SHCHEKINA, T.I., 1983, Experimental modelling of formation of nepheline syenite pegmatites: Dokl. Akad. Nauk SSSR, v. 268, no. 2, p. 409-413 (in Russian). Authors at Moscow State Univ., Moscow, USSR.

Miaskite melt at 740-830°C and $P = 4$ kbar with added Na and F splits into two immiscible melts, one enriched in volatile components. (A.K.)

YUKAWA, M. and WATANABE, M., 1983, Opaque minerals and composition of fluid attending the Sanbagawa metamorphism in the Sazare mining district, SW Japan: Neues Jahrbuch Miner. Abh., v. 146, no. 3, p. 280-301.

In the Sazare mining district, Central Shikoku, SW Japan, which forms part of the Sanbagawa metamorphic terrain, the metamorphic grade increases southwards from chlorite to biotite grade as one moves upward in the stratigraphic succession. The present study attempts to establish on the basis of the metamorphic zoning, the equilibrium relations among the opaque mineral assemblages, and the stability of sphene, the presence and composition of fluids attending the Sanbagawa metamorphism. The results of calculations at $T = 400°C$ and $P = 7$ Kb and the discovery of abundant H_2O-dominant fluid inclusions in metamorphic silicate minerals are strong evidence of the presence of H_2O-dominant fluids during the metamorphism of these rocks, irrespective of the presence or absence of graphite. Within the established limits of oxygen fugacity, it follows that the fluids in the graphite-bearing rocks (pelitic and psammitic schists) with a composition falling within the C-H-O-S system, will have H_2O, CH_4 and CO_2 as important components and some H_2S, while those in the graphite-free rocks (quartz and basic schists and ore deposits) will have significant H_2O, CO_2, and small amounts of H_2S and SO_2. Thus, there was a notable difference in abundance of CH_4, H_2S and SO_2 in the graphite-bearing and graphite-free rock systems, which was largely controlled by the oxidation state prevailing during the metamorphism. (Authors' abstract)

ZAKHAROVA, Ye.M., 1982, Mineralogical-geochemical peculiarities of quartz as one of the criteria for evaluation of the ore capacity of a territory: Vestnik Moskovsk. Univ., Ser. 4, Geologiya, no. 3, p. 43-51 (in Russian).

The paper bears general statements on importance of CO_2 content evaluation and Th determinations of inclusions, and presents some decrepitation curves of quartz. (A.K.)

ZAREMBO, V.I. and L'VOV, S.N., 1982, Limiting partial volumes of individual ions in aqueous solution: Geokhimiya, 1982, no. 3, p. 388-399 (in Russian; translated in Geochem. Int'l., v. 19, no. 2, p. 57-69, 1983).

ZAW, U.K. AND THET, D.K.M., 1983, A note on a fluid inclusion study of tin-tungsten mineralization at Mawchi mine, Kayah State, Burma: Econ. Geol., v. 78, p. 530-534. Authors at Applied Geol. Dept., Arts & Sci. Univ., Thamaing College P.O., Thamaing, Rangoon, Burma.

Fluid inclusions in fluorite (Th 120-220°C), scheelite (Th 170-270°C), and quartz (Th 200-260°C) were run. Tm ice for fluorite ranged from -2.3 to -5.6°C. No evidence for boiling or for CO_2 L was found. (E.R.)

ZAYKIN, I.D. and MOISEYENKO, V.G., 1981, Mechanism of decrepitation of gas-liquid inclusions in minerals: Dokl. Akad. Nauk SSSR, v. 259, p. 456-459 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 259, p. 158-160, 1983).

Abstracted in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 241, 1981. (E.R.)

ZAYKIN, I.D. and MOISEENKO, V.G., 1982, New method of determination of true temperatures of crystallization of minerals: Akad. Nauk SSSR Doklady, v. 265, no. 6, p. 1486-1488 (in Russian). Authors at Amur Complex Sci.-Res. Inst. of Far-East Sci. Center of Acad. Sci. USSR, Blagoveshchensk, USSR.

On the basis of theoretical studies and investigations of synthetic quartz the new method of determination of crystallization T is proposed. Determination starts from estimation of CO_2 release during decrepitation and the curves describing kinetics of CO_2 release are next elaborated by mathematic methods. From the derived equation the T of maximum gas release is determined which is suggested to be identical with the true crystallization temperature, as it is illustrated by the series of T max for three synthetic quartzes (T of synthesis in parentheses): Q-1 352.2 (357°C, P 1300 atm), Q-2 333.4 (340°C, P 650 atm), Q-3 341.0 (336°C, P 580 atm). (Abstract by A.K.)

ZHABIN, A.G., 1983, Sphalerite stalactites in endogeneous lead-zinc ores of the Kvaisa field (central Caucasus): Geol. Rudn. Mestorozhd., v. 25, no. 4, p. 115-118 (in Russian). Author at IMGRE, Moscow, USSR.

Kvaisa ore field formed at (Th) 180-220°C in Upper Jurassic limestones and Bajocian basaltoid volcanites; ores are of barite, barite + galena + sphalerite and galena + sphalerite types. (A.K.)

ZHANG, Ligang, QIAN, Yaqian, ZHUANG, Longchi and GUO, Yingshun, 1981, An oxygen isotope study of quartz crystal deposits in Guangxi: Bull. Yichang Inst. Geol. & Mineral Resources of Chinese Acad. Geol. Sci., no. 4, p. 120-123 (in Chinese; English abstract).

The oxygen isotope composition of 11 quartz crystals and the fluid inclusions of three of them were determined from 10 deposits in Guangxi. The δ^{18} values of these quartz crystals and fluid inclusions range from +24.0 to +6.0‰ and +2.8 to +1.9‰, respectively. The O^{18} content in the quartz crystals depends on the component of wall rocks. The source of mineralizing fluid was discussed as well. (Authors' abstract)

ZHANG, Ronghua, 1983, Hydrothermal phase relations in magnetite deposits of middle lower Yangtze River Valley, China (abst): Geol. Soc. Am. Abstracts with Programs, v. 15, p. 726. Author at Dept. Geol. & Geophy., Univ. California, Berkeley, CA 94720.

Thermodynamic analysis of the system Na_2O-K_2O-CaO-MgO-FeO-Fe_2O_3-Al_2O_3-SiO_2-H_2S-H_2SO_4-HCl-H_2O at high temperatures and pressures affords description and interpretation of phase relations among pyroxene, garnet, plagioclase, and phlogopite solid solutions coexisting with anhydrite and pyrite in hydrothermal magnetite deposits in the lower Yangtze River Valley. Filling temperatures of fluid inclusions in anhydrite range from 200° to 550°C and the salinity ranges from 8 to 21% NaCl. (From the author's abstract)

ZHANG, Yuxue, 1983, Geochemical characteristics and origin of Yangchuling porphyry W-Mo deposit: Geochemistry, v. 2, no. 2, p. 99-112. Author at Inst. Geochem., Acad. Sinica, China.

Includes two analyses of inclusions in quartz of igneous rocks for CO_2, K, Na, Ca, Mg, Cl, SO_4 and F, and "formation temperatures" (apparently actually mixed values of Th and Td. These temperatures range from 122-575°C. (E.R.)

ZHAO, Bin and LI, Tongjin, 1983, A preliminary study on the mechanism and physico-chemical conditions of formation of Gongchangling rich iron deposit: Geochemistry, v. 2, no. 1, p. 1-16. Authors at Inst. Geochem., Acad. Sinica, China.

Field observations and results of experimental studies show that the Gongchangling rich iron deposit is multigenetic as a result of repetition of different geological processes. It probably resulted from the infiltration of silica under the influence of aqueous solutions derived from migmatite-granite. Because the formation of rich iron deposit was accompanied by the formation of skarn minerals and the transformation of sedimentary-metamorphic poor iron deposits, characteristics of both skarn deposits and stratabound ore deposits can therefore be recognized. Experimental data indicate that physico-chemical parameters of formation of the rich iron deposit are P = 2 kbar, T = 500-600°C, pH = 8-10, and $f(O_2) = 10^{-25}$ bar. (Authors' abstract)

ZHAO, Bin, LI, Tongjin and LI, Zhaopin, 1983, Experimental study of physico-chemical conditions of the formation of skarns: Geochimica, 1983, no. 3, p. 256-267 (in Chinese; English abstract). Authors at Inst. Geochem., Acad. Sinica.

Experiments have been carried out at 400°-800°C and 500-1000 bars. Experimental media are: various natural rocks plus NaCl, $NaCl+CaCl_2$, $NaCl+CaCl_2+MgCl_2$, Na_2CO_3 and Na_2SiO_3 solutions.

Experimental results show that skarns can be formed under wide physico-chemical conditions: T = 400°-800°C, P = 500-1000 bars, pH = 4-11, and $fO_2 = 10^{-23}-10^{-11}$ bar. It is found that skarnization occurs preferentially in the media of NaCl and $NaCl+CaCl_2$ solutions. (From the authors' abstract)

ZHI, Xiachen and CHENG, Weiji, 1983, Low temperatue $lgfO_2$-pH diagrams of sulfur isotope evolution in an equilibrium hydrothermal system: Geochemistry, v. 2, no. 3, p. 201-212. Authors at Dept. Earth & Space Sci., Univ. Sci. & Tech. of China.

According to Sakai-Ohmoto theory regarding the evolution of sulfur isotopes in hydrothermal systems, in conjunction of new data on chemical reaction equilibrium constants and equilibrium isotopic fractionation factors a well as on individual ion activity coefficents of aqueous sulfur species, the following $lgfO_2$-pH diagrams are constructed:

a) mole fraction of aqueous sulfur species (Xi),

b) stability fields of some minerals in the Fe-S-O system,

c) diagram depicting the oxidation-reduction-state ratio for aqueous sulfur species (R') and

d) isotopic compositions of sulfur compounds (δS^{34}). (Authors' abstract)

ZHUYKOVA, T.L., VDOVYKIN, G.P., LEBEDEV, V.S., IL'CHENKO, V.P., MUSIN, M.Kh., and ZIMENKOVA, O.I., 1983, Gaseous hydrocarbons in igneous rocks of eastern Siberia: Dokl. Akad. Nauk SSSR, v. 272, no. 4, p. 956-960 (in Russian). Authors at All-Union Research Inst. Nuclear Geophy. & Geochem., Moscow, USSR.

Gives 41 chromatographic analyses for CH_4 and many other higher hydrocarbons. (E.R.)

ZIELINSKI, R.A., 1983, Uraniferous opal, Virgin Valley, Nevada: conditions of formation (abst.): U.S. Geol. Survey Prof. Paper 1375, p. 43.

Studies by R.A. Zielinski have shown that uraniferous, fluorescent opal, which occurs in tuffaceous sedimentary rocks at Virgin Valley, Nev., records the temperature and composition of uranium-rich solutions as well as the time of uranium-silica coprecipitation. Results have been integrated with previous geologic and geochronologic data for the area to produce a model for uranium mobility that may be used to explore for uranium deposits in similar geologic settings. Fluid inclusions preserved within opal replacements of diatomite have homogenization temperatures in the epithermal range and are of low salinty. Four samples of opal from one locality all have uranium-lead apparent ages which suggest uraniferous opal precipitation in late Pliocene time. (From the author's abstract)

ZNAMENSKIY, V.S. and NOSIK, L.P., 1981, Isotopic composition of sulfur and genesis of volcanogenic sulfur deposits (southern Kuril Islands): AN SSSR Izvestiya, Ser. Geol., no. 10, p. 120-136 (in Russian; translated in Int'l. Geol. Review, v. 25, no. 10, p. 1137-1150, 1983). Authors at Inst. Geol. Ore Deposits, Petro., Mineral., & Geochem. USSR Acad. Sci., Moscow, USSR.

We present 111 isotopic compositions for sulfur in pyrite, alunite, native sulfur, and other minerals from: the Golovnin and Mendeleyev volcanoes; the Novoye deposit, a show in the Kuybyshevka River basin; and the Maloye show, on the islands of Kunashir and Iturup. Mineral generations of different ages are distinguished, with characteristic ranges of $\delta^{34}S$ values. Secondary generations of minerals formed by oxidation-reduction processes as a rule show greater variation in $\delta^{34}S$ values. In the above five localities, sulfate-sulfide $\delta^{34}S$ values show an increase from 16 to 30‰. We propose that the mean values reflect an isotopically equilibrated initial fluid at some depth and at a high temperature, from which, upon ascent to the surface, pyrite, sulfur, alunite, and other sulfur-containing minerals were deposited. Proceeding from this proposition, the ΣS isotopic composition is determined, which in all cases is characterized by a significant proportion of "crustal" sulfur. Some of the analyzed minerals formed by secondary oxidation-reduction processes involving native sulfur and pyrite. As a result, total sulfur is "lighter." This is particularly evident in the Novoye deposit. (Authors' abstract)

ZOLOTAREV, B.P., VOYTOV, G.I. and STAROBINETS, I.S., 1981, Gases in young basaltic rocks of the Gulf of California, as shown by data from the Glomar Challenger Leg 65: Dokl. Akad. Nauk SSSR, v. 260, p. 1466-1469 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 260, p. 178-181, 1983). Authors at Geol. Inst., USSR Acad. Sci., Moscow, USSR.

Abstracted in Fluid Inclusion Research--Proceedings of COFFI, v. 14, p. 269-270. (E.R.)

ZOTOV, A.V., LOGINOV, V.P. and RUSINOV, V.L., 1983, Regularities of low-temperature metasomatism, p. 126-130, *in* Problems of petrology, mineralogy and ore genesis: "Nauka," Moscow, 224 pp., 900 copies printed, price 3 rbls. 70 kopecks (in Russian).

The paper bears some Th data on low-T hydrothermal parageneses, quoted from various papers. (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.

BEUS, A.A. and KHETCHIKOV, L.N., 1983, Contribution to the problem of determination of concentration and composition of mineral-forming solutions from gas-liquid inclusions in minerals: Geol. Rudn. Mestorozhd., v. 25, no. 6, p. 88-90 (in Russian). Authors at Inst. of Lithosphere, Moscow, USSR.

[Editors' note: This paper challenges the basic premise of all fluid inclusion study, i.e., that the composition of the fluid trapped in an inclusion is representative of the fluid from which that crystal grew. If the thesis presented here is correct, all published inclusion compositional data may be invalid, as well as many of the other kinds of data derived from inclusions. This is true even if the obvious confusion here of daughter crystals with accidental solid inclusions is clarified. Note also that the thesis presented here is flatly contradicted by recent experimental studies of synthetic fluid inclusions made from fluids of known composition (e.g., Sterner and Bodnar, 1984, Geoch. Cosmo. Acta, v. 48, p. 2659-2668; Bodnar and Sterner, and Bodnar, et al., Geoch. Cosmo. Acta, in press).]

Results of studies of gas-liquid inclusions in various minerals that were performed during last decades in our country and abroad on a wide scale, gave a lot of new data for understanding of mineral-forming processes and in elucidation of PT parameters of formation of various mineral parageneses. Significant attention was paid to the study of composition of gas-liquid inclusions, resulting in very valuable geochemical information, that permitted more exact consideration of the forms of transport of various elements that are included in minerals.

However, during determination of the concentration of the original mineral-forming solutions from gas-liquid inclusions in minerals as well as from the mode of distribution of solid phases, in our opinion, incorrect conclusions were made. Usually it is accepted that the presence of polyphase inclusions in minerals, i.e. containing L, G and solid phases, proves the crystallization of such minerals from highly concentrated solutions-brines with salt concentrations achieving tens of percent. Very instructive are topazes from Volyn', bearing, after V.A. Kalyuzhni [5], up to 13 solid phases, mostly fluorine minerals. From this it is concluded that crystallization of topazes developed from brines with total salt salt concentration 60-70 wt.%. Similar conclusions do not take into account the specific conditions of crystallization of minerals from high-temperature solutions and the most probable forms of transport of chemical elements, especially amphoteric ones, and elements forming complexes under conditions of endogeneous mineral formation. From theoretical considerations and numerous experimental data [2-4, 9], the typical scheme of high-temperature hydrothermal endogeneous mineral formation may be presented by the following mode.

1. Transport of the mobile compound of a non-reactive* chemical element under a given set of physico-chemical conditions with other components of hydrothermal solution (activity of metals in mobile compound is decreased).
2. Beginning of decomposition of mobile compound due to more or less sharp change of physico-chemical conditions, increment of activity of the included elements, which start to react with other components of hydrothermal solution.
3. Beginning of crystallization of these reaction products (minerals) usually characterized by very low solubility.
4. Continuation of crystallization of minerals due to progression of decomposition of formerly non-reactive mobile compounds, present in solution.
5. Finish of crystallization of a given mineral due to exhaustion of decomposing mobile compounds of this element in mineral-forming solution or due to change of physico-chemical conditions toward the inhibition of decomposition of mobile compounds of the element.

Most investigators agree that the most probable form of numerous amphoteric elements and complex-forming metals in endogeneous hydrothermal solutions are acid-complex compounds with ligands: chlorine, fluorine, CO_2 and various forms of sulfide ion [1-4, 10]. Being stable in the determined intervals of conditions of supercritical and hydrothermal mineral-formation, acid-complexes cause a sharp decrease of the activity of elements present in them (amphoteric and complex-forming elements), determining the possibility of their transport by solutions for long distances.

Precipitation of the transported amphoteric or complex-forming element, being the beginning of mineral crystallization, occurs due to decomposition of the acid-complex and in this process, together with formation of new mineral, the liquid and gas products of decomposition of acid-complex compound appear.

Let us consider as an example, the scheme of decomposition of complex sodium hexachloride of any four-valent metal (M), which has complex-forming properties:

$$Na_2[MCl_6] \rightleftarrows Na^+ + \underset{\text{transport}}{[MCl_6]^{2-}} \rightleftarrows \underset{\text{precipitation}}{M^{4+} + NaCl + 4Cl^-}.$$

As additional products, NaCl and Cl^- form, that are trapped in G/L inclusions by the growing crystal[sic]. Trapping of the reaction products by the growing minerals as inclusions is possible before equilibrium between reaction products and parent solution is achieved. As the result, highly concentrated brines may be trapped in G/L inclusions, whose composition does not reflect the composition of parent hydrothermal solution. Proba-

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*In Russian text the word "regulating" is printed here, an obvious misprint. (A.K.)

bility of such phenomenon cannot be ignored, considering the possible connections between the studied composition of G/L inclusions in mineral and hypothetical composition and especially concentration of parent solution.

It is necessary to take into account that a mineral, growing due to the above described reaction, after finishing its growth, is surrounded by a "cover" of the separating gas and liquid products of reaction. Thus there is a low probability of trapping of inclusions in growing crystals of solutions and gas products with the composition of the parent solution. Experimental data [6] also confirm that composition of solutions in inclusions in minerals synthesized even at relatively low T, more frequently is closer to the so-called taken* solutions.

However, the composition of gas-liquid inclusions may be widely used during the evaluation of the possible forms of amphoteric metals transport by hydrothermal and supercritical natural solutions. Thus, not always may one conclude that abundant solid phases in gas-liquid inclusions is evidence of inclusion-bearing mineral crystallization from solutions of high concentration. In solutions without amphoteric or complexing elements, experimentally it was impossible to obtain solid phases of NaCl and KCl in inclusions in quartz when salt concentration was <40% [8]†, but addition of fluorine and aluminum to such solutions caused presence in inclusions in quartz of numerous daughter crystals such as hyalite**, cryolite, villiaumite, orthoclase and nepheline from solutions of the original concentration was ≤5 wt.% [7].

Concluding, we indicate once more that studies of G/L inclusions in minerals provide extensive information about the properties of mineral-forming solutions. However, it is necessary to take into account that the composition and concentration of inclusion filling and parent solution are not always completely identical.

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*The word "otobrannyi" (≈ taken) is here in the Russian text, but probably it is the misprint for "otrabotannyi" (= the solution from which minerals precipitated, worked-out). A.K.

**Probably a misprint for chiolite $Na_5Al_3F_{14}$. (A.K.)

†Editors' note: Such synthetic inclusions (e.g., those made by Sterner and colleagues) commonly show metastable supersaturation; a simple freezing cycle causes nucleation of salt crystals, which then persist at room temperature in samples formed from appropriate solutions.

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GRISHINA, S.N., 1983, Determination of carbon dioxide and methane in inclusions in halite from Dnepr-Donets depression: Doklady Akad. Nauk SSSR, v. 273, no. 6, p. 1475-1477 (in Russian). Author at Inst. Geol. and Geophysics, Novosibirsk, USSR.

Carbon dioxide-methane fluid inclusions found presently in minerals of various goelogical objects [1,2] are an important source of information about the physico-chemical parameters of mineral-forming solutions. However, their analysis is connected with a number of widely known problems, usually caused by their extremely minute size. The most applicable method is cryometry, but presently, the experimental studies of PTV and phase equilibria in the binary system CO_2-CH_4 are not complete and quantitative interpretation from phase changes is described only up to a CH_4 content of ≤ 0.3 [3]. Thus, it is very important to obtain new data on possible relation between Tm of CO_2 and CH_4 contents.

The CO_2-CH_4 inclusions used were chosen in vein halite from Devonian salt rocks of the Dnepr-Donets depression (West-Slavyanskaya structure, borehole 2-S, depth 1357-1380 m), first described by O.I. Petrichenko [4]. Inclusions are sufficiently large (15-200 µm), are of almost cubic habit, and are filled at room T by L high density mixture of CO_2 and CH_4.

Since the shift of the triple point of CO_2 may be caused not only by CH_4 but also by other admixtures [5], to understand the dependence of Tm of CO_2 on the CH_4 content in the binary system CO_2-CH_4, it was necessary to obtain good data on the composition of the inclusions. For this reason the author used four independent methods: gas chromatography with various modes of inclusion opening, mass spectrometry, Raman spectroscopy and volumetry.

Use of the methods of bulk analysis was possible due to the presence in selected samples of isolated groups of coeval inclusions of the same type and of a single generation, with high density of filling and low T of opening.

Analyses performed by G chromatography method were made with use of device LKhM-8D improved for determination of small amounts of G [6]. Opening without heating was made in a chamber with a mechanical press after flushing with helium. Thermal opening was performed at 400-600°C. For mass spectrometry the sample was ground under high vacuum (10^{-6} to 10^{-7} mm of Hg) by use of an electromagnetic mortar [7]. Analyses were made by mass spectrometer MKh-1303 (Inst. of Geol. and Geochem. of Mineral Fuels of Ukrainian Acad. Sci.).

All methods of bulk analysis (Table 1) showed the presence in the inclusions of practically pure binary system CO_2-CH_4 [but] with significant variation of the CO_2/CH_4 ratio. Appearance of CO_2 at 500°C and complete

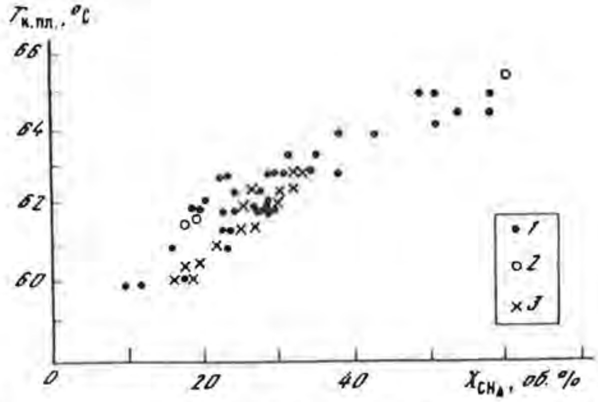

Fig. 1. Relation between Tm of CO_2 (vertical axis) and CH_4 content (in vol. %, horizontal axis) in binary system CO_2-CH_4: 1 - data from microvolumetric determinations, 2 - data from Raman spectroscopy, 3 - calculations from the Swanenberg plot.

change of CH_4 to CO at 600°C are caused most probably by reactions of methane breakdown at elevated temperatures [8].

Individual inclusions were analyzed after they were studied cryometrically. Measurements were made in a cryostage of L.Sh. Bazarov construction [9]. The stage was calibrated at the triple point of pure CO_2 in natural inclusions in quartz and on two organic standards - chlorobenzene (-45°C) and heptane (-90.6°C). Accuracy of measurements was ±0.5°C. Due to the presence of CH_4 in the inclusions, the shift of the CO_2 triple point was observed, to values -60 to -66.5°C, and Th ranged from -2 to -35°C. Inclusions of pure CO_2 were also found, with Tm -56.6°C.

Absence of fluorescence in halite made possible the analysis of individual inclusions by nondestructive Raman spectroscopy method with the MOLE microprobe (in France). Results of those analyses (Table 2) confirmed the absence of CO in the inclusions and were the control determinations for the dependence of Tm of CO_2 on CH_4 concentration.

The relation was studied in detail by the use of volumetric analytical data. Inclusions studied by cryometry were next opened in degassed glycerine. Volume increase of gas bubbles after opening of about 1000 times made possible the analysis with accuracy of ±5 relative volume percent.

Table 1

Method and analyst	T of opening, °C	Volume percent					
		CO_2	CH_4	CO	O_2	H_2	N_2
Chromatography with mechanical inclusion opening; N.Yu. Osorgin, Inst. of Geol. and Geoph., Novosibirsk		55	45	0	0	0	0
Chromatography with thermal inclusion opening; L.N. Fomina, Inst. of Geol. and Geoph., Novosibirsk	400	77	23	0	0	0	0
	400	93	7	0	0	0	0
	500	87	6	7	0	0	0
	500	94	2.3	3.7	0	0	0
	600	80	0	20	0	0	0
Mass spectrometry; T.M. Svoren', Inst. Geol. and Geochem. of Mineral Fuels, L'vov		46.6	46.15	0.0	0.0	0.32	0.55

Table 2

No.	Tm of CO_2, °C	Th, °C	CO_2	CH_4	N_2	CO
1	-	-	88.4	11.6	trace	0
2	-	-	87.5	11.9	0.5	0
3	-	-	88.0	12.0	0	0
4	-	-	87.7	12.3	0	0
5	-62	-5	82.6	17.4	0	0
6	-62	-4.5	81.5	18.5	0	0
7	-65.5	-35	40.2	59.8	trace	0

Note: Analyses 1-6 made by S. Kosztolanyi (Center of Studies for Uranium Geology, Nancy), analysis 7 - P. Dhamelincourt (Sci.-Tech. Univ., Lille).

Kerosene was used as the methane sorbent [10]. Results of 40 determinations presented in Fig. 1 showed the existence of a relation similar to the curve of Swanenberg [3], but for wider ranges of CH_4 content - up to 0.6 of total volume.

The author is grateful to O.I. Petrichenko for the specimens used and to the Director of Center of Studies of Uranium Geology, Professor B. Poty, for collaboration and performing of analyses on MOLE microprobe.
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12.V.1983

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(Translated by A. Kozlowski, Warszawa, 24.VI.1985)

KALYUZHNYI, V.A., 1982, Principles of knowledge about mineral-forming fluids: "Naukova Dumka" Publ. House, Kiev, 240 pp., 1000 copies printed, price 2 rbls. 20 kopecks (in Russian). Author at Inst. Geol. and Geochem. of Mineral Fuels of Acad. Sci. of Ukr. SSR, L'vov, Naukova Str. 3A, Ukrainian SSR.

Note: In translating this book I take into account that it represents in some sense a unique and probably most critical approach to fluid inclusion studies performed in the Soviet Union, where those studies have become presently a routine--and sometimes too routine--method of mineralogical, petrological and other geological studies. This places the author in a special and difficult position. On the other hand, this translation may give Western inclusion students something of a key to understanding and evaluating of the very extensive Soviet literature on fluid inclusions. In some places I omitted small parts of the original text that I supposed to be of minor interest to the Western reader; these places are marked by [...]. (A.K.)

PART TWO

METHODS OF STUDY OF INCLUSIONS IN MINERALS†

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† Pages 78-100 of original Russian text.

Inclusions in minerals are specific objects and their special features need non-routine methods of study.

First, inclusions in minerals, as a rule, are of microscopic size. For this reason micro- and ultramicroscopic studies are essential for these investigations.

Second, the inclusion filling consists of isolated particles of solid, L or G substance inside defect vacuoles of crystal. Specific conditions of existence, peculiarities of chemical composition and thermodynamic state need careful consideration during extraction of those substances from vacuoles in crystals, and in their presentation.

Third, inclusions in minerals are polyphase, relatively closed physico-chemical systems. Hence, during any method of study a physico-chemical analysis of the inclusion state is necessary.

Essentially inclusions in minerals are studied for determination of the chemical composition and phase state of the parent solution and thermodynamic conditions of mineral formation (T and P). Many methods exist that are applicable to inclusion studies. The main ones are chemical (macro- and microscopic), physical (cryoscopic, optical), physico-chemical, crystallographic, crystallooptical, mineralogical, spectrographical, etc.

Inclusions are relics of mineral-forming fluids, specific traces (prints) of a process that occurred long ago. Detailed studies of the relations between crystal and inclusion provide a clear relative chronology and age relationship of the inclusion. Determination, by exact methods, of the composition and properties of the inclusions and their interpretation are an important mode of recognition of the dynamics of the mineral-forming process. [...]

Composition of mineral-forming fluid. The correct recognition of trapping mechanism of inclusions from homo- or heterogeneous media is the main basis of correct determination of chemical and phase composition of mineral-forming fluids. Phase composition of the whole system may be very complicated. The most important role in mineral formation undoubtedly is displayed by the fluid-melt, solution or gas; solid phases have an insignificant, essentially indirect role in that process. Thus, the essential composition of the natural fluid is reflected completely by relics of fluid phases in inclusions - magmatic glass, water solution, gas components, dms, etc.

It is necessary to mention here the relativity of terms of xenogenic and authigenic substances in inclusions. Fluid phases [...] frequently coexist as separate phases. Although the main (but not exclusive) role is displayed in processes of crystallization by the density of a given fluid, gases may also be active agents of mineral-formation. Thus their bubbles trapped in vacuole should not always be called neutral (xenogenic) material with respect to a crystal. Solid phases are less mobile and thus are mostly xenogenic. However, dms, whose material is an immediate part of general solution composition, or solid phases that existed before inclusion sealing and then enlarged from the solution portion sealed in the inclusion, should be called completely or partly authigenic substances.

Methods and results of studies presented below are pertinent only to fluid phases in inclusions and dms (except for some special cases). The following cases are distinguished: 1) homogeneous trapping (from homogeneous or heterogeneous system) of L and G: inclusion composition essentially reflects composition of fluid of the medium or one of its fluid phases (L or G); 2) heterogeneous trapping: inclusion composition is intermediate between compositions of coexisting fluid phases in the mineral-forming medium.

Determination of initial composition of mineral-forming fluid is connected with solution of the following questions: 1) degree of alteration of fluid after its sealing in inclusions under influence of epigenetic alterations; 2) in what degree the inclusion filling composition (when not altered) reflects the composition of fluid of natural medium; 3) modes of determination of chemical composition and properties of fluid sealed in microinclusions.

Agreement of inclusion filling with composition of mineral-forming fluid. The above problem is one of the most important questions during reconstruction of geochemical conditions of endogeneous processes. The opinion has been published that inclusion solutions are "worked-out" (i.e., last residua, with important components missing, that were present earlier, A.K.) parent solutions, bearing only "soluble products of reactions." For crystallization from solutions oversaturated due to T decrease, P decrease or partial evaporation of solvent, such interpretation used to be considered as possible, but for crystals appearing due to reaction of media - is impossible.

The error of such opinions is caused rather by overestimation than by underestimation of the possibilities of the method of fluid inclusions. Solutions in inclusions may be compared only with the medium occurring immediately in contact with a given crystal at the moment of vacuole sealing. Inclusions may not always exactly reflect the composition of the solution on its way to the place of crystallization, especially if the reaction occurs between the meeting flows of solutions, migrating by various ways. In the last case it is not known what solution might be characterized by inclusions. Moreover, no essential difference exists, as a result of the mode of oversaturation and crystal precipitation - due to reaction between components of the system or due to change of physicochemical parameters (T, P, etc.) - as was indicated by Ya.O. Ol'shanskiy [157].

Thus, the seeming imperfection of the inclusion method becomes its advantage: the investigator receives satisfactorily determined information on crystallization conditions of a given zone in a specific mineral. Just this condition, in our opinion, determines the specialization of the composition of solution in inclusions with respect to mineral, as was first written by A.G. Betekhtin [10].

Formation of endogeneous deposits is a very long and complicated process. Various associations of minerals form at various times and are subjected to various alteration. These processes occur in an environment in the presence of a fluid, which also exhibits a complicated evolution due to change of conditions and reactions with surrounding minerals. It cannot be considered "worked-out" at any process stage or, particularly, after precipitation of any mineral or its zone.

Another problem is connected with the fact that with decrease in T and P, there occurs a regular concentration of easily soluble compounds not included in the composition of normal rock-forming minerals. But these components, reflecting the nature of the developing phenomena, are fixed at various stages of the process by inclusions of a determined composition. The possibility of individual studies of them is the main advantage of the method.

Precipitation of barite from solutions of $BaCl_2$ and Na_2SO_4 [10, 196]: $Ba^{2+} + 2Cl^- + 2Na^+ + SO_4^{2-} \rightarrow BaSO_4 + 2Na^+ + 2Cl^-$, as an example of crystallization due to chemical reaction of components, shows that inclusion composition reflects the composition of reacting solutions (taking into account excess concentrations of the indicated ions and admixed substances), excluding the differences of component concentrations of the mineral before reaction of solutions and after their stabilization in inclusions. Hence, fluid inclusions correctly reflect the composition of parent solution at the moment of crystallization, excluding its oversaturation degree before precipitation of mineral. Other properties of inclusion solutions (pH, total concentration, etc.), which reflect their general physico-chemical state and composition, also are in direct relation to the original parameters of mineral-forming conditions and inclusion trapping.

CHAPTER 5: METHODS OF STUDY OF INCLUSION COMPOSITION

Information about chemical composition takes a leading place among all other data on inclusion properties. Methods of thermodynamic studies may be correctly applied only in the case of recognition of the chemical nature of inclusions [...].

Studies of chemical composition and other properties of inclusions have their specific features. Before use of chemical analysis methods, the studied substances must be extracted from the inclusion vacuole by an appropriate method. The microscopic size of these objects causes great difficulty in such extraction. For this reason, together with the direct methods of determination of chemical composition, indirect ones are used (without opening of inclusion, but with use of physical and physico-chemical properties of their components). All presently known methods of studies of chemical composition of fluid inclusions may be divided into two groups: with inclusion opening (destructive) and without inclusion opening and extraction (non-destructive).

Studies of chemical composition with opening of inclusions (direct methods)

The following modes of inclusion opening are used: a) grinding of minerals to powder for release of inclusion filling; b) heating of mineral samples up to decrepitation temperature of inclusions (200-800°C); c) opening of individual inclusions with use of mechanical drilling or crushing of mineral; d) opening of inclusions by fractures during chipping of mineral (in accidental direction or along cleavage planes). Depending on the type of material and selection of analytical methods, the bulk chemical composition of inclusions or studies of individual inclusions are performed.

Studies of bulk chemical composition of inclusions

Volatiles occurring in inclusions (H_2O, CO_2, CH_4, N_2, etc.) are extracted by grinding of mineral or rock specimens in hermetic or vacuum devices (ball mills, mortars, etc.) and are then pumped to the analytical apparatus. Large numbers of volatile analyses have been performed by heating the samples to 500-800°C in vacuum, in an inert atmosphere, or in air [97, 215]; the gases extracted by this mode from minerals do not reflect the true composition of inclusions, causing serious criticism [108, 215]. Soluble compounds of inclusions are extracted by distilled water (method of water leachates).

Analysis of volatile substances (mixture of gas components of inclusions)

Devices and methods of analysis. [...]

I. Device for extraction and analysis of macroscopic samples of gas from inclusions. Construction and operation of the device were described earlier [89, 107] (see figure 33). [...]
The gas analyzer used here (VTI-2) is not shown on the diagram.

The following sequence of extraction and analysis of gas components of inclusions is applied: sample of weight 0.2-0.5 kg is crushed into fragments 1-4 cm^3, and the material is selected. The sample is then carefully washed and put in distilled water for 8-16 hours; water is continuously changed. After this the sample is dried and placed in ball mill A. The mill is hermetically sealed and then pumped out to 10^{-3} mm Hg (~0.131 Pa), by vacuum and diffusion pumps. After evacuation, valves 1 and 3 are closed, and mill is separated from the system. The sample is then ground in vacuum for 1-1.5 hours. Next the mill in joined again with the system

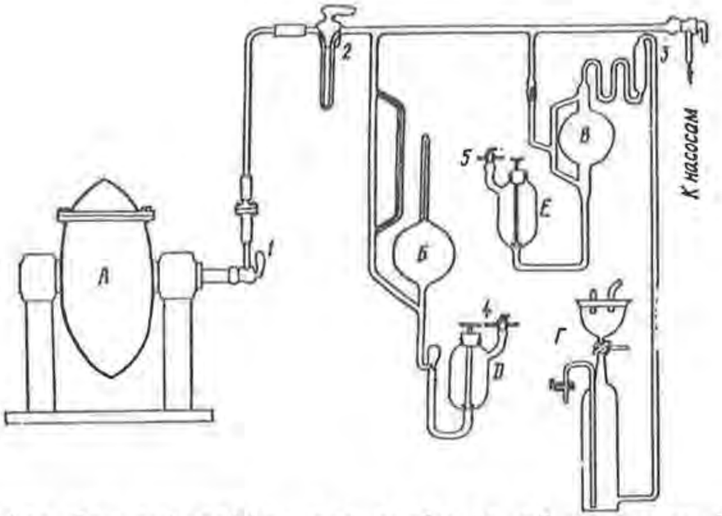


Fig. 33. Device for extraction and analysis of macroscopic samples of gas from inclusions and their analysis: A - vacuum ball mill, B - MacLeod manometer, C - Toepler mercury pump, D - vessel collecting gas, E,F - reservoirs for regulation of mercury supply, 1-5 - vacuum valves.

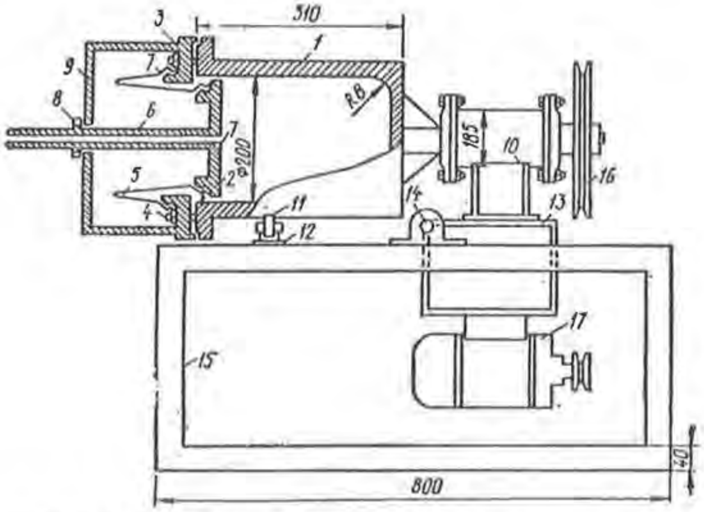


Fig. 34. Hermetic ball mill with elastic piston for extraction of gas from fluid inclusions and its transport to analyzer: 1 - cylindrical body, 2 - piston, 3,9 - lid, 4 - screws with nuts, 5 - conical rubber packing, 6 - stem of piston, 7 - filter, 8 - nut on stem, 10,11,12 - ball supports, 13 - rotating frame, 14 - axis of rotating frame, 15 - base, 16 - movement transmission [i.e., pulley], 17 - electric motor.

and air is pumped out to the original vacuum. The valve 3 is closed and pumps are switched off. After opening of valve 1, gas from mill expands into the whole system. Water vapor is frozen in special trap (valve 2). Next, with help of vacuum, gas is moved by the Toepler pump C into gas collector D. From the gas collector gas is taken for analysis and the ground mineral is removed from mill for preparing of water leachate of the soluble components.

Similar devices were first used by M.M. Elinson and F.M. Chistyakov [207] and M.A. Umova, R.I. Glebov, P.N. Shibanov [181]. Our device has certain improvements, that result in a) lower gas contamination or absorption by metal of the mill (instead of special steel, ordinary ST-3 steel with hardened inner surface is used) and by using mercury instead of concentrated water solutions as a working solution; b) the gas sample is under normal P that helps in determining its volume easily and in transporting it into the gas analyser etc.; c) water vapor is frozen out and does not come to the gas collecting system.

Gases from inclusions were analyzed by known chemical methods, mostly in the gas analyzer VTI-2. There are determined: CO_2 + other "acid" gases, O_2, CO, H_2, C_nH_{2n+2}, N_2 + rare gases (by difference) and total gas volume.

II. Device for rapid analysis of CO_2 and collecting of gas samples for carbon isotope analysis. CO_2 is the main component of the gases in inclusions. In endogene volatile fluids it is second to H_2O and sometimes, in exceptional cases, second to CH_4 and N_2. Its quantitative enrichment is connected with hydrothermal-metasomatic bodies in magmatic rocks or with post-magmatic veins. Moreover, high CO_2 content is connected with precipitation of raw materials and ores such as gold, piezooptic quartz, polymetals, etc. For this reason, it is necessary to have a highly reproducible analytical procedure for determination of CO_2 in rocks and minerals for geological-prospecting purposes. [...]

The device for quantitative analysis of CO_2 [99] consists of two parts: 1) non-vacuum hermetic ball mill with elastic piston for expelling of gas from the body of mill (Fig. 34) and 2) CO_2 analyzer working by sorption of CO_2 and titration (Fig. 35). Free space of mill body during grinding is filled with air or inert gas. $BaCO_3$ precipitated from $Ba(OH)_2$ solution during CO_2 absorption is then used for mass-spectrometric determination of isotope ratios of carbon. Weight of mineral or rock is 2-3 kg. This device may perform 3-4 analyses in 8 hours.

Determination of bulk CO_2 content in inclusions includes the following operations:

1. The samples (3-6 kg) are crushed to 2x2x3 cm. For water-free pore gases the sample is dried at least 2 hours in vacuum at 110°C.

2. With the mill body in a vertical position, the sample (2.5-3 kg) is placed in the mill, the mill is closed, and the piston is moved to the extreme extended position (largest volume) and clamped by nut 8. Piston stem 6 is used to expel the gas from mill; it is closed by Mohr's tights [i.e., pinch clamps] (Fig. 35). The mill is moved to the horizontal working positon, and grinding time is chosen experimentally; average time is 2.5 hours.

3. During grinding the analyzer (Fig. 35) is prepared. Before filling with reagents, the whole analyzer is flushed with CO_2-free air by pumping with the bulb (7). The following vessels are filled: Wulf bottle 16 with tube, burette 14, and gas filters 10-12 by 0.05n $Ba(OH)_2$ solution. Wulf bottle 15 and burette 13 by 0.05n HCl, gas filter 9 by saturated $H_2Cr_2O_7$ solution, pipette by 1% alcohol solution of phenolphthalein. $Ba(OH)_2$ concentration is determined every day by titration, and after filling of analyzer by new $Ba(OH)_2$ solution. The preparation of analyzer is completed by a blank determination, performed every day before determinations. The blank determination is performed by conducting air with CO_2 from an empty mill by full piston movement. The calculated amount of CO_2 in air volume is subtracted during CO_2 determinations from inclusions.

4. After grinding the mill is moved to vertical position so the ground sample and balls fall to the bottom. The mill is joined by rubber tube with analyzer (1 in Fig. 35). Nut of stem 8 and clamps 2 and 6 are released. Gas from mill is pushed by piston and sucked by pressure regulator 17; it passes through gas filters with $H_2Cr_2O_7$ and next through gas filters 10-12 with $Ba(OH)_2$ solution for CO_2 absorption. Saturated solution of chromium anhydride in H_2SO_4 absorbs H_2S, frequently occurring in minerals of Volynian pegmatites, as shown by I.N. Maslova [141]. Other acid gases

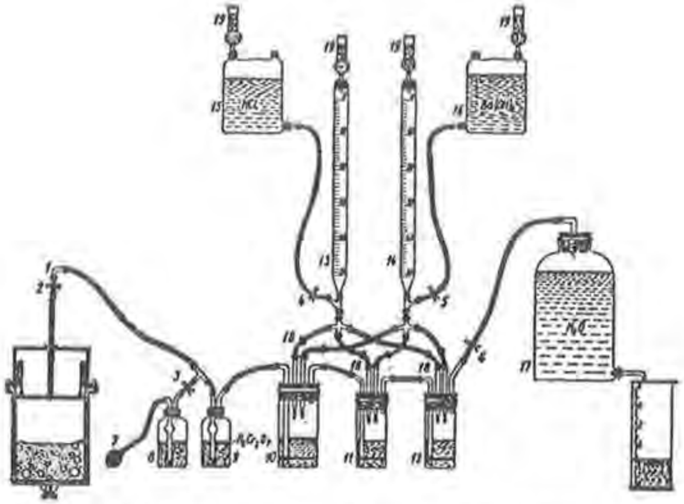


Fig. 35. Scheme of CO_2 analyzer: 1 - connecting tube, 2-6 - Mohr's tights [i.e., pinch clamps], 7 - rubber bulb, 8 - gas filter with KOH, 9 - gas filter with $H_2Cr_2O_7$, 10-12 - gas filters with $Ba(OH)_2$, 13 - burette with HCl, 14 - burette with $Ba(OH)_2$, 15 - Wulf bottle with HCl, 16 - Wulf bottle with $Ba(OH)_2$, 17 - pressure regulation, 18 - pipettes with ball valves, 19 - tubes with askarite.

(NO_2, Cl_2CO) that react with $Ba(OH)_2$ were not found in inclusions in minerals from Volyn'; their absence was confirmed by mass spectrometry [102].

5. After complete absorption of CO_2 pushed with air from the mill clamp 2 is closed and the clamp 3 is opened. In gas filters 10-12 some drops of phenolphthalein [are added and the] $Ba(OH)_2$ solution that was not neutralized by CO_2 is titrated by HCl. For faster titration, the solution is mixed by air flow from the bulb 7.

6. The mill is cleaned of ground sample by sieving through sieves fixed in place of the lid of the mill. The mill is turned with its opening down and moved by the motor; the balls remain above the sieves.

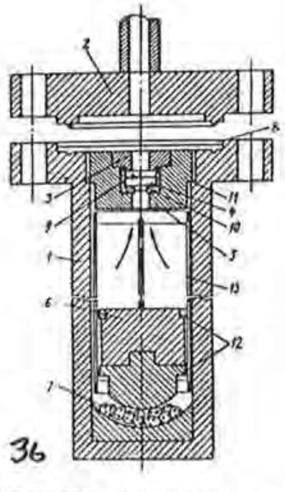
The content of CO_2 (in cm^3), calculated by 1 kg of sample, is determined from the following formula:

$$V(CO_2) = \frac{[(N_1V_1 - N_2V_2)E - p]V_3}{PdV_4},$$

where N_1 and V_1 - normal concentration and total volume of $Ba(OH)_2$ solution that filled gas filters, N_2 and V_2 - same for titrating HCl solution, E - equivalent mass of CO_2 (equals 22), p - mass of CO_2 in air volume removed from mill in blank determination (in grams), V_3 - total volume of air in mill during rock grinding, determined by calculation from density and mass of the ground rock (in cm^3), V_4 - air volume removed during blank determination, P - mass of sample(in grams), d - CO_2 density under normal conditions (1.96 g/l).

Determination of the error in the method was made using fresh granite. Absolute error did not exceed 0.38 cm^3/kg, relative - 15%.

III. Mass-spectrometric device with electromagnetic vacuum mortar. It consists of: mass-spectrometer MKh-1303 (or MSKh-3A); ion counter SI-01; electromagnetic mortar [101, 102] joined immediately to mass-spectrometer input. Use of ion counter increases the sensitivity of the method by two orders of magnitude. Mortar (Fig. 39) is a cylinder made from stainless steel with an air-tight cap. Through a hole in the cap gas goes to P_2O_5 absorber for H_2O (10) and next to the mass spectrometer. The bottom of the mortar and working surface of the pestle are made from an



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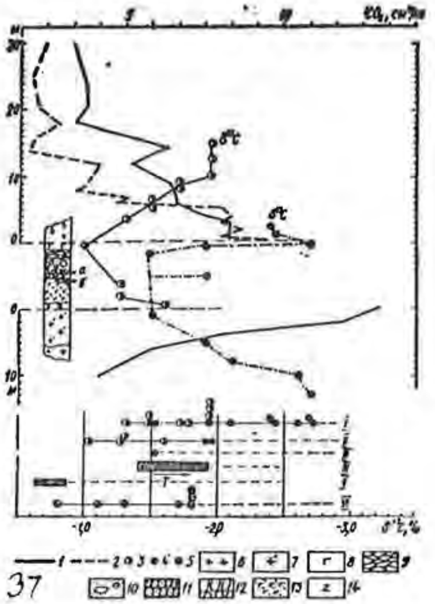

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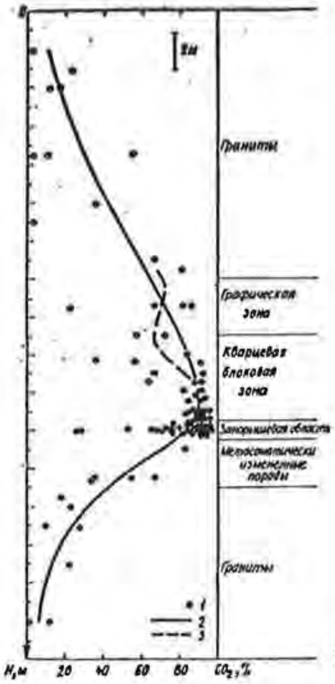

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Fig. 36. Scheme of vacuum electromechanical mortar connected to mass-spectrometer MKh-1303 for release of gas from fluid inclusions: 1 - body of non-magnetic steel, 2 - cap, 3 - cover of container for P_2O_5, 4,9,10 - container for P_2O_5, 5 - cover of mortar body, 6 - inner core of pestle, of magnetic steel, 7 - sample, 8 - aluminum vacuum seal, 11 - tightening ring, 12 - guiding rings, pestle head and bottom of mortar from hard alloy (pobiedite), 13 - guiding rods of electrolytic copper.

Fig. 37. Content of CO_2 and values of $\delta^{13}C$ in inclusions in granites and pegmatites of the Korosty pluton [99, 139]. CO_2 distribution: 1 - from drilling cores, 2 - from samples of wall rocks, 3,4 - pegmatites A and B, 5 - siderite, 6 - granite, 7 - metasomatically altered granite, 8 - graphic pegmatite, 9 - blocky quartz, 10 - zanorysh, 11 - albite-microcline zone of leaching, 12 - microcline zone of leaching, 13 - graphic pegmatite, 14 - pegmatoid. In Roman numerals, $\delta^{13}C$ of inclusion CO_2: I - in granite, II - in pegmatite, III - in bulk sample of quartz, IV - in individual types of quartz, V - $\delta^{13}C$ of deep CO_2 [27a], VI - $\delta^{13}C$ of siderite.

Fig. 38. Distribution of endogeneous CO_2 in granites and pegmatites of Volyn': 1 - analytical data, 2 - average CO_2 contents, 3 - possible shape of the curve.

extra hard alloy ("pobiedite"), and highly polished. The pestle has an inner core of magnetic stainless-steel and under the action of an electromagnetic field it moves upward, and then drops by gravity to crush the sample. Four rods of electrolytic copper (13) protect pestle from friction with the mortar walls. Regulation of frequency, strength and duration of pestle grinding is performed by an apparatus of I.M. Svoren'. A sample holder may be inserted in the mortar for opening individual inclusions with a pobiedite needle (see Fig. 43). Determination of quantitative composition of gas of each sample is controlled by analyses of standard gas mixture. If H_2O is determined, container 10 is not filled with P_2O_5.

Mass spectrometers applicable for gas analysis differ on the basis of mode of operation, sensitivity, and selectivity. Optimum sample mass for bulk analysis of inclusion gas with the MKh-1303 is 1-3 g, with the MSKh-3A - 10-30 mg; minimum size of individual inclusions for analysis is

0.1 mm^3 and 0.00001 mm^3, respectively.

The first mention of the use of mass spectrometer for analysis of inclusion gas is by [238]. However, the first more complete studies of the instrument possibilities for determination of bulk gas composition released from inclusions by heating or grinding in vacuum were made by C.G. Barker [212], R. Kranz [230, 231], and J. Touray [253].

Results of studies of geological objects. Most complete data about spatial distribution and chronological evolution of volatiles from mineral-forming fluids were obtained for pegmatites of Volyn'. From studies of gas profiles taken from large quartz crystals and the zoning of pegmatites and granites, increases in CO_2 and heavy C isotope were found in: a) in low-temperature zones of quartz crystals, b) in low-temperature zones of pegmatites, c) in zones of granite occurring in various distances from contact with pegmatite up to 30-15 m. These agree with the sequence of crystallization (Figs. 37, 38).

Rapid CO_2 analysis was performed on two areas of various parts of pegmatite field, for detection of hidden deep pegmatites. In the first area pegmatites were not found by prospecting boreholes in a 50x80 m network. Sampling for gas analysis was made by nine drill cores to a depth of 100 m; analyzed samples were taken each 6 m, and if higher CO_2 contents were found, samples were taken each 3 m. The background CO_2 content was 3.5 cm^3 per kg, and a zone of increased CO_2 concentration was distinguished. It appears distinctly in the NW area of the field at a depth of 40-1090 m. Boreholes found pegmatite bodies here, confirming the validity of the CO_2 method.

During sampling of a second area samples were taken each 3 m over a distance of 300 m. Samples taken each 6 m were analyzed, and if high concentrations of CO_2 were found - each 3 m. Background CO_2 content (2.0-2.5 cm^3 per kg) is much higher than that for the first area. Abnormal CO_2 contents reach 8.0-8.5 cm^3 per kg (Fig. 39).

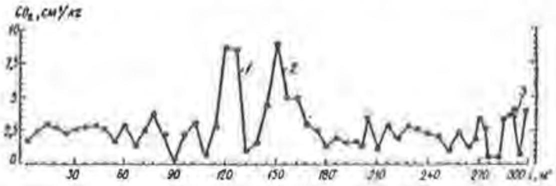

Fig. 39. Distribution of endogeneous CO_2 in granites from data of sampling of horizontal working pit: 1-3 - anomalous contents of CO_2.

Comparing the obtained data and the results of detailed prospecting shows that anomalies 2 and 3 indicate pegmatite occurrence. Anomaly 1 has no direct connection with pegmatites; however, next to it at a depth of 58 m pink granite was found with a graphic quartz intergrowth zone 9 m thick. Thus, the CO_2 anomaly found indicates the possible existence of hidden pegmatite adjacent to the zone of altered granite.

The results obtained suggest that the proposed method may be used for: a) contouring of areas of granites possibly bearing pegmatites, b) finding of hidden pegmatites, c) evaluation of commercial value of pegmatite bodies.

The principles of the rational use of gas analysis (the problem of hydrogen determination). The major goal of the method of bulk analysis is the determination of gases occurring directly in inclusions as relics of mineral-forming media, from which the composition of mineral-forming fluids may be reconstructed in real ranges as it existed under endogeneous conditions.

Gases and other substances may occur in incompletely sealed intergranular space and open fractures. Usually these do not reflect the relics of mineral-forming medium but they have late, secondary filling, because such opened or half-opened fractures may have undergone numerous changes under conditions that are not pertinent to mineral formation. These admixtures are removed by long heating of samples, ground to the dimension of composing grains, under vacuum at 105-110°C. Gases adsorbed from the surrounding atmosphere on the chip surfaces may be also removed during heating under vacuum. Such adsorption, however, is very small, as shown by Dewar and Ansdell [217].

Inclusion in minerals as fluid-filled groups of vacancies in the crystal lattice may have various dimensions - from macro- and microvoids to individual single-atom vacancies. It is known that foreign atoms may also occur in interaction spaces or "channels" in the crystal lattice. Dimensions of these "channels" vary over a relatively wide range. In zeolites, for instance, channels are able to hold foreign substances in amounts comparable to open or half-open fractures. In quartz and numerous other minerals the structural voids approach the closed pores of vacancies.

As studies by IR and EPR methods prove, quartz may contain, as structural or extrastructural admixtures (but not connected with visible fluid inclusions) protons, Li, K, Na, OH, H_2O and CO_2 [28, 56]. L.V. Bershov [9], using the EPR method, found atoms of hydrogen and molecular methane in structural channels or interstices of beryl and other minerals.

One may suppose that various relative dimensions of the possible volumes for relics of mineral-forming media mentioned above and the character of action of electrostatic forces in them, may influence to various degree the filling of trapped fluid under crystallization conditions. Inclusions of ordinary microscopic size may trap an adequate sample from the surrounding environment, but pores in the range of vacancies in the crystal lattice may isolate parts of the medium with a significantly disturbed primary composition, due to the action of electrostatic fields on dissociated elements in the fluids. Thus, the features of inclusions of microscopic and ultramicroscopic (<1.0 to 0.01 μm) dimensions should be distinguished. The first ones are quite close to the composition of the mineral-forming fluid, but the second ones, especially those approaching the dimensions of vacancies, strongly differ from the parent fluid.

Hence, during selection of a method of gas release from inclusions and interpretation of the analytical data obtained, it is necessary to remember that under certain conditions, gases may be introduced in various quantitative proportions from opened fractures and structural channels of minerals of zeolite types, closed and half-closed pores and channels that practically have no exchange with the surrounding medium (in quartz, feldspar and other minerals), and individual vacancies or their groups formed during replacement like $Si^{4+} \rightarrow Al^{3+} + H^{+}$. Probably, the gas release by grinding should be performed using a mode that would open all inclusions of macro- and microscopic size and a minimum amount of pores of crystal lattice or molecular dimension. The finer the sample powdering and the larger the total free sample surface, the larger are the number of the smallest pores opened and the higher the contamination by non-characteristic admixtures. For this reason the total sample mass [Russian text says "total dimension of sample," but the context indicates mass, A.K.] should be adequate for the sensitivity limit of the analytical method used.

Determination of true composition of gas components of inclusions by the bulk method is complicated by the fact that during the release of volatiles, new gases may be formed or adsorbed. Two main modes are used for gas release from rocks under vacuum: 1) heating to 800-1200°C, 2) powdering of samples at room temperature.

Only an insignificant part of the gases released by the first mode are from inclusions of parent fluid [97, 215]. Most of the gas is generated during reaction of H_2O vapor and CO_2 with Fe-Mg minerals (producing H_2 and CO), during decomposition of carbonates yielding CO_2, during reaction between CO and H_2 (yielding CH_4), etc. Interesting data were published by C.G. Barker [212], who released gases from the same sample of fluorite by heating and by powdering in vacuum at room temperature. Comparison of results shows that all CO and part of the H_2 and CH_4 comes from reaction at elevated temperature (Table 4).

Table 4. Comparison of gas composition (vol. %) extracted under vacuum by inclusion heating up to 400°C and by powdering

	Fluorite I		Fluorite II		Fluorite III	
Component	Heating	Powdering	Heating	Powdering	Heating	Powdering
CO_2	61.43	82.41	72.53	81.17	70.59	51.14
H_2	18.58	5.32	11.90	4.27	10.93	2.38
CO	16.34	0.00	9.04	0.00	9.45	0.00
CH_4	2.60	0.01	5.29	2.41	7.74	0.00
N_2	1.02	12.18	1.23	2.13	1.26	46.48

Evidently, at very high temperatures gases are released from pores of submolecular dimension. It is practically impossible to avoid thermally dissociating microscopic solid inclusions such as carbonates. For this reason it may be supposed that degassing of rocks and minerals at elevated temperatures cannot yield purely volatiles from inclusions of mineral-forming fluids.

The second mode of gas release from inclusions gives more valid results but it also has imperfections. The first time the errors in results of bulk analyses were noted was by R. Goguel [220] during powdering of mica and carbonates. It was found that the amount of hydrogen increases with increase in powdering time. That author supposed that hydrogen occurs mostly not in inclusions but dissolved in mineral. He also indicated the possible decomposition of carbonates during grinding with formation of CO_2. S.I. Golosov and Yu.A. Dolgov et al. [35] reported the intensive emanation of hydrogen during powdering of quartz in water or in air with use of a highly effective planetary steel ball mill. On using a water medium, hydrogen emanates for a long time after finishing powdering. Comparison of the obtained experimental results of the bulk analyses of gas extracted from inclusions in usual vacuum ball mills and analyses of individual inclusions by the volumetric method [54] caused the authors to conclude that "amounts of the emanating hydrogen significantly exceeds the amount of this gas present in gas-liquid inclusions" and that those amounts of hydrogen "are not probable for gas mixtures of endogeneous origin, because during analysis of individual inclusions hydrogen is completely absent" [35, p. 220, 222]. The authors proposed several possible modes of hydrogen generation, essentially due to reaction of water (vapor) and finely dispersed iron of the mill body.

Experimental studies by other authors showed the limited degree or complete absence of hydrogen or CO_2 generation during powdering of quartz, calcite, topaz and other minerals in steel mills [107, 205]. Particularly, M.M. Elinson found that during operation of empty (i.e., containing no mineral sample) mills, hydrogen is given off from the presence of impurities in the metal of the mill body and balls.

Later G.N. Vertushkov et al. [16] published results of detailed studies of the extraction of inclusion gas with steel ball mills. They concluded that hydrogen forms due to reaction of new-formed weak carbonic acid and dispersed iron. For formation of H_2CO_3 in the mill atmosphere,

CO_2 and H_2O vapor should occur; presence of only one of those components does not lead to hydrogen formation. The latter, however, does not agree with the mode that they propose for hydrogen formation due to iron oxidation: $2Fe + 6H_2O \rightarrow 2Fe(OH)_3 + 3H_2$.

These ambiguous results did not solve the problem, because it was impossible to conclude about the degree of imperfection of the method and the true causes of disturbance of the primary composition of the gases released from inclusions. However, performing of analyses with these methods, and publishing of the obtained results were continued. Sensitivity of the analyses and the range of determinable components were extended with the introduction of mass spectrometers [92, 102]. They were used not only for bulk composition, but also for gases in individual inclusions. After some years the problem of accuracy of the composition of inclusion gases released by various methods is still unsolved [102].

For elucidation of the reasons of disagreement between the results of bulk and individual inclusion gas analyses, special studies were performed [101, 102]. Mass-spectrometric analyses of individual inclusions did not reveal hydrogen in the inclusion gases (Table 5).

The possibility of performing multiple and strictly parallel determinations verified that in the studied samples, hydrogen is not connected with inclusion fillings. The first model of electromagnetic mortar was made of stainless steel without pobiedite inserts (as shown in the Fig. 36). The sample was crushed by a steel pestle on the steel bottom of the mortar. With this mortar a series of analyses was performed for determination of the error of the method and reproducibility of the results. Each of the three selected quartz samples (from Volyn') were analyzed three times. Simultaneously with each determination a standard gas mixture was analyzed (CO_2 24.5%, N_2 60.0%, CH_4 5.3%, H_2 10.2%). Powdering conditions maintained were the same for each sample (sample weight 2 g, grain size 3-5 mm, powdering time 4 min. with frequency of 60 strokes per min.). Results are given in the Table 6, where limits of error for the determination of each component are shown.

For determination of the source of contamination for inclusion gas by hydrogen, metal of the mortar was separated from the sample and powdering was performed between a porcelain insert and a porcelain pestle cover. Comparison of the data obtained shows a distinct decrease of hydrogen emanation for samples powdered in a porcelain mortar (Table 7). However, the complete elimination of hydrogen has not been achieved. To determine if the metal of the device really emanates hydrogen during its deformation by impact, pieces of metal were flattened in a mortar with pobiedite working surfaces, with and without the guiding copper rods (Fig. 36). From stainless and ordinary steel during this treatment hydrogen was released in amounts of 33 mm^3 per 1 g (under $P = 101.3$ kPa at 20°C); only insignificant traces were obtained from the electrolytic copper. Thus the experiments showed that hydrogen in noticeable amounts is released from the metal due to mechanical deformation. This, however, is not unexpected, because it is known that metal, especially steel, significantly adsorbs and concentrates dissociated (ionic) hydrogen on its surface and in internal layers (essentially in intergranular pores and as a compensating ion during the breaking of bonds in the metal structure [27]).

The incomplete elimination of hydrogen found during powdering of minerals in mortars with porcelain and pobiedite or copper working surfaces needed more extensive studies of many minerals and especially of those which, due to their low hardness, should cause absolutely no deformation of the material of the working surfaces. Such experiments were performed with numerous minerals of various composition and origin.

Results of determination of amount of hydrogen (mm^3), released during

Table 5. Results of mass-spectrometric analysis of gas from individual inclusions in crystals of quartz and topaz

No.	Characterisitcs of inclusion	Input pressure Pa	Composition of inclusion gas, %						
			CO_2	N_2	CH_4	C_2H_4	C_3H_8	Ar	He
1	Volyn', pegmatite, smoky quartz L<G, early S, type 4, L 35-40%	4.1	66.2	29.6	4.2	--	--	--	--
2	Volyn', pegmatite, topaz essentially G, early S, occurring in cleavage planes, irregular shape, dimensions 1.0x3.0 to 2.0x5.0 mm, L 5-10%, at 5-7°C LCO_2 is absent	5.2	93.3	6.5	0.2	--	--	--	--
3		4.4	90.8	6.3	2.9	--	--	--	--
4		4.9	90.9	7.3	1.3	--	--	--	--
5		5.1	92.8	3.4	3.8	--	--	--	--
6	Volyn', pegmatite, smoky quartz G late S, healed fracture cuts whole crystal, dimensions 1.0x2.5 mm, L 1%	4.8	87.4	8.6	4.0	--	--	--	--
7		7.3	88.5	8.7	2.8	--	--	--	--
8	Volyn', pegmatite, regeneration quartz G S, vacuole walls covered by film with polygonal fractures.	6.5	81.6	17.2	1.2	--	--	--	--
9		5.2	84.6	13.9	1.5	--	--	--	--
10	Similar to above but without polygonally fractured film	26.7	73.9	8.6	17.4	0.05	0.05	--	--
11		6.5	53.3	20.3	26.4	--	--	--	--
12	Volyn', pegmatite, icy transparent quartz G S equant, L<1%, dimensions 1.0x3.2 mm to 3.1x3.5 mm, refilled by various inclusions	21.3	94.7	0.7	4.4	0.04	0.04	0.04	0.07
13		19.3	89.7	6.2	3.9	0.03	0.03	0.03	0.07
14		6.7	27.97	71.2	--	--	--	0.34	0.49
15	Transcarpathia, quartz ("Marmarosh diamond") Essentially G, P negative crystals, L 1-2%, dimensions 1.5x2.0 mm.	--	2.1	24.8	73.1	--	--	--	--
16		--	1.6	3.7	94.7	--	--	--	--
17	G P, oil(?) droplets on inclusion walls.	4.7	--	--	99.9	0.1	--	--	--
18	Same.	4.9	--	--	99.9	0.05	0.05	--	--
19	Inclusion of paraffin-like substance, P	4.0	--	--	100.0	--	--	--	--

Table 6. Results of determination of errors

No. of Sample	P in input system, Pa	Components of mixture	Average of measurements, %	Error (±n), %	
				absolute	relative
1	9.3 - 12.0	CO_2	84.6	1.2	1.4
		N_2	8.4	2.0	24.1
		CH_4	1.7	0.5	31.2
		H_2	5.3	1.8	33.4
2	9.4 - 9.7	CO_2	76.5	0.9	1.2
		N_2	13.8	2.0	14.5
		CH_4	0.8	0.1	16.2
		H_2	8.9	2.2	25.0
3	9.4 - 10.7	CO_2	57.3	2.1	3.6
		N_2	27.4	3.3	12.0
		CH_4	7.9	0.9	11.8
		H_2	7.4	2.7	36.5
4	9.7 - 12.7	CO_2	25.6	1.5	5.8
		N_2	59.6	2.4	4.1
		CH_4	3.8	0.4	10.3
		H_2	11.0	2.1	19.5

Note: 1 - icy, slightly smoky "reticulated" quartz from the inner part of morion; inclusions of negative crystal habit, L 40%, S inclusions practically absent; 2 - milky-white "reticulated" quartz from the central part of very large morion crystal from pegmatite, inclusions of irregular habit, formed from boiling solutions, S inclusions are practically absent; 3 - brownish-gray (smoky) blocky quartz from the contact with feldspar zone of pegmatite; 4 - standard gas mixture.

Table 7. Comparison of gas composition (volume %), extracted in vacuum by opening of individual inclusions and by sample powdering in metal or [porcelain] ceramic mortars (Volyn' pegmatites)

Component	Topaz (av. of 2-4 analyses)		"Reticulate" quartz		"Reticulate quartz		Blocky quartz	
	Stainless steel	Individual inclusions	Stainless steel	Ceramics	Stainless steel	Ceramics	Stainless steel	Ceramics
CO_2	70.3	92.0	84.6	93.2	76.5	90.3	57.3	54.9
N_2	6.0	5.9	8.4	3.7	13.8	8.4	27.4	36.5
CH_4	2.4	2.1	1.7	1.7	0.8	0.4	7.8	6.3
H_2	21.3	0.0	5.3	1.4	8.9	0.9	7.4	2.3

crushing of various samples under vacuum of input system of mass-spectrometer MKh-1303 (bottom and pestle of mortar - polished hard alloy "pobiedite;" conducting rods of the pestle - electrolytic copper; time of sample powdering 5 min., frequency 60 strokes per min;., sample weight 3 g) under conditions reduced to normal (P - 101.3 kPa, T = 20°C):

Stainless steel	98	Albite-cleavelandite (Volyn')	92
Copper, chips	64	Same, another sample	33
Copper (electrolytic)	-	Albite, thick plates (Volyn', pegmatite)	-
Steel-3	39	Same, another sample	9
NaCl (reagent)	66	Same, another sample	4
NaCl (grown at 20°C)	56	Quartz without inclusions (synthetic)	-
Halite without inclusions (Forecarpathians)	22	Same, another sample	65
Gypsum (natural)	77	Quartz (natural, hydrothermal)	56
Calcite (Transcarpathians)	146	[Presumably the"-"symbol refers to zero]	
Calcite (Crimea)	23		
Calcite (Crimea, another sample)	54		

The conclusions are as follows: 1) all minerals, although in various amounts, emanate hydrogen, including synthetic or hypogene halite, calcite and gypsum; 2) absolute amount of the emanated hydrogen is relatively low (1-50 mm^3 per 1 g of mineral); it increases with the degree of powdering (or proportionally to the powdering duration); 3) relative volume of hydrogen (in %) significantly increases in samples bearing small numbers of inclusions.

Thus, experiments with powdering of samples of minerals without mechanic interaction with metal of the working surfaces and in a medium free of water vapor prove the continuous presence of hydrogen admixture in the analyzed mixtures, that is not typical of usual microscopic-size inclusions and it appears due to its release from structural and nonstructural ultramicropores of crystals; one may suppose that hydrogen is not completely absent in inclusions but it occurs in so small amounts that they are not detectable by the procedures used.

Evidently, for decrease in the influence of noncharacteristic impurities upon the studied composition of gases from inclusions, it is necessary to take into account during powdering the amount and size of inclusions and not exceed the optimum lower grain size of the powdered material.

Gas extracted from inclusions may change under action of mechanic-chemical and sorption processes. The present-day studies show that destruction of crystal lattice by mechanical action (chipping, pressing, etc.) is accompanied by emanation of certain components of the crystal substance due to its decomposition. It is easily detectable for such unstable compounds as carbonates, sulfides, etc. The performed studies show that amongst carbonates only siderite decomposes in ball mills with emanation of noticeable amounts of CO_2. Decomposition of calcite was not observed under such conditions. Sulfides release hydrogen during powdering in water [145]. Amounts of the released gases are very low and in significant degree they depend on the intensity of the powdering of the mineral.

Due to increase in the active surface, the finely powdered mineral is able to absorb gas components released from inclusions even under vacuum. Experiments performed by S.V. Ikorskiy and Ye.A. Evetskaya [81] prove that sorption is variable for different gases and depends on the sorbent material. The limit of CO_2 sorption by gabbro-norite and khibinite is 100 and 33 cm^3 per kg, respectively. The difference is explained by phenomena of active chemical sorption with carbonate formation by minerals containing Ca and Mg (plagioclase of gabbro-norites). Quartz practically does not absorb CO_2. Methane is almost not absorbed by the above rocks and minerals.

Taking into account the above listed factors on the results of analysis by vacuum extraction, the following conclusions may be made:

1. Behavior of gases during powdering of minerals (their emanation or sorption) have not been studied sufficiently; in a given stage it is ascertained that the essential influence on the results of analysis of gas composition of inclusions of usual microscopic size (>1.0-0.01 mm*) occurs due to hydrogen emission from ultramicropores in the studied minerals and CO_2 sorption by powdered samples.
2. The more finely powdered the sample, the stronger the influence of both of the above factors, for this reason optimally, powdering should be kept to the minimum possible if a) the analytical devices used are of high sensitivity; b) sample contains numerous inclusions; c) average size of inclusions is large.
3. Hydrogen in results of analyses should be deleted if it is absent in control determinations of individual inclusions.
4. Analyses of inclusion gases from quartz rocks are practically not influenced by CO_2 sorption; essentially feldspathic rocks (and siderites and dolomites) should not be analyzed by bulk method - it may be only used for comparison of relative quantities of gas, released from feldspar-quartz and other rocks of the same or close composition. It is desirable to perform analyses under standardized conditions.

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*Russian text gives here "μm" but seemingly it is a misprint for mm. A.K.

NAUMOV, V.B., IVANOVA, G.F. and SHAPENKO, V.A., 1983, Genetic aspects of the formation of rare metal ore bodies, p. 48-56 in Genetic models of endogenous ore formation, vol. 2, Tin-tungsten, transition metal, gold-ore deposits: Novosibirsk, Izd. "Nauka" (in Russian; translation courtesy of Paul R. Bannes).

In order to create genetic models for the formation of endogenous ore deposits one must assemble complex data on the geological, mineralogical, geochemical, and physico-chemical peculiarities of the evolution of various natural processes. Considering the present status of geological science, one should first attempt to find the correct principles and approaches to the creation of such models, to clarify the indispensable data necessary to construct these models. Therefore, in the present work we will examine a number of genetic aspects, which, in our opinion, must be taken into account in a model of the formation of rare metal deposits. Principal attention has been given to new results obtained in recent years.

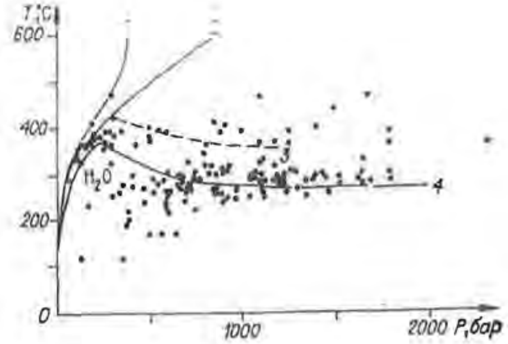
The approach used in setting up the analysis of the genetic peculiarities of rare metal formation consists of a study of the material composition and the sequence of processes in mineral formation, of an investigation of the chemical components of the minerals and their geochemical characteristics, as well as a clarification of the development of physico-chemical parameters of the formation both of the rare metal deposits themselves and of the magmatic rocks associated with them. The analysis is based on the results of our own investigations of more than 30 rare metal deposits and on published data on analogous deposits in various regions of the world.

The ore formation being examined has specific peculiarities. We shall examine a few of them. First, we observe the extensive chronological relating of the deposits to granitoid rocks, noting that the extensive typical connection is with granites of two geochemical types -- the lithium-thorium type and the standard type (Kovalenko, V.E. et al., 1971; Kovalenko, V.E., 1977). Second, we note the characteristic complexity of ore mineralization, represented normally by molybdenite, cassiterite, wolframite, scheelite, and beryl. The correlation of ore minerals in early associations is diverse, and leads, in some cases, to tin-tungsten or molybdenum-tungsten deposits, and in other cases, to tin, molybdenum or tungsten deposits. Third, a regular time sequence has been established for the formation of mineral associations: early -- rare metal; later -- sulfides; and concluding -- carbonate-fluorites (Ivanova, 1976; Kelly, Turneaure, 1970; Kelly, Rye, 1979; et al.). Fourth, we note the typically significant development of fluorine mineralization, manifest in the form of topaz in early ore mineral associations and in the form of fluorite -- in ore and post-ore mineral associations. Fifth, we note, for basic minerals of early associations, the characteristic high content of a series of indicator elements, for example, in wolframites -- tantalum and niobium.

Investigations of fluid inclusions in minerals shows that the formation of ore associations in rare metal deposits always occurs at high temperatures -- 500-200°C, in the majority of cases at 400-250°C (Naumov et al., 1979; Naumov, Ivanova, 1975, 1980; Durisova et al., 1979; Groves, Solomon, 1969; Landis, Rye, 1974; Roedder, 1971; Takenouchi, Imai, 1971; et al.) [p. 49]. No less characteristic, also, are the high pressures of ore-forming solutions. In Fig. 1 are assembled all published data on the P-T conditions of formation in rare metal deposits both of ore associations (all points above 200°C). In Fig. 1 there are 145 determinations, 70% of which are our data. These results are derived from 43 deposits. We note that the temperatures were measured directly in the heating stages (these are Th values), while two methods, basically, were used for the determination of pressure. The first method is linked with the use of the P-V-T properties of CO_2, studied experimentally with great precision over a wide interval of temperatures and pressures (Melnik, 1978). The second method, first used by P.V. Klevtsov and G.G. Lemmlein (1959), is used for multiphase inclusions with daughter crystals. We turn our attention to the latter. If a natural fluid consisted only of pure water and CO_2, then, in the area of temperatures beyond 300°C, and pressures higher than 300 bars, heterogenization would be impossible (see Fig. 1, line 4). However, the presence of dissolved components in the melt significantly elevates the boiling point of the fluid and the transition to gaseous phase (see Fig. 1, line 3). Such situations arise quite often in the formation of rare metal deposits.

What kind of conclusions follow from the data shown in Fig. 1? In the opinion of many geologists the most probable depth of formation of rare metal deposits does not exceed 1-3 km. At a gradient of 50°C/km (elevated in comparison with the usual geothermal gradient) the temperatures of the country rock even at a depth of 3 km are significantly lower (more than twice as low) than the real temperatures derived for ore associations. From this the conclusion follows that there must be a substantial heat input for the formation of rare metal deposits. Therefore it is probably no accident that there is a constant and widespread connection between these deposits and magmatic massifs.

Moreover, comparing the data on pressures of ore-forming solutions (see Fig. 1) with possible pressures resulting from a lithostatic burden of rocks (270 bar/km) at depths of 1-3 km, it is easy to see that many determinations fall in the area of significantly higher pressures. Thus, it is possible to draw the conclusion that elevated temperatures and pres-



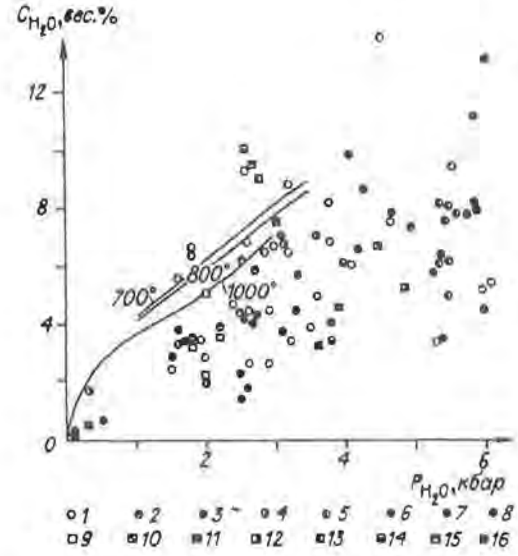


Fig. 1. Temperatures and pressures determined for fluid inclusions in minerals of ore and post-ore associations of rare metal deposits. 1 - line of three-phase equilibrium liquid-gas-halite in the system H_2O-NaCl; 2 - line of two-phase equilibrium liquid-gas in the system H_2O-NaCl (30 weight %); 3,4 - lines showing projected critical points in the systems H_2O-CO_2-6 weight % NaCl (3) and H_2O-CO_2 (4).

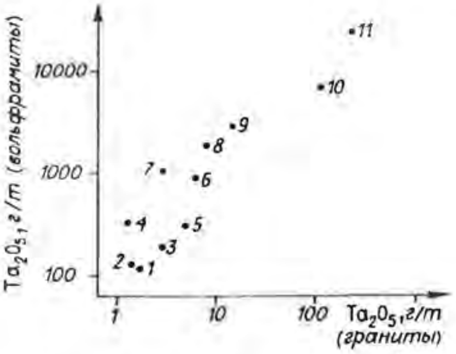
Fig. 2. Concentrations and pressures of water obtained for melt inclusions in minerals of magmatic rocks of acid composition.

sures of hydrothermal solutions are characteristic peculiarities of the formation of rare metal deposits.

Already noted above is the close and widespread connection between rare metal deposits and acid intrusive rocks. In order to discover whether there is a genetic link between them, and if there is, in what it consists, it is ultimately necessary to make a detailed study of the peculiarities both of magmatic and of early postmagmatic processes, that is, of the system of magmatic melt/hydrothermal solution.

The study of melt and fluid inclusions in minerals of magmatic rocks, carried out over the last 5 years, is witness to the fact that, along with temperature measurements begun 15 years ago, [p. 50] there has emerged the possibility of determining other important parameters of crystallization, such as pressure and the concentration of volatile components. Here we should note the new and very important fact of the visual detection, in primary melt inclusions, in minerals of acid effusive rocks, granites and pegmatites, of a true water-rich fluid phase, represented at room temperature by a gas bubble and a liquid solution. The measurement of the volume and density of the water phase in these inclusions makes it possible to calculate the concentration of water in the melt at the moment of crystallization of the mineral being investigated, as well as its pressure. The details of the method of such determination have been published (Naumov, 1979); therefore we shall attend only to the results which have been obtained at the present time. All of them (more than 100 determinations) are shown in Table 1 and Fig. 2, wherein lines are drawn to characterize the dependence of water solubility on pressure for temperatures [p. 51] of 700, 800, and 1000°C, experimentally determined for the Eljurtinsky granite (Kadik et al., 1971).

The results obtained indicate significant variations in the concentration of water, dissolved in magmatic melts of acid composition, --



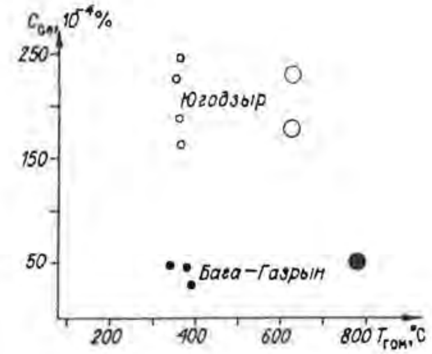


Fig. 3. Dependence of tantalum concentration in wolframites on tantalum content in granites. Granitic massifs of Mongolia (M.P.R.) [Ivanova, 1976]: 1 - Buryanti, 2 - Modoto, 3 - Ikh-Khairkhan, 4 - Salaa, 5 - Tsagan-Daba, 6 - Tumen-Tsogto, 7 - Chulun-Khvriete, 8 - Baga-Gazrin, 9 - Yugodzir, 10 - Borun-Tsogto, eastern stock of amazonitic granites, 11 - amazonitic granites [Severov et al., 1975]. Geochemical types of granites: 1-4 - standard, 5-7 - intermediate, 8,9 - lithium-thorium, 10,11 - amazonite tantalum-bearing.

Fig. 4. Concentration of germanium in topazes from granites and ore zones of rare metal deposits of Yugodzir (Mo-W) and Baga-Gazrin (Su-W). Large circles - magmatic melts; small circles - hydrothermal solutions.

Table 1, Concentration and pressure of water in magmatic melts of acid compositon

No. of structure	Characteristic of structure	n	Concentration, weight %	Pressure, kbar
1	Quartz, alkaline granites and rare metal ekerites, Khan-Bogdo, Mongolia	4(29)	$\frac{2.4-13.9}{5.7}$	$\frac{1.5-6.1}{3.4}$
2	Quartz, granite-porphyries of Kyzyl-Tausky massif, Mongolia	1(8)	$\frac{6.3-13.1}{7.8}$	$\frac{4.7-6.1}{5.8}$
3	Quartz, medium-grained lithium-thorium granites of the Baga-Gazrinsky massif, Mongolia	2(7)	$\frac{1.7-4.4}{3.4}$	$\frac{1.4-3.3}{2.5}$
4	Quartz, leucocratic granites of Levo-Omsukchansky massif, Magadan region	3(5)	$\frac{1.7-7.0}{4.1}$	$\frac{0.3-3.6}{2.1}$
5	Quartz, medium-grained biotitic granites of the Tsagan-Dabinsky massif, Mongolia	1(7)	$\frac{4.8-8.1}{6.9}$	$\frac{5.4-5.6}{5.5}$
6	Quartz, medium-grained granite of the Zavrulyonguyevsky massif, Eastern Zabaikal	1(11)	$\frac{3.4-9.8}{6.0}$	$\frac{3.8-4.1}{4.0}$
7	Quartz, hornblende granite, Dalnegorsky ore deposit, Black Sea shore	1(5)	$\frac{3.4-6.2}{4.7}$	$\frac{1.8-2.7}{2.3}$
8	Quartz, Eljurtinsky granite, Tyrnyauz region, Northern Caucasus	5(15)	$\frac{0.1-8.6}{4.4}$	$\frac{0.1-5.4}{2.9}$
9	Quartz, fine-grained muscovitic granite of Yugodzirsky massif, Mongolia	1(5)	$\frac{2.1-5.1}{3.5}$	$\frac{1.8-2.2}{2.0}$
10	Topaz, lithium-thorium granites of the Khangilai-Shila, Eastern Transbaikal	1(4)	$\frac{3.2-4.5}{4.0}$	$\frac{3.6-3.9}{3.8}$
11	Quartz, liparites of the Tyrnyauz region, Northern Caucasus	1(8)	0.5	0.3
12	Quartz, granite-porphyries of the First of May massif, Jidinsky ore field, Southwestern Transbaikal	1(2)	5.2-6.6	4.5-4.9
13	Topaz, pegmatites of Nigeria, Africa	1(4)	9.0	2.8
14	Topaz, pegmatites of Volhynia	-	10	2.6
15	Quartz, rapakivi of Vyborg massif	-	9-10	2.5-3.0
16	Quartz, granosyenites of the Orkhon-Selenginsky basin, Mongolia	-	7-8	3.0

Note: n - number of specimens and inclusions; in the numerator - limits of measured quantities, in the denominator - average value. Item 14 - data [Lemmlein et al., 1962]; item 15 - [Chupin et al., 1979]; item 16 - [Chupin, Matrenitsky, 1980].

from 0.1 to 13.9 weight %. The majority of determinations are characterized by high values (on the order of 2-8 weight %). In Fig. 2 it is apparent that many structures are poor in water in comparison with the isotherms of saturation for water of the melt of the Eljurtinsky granite. This means that the melts at the moment of isolation of the inclusions were unsaturated with respect to water, although quite often also rich in water. Above the lines of saturation are found only melts of increased alkalinity (alkaline granites of Khan-Bogdo, Mongolia) and melts with a high content of fluorine (topazes from pegmatites). Experimental data on melts of such composition point to the possibility of higher water solubility (Kovalenko, N.I., 1979).

Significant variations are observed also for water pressure; it can vary from 0.1 to 6.1 kbar, since there is a quite obvious direct correlation between water pressure and its concentration in the melt. For a series of structures, for example the Eljurtinsky and the Levo-Omsukchansky granitic massifs, there has been established a substantial elevation both of water pressure and its concentration, arising during the formation of the massifs. Melts with a minimal concentration of water (0.1-0.5 weight %) are characterized by the highest temperatures of homogenization (1030-950°C), while the relatively low-temperature melts (850-730°C) one finds high water pressure (up to 4-5 kbar) and a high concentration of water (up to 5-8 weight %).

To clarify the genetic connection between processes of magmatic crystallization and the formation of rare metal mineralization, we thoroughly analyzed a series of indicator elements in granites of various geochemical types (fluorine, lithium, rubidium, cesium, tantalum, niobium, tungsten, tin, molybdenum) and in minerals of early ore associations from 10 tungsten ore regions of Mongolia (Ivanova, 1976). In particular, the following contents were determined: lithium in micas, tantalum and niobium in wolframites, and germanium in topazes.

In Fig. 3 are shown correlations of tantalum in wolframites from ore zones and in granites. Each point corresponds to the average values of tantalum concentration: for granites -- the average from 5-20 analyses, for wolframites -- the average from 3-10 analyses. The direct proportionality is clearly evident. A minimum content of Ta_2O_5, not exceeding 130 g/T, has been established in wolframite ore deposits associated with the standard type of granites containing minimal concentrations of Ta_2O_5 equal to 1.4 g/T. Wolframite ore deposits coincidental with lithium-fluorine granites and often with amazonite granites are characterized by maximum concentrations, with a content of Ta_2O_5 from 6 to 100 g/T (Ivanova et al., 1981).

[P. 52] The analogous character of the link between granites and ore zones is established for lithium also, concentrated in such minerals as mica, typical of rare metal deposits (Ivanova, 1976).

A geochemical peculiarity of a series of tungsten ore regions is the widespread occurrence of topaz in various genetically connected formations: in rare metal granites, pegmatites, greisens, and ore bodies. This permitted a look at one more geochemical characteristic -- the development of a concentration of germanium in topazes formed over a wide interval of physicochemical conditions (Naumov et al., 1977). In Fig. 4 are presented the results of determination of germanium content in topazes from two ore regions of Mongolia -- the Yugodzirsky, with a molybdenum-tungsten ore body, and the Baga-Gazrinsky, with a tin-tungsten ore body. Along the x-axis in Fig. 4 are plotted Th of melt- and fluid inclusions in topazes. The data cited point to various levels of concentration of germanium: 180-230 g/T for the Yugodzirsky region and 48-51 g/T for the Baga-Gazrinsky. For both deposits there is the characteristic inheritance of germanium

Table 2, Coefficients of pair correlation of elements in wolframites of ore deposits of Yugodzir and Modoto (Mongolia)

Elements	Ta_2O_5	Sc_2O_3	Y_2O_3	Yb_2O_3	ΣRZE
Nb_2O_5	$\frac{0.83}{0.73}$	$\frac{0.72}{--}$	$\frac{0.54}{--}$	$\frac{0.73}{--}$	$\frac{0.70}{--}$
Ta_2O_5		$\frac{0.84}{--}$	$\frac{0.67}{--}$	$\frac{0.79}{--}$	$\frac{0.79}{--}$
Sc_2O_3			$\frac{0.75}{--}$	$\frac{0.86}{--}$	$\frac{0.84}{--}$
Y_2O_3				$\frac{0.89}{0.60}$	$\frac{0.89}{0.94}$
Yb_2O_3					$\frac{0.99}{0.71}$

Note: Numerator - Yugodzir deposit (Mo-W) 41% $MnWO_4$, 15 g/T Ta_2O_5, 0.24% F; denominator - Modoto deposit (Sn-W), 45% $MnWO_4$, 1.4 g/T Ta_2O_5, 0.12% F.

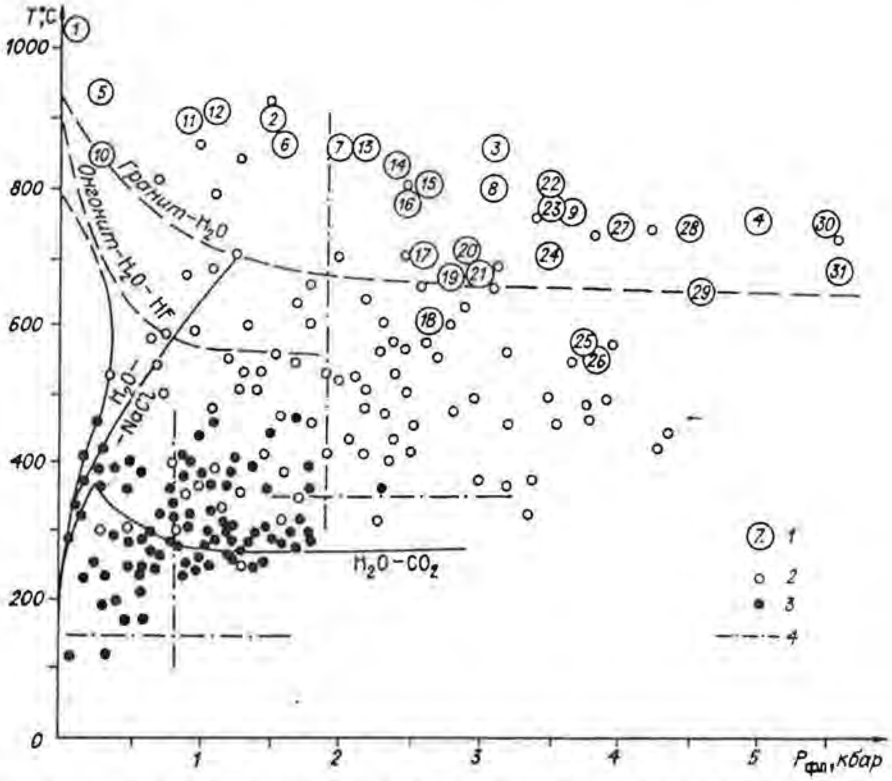


Fig. 5. Temperatures and pressures obtained from the study of mineral inclusions. 1 - magmatic melts (the numbers from 1 to 31 correspond to the numbers of the specimens in Table 3); 2 - magmatic and post-magmatic fluids in granitoids and their metasomatic phases; 3 - hydrothermal solutions of ore and post-ore stages in rare metal deposits; 4 - temperatures (at a gradient of 50°C/km) and pressures (under a lithostatic pressure of 270 bar/km) at a depth of 3 and 7 kilometers.

concentration in the series granites to griesen to ore bodies.

The geochemical specifics of the granitoids influence yet another geochemical peculiarity of the wolframites -- the character of the correlative link of elements in wolframites. In Table 2, for example, are cited the values of paired correlation coefficients of tantalum, niobium, scandium, yttrium, ytterbium, the amounts of trace elements in wolframites of two geochemically contrasting deposits, which have the identical chemical makeup of the wolframites (41-45% $MnWO_4$), formed at the same temperature interval from solutions on very similar chemical composition, but

Table 3. Data on Th and fluid pressures in magmatic melts of acid composition, obtained from the investigation of mineral inclusions

Specimen number	Characteristic Specimen	Th (°C)	Fluid Pressure, kbar	References
1	Quartz, Eljurtinsky granite, Tyrnyauz region, Northern Caucasus	1030	0.1	Our data
2	"	900	1.5	"
3	"	850	3.1	"
4	"	750	5.0	"
5	Quartz, leucocratic granite of the Levo-Omsukchansky region, Magadan Oblast	940	0.3	"
6	"	860	1.6	"
7	"	860	2.0	"
8	"	800	3.1	"
9	"	760	3.6	"
10	Quartz, liparites of Tyrnyauz region, Northern Caucasus	850	0.3	"
11	Quartz, Transzinian complex, Eastern Zabaikal	900	0.9	Reif, 1976
12	Quratz, granites of Western Zabaikal	910	1.1	Schvadus, 1978
13	Quartz, muscovitic granites, Yugodzir massif, Mongolia	860	2.2	Our data
14	Quartz, lithium-thorium granites, Baga-Gazrinsky massif, Mongolia	830	2.4	"
15	"	800	2.6	"
16	Quartz, hornblende granite, Dalnyesgorsky deposit, Black Sea shore?	780	2.5	"
17	Topaz, pegmatites of Volynia	700	2.6	Lemmlein et al., 1962
18	Quartz, rapakivi, Vyborg massif	600	2.8	Chupin et al., 1979
19	Topaz, pegmatites of Nigeria, Africa	670	2.8	Our data
20	Quartz, Barguzinsky complex, Eastern Prebaikal	705	2.9	Reif, 1976
21	Quartz, granosyenites of the Orkhan-Selenginsky trench, Mongolia	680	3.0	Chupin, Matrenitsky, 1980
22	Fluorite, granites of the Bayan-Ulansky massif, Mongolia	800	3.5	Our data
23	Quartz, granite-porphyries of the First of May massif, Jidinsky ore field, Southwest Zabaikal	780	3.5	"
24	Emerald, Urals	700	3.5	Bazarov et
25	Quartz, pegmatites of the Kyrinsky massif, Eastern Zabaikal	580	3.7	Bakumenko, Kosukhin, 1977
26	Quartz, pegmatites of the Jeltavsky massif, Kazakhstan	560	3.8	Kosukhin, 1978
27	Quartz, granites of the Zaurulyunguyevsky massif, Easten Zabaikal	740	4.0	Our data
28	Beryl, Eastern Siberia	740	4.5	Bazarov, 1974
29	Topaz, lithium-thorium granites of the Khangilai-Shila massif, Estern Zabaikal	650	4.6	Our data
30	Quartz, biotitic granites of the Tsagan-Dabinsky massif, Mongolia	750	5.5	"
31	Quartz, granite-porphyries of the Kyzyl-Tausky massif, Mongolia	680	5.6	"

associated with different geochemical types of granites. From Table 2 it can be seen that, for wolframites of molybdenum-tungsten deposits of Yugodzir, the correlation coefficients for each pair of elements are known with 99% accuracy. For the tin-tungsten deposit of Modoto, related to standard granites with low tantalum content, the link between elements is lacking, being preserved only for the geochemically closest, yttrium and ytterbium.

In conclusion let us examine data from the present study on melt and fluid microinclusions, which permit the clarification of peculiarities of temperature and pressure changes in the system magmatic melt/hydrothermal solution. The data are assembled in [p. 53] Fig. 5. Here, dashed lines indicate the solidus in the systems granite-H_2O and ongonite-H_2O-HF. Lines are also drawn to indicate temperatures (at a gradient of 50°C/km) and pressures (under a lithostatic burden of 270 bar/km) corresponding to depths of 3 and 7 km. The first version of this kind of diagram [p. 54] has already been published (Naumov, Ivanova, 1980), wherein there was a discussion of the basic conclusions which follow from these results. Over the intervening time there has been a doubling of the amount of data on melt inclusions (their connection with natural structures is cited in Table 3) and on fluid inclusions of the magmatic stage. New results confirm the correctness of conclusions made earlier.

It is definitely obvious in Fig. 5 that crystallization of magmatic melts of acid composition, in the majority of cases, occurs at high fluid pressures, significantly exceeding lithostatic pressure [p. 55]. Water-rich fluids in the act of separating during the magmatic stage are also found under great pressure, consequently, they will possess high density and high dissolving capacity for many elements. There is no doubt that such excess pressure gradients may be the cause of movement of hydrothermal solutions that form rare metal deposits. Therefore, the given phenomenon may serve as one of the criteria of the genetic link between the processes of hydrothermal ore formation and acid magmatism, a sign of potential ore content in the latter.

Thus, the data cited testify to the reality of a genetic link between rare metal ore bodies and acid magmatism. Further efforts must be directed to the clarification of the peculiarities of this link, to the unraveling of the evolution of temperatures, pressures, structure and concentration of ore-forming solutions at all stages of the formation of rare metal ore bodies, and to the establishment of causes of the concentration of rare elements in ore zones.

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... Roedder(1) found densities of 0.7-0.8 g/cm^3, except one at 0.89 g/cm^3; one contained H_2O as well. Murck et al.(2) reported 1.0 to 1.14 g/cm^3 values. We studied a lherzolite xenolith from Dreiser Weiher in the Eifel district of West Germany. Here is Quaternary volcanism of maar-type with a vent facies of various alkalic basalts and many nodules of numerous petrologic types(3). Two types of lherzolites were recognized - dry (no amphibole), and hydrous (with amphibole). The latter is a result of mantle metasomatism.

The samples studied consist of olivine, orthopyroxene, clinopyroxene, and a little amphibole, spinel, sulfide, and glass. The indices of the olivine ($\gamma = 1.673$; $\alpha = 1.658$) indicate Fo 95. All the minerals contain fractures, some fresh and some healed. The olivine and orthopyroxene show no evidence of alteration, but clinopyroxene shows such signs. Inclusions in the orthopyroxene are of three types: crystals, P and S melt; P and S fluid; we studied the third type in detail.

P inclusions are mainly tubular and generally <15-20 μm in length, but some are 100-120 μm long and 2-3 μm wide. Most (80-90%) are unsealed by fractures. At room T, most are single phase; some show a small highly birefringent crystal (carbonate?).

The data (Table 1) were obtained using a cooling stage using LN_2. Tm CO_2 ["Th" in Table] of -57 to -58°C indicate nearly pure CO_2, plus minor other gases. Th of P inclusions is very low, -35 to -57; this shows(4) that the CO_2 density is greater than that of pure water. Four inclusions showed melting (and freezing) of CO_2 without appearance of a gas phase. Similar inclusions were reported in quartz from an eclogite in the eastern Alps(5).

Olivine, orthopyroxene and clinopyroxene also showed a few crystallized melt inclusions with Te = 1090-1100°C; only melt and vapor were present at 1300°C and Th could not be determined due to leakage. Th might have been at 1350-1450°C. S inclusions in all minerals contain glass, a birefringent microcrystalline phase (Tm - 870-1080°C), and CO_2 fluid. Th $CO(L-V)$ 24-26.5°C, corresponding to density 0.69-0.73 g/cm^3; Th (total) 1150-1170°C. Estimates of the concentration of CO_2 in the melt(6) made on several inclusions, at the time of fracturing and healing, gave 2.9 ± 1 wt.% CO_2.

The pressure was estimated from the P-V-T properties of CO_2 (Mel'nik, 7) for 400-1500 K and 0.15-15 kb (Table 1). For P inclusions it is 9.7-10.8 kb, corresponding to depths of 35-40 km. Such high pressures must have caused leakage during eruption [as] only inclusions <10-15 μm remained sealed. Even at room T (25°C) the pressures are 0.8-1.3 kb. Inclusions

Table 1. Properties of fluid CO_2 inclusions in orthopyroxene from a lherzolite xenolith

Th	No. of Inclusions	Density (g/cm^3)	Pressure* (kb)	Probable depth** (km)
		Primary		
-57	4	1.18	10.8	38.6
-46	4	1.14	10.3	36.8
-44	13	1.13	10.2	36.4
-43	8	1.13	10.2	36.4
-41	7	1.12	10.1	36.1
-39	1	1.11	10.0	35.7
-36	4	1.10	9.8	35.0
-35	2	1.09	9.7	34.6
		Secondary		
24.0	1	0.73	4.5	16.1
24.4	2	0.72	4.4	15.7
25.0	1	0.71	4.3	15.4
26.5	1	0.69	4.0	14.5
		Partly Unsealed		
-12.5	1	0.99	7.9	28.3
14.0	1	0.83	5.8	20.7
20.0	3	0.78	5.4	19.3
23.4	4	0.74	4.7	16.6
30.9	3	0.49	2.2	7.9

*Pressure calculated for 1350°C (primary inclusions) and 1200°C (others).
**Lithostatic, assuming 280 bars/km.

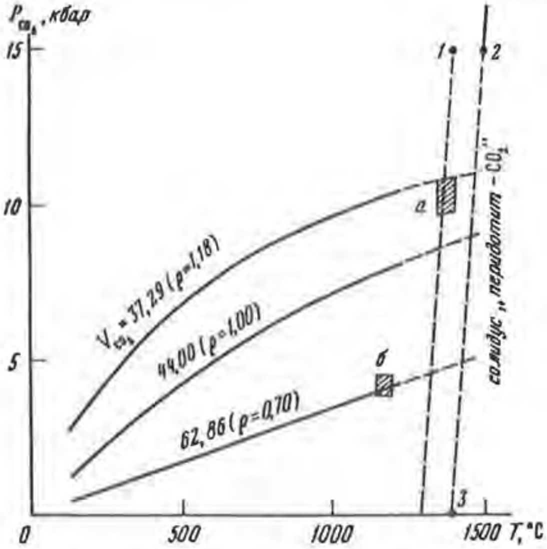

Fig. 1. P-T diagram for CO_2 and peridotite-CO_2 solidus. Area "a" - possible conditions for primary crystallization of lherzolite; area "b" - conditions for its reworking. 1. = natural lherzolite solidus with excess CO_2(8); 2-3 = start of melting of lherzolite-type composition in system $CaO-MgO-SiO_2-CO_2$(9-10).

with higher densities (and hence pressures) could also have leaked, so the 9.7-10.8 kb are probably minimum values. S inclusions yielded lower pressures (4-4.5 kb). Apparently the xenoliths remained in an intermediate chamber at 14.5-16 km for some time, and were reworked there.

These data, plus experimental data on the system peridotite-CO_2(8-10), are plotted on a P-T diagram (Figure 1). The intersection of CO_2 isochores with the periodite solidus yields the probable formation conditions for the lherzolite and its reworking (hatched areas on Figure 1).

Thus, these mantle rocks have had a complex and lengthy evolution, and CO_2 has been the predominant fluid present at depths corresponding to at least 10-11 kb.

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Recent success in the exploration and development of epithermal gold deposits in the western United States stimulated the study of transportation and deposition of gold and other metals at shallow depths, combined with the study on the metal contents of geothermal waters. The Nansatsu-type disseminated gold deposits occur in "mushroom" shaped highly silicified bodies which accompany acid hydrothermal alteration minerals such as alunite and kaolinite, and seem to correspond to the so-called "hot spring type" gold deposits. Until recently there were almost no fluid inclusion data of these deposits, because of the fine size fluid inclusions, but a few data on fluid inclusions were obtained from the Kasuga and Iwato deposits of the Nansatsu-type, and the physiochemical condition of fluids was considered based on these data. Temperatures of fluids generally range between 120° and 275°C and salinity is low, ranging from about 0.5 to 2.0 wt% NaCl equivalent. The temperature range of the Kasuga deposit is apparently higher than that of the Iwato. This difference is probably owed to the difference of the size of orebody and the location of samples. In most of the samples, gaseous and liquid inclusions coexist, suggesting a remarkable boiling phenomena. Taking into account of this fact, the pressure of fluids is estimated to be 10-40 bars.

Introduction

In recent years, active investigation has been carried out in the Western United States, in particular in Nevada and northen California, into low grade, large scale shallow hydrothermally formed hot-spring type gold deposits.

Along with the progress of geothermal resource investigation in such places as Geysers (California) and Steamboat Springs (Nevada), hydrothermal formations and activity in the earth's crust are also being clarified. Because of the large number of similarities between the two, examination is being made of the physiochemical condition of the shallow hydrothermally formed Au-Ag mineralization process based on these data.

In Japan we can consider the various ore deposits (the so-called Nansatsu-type gold deposits) at Kasuga, Iwato and Akeshi in the Makurazaki area of the western tip of the Satsuma Peninsula in Kagoshima Prefecture, to constitute shallow hot-spring type gold deposits corresponding to these. Data relating to the temperature and salinity of these ore deposits have not been hitherto reported. The reasons for this are the extremely fine particle size of minerals, such as quartz and others, which constitute these ore deposits, and the difficulty in obtaining fluid inclusions of a size suitable for temperature and salinity measurement. In this study we were able to obtain a small amount of data on fluid inclusions in quartz in the Kasuga and Iwato deposits. Based on this, we consider the hydrothermal conditions which prevailed when the Nansatsu-type gold deposit was formed.

Hot-spring type gold deposits

The hot-spring type gold deposit is a product of the mineralization process which is accompanied by siliceous sinter from hot spring sediment and silicified rock just under the earth's crust with a gold grade of several g/t.

Ore reserves are large, at 5,000,000 to 20 million tons, and a characteristic feature is that they are at or just below the earth's surface. The ore deposits at Carlin, Jerritt Canyon and Goldfield in Nevada and McLaughlin in California can be cited as examples.

The Carlin deposit, with reserves of over 10 million tons of 6 g/t Au ore, was discovered in 1962. The ore deposit has a matrix of dolomite ash rock[sic] rich in organic carbon from the Silurian period and is thought to have formed in the base of the host spring system active at the end of the Tertiary period. It accompanies such ores as Au as well as Hg, Sb, As etc. (Dickson et al., 1979).

It is reported that the hydrothermal temperature of this deposit's main mineralization period was 175°-225°C and salinity was 2-4 wt% (Radtke et al., 1980). The ore is largely oxide with extremely fine gold particles. The ore deposit became silicified rock when carbonate rock was replaced by hydrothermal solutions which were prevented from flowing up to the earth's surface. However, part of the orebody is considered to have been oxidation leached by sulphuric acid hydrothermal solutions formed by the oxidation of H_2S near the earth's surface (Noble & Radtke).

Jerritt Canyon, discovered at Elko in Nevada is a similar ore deposit, with reserves of 9 million tons of 8.2 g/t Au ore (World Mining, 1980). These deposits are sometimes referred to as Carlin-type ore deposits.

The McLaughlin deposit is located NNE of San Francisco, east of the Geysers geothermal district and situated between Clear Lake and Lake Berryessa. It is discovered in 1979 and reports indicate that 20 million tons of 5.5 g/t gold ore have been secured to-date (World Mining, 1981, Skilling, 1983). The deposit is located within siliceous sinter and leached silicified basalt which accumulated through hot spring activity after the Knoxville Basalt (2-0.1 Ma; McLaughlin, 1981) activity. It consists of a thin layer of cinnabar-stibnite accompanying fine particles of gold and a layer of thin chalcedony-type quartz or a chalcedony-type quartz vein which cuts silicified rock. The development of crushed breccia bodies throughout the orebody is prominent. This deposit is not like the Carlin-type ore deposit which replaced carbonate rock in shallow depths below the surface. It is considered that sinter, from hot springs which flowed up to the earth's surface forms a part of the ore which is probably one type of the Hot Springs type gold deposit. Consequently, the mineralization process is characterized by sudden temperature drops near the earth's surface and by the repetition of a series of silicification process activities such as the closure of the hydrothermal system by silicified siliceous sinter precipitation - rises in fluid pressure causing hydraulic pressure crushing and the opening of the hydrothermal system - boiling of hydrothermal solutions.

There are occasions when Au is included in the precipitation of currently active geothermal regions.

At Steamboat Springs in western Nevada there is a deposit of siliceous sinter accompanied by cinnabar and silica accompanied by sulphur brought about by basalt leaching. Hydrothermal solution flows out of several places from the sinter which forms a small hill. Black colored iron sulphide and red-orange colored Hg-Sb sulphides are precipitated in the flow path, and 20-30 g/t gold is contained in this (White, 1981). The famous Comestock gold mineralized zone is located approximately 10 km SE of Steamboat Springs but between the two is a zone altered by acidic hydrothermal activity, accompanied by kaolin, alunite, pyrophyllite and diaspore.

Apart from this, Au, Ag, As, Sb, Hg, Ti have been recognized in siliceous sinter in the Ohaki district in New Zealand. Au 85 g/t, Ag 500 g/t is contained in the Ohaki Pool sediment. The temperature of the hydrothermal solution is 180°-295°C, the salinity 0.2-0.3 wt% and it has been reported that there is a cycle in the alteration of the various types of hydrothermal solutions (Weissberg, 1969, Weissberg et al., 1979). It is also reported that the sediment from the NaCl-bearing acidic spring at Beppu Hot Springs in Japan, contains 56 g/t gold (Furuga, 1961).

White (1981) broadly divides shallow, hydrothermally formed gold and silver deposits into gold-dominant types and silver-dominant types.

(1) The silver-dominant type is rich in silver and heavy metal sulphide ore while alteration of the matrix, silicification, sericitization, adularia and propylitization are conspicuous. The vein is accompanied by quartz, calcite, adularia etc. but lacks fluorspar, alunite and kaolin. The formation conditions of this type are similar to conditions in the lower areas of geothermal systems.

(2) The gold-prevailing type is further divided into two types. One of these types is accompanied by stibnite plus cinnabar and tellurium minerals with few silver minerals or heavy metal sulphides. Alteration of the matrix is generally weak, apart from acidic leaching, and is accompanied by alunite and kaolin. The conditions for the formation of this type are

similar to conditions in upper areas of geothermal systems.

The above information is listed in a table from White (1981). Based on this table it is thought that the Nansatsu type gold deposits belong to the Type II gold prevailing type.

Eimon (1981) summarizes the characteristics of hot spring type gold deposits and within them there are many which can be recognized in the formation of Nansatsu type gold deposits. These are:

1. The surface of the deposit is related to the topography at the time of formation and has many undulations.
2. Shows a "mushroom" shaped configuration and has an irregular root which extends to the lower reaches.
3. Sulphides are generally scarce.
4. Gold mineralization is mainly prominent in the upper level zone of mixed sulphide ore - oxide ore of the sulphide zone.
5. High grade zones can be seen immediately below the hydrothermal "boiling" zone.
6. Temperature of hydrothermal solutions is 100°-300°.
7. Apart from Hg, Sb, As minerals, barites can be seen.
8. Alunite and kaolin are formed in the hydrothermally altered zone.
9. In the mineralization stage there is a repetition of the following scenario: rise of fluid pressure → fluid crushing (formation of brecciated crushed zone) → boiling of hydrothermal solutions → lowering of fluid temperature by adiabatic expansion → precipitation of dissolved components within hydrothermal solutions (silicification process, mineralization process) → closure of hydrothermal system → rise of fluid pressure.

Nansatsu type gold deposit

In the area of Makurazaki City on the Nansatsu peninsula of Kagoshima Prefecture are distributed gold infiltrated siliceous rock bodies of the so-called Nansatsu type gold deposits at Kasuga, Iwato and Akeshi etc. (Fig. 1).

The deposits produce gold ore containing 2-6 g/t Au, 4-10 g/t Ag and ~95% SiO_2. The total production from this district between 1932 and 1980 reached approximately 14 t [Au?] (Miyahisa(?) 1975, Miyahisa et al., 1975). These deposits are probably Japan's best examples of hot spring type gold deposits. Many reports have already been written on the geology and deposits of this district, (Eg. Tokuraga, 1954, Saito Sato, 1978, Urashima et al., 1981, Metal Mining Industry Association, 1981, etc.).

Geology (Fig. 1)

The basement of this area is the Shimanto group, consisting of sandstone and shale. It is distributed in the western and northern sides of the district and presents an open basin shape plunging to the south. There is a wide distribution of Tertiary (Miocene) Nansatsu Group covering the basement. It is divided into upper and lower strata but the host of the deposit is mainly the upper stratum, which consists of pyroxene andesite and tuff enclosing a thin layer of tuff and mudstone. The K-Ar date of the pyroxene andesite in the lower stratum is 7.6 ± 2.3 Ma (Metal Mining Industry Association, 1981).

Post-Nansatsu era volcanic rocks, mainly amphibolite, pyroxene andesites and quartz andesite, unevenly cover the Nansatsu Group. The K-Ar date is 0.8 ± 0.6 Ma. Covering all the above strata is the Ata Pyroclastic flow.

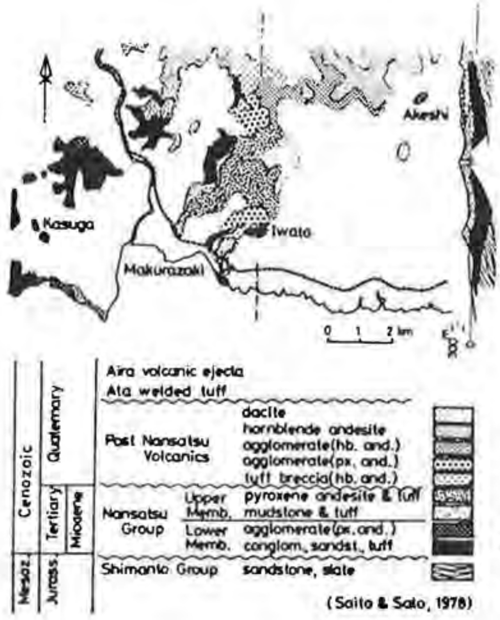


Fig. 1 Geologic map and column of the Nansatsu area, Kagoshima. (Redrawn from SAITO and SATO, 1978).

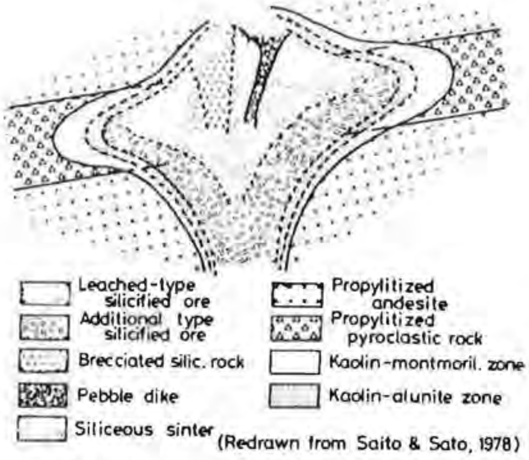


Fig. 2 Schematic model of the Nansatsu-type gold deposits. (Redrawn from SAITO and SATO, 1978).

Deposits (Fig. 2)

The silicified rock bodies present a "mushroom" shape and the top section of many show extensions in a horizontal direction. Generally the top extension has developed in volcanic fragmental rocks and the root of the lower section has a tendency to originate in andesite.

There are several ore bodies side by side with the head sections connected, and there are also discernible ore bodies which show extension in a horizontal direction. Surrounding the silicified body is a weakly silicified zone (alunite zone) then passing a argillized zone including kaolin which changes to a chloritized andesite rock.

Within the silicified rocks there is the highly porous leached-type which leaves the original rock formation and a fine replacement-type which was replaced by SiO_2 while still leaving the original rock composition[sic] (Urashima et al., 1981). Both are aggregates of fine grained quartz with SiO_2 being 90-95%. Fine grained pyrite is included in the dark colored silicified rock which is also sometimes accompanied by small amounts of enargite and luzonite but there are generally few heavy metal sulphides.

Apart from the presence of hematite and limonite in the red-brown colored silicified rock, it is often accompanied by red-brown clay in the cracks and fissures. Silicified rock is occasionally accompanied by native sulphur.

The gold mineralization process occurs following the silicification process and there is the interpretation that it is controlled by the fractures. However, there is also mineralization in porous silicified rock and the distribution of gold grade is fairly even in silicified rock formations. Moreover, it is also reported (Urashima et al., 1981) that rich ore areas are numerous in the enlarged and central sections of silicified rock bodies. There is a paucity of data relating to the shallow secondary enrichment of gold although there are high grade gold sections in red-brown clay.

Irregular breccia pipes have been reported in silicified rock bodies. It is presumed that these were formed by a hydrothermal crushing process during the silicified rock formation stage.

Again, the formation of a uniform accumulation of siliceous sinter has also been reported (Urashima et al., 1981). All of these suggest vigorous hydrothermal activity near the surface of the earth.

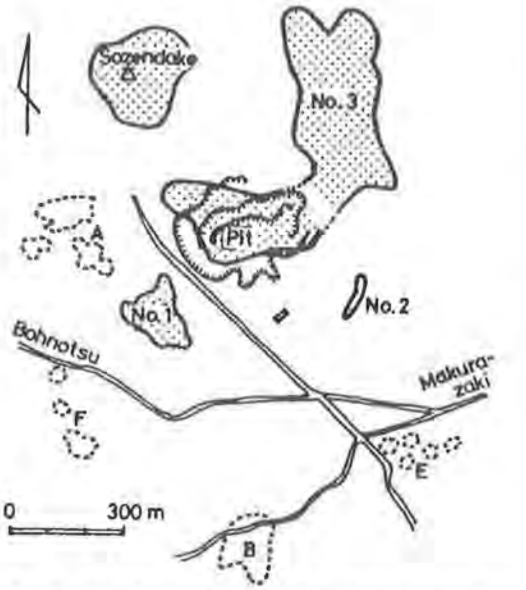
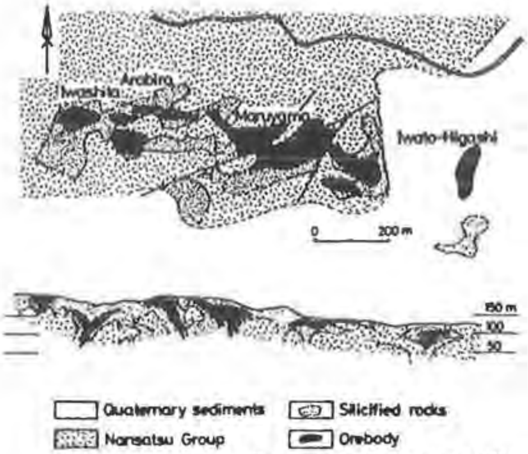


Fig. 3 Distribution of silicified rocks in the neighborhood of the Kasuga deposit.



(Redrawn from Saito & Sato,1978)

Fig. 4 Plain and vertical map of the Iwato deposit.

Kasuga deposit

Apart from the main orebody currently being mined (EW 400 m, NS 180 m) there are several silicified rock bodies such as the No. 1 ore shoot to the west (100 x 50 m) and No. 3 orebody to the NE (Fig. 3). The main orebody is within Nansatsu Group tuff breccia while several roots extend towards the lower sections and an extension of approximately 100 m is indicated in the vertical direction. Cracks in NE and EW directions have developed within the silicified rock bodies and rich ore sections have formed in the areas where most cracks are concentrated.

Amongst the ore accompanying dark grey colored sulphide ore, apart from fine-grained pyrite, natural sulphur, enargite, and luzonite have been recognized. However, most of the ore is accompanied by brown iron oxide and it is said that gold accompanies yellow-brown colored clay more than red-brown clay.

Iwato deposit

The orebody groups Maruyama, Arabira, Iwashita and Iwatoyama originate in silicified rock 2000 m EW and 200-400 m NS (Fig. 4). Single orebodies are of the "mushroom" shape which has extended slightly E-W with a horizontal size of 100-200 m and 100-150 m vertically.

The umbrella section of the "mushroom" is mainly within tuff or tuff breccia while the shaft section is in andesite (Urashima et al., 1981). The ore is similar to that of the Kasuga deposit but there has been no report of the production of enargite or luzonite.

Recently cassiterite, stannite and canfieldite have been reported as well as the formation of gold particles in small crevices accompanied by non-crystalline iron-antimony oxides (Kawozaki et al., 1982).

Akeshi deposit

Within a 200 m x 200 m silicified zone there are No. 1 orebody (100 x 40 m, vertical direction 150 m), No. 2 orebody (50 x 50 m, vertical direction 130 m) and No. 3 orebody currently being mined. The No. 1 orebody has a regular dip to the NW of 60° while No. 2 orebody is almost

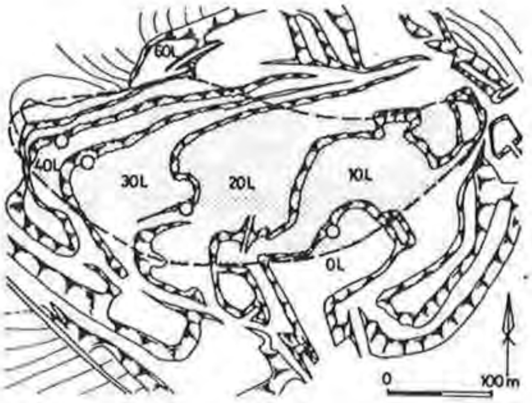


Fig. 5 Map of open pit of the Kasuga mine and sample location (open circle).

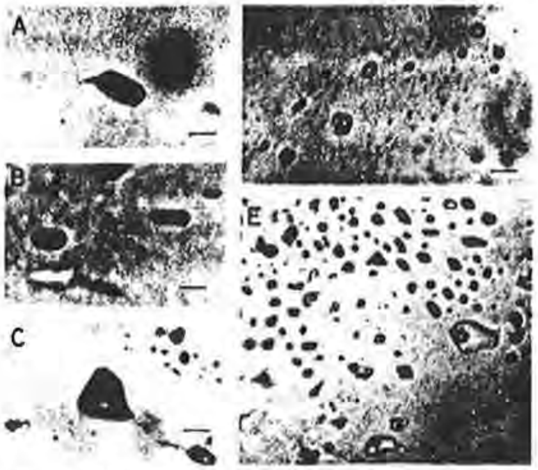


Fig. 6 Microphotographs of fluid inclusions. (A) gaseous inclusion (Kasuga No. 1 Orebody, 10 mL), (B) gaseous inclusions (Kasuga No. 1 Orebody, 10 mL), (C) liquid inclusion (Kasuga No. 1 Orebody, 10 mL), (D) distribution of gaseous inclusions (Kasuga No. 1 Orebody, 10 mL), and (E) distribution of gaseous and liquid inclusions (Iwato, Iwashita 190 mL). Bar shows 10 micrometer.

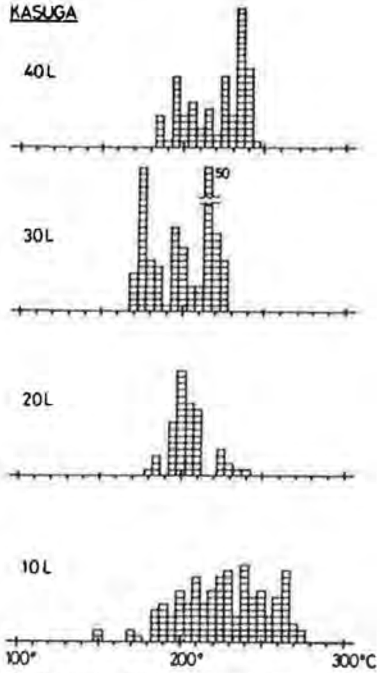


Fig. 7 Homogenization temperature of fluid inclusions in quartz from the Kasuga deposit.

perpendicular above 0mL and changes to a W60° drop below 0mL.

In comparison with the Iwato and Kasuga deposits the "mushroom" umbrella section is relatively smaller than the handle section and is nearly a pie-shaped orebody.

Ores include luzonite while natural sulphur is somewhat greater here than in the above two deposits.

Fluid inclusion studies

The quartz material which we observed fluid inclusion and measured Th was test material from Kasuga Deposit 4 and Iwato Deposit 3. We were unable to find fluid inclusions suitable for measurement in quartz from the Akeshi deposit.

Kasuga deposit (Fig. 5)

The 4 test samples were taken from the bench side walls of 10mL, 20mL, 30mL and 40mL in the western area of the main deposit.

They all had small columnar crystals concentrated in cavernous silicified rock; many were 5-15 mm long. As seen in Fig. 6, many of the fluid inclusions are 5-15 microns in size and in some cases the distinction can be made between primary inclusions and secondary inclusions but there are also many whose origin could not be determined. However, there was a general tendency for irregularly shaped fluid inclusions to show a low temperature.

Many gaseous inclusions with low density, and one group of fluid inclusions with various filling ratios overlaps and intermingles with the gaseous ones, indicating intensive boiling during the hydrothermal activity. Because of this it was necessary to be careful in the selection of inclusions to be measured for Th. That is, we were careful to select and use only inclusions with the greatest degree of filling within a group of inclusions formed during the same period. However, the availability of such inclusions was extremely limited and it was also difficult to judge accurately the volume ratio under the microscope hence it is possible that within the measured inclusions there are mixed in some which show apparent high Th (refer to later explanation of boiling) Fig. 7.

1. 10mL test material: Of all the samples this had the largest columnar crystals of ~5 x 10 mm. There are parts with particularly numerous gaseous inclusions. Within the group of fluid inclusions which can be considered to be clearly secondary, many indicate the same somewhat low Th of 150-210°C. In the inclusions with high Th, shapes which indicate boiling can be recognized[sic].

2. 20mL test material: The crystals are somewhat small (2-3 x 5 mm). Many of the fluid inclusions were almost negative crystal shape, and the Th of 195°-210°C was somewhat low. The shape of inclusions which indicates fluid boiling was recognized[sic], and a small amount of inclusions with no vapor bubbles was also seen.

3. 30mL test material: Crystals are virtually the same size as the 20mL test material. About 20 fluid inclusions showed a uniform Th of 215°C. These were of a group which were comparatively simple in shape and which are thought to be primary.

4. 40mL test material: Crystals similar to 20 and 30 mL test material. Formation of inclusions indicating boiling is discernible but there are few gaseous inclusions with a small filling rate. Of the measured Th, many were in the range 195°-205°C and 225°-240°C but the Th of those thought to be irregularly shaped secondary inclusions was somewhat low, at ~195°C.

Because the Kasuga ore deposit contained somewhat larger inclusions, we performed salinity measurements. The results are shown in Table 2. Overall, salinity was extremely low.

Table 2

Salinity of fluid inclusions from Kasluga Deposit
(Th range 225-245°C)

Salinity range (wt%/NaCl)	0-0.5	0.6-1.0	1.1-1.5	1.6-2.0
Number of measurements	2	5	3	1

Iwato deposit (Fig. 8)

We utilized the following: 10 mm width vein quartz from the 190mL in the western section of the Iwashita orebody; quartz particles of igneous

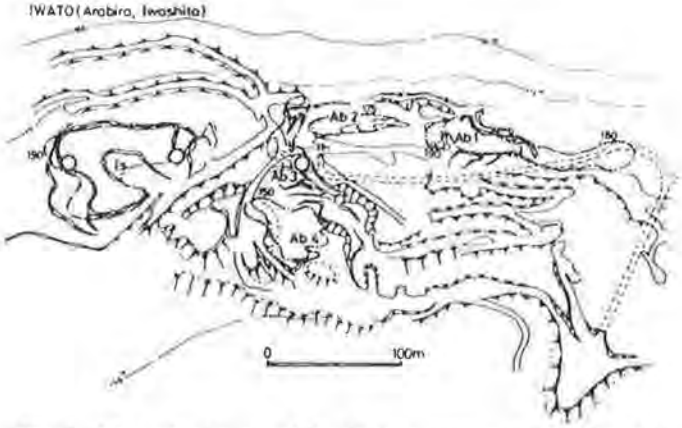


Fig. 8 Map of open pit of the Arabira (Ab) and Iwashita (Is) orebodies of the Iwato deposit and sample location (open circle).

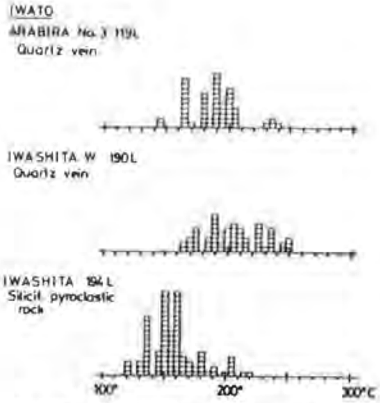


Fig. 9 Homogenization temperature of fluid inclusions in quartz from the Iwato deposit.

origin (from) within silicified rock from Iwashita orebody 194mL; 10 mm width vein quartz from Arabira No. 3 orebody 119mL (Fig. 9).

1. Iwashita Orebody Western Section 190mL Material: There were many gaseous inclusions and the formation of inclusions indicating boiling was conspicuous. Th was 165°-250°C and no distinguishing temperature distribution was observed. However, high temperature inclusions were common and comparatively simple in shape.

2. Arabira No. 3 Orebody 119mL Test Material: This was somewhat white, cloudy vein quartz with fluid inclusions being small overall. There were 2 temperature ranges with one around 65°C and the other from 180°-200°C. The temperature of the simple shaped inclusions, thought to be primary, belonged to the higher group.

3. Iwashita Orebody 194mL Test Material: This is a coarse grained silicified clastic rock including quartz particles 0.2-0.8 mm in diameter. Apart from transparent inclusions, the quartz grains contain inclusions. Th of these fluid inclusions was concentrated at 150°-160°C, showing a lower temperature than the other two samples.

Hydrothermal boiling indicated by means of fluid inclusion formation

The view that hydrothermal boiling is related to the mineralization process has been indicated by Kelly and Turneaure (1970) in research on fluid inclusions in Bolivian tin deposits. In shallow epithermal gold and silver deposits, especially in the case of hot spring type deposits, there is also the fact of the area of formation being close to the earth's surface and fluid inclusions indicating hydrothermal boiling have been frequently observed.

Eimon (1981) relates that in epithermal gold deposits, mineralization can be seen directly beneath the hydrothermal boiling zone and if this is a fact one can say that boiling is an important phenomenon from the ore deposit investigation viewpoint. Fig. 10 is a P-T diagram showing the relationship between hydrothermal solutions and the formation of fluid inclusions.

A in Fig. 10 represents the formation of a fluid inclusion from a hydrothermal solution pressurized above the vapor pressure. Because the inclusions are filled only with a hydrothermal solution, each inclusion has the same degree of filling (liquid volume/inclusion volume) which moreover is high. In this case, to obtain the trapping temperature you have to add a pressure-correction value ΔT to Th. When inclusions form

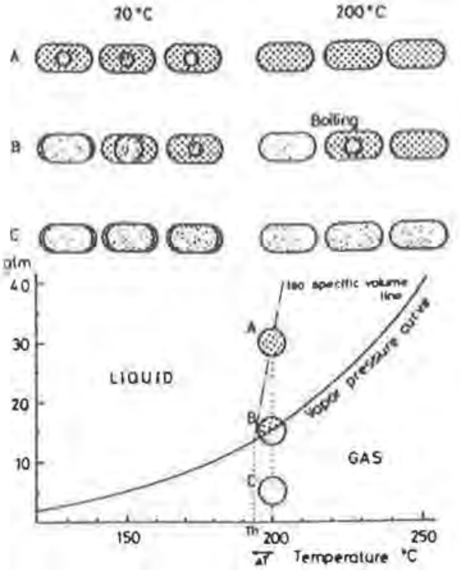


Fig. 10 Pressure-temperature diagram of water and the relation between the occurrence of fluid inclusions and the boiling phenomena. As the pressure-specific volume-temperature relation is schematically shown in the figure, the temperature correction for pressure (ΔT) does not show a true value. The true value for the condition A is about 2°C.

from vapor they become gaseous inclusions with a low degree of filling and which are moreover the same (C in Fig. 10). In this case, on increasing temperature, the fluid in the gaseous inclusions decreases and when it ultimately all turns to gas, it homogenizes.

When inclusions form from boiling hydrothermal solutions the individual inclusions trap various proportions of liquid and gas so that in one group of inclusions formed in the same period, (as seen in B in Fig. 10) the filling rate which corresponds to the various values from the gas density value to the liquid density value can be observed. In this case, if you measure Th of inclusions which have taken in liquid only within one group of inclusions (indicating maximum filling density) or inclusions which have taken in gas only (indicating minimum filling density) then that temperature is the formation temperature and the vapor pressure at that time is the pressure of the inclusion formation stage.

Looking at temperature data from the Nansatsu type ore deposits, there are several groups of fluid inclusion Th values which show the above formation. Most are distributed between 180°C and 250°C. From these temperatures and Fig. 10, it is presumed that the fluid pressure at the time the ore deposit was formed was approximately 10-40 atm.

A. Discussion

There have been no previous reports on investigations of fluid inclusions in Nansatsu type ore deposits. We have been able to obtain some, although still insufficient, temperature information, and so we attempt to consider the conditions of hydrothermal activity base on this.

Overall, the Th of fluid inclusions in Nansatsu-tye gold deposits falls within the range 120°-275°C although the temperature range for the Kasuga deposit is 160°-275°C which is somewhat high compared to the Iwato deposit temperature range which is 120°-250°C. One of the reasons for this could be that compared to the Iwashita and Arabira orebodies in the Iwato deposit, the Kasuga main orebody as a single orebody, is large. Thus the scale of hydrothermal activity which contributed to the formation of the Kasuga main orebody was greater than that of the Iwashita and Arabira orebodies and consequently hydrothermal solutions reached even higher temperatures. However, differences in temperature can be seen even within samples from the same orebody. For example, sample 4 from the Kasuga main orebody is a small columnar quartz formed in small crevices within the same orebody but differences were observed in the measured temperature range suggesting that there were variations in space and time in the hydrothermal activity.

Furthermore, as can be seen in the samples of silicified rock and quartz veins from the Iwashita orebody, there is a possibility that the hydrothermal temperature which formed quartz veins which cut the silicified body was higher than the hydrothermal temperature related to silicification. That is, against the Th distribution of 120°-210°C for fluid inclusions in silicified rocks, the range for fluid inclusion in quartz veins is between 155°-250°C and that temperature range almost exactly matches the temperature range gained from quartz vein samples from the Arabira orebody.

We cannot say that we have gained sufficient data relating to the formation conditions or the gold mineralization period of the Nansatsu-type gold deposit. Previously it was reported that gold mineralization was regulated by fracture systems which cut silicified bodies (Matsu?ya, 1967). Recently there have been reports suggesting secondary enrichment (Kawazaki et al., 1982; IMAA et al., 1983) reports of the presence of tin minerals and molybdenite (Imai et al., 1983) and reports on hydrothermal alteration (Hashizume(?), Izawa, 1983) etc.

Boyle et al., (1973) measured the solubility of gold in various types of solutions and gained results which give strong suggestions in regard to the secondary enrichment process of gold and its solubility in hot spring water. That is, gold was transported by water containing humic acid in the form of metallic-organic compounds (chelates) or in a form adhered to humic matter or it was also transported by water containing ferric sulphate. It is also reported that gold often dissolves also in alkaline carbonate solutions which contain H_2S, AsH_3 and SbH_3. The fact that gold particles can be recognized in iron-antimony hydroxide which formed as a coating in the small cavities of the Iwato ore deposit and the fact that gold is concentrated in the oxide zone of the Carlin deposit can be considerd to be due to the tranportation mechanisms related above.

It is believed that the hydrothermal solution which produced the silicified bodies contained sulfuric acid, from the alunite and kaolinite altered zones into the vicinity of silicified bodies (Tokunaga, 1955). However, gold forms a thio complex ($Au(HS)_2$) in medium-to-weak alkaline hydrothermal solutions which contain H_2S and then dissolves (Hikokuni(?), 1978, 1981).

Because the solubility of $Au(HS)_2$) decreases in acidic hydrothermal solutions it would be difficult to have economic gold mineralization with the acidic hydrothermal solutions which brought about leaching and silicification of the country rock of the Nansatsu-type deposits. The gold mineralization of these deposits was effected by a hydrothermal process which followed the silicification process and perhaps a shallow secondary enrichment process overlapped with this.

Apart from the vicinity of Makurazaki City in Kagoshima Prefecture, silicified bodies accompanying altered zones bearing alunite and kaolinite exist in the Ukusu silica deposit on the Izu Peninsula in Shizuoka Prefecture and in the Kawaharamo silicified body in Yuzawa City in Akita Prefecture. Both of these show enlargement at the top and present a "mushroom" shape which becomes narrower as it proceeds downwards. They are thought to have been formed by local acidic hydrothermal activities centered on the silicified bodies.

The silicified zone of the Ukusu silicified body has huge alunite and argillized zones but the width of altered zones bearing alunite and kaolinite in the Nansatsu and Kawaharamo silicified bodies is relatively narrow, changing to weakly altered rock at a distance of 1-10 m, indicating a rapid change as the hydrothermal solutions moved out from the center of activity.

The quartz grains which make up the silicified bodies are extremely fine and fluid inclusions cannot generally be detected under a microscope. However, in the case of Kawaharamo silicified body, because the country rock is a quartz andesite volcanic clastic rock with phenocrysts of quartz, it is possible to use secondary inclusions from within the quartz grains contained in these rocks. Whether these fluid inclusions correspond to a given period of hydrothermal activity should be investigated, as this would be useful in the study of fluids in altered zones and geothermal zones. A temperature range of 205°-285°C (Av. 244°C) and 175°-250°C (Av. 216°C) was obtained from the altered porphyritic quartz from the Kawaharamo silicified body sample and these temperature ranges are quite similar to those obtained from the Nansatsu type gold deposits.

Although given the generic term of hot-spring type gold deposits, this includes a range from the Carlin type and Nansatsu type deposits formed at a depth under the earth's surface (~100-400 m in the case of Nansatsu type), right up to those deposits like the McLaughlin which are like silicified sinter buried within the earth's surface, and their formations differ. Hitherto, in Japan, Tertiary period gold-silver ore veins have been the main focus in terms of gold deposits but there is a need to investigate those low grade shallow formation massive gold ore deposits which have not received attention to-date. For example, within the Izu Peninsula are gold and silver deposits described as stockwork deposits and massive deposits (Japan Mineral Production Magazine 81-a).

The Taihei (Pacific) deposit is a stockwork deposit within rhyolite which has been silicified. It has porous silica at its center and this section as well as the section in which white, fine quartz-veins are concentrated, is accompanied by gold with a grade of 5-15 g/t in clay-ore. The Hinode deposit is held to be a massive siliceous deposit within rhyolite with a gold grade of 18-20 g/t. There are no detailed data available regarding wall-rock alteration of the deposits but it is probably necessary to review their formation from the point of veiw of hot-spring type gold deposits.

In recent years, along with the investigation and development of geothermal resources, we have gained a substantial body of information relating to hydrothermal solutions and hydrothermal alteration at a subterranean depth of 1000 to 2000 m. Most of the geothermal hydrothermal solutions being developed are medium to weakly alkaline chloride-containing hydrothermal solutions but they are sometimes accompanied by a silicified zone, a leached zone and acidic springs near the earth's surface so we should be able to gain clues into epithermal gold deposit research by clarifying the similarities and differences between the formation of these present geothermal systems and hot spring type gold deposits which are fossilized hydrothermal systems.

White (1981) discussed the similarities between epithermal gold deposits and present geothermal systems and gave 4 reasons why gold deposits have still not been discovered in present geothermal systems, but these have not necessarily been verified.

Breccia veins or pipes have been frequently recognized in hot spring type gold deposits and silicified bodies. In their formation these have had the hydrothermal solution route blocked by sinter and eruptions and they are thought to have been formed by hydrothermal crushing as a result of increased fluid pressure. Similar breccia veins and pipes have been recognized in the upper sections of porphyry copper ore deposits. Eimon (1981) cites the repetition of hydrothermal activities indicated by the following sequence, as one characteristic of hot spring type gold deposits: [increase in fluid pressure → fluid crushing (formation of breccia veins and pipes) → decrease in fluid pressure (boiling of hydrothermal solutions, escape of gas) → decrease of fluid temperature by adiabatic expansion (precipitation of soluble constituents, namely silicification process and mineralization process) → closure of hydrothermal system → increase in fluid pressure].

Regardless of their epithermal formation, there exists a group of inclusions within the fluid inclusions of Nansatsu type gold deposits and silicified rock bodies which show temperatures as high as 280°C or 290°C and moreover have uniform Th. This indicates that there was a period of high fluid pressure when the temperature was at least at a level which did not cause boiling of hydrothemal solutions and these inclusions are probably those which contain hydrothermal solutions from the pressure increasing period which occurred before the fluid crushing.

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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 this 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 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 semi-quantitative 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 345. 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.

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*	
14	xiii	2	5	Change % symbol to ‰.
14	244	2	4	Change to C.N.R.S.
15	83	4	14	Change clorargyrite to chlorargyrite.
15	107	4	9	Change moles to mole fractions.
15	154	4	10	Change Karolra to Karelia.
15	207	2	20	Add colon after "types"
15	255	1	5	Change polyxene to Fe-platinum.
15	261	2	2	Change frame to edge.
15	283	-	-12	Change to Secondary.
15	289	2	5	Change to read Partial translation by A. Kozlowski; to be continued in later volumes.
15	333	1	12	Add To be continued in later volumes.

†Partial items are also counted.
*Minus refers to lines up from end.

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