FLUID INCLUSION RESEARCH

Proceedings of COFFI

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

Volume 14

1981

Harvey Belkin

Fluid Inclusion Research

Volume 14

Camera-ready copy for this volume
has been provided by the editor

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Volunteers Needed

The editors would appreciate any help that can be offered by the readers in issuing future volumes of Fluid Inclusion Research--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 entrée 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. 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 274 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 536 items from other foreign language sources and English language literature for a total of 810 abstracts, citations, or annotated citations, plus subject and locality indices, and translations of four Russian 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 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 ask a computer data base to make various subject searches 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 limited number of their copyrighted abstracts, as indicated by a CA number in the abstract citations. Translations have has also been received from Drs. H.A. Stalder (Bern, Switz.); P. Lattanzi (Firenze, Italy); J.-C. Touray (Orleans, France); M.J. Logsdon (Denver, Colo.); and Huan-Zhang Lu (Guiyang, PRC). Many other individuals, too numerous to list here, have helped by sending books, reprints, references, and abstracts. I am also indebted to Prof. J. Guha (Chicoutimi, Quebec); and particularly to H.E. Belkin (U.S.G.S.) for 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 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 this volume, which is being sent to press just 5-1/2 months after Volume 13 was sent; work on future volumes is also proceeding rapidly, and I hope to submit Volume 15 (1982) to press within 2 months.

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 dissertations.

Nov. 22, 1984 Edwin Roedder, Editor

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Past Meetings

In Warsaw, Poland, in October 16-17, 1981, a scientific session "Postmagmatic processes in plutonic and volcanic rocks - igne formata '81" was organized by the Institute of Geochemistry, Mineralogy and Petrography of the Warsaw University, and Commission of Mineralogical Sciences of the Committee of Geological Sciences of Polish Academy of Sciences. Twenty lectures were presented, half of them with fluid inclusion data (abstracts of these will be found in this volume). The full papers were published in Archiwum Mineralogiczne, Vol. 39, Part 1, 1983, and hence will be found in Vol. 16 of COFFI.

A joint meeting of the Mineral Deposits Studies Group and the Applied Mineralogy Group of the Mineralogical Society [G.B.] was held 14 May 1981. Fifteen papers were presented (see Fortey, 1982, this volume); those abstracts that are pertinent will be found in this volume of COFFI.

A short course on Fluid Inclusions: Applications to Petrology was sponsored by the Mineralogical Association of Canada, in Calgary, Alberta Canada, May 7-10, 1981. A book was produced (see Hollister and Crawford, 1981, this volume) stemming from this short course. Each of the 12 individually-authored chapters are cited in this volume of COFFI.

A symposium "Current Research on Fluid Inclusions" was held at Utrecht, The Netherlands, April 22-24, 1981. This symposium was the sixth in a series of informal symposia organized every other year, aimed at bringing European fluid inclusion workers together to discuss their results. Most of the abstracts for this meeting were published in COFFI, Vol. 13 (1981). Although some were published elsewhere, full papers for many of the presentations at that symposium were published in a special 214-page issue of Chemical Geology (see Kreulen and Touret, 1982, this volume of COFFI), and these papers are individually cited here.

A meeting was held 23 September, 1982, on Fluids in Metamorphism, at the Univ. of Glasgow, Scotland, convened by Prof. B.E. Leake. All ten papers presented are obviously pertinent to fluid inclusion studies and are abstracted in this volume of COFFI.

A workshop on Fluid Inclusion Studies was held 22-23 March, 1982, at the Indian Inst. of Technology, Bombay, convened by Prof. K.C. Sahu. Abstracts of these papers are in this volume of COFFI.

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 these papers will be found in Volume 16 of COFFI (1983).

The Sixth Symposium of the International Association on the Genesis of Ore Deposits (IAGOD) was held in Tbilisi, August 30 - September 17,

1982. The volume of Collected Abstracts from this meeting, edited by A.D. Shcheglov and V.I. Smirnov (Tbilisi, 334 pp., in English) contains many abstracts of pertinence to fluid inclusion study, particularly from the meeting of the Commission on Ore-Forming Fluids in Inclusions (COFFI), as well as from other sessions; these will be found in this volume of COFFI.

A meeting on Hydrothermal Phenomena Associated with Granitic Rocks of Europe, convened by Dr. A.H. Rankin and Prof. A. Weisbrod, was held in London, 27-28 May, 1982. Twenty-four papers were presented; many of these involve fluid inclusion studies, and will be found in 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, by J.-C. Touray, will be found in Bull. de Minéralogie. Supplement to Vol. 106, p. 55-56, 1983. Abstracts of the papers were published in Bull. de Minéalogie, Vol. 107, no. 2, and will be found in COFFI Vol. 16.

A meeting on Geothermometry and Geobarometry was held 13-19 January, 1983, at Aussois, École D'Hiver, France, organized by the Soc. fr. Minéral. 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 Vol. 16 of COFFI (1983).

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 Vol. 16 of COFFI (1983).

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).

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

The Seventh All-Union Conference on Thermobarogeochemistry was tentatively rescheduled for L'vov, in 1984.

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. Abstracts of the 11 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, convened by Dr. R.R. Patil at the Wadia Institute of Himalayan Geology. Abstracts will be found in COFFI, Vol. 17 (1984).

Future Meetings

A meeting of European Current Research on Fluid Inclusions ("ECRFI") will be held 10-12 April, 1985, at the University of Göttingen, Göttingen, FRG, convened by Dr. E.E. Horn of that Institute.

A Conference on Stable Isotopes and Fluid Processes in Mineralization will be 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 is being organized by P. Fritz and S.K. Frape, in connection with the GAC/MAC Joint Annual Meeting, 15-17 May, 1985, Frederickton, New Brunswick, Canada.

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

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

The Seventh IAGOD Symposium will be held at Luleå, Sweden, August 18-22, 1986.

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

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.

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Abbreviations

The Cyrillic sequence, *а, б, в, г, д, е* are 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)	Ka	thousand years
ppm	parts per million (10^6)	My	million (10^6) years
µg/g	parts per million (10^6)	Ma	million (10^6) years
%	parts per thousand	mybp	million years before present
ppt	parts per thousand	Ga	billion (10^9) years
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		

The original author's usage has also been followed on <u>pressure</u>. Most use bars (≈ atm ≈ kg/cm^2), kilobars (kb or kbar), or megabars (Mbar), but others use pascals: one kPa = 0.1 kbar; one GPa = 10^8 bars = 10^5 kbar = 10^2 Mbar. Still others use N/m^2 for newtons per square meter (10^5 N/m^2 = 1 bar).

Microthermometry Abbreviations

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

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

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

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

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

Tn - The temperature of nucleation of a given phase. This generally refers to nucleation on cooling, from a normally 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.

Abstracts, Translated Abstracts, or Citations to World Literature, 1981

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 Russian. The first author's address is given as of the publication date only.

ACAD. SINICA, 1981, Symposium, National Meeting [1978] on Experimental Studies of the Inclusions in Minerals and the Genesis of Rocks and Minerals, Volume 1 [Collected Papers]: Scientific Publ. House, Beijing, 335 pp. plus many plates (in Chinese).

This book, although published in 1981, contains 44 papers and 10 abstracts from as early as pre-1977; most are papers that were given at the symposium held in 1978. The meeting and publication was sponsored jointly by Acad. Sinica, the Ministry of Metallurgy, the Ministry of Geology, and the Beijing Inst. Uranium Minerals. English abstracts of several of these will be found in this issue. (E.R.)

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Abstracts

ADCOCK, S.W. and MacKENZIE, W.S., 1981, The solubility of minerals in supercritical water: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The National Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 9-11.

AFRASIABI, H., 1981, A study of mineralization in the Dugway Range, Tooele county, Utah: Master's thesis, Univ. Utah, Salt Lake City, UT, USA, 75 pp.

The Dugway Mining district lies at the northern end of the Dugway Range, Tooele County, Utah. The country rock is the Cambrian Prospect Mountain Quartzite. Primary fluorite, galena and quartz and secondary cerussite are found along fissures.

Th of all primary inclusions in fluorite and quartz ranged 196°-230° and 181°-196°C, respectively, in the liquid phase. The ore solution ranged from 6.5-10.0 equiv. wt. % NaCl (61 P inclusions in fluorite). No liquid carbon dioxide was observed. The pressure, from burial depth, was in the range 80 to 120 bars, yielding a pressure correction of 20° to 25°C. The overall results indicate similarities with hydrothermal fluorite deposits and obvious contrast with the "Mississippi Valley" type deposits. (From the author's abstract)

AGAPOVA, G.F., SHMAROVICH, Ye.M., KHITAROV D.N. and VOROB'YEV, I.M., 1981, Experimental studies of behavior of uranium in thermal alkaline sulfide-carbonate solutions: Geol. Rudn. Mest., v. 23, no. 3, p. 87-98 (in Russian). Authors at MinGEO, Moscow, USSR.

The experiments proved that in thermal (473.15K) moderately alkaline $S-CO_3$ solutions similar to most typical solutions in inclusions in minerals of pitchblende endogene U deposits, depending on pH, the U content may reach $n \cdot 10^{-1}$ g/l as the complex ion $UO_2(CO_3)_3^{4-}$. Solid phase in equilibrium is pitchblende with oxygen coefficient of 2.06-2.42, increasing with solution alkalinity and with redox potential. In plots of $-\lg fH_2$ vs pH at 473.15K isosolubility lines were obtained for pitchblende, outlining field of U-bearing potentially ore-forming hydrotherms. Decrease of pH and increase of fH_2 probably are the factors determining U precipitation from those solutions. (Authors' abstract; translated by A.K.)

AGAR, R.A., 1981, Copper mineralization and magmatic hydrothermal brines in the Rio Pisco section of the Peruvian Coastal batholith: Econ. Geol., v. 76, p. 677-693. Author at Geol. Survey Dept., Ministry of Mines, P.O. Box R.W. 135, Lusaka, Zambia.

Cu-Fe-Mo mineralization in the Rio Pisco section of the Peruvian Coastal batholith is spatially associated with the Linga superunit, a suite of monzonitic rocks intruded into Albian volcanics. Petrochemical studies of this superunit indicate emplacement of a differentiation series at a subvolcanic level in the crust. The Cu-Fe-Mo mineralization is located principally in the Albian volcanic envelope and is essentially a low-grade porphyry copper type, although the grade is enhanced where structural controls on the movement of the ore-bearing fluids produced more sulfide-rich vein- and manto-type deposits. Alteration patterns associated with both the mineralization and the Linga superunit suggest a close, predominantly magmatic control on the nature of the hydrothermal fluids. Fluid inclusion studies of quartz from the Linga superunit support this and indicate that emplacement of magmas and mineralization took place at a depth of approximately 3 km. The characteristics of the Linga porphyry copper are compared to those of other such deposits and used to suggest a possible telescoping of geometry of the Andean model of Lowell and Guilbert (1970). Thus, in magmatic hydrothermal systems like the Linga, the deeper parts of the model are effectively brought nearer the surface. (Author's abstract)

(Continued)

(Dms. halite, sylvite, hematite, anhydrite, calcite and four unknowns were found.)

AGATA, Takashi, 1981, Hornblende-rich gabbro-diorite sequence in the Oura Igneous Complex, Maizuru City, Japan, part II: hydrothermal events and genesis of igneous albite: J. Japan. Assoc. Min., Petr. Econ. Geol., v. 76, p. 35-48. Author at Dept. Consumer Economics, Ichimura-Gakuen Univ., Inuyama City 484, Japan.

The Main Appinitic Sequence is a suite of hornblende-rich gabbroic and dioritic rocks, late differentiates of the Oura Igneous Complex. Hydrothermal minerals including hornblende, epidote, biotite, plagioclase, and quartz are spread out in the Main Appinitic Sequence, and they form such mineral assemblages as honrblende-rich, epidote-rich, and biotite-rich. An appreciable amount of copper sulfide concentration occurs in a biotite-rich altered area. Fluid inclusions in the quartz crystals from the mineralized area show fairly high Th, suggesting that the mineralization and alteration were caused essentially by fluid which escaped from the magma forming the Main Appinitic Sequence. The variation of hydrothermal assemblages may be the result of fractional separation of fluid: the earlier separated fluid brings about the hornblende-rich and epidote-rich assemblages in the earlier formed Appinitic rocks, and the biotite-rich assemblage and copper sulfide concentration in leuco albite tonalite are formed by the fluid escaping from the later differentiated magma.

The albite with the igneous textures from the Main Appinitic Sequence is sometimes replaced by the hydrothermal calcic plagioclase and presumably is an original product crystallized from the magma. The generation of albite may be accounted for by the large amount of hornblende concurrently crystallizing from the magma: in view of incongruent melting of hornblende, hornblende in liquid comes out at the expense of anorthite, clinopyroxene, and orthopyroxene components in the final stage of crystallization of clinopyroxene and brings down the activity of anorthite in liquid. (Author's abstract)

AKIYAMA, Shin-ichi, 1981, Recent information about the mineralization in the Kamioka mining area - studies on regional geology and mineralization in the Kamioka district, No. 2: Min. Geol. (Japan), v. 31, no. 3, p. 157-168 (in Japanese; English abstract).

In the Kamioka silver-lead-zinc mining area, zonal arrangement of ore and skarn minerals is recognized in accordance with the distance from the rock mass called metabasite. Besides mineral assemblage data, Ag-Pb-Zn ratio in ore and decrepitation temperature of skarn minerals can be used to delineate the zoning pattern. Molybdenum mineralization with actinolite skarn occurs in some zones overlapping the silver-lead-zinc mineralization, and is likely to be related to the activity of granite porphyry.

There are four types of Ag-Pb-Zn ores in the mining area; "mokuji" type, "shiroji" type, dissemination type and gold-silver type. The mokuji type ore, which is most prevalent and appears to have the highest formative temperature in this mineralized sphere, is found, without exception, in contact with the Inishi-type migmatite.

Thus, it is thought that the silver-lead-zinc mineralization in this mining area has been genetically related to the metabasite and the Inishi-type migmatite. Distribution of these rocks, and therefore the indication of silver-lead-zinc mineralization, is confined to a specific tectonic unit of the Hida metamorphic belt, named the Central massif.

It has been suggested from the ore lead isotopic data that leads in this area came from more than a single source of material. There is also some indication that primary concentration of Ag-Pb-Zn in this area might have occurred prior to the formation of the migmatite and the metabasite. (Author's abstract)

Contains a diagram (p. 160) showing Th ranges as follows: Mokuji 290-335°C; Shiroji 200-235°C; gold-silver 155-210°C. (E.R.)

ALLISON, I. and KERRICH, R., 1981, History of deformation and fluid transport in shear zones at Yellowknife, in Proceedings of the Gold Workshop, Yellowknife, N.W.T., Dec. 3-7, 1979, ed. R.D. Morton: Alberta, Univ. Alberta, p. 204-231. First author at Dept. Appl. Geol., Univ. Strathclyde, Glasgow, G1 1XJ, Scotland.

Shear zones transecting the metabasalts of the Yellowknife greenstone belt are the sites of economic lode gold deposits. Three vein systems each with a distinctive geometry and relationship to other structures are present in the shear zones. Each vein system has characteristic geochemical features indicative of differing fluid transport regimes. Veins of the earliest system are barren and do not possess an alteration halo. They formed by short range mass diffusion within the developing shear zone. The second vein system comprises the massive gold-bearing veins which have an extensive alteration halo and which represent the passage through the shear zone of large volumes of hydrothermal fluids. The veins of the third system are not as massive as those of the second system although they are gold-bearing and their alteration halo is correspondingly less extensive. They are thought to have formed during waning of the hydrothermal convective system.

The geometry of their vein systems indicates that all three systems formed by hydraulic fracturing under conditions of very high fluid pressures. The changing conditions are conveniently illustrated by means of Mohr diagrams. (Authors' abstract)

ANDERSON, A.T., Jr., 1981, Micron thick oscillatory zones on plagioclase: a volcanological clock (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 396. Author at The Univ. Chicago, 5734 South Ellis Avenue, Chicago, IL 60637.

Upon eruption plagioclase phenocrysts in high-alumina basalts have micron thick oscillatory zones. Such zones are absent or indistinct on overgrowths of plagioclase which form in the interiors of lava flows and associated segregation veins which cooled at various rates. Unzoned overgrowths surround oscillatory zoned interiors in certain cognate inclusions and probably grew after the crystals became attached to the stationary wall of the magma body. Consequently, the micron thick zones are associated with movement of magma. Phenocrysts erupted from Fuego in 1974 have about 28 micron-thick oscillatory zones between disturbed or inclusion-rich zones. Zones which are incomplete on a particular face suggest that zones grow sideways, not perpendicular to the face as required by models involving oscillating interactions between diffusion and growth at a constant rate of cooling. I explain the micron thick zones according to tidally triggered and other motions of magma which disturb (shear) the local environment around growing crystals and thereby modulate the inception and growth of micron thick steps on plagioclase phenocrysts. Estimates of supersaturation and distances between crystals combine with tidal triggering to suggest that micron thick zones are twice daily ticks of a volcanological clock. (Author's abstract)

APLONOV, et al., 1981 - See Appendix

ARANOVICH, L.J., PODLESSKII, K.K. and SHCHEPOCHKINA, N.I., 1981, Experimental determination of the CO_2 solubility in cordierite: Akad. Nauk SSSR Doklady, v. 261, p. 728-730 (in Russian).

ARCULUS, R.J. and DELANO, J.W., 1981, Intrinsic oxygen fugacity measurements: techniques and results for spinels from upper mantle peridotites and megacryst assemblages: Geochimica et Cosmochim. Acta, v. 45, p. 899-913.

ARUTYUNYAN, G.A., 1981, The results of investigations on gas-fluid inclusions in quartz of the Ankadzorskoye deposit: Isvestiya Akad. Nauk Armyanskoy SSR, Nauki O Zemle, v. 34, no. 1, p. 79-81 (in Russian).
Indexed under fluid inclusions. (E.R.)

ASHIKHMINA, N.A., GORSHKOV, A.I., MOKHOV, A.V. and OBRONOV, V.G., 1978, Sylvite and halite in lunar soil: Dokl. Akad. Nauk SSR, v. 243, p. 1258-1260 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 243, p. 155-158, 1981).
See Fluid Inclusions--Proc. of COFFI, v. 11, p. 242-243, 1978. (E.R.)

ASHWAL, L.D., MOGK, D.W., BERGMAN, S.C., GIBSON, E.K., Jr., HENRY, D.J., WARNER, J.L. and LEE-BERMAN, R., 1981, Liquid-vapor inclusions in achondritic meteorites (abst.): Meteoritics, v. 16, p. 290-291. First author at Lunar and Planet. Inst., Houston, TX.

Two-phase (liquid-vapor) and three-phase (glass-liquid-vapor) inclusions have been discovered in achondritic meteorites including diogenite ALHA 77256. The vapor bubble moves spontaneously within its liquid host at room temperature proving that the host is liquid and not glass, although glass inclusions with non-moving vapor bubbles also exist. Fluid inclusions are abundant but distributed in an inhomogeneous manner. Fluid inclusions in ALHA 77256 are both spheroidal (up to 5 micrometers across) and irregular outlined discs (up to 20 micrometers across). Fluid inclusions with occurrences described are suggestive of secondary origin. Microthermometric analysis on these inclusions was performed utilizing a CHAIX-MECA freezing-heating microscope stage. For the diogenite, final melting temperatures are as high as -2°C and temperatures of liquid + vapor homogenization to liquid are as low as 75°C. These data suggest that the fluid is an aqueous solution with a few percent weight equivalent NaCl and a density as high as 0.97 g/cc. Assuming that the inclusions were trapped at the petrologically derived temperature of pyroxene equilibration (900°C), the pressure of formation is calculated at about 9 kbars. To achieve such a pressure the diogenite must have formed at substantial depth in planetary object: for example, (i) 500 km depth in a Ceres-sized asteroid or (ii) 70 km depth in a Mars-sized planet. (Authors' abstract)

ASPDEN, J.A., 1981, The composition of solid inclusions and the occurrence of shortite in apatites from the Tororo carbonatite complex of eastern Uganda: Min. Mag., v. 44, no. 334, p. 201-205.

AYRES, D.E., BURNS, M.S. and SMITH, J.W., 1981, A sulphur isotope reconnaissance study of the porphyry copper deposits at Panguna and Mt. Fubilan, Papua New Guinea: Pacific Geol., v. 15, p. 37-50. First author at Exxon Min. Co., P.O. Box 2189, Houston, Texas 77001, USA.

The epicontinental and island arc origins of the porphyry sulphide deposits at Mt. Fubilan and Panguna respectively are in sharp contrast. However, in spite of the close proximity of ocean sulphate to the Panguna deposit, the sulphate isotope analyses of both gave a range of values near zero. Accordingly, on this evidence a purely magmatic origin for both deposits is indicated. (Authors' abstract)

BAGDASAROV, Yu.A. and GRINENKO, L.N., 1981, On the isotopic composition of sulfur in carbonatites of the Chernigovskaia zone (Priazovie) and the causes of its variation in carbonatite complexes: Akad. Nauk SSSR Doklady, v. 258, no. 5, p. 1192-1195 (in Russian).

BAILEY, J.C., GWOZDZ, Raymond, ROSE-HANSEN, John, ANDERSEN, L.S. and SØRENSEN, Henning, 1981, Distribution of lithium and fluorine in lujavrites from the Ilímaussaq intrusion: Rapp. Grønlands geol. Unders., v. 103, p. 77-86.

The development of a relatively rapid neutron activation technique, involving fast-transfer of samples from the reactor followed by Cerenkov counting, has allowed us to extend the analytical coverage of Li and F in the Ilímaussaq lujavrites and their minerals. On geological grounds the lujavrites have been regarded as crystallizing from the final agpaitic magmas at Ilímaussaq. In agreement with this, contents of Li and F - which are normally maximal in residual magmas - have been shown to attain their highest levels within the lujavrites (Gerasimovsky, 1969; Ferguson, 1970). However, these studies failed to agree on the absolute contents of Li in the lujavrites. For aegirine lujavrite and arfvedsonite lujavrite, Gerasimovsky (1969) reported averages of 155 and 791 ppm, respectively, whereas Ferguson (1970) found only 90 and 226 ppm. Hamilton (1964) only reported 80 ppm Li in a single sample of arfvedsonite lujavrite.

More recent mapping within the intrusion has revealed further divisions within the lujavrite sequence (Sørensen et al., 1969, 1974; Demin, 1971; Engell, 1973; Andersen and Bohse, 1978, this volume). These subdivisions provide an increased geological control for the interpretation of Li and F data. Samples of the various lujavrite varieties were taken from the drill cores obtained in 1958, 1962 and 1969.

In the southern half of the intrusion, aegirine lujavrite I is concordant with the (upper-most) transitional layered kakortokites and like them shows mineralogical layering and a relatively high content of eudialyte. It passes upwards into aegirine lujavrite II and arfvedsonite lujavrite (samples frm Tunugdliarfik). In the Kvanefjeld area, the early fine-grained lujavrites are mainly arfvedsonite lujavrites, but they include locally developed naujakasite and villiaumite-bearing lujavrites. They are cut by sheets of medium- to coarse-grained (M-C) lujavrite, the final major intrusion of the whole massif. (Authors' abstract)

BAILEY, J.C., LARSEN, L.M. and SØRENSEN, Henning, eds., 1981, The Ilímaussaq intrusion, South Greenland: Grønlands Geologiske Undersøgelse Rapport Nr. 103.

A comprehensive review of the geology, mineralogy, geochemistry and economic geology of pertinence to the many studies of the unusual fluid inclusions in these minerals. (E.R.)

BAKER, M.B. and LOFGREN, G.E., 1981, Dynamic crystallization study of an alkali olivine basalt (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 401.

BAKSHEEV, S.A., MAKRYGINA, V.A. and KARPOV, I.K., 1981, Calculation of the mineral composition of metapelites with mobile behavior of water by the method of thermodynamic potential minimization: Akad. Nauk SSSR Doklady, v. 259, p. 176-179(in Russian).

BAKUMENKO, BAZAROVA, et al., 1981 - See Appendix

BAKUMENKO, I.T. and KOSUKHIN, O.N., 1981, Magmatic quartz in zanorysh (chamber) pegmatites: Akad. Nauk SSSR Doklady, v. 258, no. 6, p. 1441-1445 (in Russian). Authors at Inst. Geol. and Geophysics, Novosibirsk, USSR.

Pegmatitic magma parent for the most important zones of chamber pegmatites was rich in water and other volatiles. Already in the stage of crystallization of granophyric intergrowths in many pegmatites, the distinct signs of saturation and boiling of melts were detected: melt crystallized inclusions are associated with syngenetic P G/L inclusions of the exsolved fluid. In most of the studied pegmatites except from Volynia and Zolotaya Gora (Transbaikalia), process of crystallization of the zanorysh aggregates (from boiling melt) occurs at T<T of quartz inversion, and hence quartz inversion cannot be the reason of the formation of the zanorysh. Primary zanorysh should be formed due to separation of fluid phase from crystallizing pegmatite magma. Inner cores of zanorysh quartz formed at T lower than T of formation of wall rock aggregates; Th for melt inclusions are 630-590°C and 640-560°C, respectively, for all samples presented in the paper. P melt inclusions occur either as single ones in zanorysh quartz crystals or as groups along growth zones. They are accompanied by syngenetic P fluid (i.e., non-melt) inclusions that proves the intensive boiling of melt. Melt inclusions bear crystallized melt plus fluid (L+G) occupying 20-25 vol.%. On heating this fluid part homogenizes in L at 200-300°C (total salt concentration 4-10% NaCl equiv.). At ~500°C the melting of crystal phases begins and fluid causes a pressure of 3-5 kbar, hence causes the opening of almost all melt inclusions of size >3 µm. During further heating P in inclusions decreases and at Th of whole inclusion is equal P of pegmatite magma.

Pegmatites with honeycomb quartz form under low total P and fluid separated from boiling pegmatitic melt has low density. Th of P inclusions in honeycomb quartz are almost the same as in early usual zanorysh quartz. (Abstract by A.K.)

BAKUMENKO, I.T., KOSUKHIN, O.N., KOSALS, J.A. and LKHAMSUREN, Zh., 1981, On the genesis of rhythmically banded textures in granitoids: Akad. Nauk SSSR Doklady, v. 260, p. 444-448 (in Russian). See Appendix

BAKUMENKO, KOSUKHIN, SIMONOV, et al., 1981 - See Appendix

BALAKIREV, V.G., 1981, Dislocation substructures of grain boundaries on splitting surfaces of quartz rocks: Phys. and Chem. of Minerals, v. 7, p. 5-9.

BALLANTYNE, G.H., 1981, Chemical and mineralogical variations in propylitic zones surrounding porphyry copper deposits: Ph.D. dissertation, Univ. Utah, Salt Lake City, UT, USA, 227 pp.

Mineralogy, mineral chemistry, isotopic compositions and fluid inclusion filling temperatures have been investigated along traverses across the propylitic zones which surround porphyry copper deposits in the Silver Bell, Safford, and Christmas districts of southern Arizona. Mineralogical sub-zoning occurs in the propylitic zone in each district. At North Silver Bell, a sub-zone containing chlorite-epidote ± albite ± K-feldspar ± calcite ± magnetite extends for 1000 meters from the secondary biotite zone, and is surrounded by an extensive chlorite-calcite ± specularite zone. At Safford, propylitic mineralogy is similar to that in the inner sub-zone at North Silver Bell but actinolite occurs as an additional phase in some samples within the innermost 550 meters of the propylitic zone. Epidote abundance decreases outwards at Safford and calcite becomes scarce or absent close to the biotite zone. At Christmas, a chlorite-epidote-actinolite sub-zone extends 700 meters beyond the biotite zone and more remote samples contain a chlorite-prehnite-epidote-oligoclase assemblage.

A compilation of published data on additional deposits shows that the disappearance or decrease in abundance of actinolite, epidote and magnetite, and the appearance or increase in abundance of calcite and specularite outwards across the propylitic zone, are common to many deposits. Evaluation of mineral stabilities in the system $CaO-Al_2O_3-SiO_2-H_2O-CO_2$ suggests that SiO_2 and CO_2 activities largely control the differences in zoning seen between individual deposits.

Chlorite major element compositions vary systematically at North Silver Bell where the $\Sigma Fe/\Sigma Fe+Mg$ ratio increases from 0.33 in the biotite zone to 0.48 in the outer propylitic zone, and birefringence varies outwards from pale grey to brown to blue. Birefringence data and a few analyses suggest the same trend in the Christmas area. At Safford, chlorite close to ore has a wider compositional range than chlorite in more remote samples. Epidote compositions range from Ps_{24} to Ps_{34} at North Silver Bell and from Ps_{24} to Ps_{29} at Safford and do not exhibit systematic spatial variations.

The manganese contents of chlorite and epidote exhibit useful spatial variations at North Silver Bell, Safford and at other deposits. The manganese content of chlorite increases inwards across the propylitic zone to a maximum of 1% or more near the inner edge of the propylitic zone and then decreases sharply to approximately 0.25% near the center of the biotite zone. The manganese content of epidote likewise increases inwards to a maximum and then decreases, but the change is more subdued. The ratio of manganese-in-epidote to manganese-in-chlorite increases rather uniformly towards the Safford deposit over a four kilometer interval, and shows a similar but less uniform trend at North Silver Bell. An expression for the temperature dependence of this ratio has been derived and calibrated empirically.

Fluid inclusion filling temperatures for low salinity, secondary inclusions in pre-mineral rocks at North Silver Bell decrease across the propylitic zone. Maximum filling temperatures are 375° at the outer edge of the biotite zone, 232° at the outer edge of the epidote zone, and 193° in a sample from the outer part of the propylitic zone. The filling temperatures decrease outwards at about 57° per kilometer. Oxygen isotopic compositions of whole rock samples and chlorite and calcite from North Silver Bell suggest that the O^{18} content of the hydrothermal fluids decreased outwards across the alteration aureole. These data are consistent with an increasing meteoric water component outwards, but also suggest that a minor component with magmatic affinities persisted into the propylitic zone. Whole rock chemical analyses indicate that propylitization involved chemical modification of the host rocks at Silver Bell for at least 1600 meters beyond the biotite zone.

In each of the study areas propylitized rocks, at least locally, directly adjoin biotitized rocks. Phyllic alteration decreases with depth and appears to largely post-date propylitic and potassic alteration. Mineralogical, fluid inclusion, isotopic and compositional data all show smooth gradients across the potassic-propylitic boundary and on out across the propylitic zone. These data suggest that propylitic alteration was largely coeval with potassic alteration and mineralization. Chemical and thermal anomalies associated with mineralization appear to have extended from two to four kilometers or more beyond the biotite zones in the areas studied. (Author's abstract)

Freezing studies were attempted but the fluids remained metastable and supercooled after several hours at liquid nitrogen temperature. Primary inclusions at North Silver Bell had a ~40 vol.% bubble which "appear to consist of two or more phases concentrically arranged" (p. 120) and had Th >440°C. (E.R.)

BANNIKOVA, L.A., 1981, Connection of isotopic composition of calcites and their luminescence with character of transformations of organic matter under hydrothermal conditions: Geokhimiya, no. 11, p. 1688-1693 (in Russian, English abst.). Author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The paper bears some data on Th and composition of inclusion fluids from the Hg deposit Pereval'noe, NW Caucasus, cited from literature. (A.K.)

BANNIKOVA, L.A. and MILOVSKIY, G.A., 1981, Isotope composition of carbonates of the Orlovskoe pyrite-polymetal deposit: Geokhimiya, no. 5, p. 722-728 (in Russian, English abst.). First author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Th in carbonates = 215-250°C, Td = 300-360°C. (A.K.)

BARANOVA, N.N. and RYZHENKO, B.N., 1981, System Au-Cl-Na-S-H_2O in relation to the conditions of transport and deposition of gold in hydrothermal process (computer simulation): Geokhimiya 1981, no. 7, p. 989-1002 (in Russian; English abstract).

Computer simulation of equilibria in the system Au-Cl-Na-S-H_2O at 25 to 300°C under different hydrogen fugacities, total sulfur concentration, and pH was made and the data obtained were used for thermodynamic analysis of some mineral paregeneses of the gold-ore deposits. (Authors' abstract)

Pertinent to composition of inclusion fluids. (A.K.)

BARBERI, F., BIZOUARD, H., CLOCCHIATTI, R., METRICH, N., SANTACROCE, R. and SBRANA, A., 1981, The Somma-Vesuvius magma chamber: a petrological and volcanological approach: Bull. Volcanol., v. 44-3, p. 295-315. First author at Instituto di Mineralogia e Petrografia, Univ. Pisa, Italy.

The volcanic history of Somma-Vesuvius indicates that salic products compatible with an origin by fractionation within a shallow magma chamber have been repeatedly erupted ("Plinian" pumice deposits). The last two of these eruptions, (79 A.D. and 3500 B.P.) were carefully studied. Interaction with calcareous country rocks had limited importance, and all data indicate that differentiated magmas were produced by crystal-liquid fractionation within the undersaturated part of petrogeny's residua system at about 1 kb water pressure. The solid-liquid trend indicates that the derivative magmas originated by fractionation of slightly but significantly different parental liquids. Some lavas of appropriate composition were selected as parental liquids to compute the entity of the fractionation. Results suggest that in both cases a fractionation of about 70 weight % was needed to produce liquids with the composition of the pumice. The combination of all data indicates that the two Plinian eruptions were fed by a magma chamber (3-4 km deep) having a volume of approx. 2.0-2.5 km^3. The temperature of the magma that initially entered the chamber was about 1100°C, whereas the temperature of the residual liquids erupted was Plinian pumice was 800° to 850°C respectively. There is no evidence that such a magma chamber existed at Vesuvius after the 79 A.D. eruption. These results have relevant practical implications for volcanic hazard and monitoring and for geothermal energy. (Authors' abstract)

Complete microprobe analyses of glass inclusions in nepheline, leucite, clinopyroxene, and olivine are given (Table 8) and interpreted (p. 311). Th of melt inclusions in sanidine, scapolite, nepheline, clinopyroxene, leucite, and olivine were also determined (Table 12); these ranged from 1200 to 780°C. (E.R.)

BARIAC, Thierry, FERHI, André and LETOLLE, René, 1981, A redetermination of the oxygen-18 fractionation factor between CO_2 and H_2O at 25°C: Comptes Rend. Acad. Sci. (Paris), v. 292, no. 7, p. 605-607.

BARKAN and YAKUTSENI, 1981 - See Appendix

BARKER, C.E. and ELDERS, W.A., 1981, Vitrinite reflectance geothermometry and apparent heating duration in the Cerro Prieto geothermal field: Geothermics, v. 10, no. 3/4, p. 207-223. First author at U.S. Geol. Survey, Denver, CO 80225, U.S.A.

Vitrinite reflectance measured in immersion oil (R_0) on kerogen extracted from hydrothermally altered mudstones in borehole M-84 at the Cerro Prieto geothermal field exhibit an increase in mean reflectance (R_0) from 0.12 per cent at 0.24 km depth to 4.1 per cent at 1.7 km depth. Downhole temperatures measured over this interval increase from about 60° to 340°C. These R_0 data plotted against temperature fall along an exponential curve with a coefficient of determination of about 0.8. Other boreholes sampled in the field show similar relationships. A regression curve calculated for temperature and R_0 in borehole M-105 correctly predicts temperatures in other boreholes within the central portion of the geothermal system. The correlation between the reflectance values and logged temperature, together with consistent temperature estimates from fluid inclusion and oxygen isotope geothermometry, indicates that changes in R_0 are an accurate and sensitive recorder of the maximum temperature attained. Therefore, vitrinite reflectance can be used in this geothermal system to predict the undisturbed temperature in a geothermal borehole during drilling before it regains thermal equilibrium. Although existing theoretical functions which relate R_0 to temperature and duration of heating are inaccurate, empirical temperature-R_0 curves are still useful for geothermometry.

A comparison of temperature-R_0 regression curves derived from nine boreholes within the Cerro Prieto system suggests that heating across the central portion of the field occurred penecontemporaneously, but varies near margins. Boreholes M-93 and M-94 appear to have cooled from their maximum temperatures, whereas M-3 and Prian-1 have only recently been heated.

Comparison of the temperature-R_0 data from the Salton Sea, California, geothermal system indicates that the duration of heating has been longer there than at the Cerro Prieto field. (Authors' abstract)

BARNES, H.L., 1981, Measuring thermodynamically-interpretable solubilities at high pressures and temperatures, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 321-344. Author at Ore Deposits Research Sec., The Pennsylvania State Univ., University Park, PA 16802, USA.

Solubilities are useful only if measured in defined systems where at least the minimum number of intensive variables required by the Gibbs' phase rule for invariancy are either fixed, measured, or controlled in the experiment. The array of determined intensive variables and any necessary buffers should be selected also to provide maximum resolution of identifying stoichiometries of solute species and in evaluating equilibrium constants of solubility-controlling reactions. Simultaneous measurements of volumetric properties of solutions and gases present during solubility measurements are practical and simplify thermodynamic analysis of solubilities. Equilibration is best demonstrated by equal solubilities for the same conditions approached from opposite directions.

In solubility experiments at high pressures and temperatures, continuous analyses are possible using spectra, cell potentials, or radioactive tracers but they are uncertain indicators of total solute concentration. Methods providing only a single data point per experiment, by nutrient weight-loss or by analysis of quenched fluids, are comparatively slow and are not reversible. Better are periodic sampling and analysis of quenched, filtered fluids from two types of experimental systems. Condensed fluids are investigated effectively with an external-fluid-supported flexible cell but vapor-containing or supercritical experiments are less complex in a fixed-volume, rocking vessel. In both systems the parent solution remains virtually isothermal and isobaric during sampling, replicate sampling is possible, and reversing of reactions is simple. The less-complicated, fixed-volume system also permits P-V-T measurements on liquids and gases together with sampling.

The stoichiometry of the dominant solute species is given, commonly with satisfactory resolution, by the exponential dependence of the solubility on the concentration of each potential ligand. The exponent closely approximates the stiochiometric coefficient of the ligand in the solute species. From these ligand and solute concentrations and tabulated or calculated activity coefficients, activities are obtained for dominant solute species, ligands, and gases corresponding to each solubility measurement. These activities permit the calculation of an equilibrium constant for each principal reaction representing equilibration among the solute, its dissolved species, and reacting ligands. The resulting constants, based on individual solubility measurements may then be compared for consistency both isothermally and polythermally.

Measurements of solubilities at high temperatures and pressures are now impeded primarily by the lack of (1) well-calibrated buffers of oxidation state and acidity with known reaction rates for hydrothermal use, and

(2) inert high-strength alloys that are resistant to hydrogen embrittlement, nonreactive with acidic and other high temperature fluids, and with mechanical properties compatible with use in the bodies or liners of reaction vessels. (Author's abstract)

BARRON, L.M., 1981, The calculated geometry of silicate liquid immiscibility: Geochimica et Cosmochimica Acta, v. 45, no. 4, p. 495.

BARSUKOV et al., 1981 - See Appendix

BARTON, M.D., 1981, The thermodynamics of topaz solid solutions and some applications (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 404.

BARTON, P.B., Jr., 1981, Physical-chemical conditions of ore deposition, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 509-528. Author at U.S. Geol. Survey, Reston, VA 22092, USA.

Ore deposits form under a wide range of physical and chemical conditions, but those precipitating from hot, aqueous fluids - i.e., the hydrothermal deposits - form generally below 700°C and at pressures of only 1 or 2 kbar or less. Natural aqueous fluids in rocks may extract metal and sulfur from a variety of rock types or may acquire them as a residual heritage from a crystallizing silicate magma. Ore-forming hydrothermal fluids never appear as hot springs (except in deep, submarine situations) because they boil, mix with surface waters, and cool, thereby losing their ore-bearing ability before reaching the surface.

Mineral systems function as chemical buffers and indicators just as buffers and indicators function in a chemical laboratory. By reading the record written in the buffer indicator assemblages of minerals one can reconstruct many aspects of the former chemical environment. By studying the record of changing conditions one may deduce information regarding the processes functioning to create the succession of chemical environments and the ore deposits they represent.

The example of the OH vein at Creede, Colorado, shows a pH buffered by the K-feldspar + muscovite + quartz assemblage and the covariation of S_2 and O_2 buffered by the assemblage chlorite + pyrite + quartz. Boiling of the ore fluid led to its oxidation to hematite-bearing assemblages and simultaneously produced an intensely altered, sericitic capping over the vein in response to the condensation of vapors bearing acidic components. The solubility of metals as calculated from experimental and theoretical studies of mineral solubility appears too low by at least one or two powers of ten to explain the mineralization at Creede.

In contrast to Creede where the mineral stabilities all point to a relatively consistent chemistry, the Mississippi Valley type deposits present a puzzle of conflicting chemical clues that are impossible to reconcile with any single equilibrium situation. Thus we must seriously consider metastable equilibria; those most likely involve redox disequilibrium among the sulfur species in solution and perhaps also involve organic compounds. (Author's abstract)

BASALTIC VOLCANISM STUDY PROJECT, 1981, Basaltic volcanism on the terrestrial planets: New York, Pergamon Press, 1286 pp.

Includes much of pertinence to the interpretation of silicate melt inclusions in basaltic rocks. (E.R.)

BASSETT, R.L. and ROEDDER, Edwin, 1981, Water content in Palo Duro salt, Randall and Swisher County cores, in Gustafson, T.C., and others, Geology and geohydrology of the Palo Duro basin, Texas Panhandle: The Univ. of Texas at Austin, Bureau of Econ. Geology Circular 81-3, p. 119-122.

Preliminary values of water content in Palo Duro salt have been obtained by two analytical methods. Free water ranges from 0.15 to 2.4 weight percent. Water trapped in evaporite minerals affects their structural properties and may become mobile when placed in a thermal gradient. Inconsistencies in published values reflect a misunderstanding concerning the exact nature of water in salt. (Authors' abstract)

BAYDAKOV et al., 1981 - See Appendix

BAZAROVA, T.Yu., KOSTYUK, V.P. and KHMEL'NIKOVA, O.A., 1981, Peculiarities of formation of alkaline basalts of Bolshoy Anyuy River (tributary of Kolyma River): Akad. Nauk SSSR Doklady, v. 259, no. 5, p. 1192-1194 (in Russian). First author at Inst. Geol. and Geoph. of Siberian Branch of Acad. Sci. USSR, Novosibirsk, USSR.

Alkaline basalts of Tertiary age in pyroxene phenocrysts bear P inclusions filled by glass, glass + G + dms (magnetite, apatite). Glass chemical composition is as follows: SiO_2 57.50, TiO_2 0.19, Al_2O_3 22.34, FeO (total Fe) 2.03, MgO 0.10, CaO 2.17, Na_2O 4.10, K_2O 8.85, total 97.28 (in wt.%), by electron microprobe, average of three analyses. The composition is more acid than initial basalt melt, because magnetite, pyroxene and part of leucite already crystallized from this melt. Th of melt inclusions are 1140-1240°C. (Abstract by A.K.)

BEDSON, P. and HAMILTON, D.L., 1981, Kimberlites, carbonatites and liquid immiscibility: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 29-33.

BEHR, H.J., AHRENDT, H., SCHMIDT, A. and WEBER, K., 1981, Saline horizons acting as thrust planes along the southern margin of the Damara Orogen (Namibia/SW-Africa), in Thrust and nappe tectonics: The Geological Society of London, p. 167-172. (E.Horn)

BEHR, H.J. and HORN, E.E., 1981, Hypersaline fluid inclusions in metamorphic playa-lake deposits and related giant quartz crystal occurrences (Damara Orogen/Namibia) (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Authors at Geologisch-Paläontologisches Institut, Goldschmidtstr. 3 3400 Göttingen, Germany.

Fluid inclusions have been analyzed on sections through the Upper Proterozoic Damara Orogen (Namibia). Two genetically different fluid systems of regional importance could be distinguished:

1) fluid systems with 25-50% gross salinity ($NaCl-KCl-CaCl_2$), Na/K < 1 to 1; source: continental saline sequences; and

2) fluid systems with 4-16% gross salinity (NaCl); source: metamorphic waters generated by pelitic geosynclinal sediments.

Further fluid systems of local importance are limited to numerous late tectonic granite and alaskite intrusions.

The supersaturated fluid system originated from widespread playa-sabkha environment intercalated in graben sediments. Corresponding metamorphic rocks containing palaeo-evaporite minerals (Na carbonates, sulfates, and borates) are present. The interstitial brines have been included in a geothermal water system with hot water/rock alterations.

Mineralization of stratiform Cu-deposits, stratiform tourmaline-quartz-deposits and numerous giant quartz reefs have been caused by residual saline solutions. These reefs contain quartz crystals up to 50 m long showing excellent Brazil twinning, extremely rhombohedral cleavage, and contain hypersaline fluid inclusions.

As sole dolomites the metamorphic playa-sabkha rocks enriched in hypersaline fluids have enabled thrust and nappe tectonics at the margins of the orogen. In various places the saline carbonate mush saturated in fluids has penetrated and intruded the overlying rocks. In the Cu deposits of Tsumeb and Kombat in the northeasten part of the Damara Orogen pipe-like intrusions of saline rocks might have developed. There is a very great variety of daughter minerals in the fluid inclusions - feldspars, quartz, zeolites, analcite, talc, sulfates, sulfides, apatite, oxide, and Ca-Mg-hydrosilicates (?). This supersaturated fluid system is very similar to that of porphyry copper ore deposits. But boiling is limited to places with tectonic opening of ruptures and fractures. These phenomena are especially developed in sole dolomites and thrust zones.

The composition of the low-saline fluid systems can be derived from the metamorphic reactions of pelitic rock sequences, especially from the decomposition of biotite. These fluids are concentrated in quartz lenses which have segregated into the planes of schistosity, into discordant late-tectonic quartz veins, Li-pegmatites and Sn/W bearing quartz veins. (Authors' abstract)

BENDING, D.A., 1981, Cathodoluminescence and microthermometry of zinc-lead mineralization in the Metaline Formation, N.E. Washington, U.S.A. (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-4.

Cathodoluminescence microstratigraphy and fluid inclusion studies of the stratabound Zn-Pb mineralization in the carbonate rocks of the Metaline Formation provide a chronology for porosity development, hydrocarbon migration, and two major cycles of sulphide mineralization. Solution and reduction of sulphates along the Yellowhead horizon was accompanied by brecciation, sulphide precipitation, and settling that helped open fluid pathways higher in the carbonate complex. The first cycle of mineralization and almost all the sulphides along the Yellowhead horizon were precipitated from brines with salinities (fusion temperatures 'Tf' -10° to -26°C) and temperatures (homogenization temperature 'Th' of 95° to 150°C) typical for Mississippi Valley type deposits. The second cycle of mineralization, associated with the early stages of Devono-Mississippian tectonic activity, was concentrated in the Josephine breccias. Solution, silicification, and collapse were associated with dilute (Tf -2° to -5°C) fluids at higher temperatures (Th 200° to 230°C). High grade pods of galena and sphalerite are associated with saline (Tf -10° to -20°C) cooler fluids (Th 210° to 185°C). These inclusions contain sulphate, phyllosilicate, and possibly carbonate daughter crystals. Barren cockade quartz was precipitated from cooling, more dilute fluids (Tf -4.5° to -9.5°C, Th 195° to 175°C). Later sphalerite contains inclusions with fusion temperatures of -4.0° to -6.5°C that homogenize from 155° to 130°C. Microthermometric data and trends for the second cycle are similar to some epithermal vein deposits, but since no contemporateous igneous rocks are known the regional setting suggests a link with the upper Paleozoic (Antler) tectonism. (Author's abstract)

BENEŠOVÁ, Zdeňka and ĎURIŠOVÁ, Jana, 1980, Fluid inclusions and their significance for geology: Prague, Ústřední Ústav Geologický, 80 pp. (in Czech).

A review of studies on fluid inclusions in minerals. The mechanism of the origin of fluid inclusions and the relationship of included solutions to original mineralizing solutions are discussed. Methods for the determination of temperature, pressure, chemical composition and concentration of the solutions are summarized, with special reference to the methods applied in the laboratory of the Geological Survey in Prague. In conclusion examples of successful applications of the studies of inclusions are given along with the results of studies in the Geological Survey, Prague. (English abstract prepared by the authors)

Part of a series of 28 photographs in the volume are of fluid inclusions mainly from Czech localities. The captions to these are as follows (translation courtesy J. Durisova):

1. Inclusion of volcanic glass with a gas bubble in quartz from liparite. North Caukasus. Magnification 350X.

5-7. Gaseous inclusions in quartz. Horni Krupka (the eastern Krusné Hory Mts.). Magnification - photos 5, 6 355X, photo 7 180X.

8-9. Fluid inclusions in quartz. Horni Krupka. Magnification 130X.

10-11. Fluid inclusions in cassiterite. Horni Krupka. Magnification 180X.

12. Two-phased inclusions in quartz: A - H_2O+CO_2 inclusions (large gas bubble), B - H_2O inclusions (small gas bubble). Zlaté Hory in the Jeseniky Mts. (Morávia). Magnification 355X.

13-14. Liquid inclusions in gypsum. Hanusov near Presov (Slovakia). Magnification photo 13 50X, photo 14 100X.

15-16. Two-phased fluid inclusions in quartz. Horni Krupka. Magnification photo 15 160X, photo 16 355X.

17. Two-phased fluid inclusions in synthetic quartz. Magnification 100X.

18. Two-phased fluid inclusions in a crystal of smoky quartz. Dolni Bory (Moravia). Magnification 45X.

19-21. Multiphased inclusions in topaz. Cinovec. Magnification photo 19 530X, photo 20 725X, photo 21 600X.

22. Multiphased inclusions in quartz, Horni Krupka.

23. Secondary inclusions on healed fractures in quartz. Horni Krupka. Magnification 75X.

24. Three-phased H_2O-CO_2 inclusion in a smoky quartz. 1 - liquid CO_2; 2 - gaseous CO_2; 3 - liquid water solution. Dolni Bory. Magnification 45X.

25. Three-phased inclusion in quartz. Phases are indicated as on photo 24. Zlaté Hory. Magnification 355X.

BENY, Claire, GUILHAUMOU, Nicole and TOURAY, J.-C., 1981, Fluid inclusions in the H_2O-NaCl-CO_2-H_2S-S system in quartz and fluorite from Siera de Lujar (Granada, Spain); microthermometry and Raman microprobe data: C.R. Acad. Sc. Paris, v. 292, Serie II, p. 797 (in French; English abstract).

Microprobe analysis by Raman scattering spectrometry of multiphase fluid inclusions.

Native sulfur was identified as "daughter mineral." CH_4 was not detected. CO_2 and H_2S were analyzed in the gas bubble, in the aqueous phase and in an expandable liquid immiscible with water (H_2S/CO_2 mole ratio from 0,1 to 0,3). This liquid and the gas phase homogenize between +28°C to +40°C. There is a positive correlation between this temperature and the H_2S/CO_2 mole ratio, reflecting the higher critical temperature of H_2S(+100, 4°C) when compared to CO_2(+31, 1°C). (Authors' abstract)

BERDNIKOV, N.V. and KARSAKOV, L.P., 1981, Metamorphic inclusions in minerals of rocks of granulite facies from massif Khanka: Akad. Nauk SSSR Doklady, v. 259, no. 5, p. 1172-1175 (in Russian). Authors at Inst. Tectonics and Geophysics of Far-East Sci. Center of Acad. Sci. USSR, Khabarovsk.

Granulite complex consists of gneisses, quartzites, metamorphosed basic and carbonate rocks and granitoids. Mineral parageneses of gneisses belong to garnet-cordierite-biotite and biotite-sillimanite stages of metamorphism; by garnet-biotite geothermobarometer P was determined to be 5×10^8 to 6×10^8 Pa, T to be 750-820°C. Metamorphic inclusions in quartz of garnet-sillimanite-cordierite quartzite, schist and gneiss, are one phase LCO_2 (5-7 µm in size), PS type and P type, triple point close to -56.6°C. Post-metamorphic inclusions of LH_2O ± halite dm and other filled by GCO_2 were also found, but not studied. LCO_2 inclusions have Th from -36 to +18°C (specific volumes 0.91 to 1.25 cm^3 per g). The most dense LCO_2 inclusions could not form under the P and T specified above, but most probably at 900-1000°C and 8.0×10^8 to 9.5×10^8 Pa. Inclusions LCO_2 with specific vol. of 0.97-1.10 cm^3 g formed at conditions found by garnet-biotite method, and those with 1.10 to 1.25 cm^3/g - during retrograde metamorphism at 650-750°C and 2.8×10^8 to 4.5×10^8 Pa. A part of LCO_2 inclusions has triple point -58 to -62.5°C, suggesting CH_4 admixture in inclusion fluid. (Abstract by A.K.)

BERDNIKOV, N.V. and PRIHOD'KO, V.S., 1981, Carbon dioxide degassing of alkaline-basaltoid magmas: Akad. Nauk SSSR Doklady, v. 259, no. 3, p. 708-710 (in Russian). Authors at Inst. Tecton. and Geophys. of Far-East Sci. Center of Acad. Sci. of USSR, Khabarovsk, USSR.

Studies of fluid inclusions in minerals of basaltoids prove that under P $5 \cdot 10^8$ Pa volatiles (mainly CO_2) separate from magmas, i.e. the depth of this process is ~20 km. However, magmas exist also at greater depths. Megacrysts of clinopyroxene found in Neogene-Quaternary alkaline basalts of Soviet Far-East formed under P $10 \cdot 10^8$ Pa (depth ~35 km), as appears from calculations and experimental data. The inclusions found bear LCO_2 (triple point -56.6°C); external zones of megacrysts also contain inclusions of water solutions in healed fractures. P LCO_2 inclusions have Th from -28.5 to -30.5°C, other LCO_2 inclusions are PS with Th -22 to -31°C and +13 to -20°C. Part of P and PS inclusions has a halo of tiny LCO_2 inclusions due to natural decrepitation. On the basis of equation of state of pure CO_2, for T of basalt magma 1300-1250°C and specific volume of CO_2 0.97-0.93 cm^3/g, P was $10.4 \cdot 10^8$ to $11.2 \cdot 10^8$ Pa for P and early PS inclusions; late PS inclusions yield pressure $6.4 \cdot 10^8$ to $10.4 \cdot 10^8$ Pa. In the beginning of gas separation, CO_2 content in magmas was ≤ 5 mass %. (Abstract by A.K.)

BERGMAN, S.C., 1981, Fluid inclusions in xenoliths: samples of the mantle metasomatic fluid? (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 408. Author at Dept. Geol., Princeton Univ., Princeton, NJ.

All phases in ultramafic nodules from the Lunar Crater Volcanic

Field, Nevada, commonly contain secondary CO_2-rich fluid inclusions, often coexisting with a silicate glass. Typically less than 10 µm, they occur in groups along healed crack surfaces, and form <0.05 vol% of a given nodule. Inclusion shapes range from subspherical to tubular to dendritic, representing varying degrees of host-phase recrystallization.

Microthermometric data on >300 inclusions show that final melting T's (Tm CO_2) range from -56.4 to -57.7±.3°C, while homogenization T's (Th V-L(L)) range from -35.6 to +22.5±.3°C. These phase equilibria indicate that the fluid is CO_2-rich (pure CO_2 melts at -56.6°C) with a density of 0.7-1.1 g/cc. Th varies widely within a given sample and even within a given healed fracture surface. Tm depressions below -56.6° indicate the presence of <10 mole% of an additional species (probably CH_4, CO or N_2). Using pure CO_2 PVT data, these densities correspond to minimum pressures of entrapment of 3-10 kb, at T = 800-1250°C.

The proportion of glass in inclusions along a given healed fracture varies from 0 to 100% indicating that trapping occurred while a CO_2 fluid and silicate melt coexisted as two discrete phases. Microprobe (EDA) compositions of the glass vary widely: (wt% oxide) 40-63 Si, 11-33 Al, 2-7 K, 3-6 Na, 4-14 Ca, .1-14 Fe, .3-23 Mg, .1-3 Ti, .1-6 P. Oxide totals are low (95-99%) and are interpreted as evidence of water in the glass. Experimental work by Boettcher's and Eggler's groups have shown that the CO_2 fluid- and hydrous melt-phases would be miscible at high P. Decompression would allow for the separation of the insoluble CO_2 fluid. Therefore, these inclusions are evidence for a CO_2+H_2O-rich fluid with dissolved silicates at P >15 kb. The glass compositions indicate variable degrees of reaction of the CO_2-H_2O 'solvent' with mantle rocks and post-entrapment crystallization of the host phase. This complex fluid would have physical properties intermediate between a silicate melt and a CO_2-H_2O fluid, would be mobile, and could play an important role in the process of 'mantle metasomatism.' (Author's abstract)

BERNATOWICZ, T.J., 1981, Noble gases in ultramafic xenoliths from San Carlos, Arizona: Contrib. Mineral. Petrol., v. 76, p. 84-91. Author at McDonnell Center for the Space Sci., Washington Univ., St. Louis, MO 63130, USA.

The work reports the results of noble gas (Ne, Ar, Kr, Xe) analyses of accidental mantle xenoliths from San Carlos, Arizona. Except for the addition of radiogenic ^{40}Ar and mass fractionation effects, the isotopic structures of these gases are indistinguishable from atmospheric composition. The absence of ^{129}Xe excesses in these rocks may reflect indirect mixing of atmospheric gases with the source region of the xenoliths. The dominant influence on the noble gas abundances in the San Carlos xenoliths appears to have been diffusive gas loss, which may have occurred in a mantle metamorphic event or during contact with the host basanite magma. Evidence is presented for the partitioning of significant amounts of the heavy noble gases in fluid inclusions in the xenolith minerals; the proportion of each gas in the inclusions increases with increasing atomic weight of the gas, possibly reflecting solubility effects. The noble gases are present in greater concentration in pyroxenes than in olivine, similar to the behavior of other incompatible elements. (Author's abstract)

BESPALOV, V.Ya., 1981 - See Appendix

BIGGAR, G.M., 1981, Electron microprobe analysis of glasses: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 96-98.

BIGGAR, G., 1981, Melting experiments on ocelli and matrix samples from Proterozoic lavas in South-Africa: Bull. de Minéralogie, v. 104, no. 4, p. 369-374.

Pertinent to silicate immiscibility. (E.R.)

BINSTED, N., 1981, The system Ab-Ne-NaCl-H_2O: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 34-36.

BIRD, D.K. and NORTON, D.L., 1981, Theoretical prediction of phase relations among aqueous solutions and minerals: Salton Sea geothermal system: Geochimica et Cosmochim. Acta, v. 45, p. 1479-1493. Authors at Dept. Geosci., Univ. Arizona, Tucson, AZ 85721, U.S.A.

Thermodynamic calculations of compositional relations among aqueous solutions and minerals in the system Na_2O-K_2O-CaO-MgO-Fe_2O_3-Al_2O_3-SiO_2-H_2O-CO_2-HCl at pressures and temperatures corresponding to liquid-vapor equilibrium of H_2O permit quantitative description and interpretation of phase relations among rock forming minerals and aqueous solutions in magma-hydrothermal systems. The extensive data base on the Salton Sea goethermal system provides an exemplary case for predicting the chemical characteristics of geothermal fluids associated with metasomatic mineral zones observed in deep drillhole samples. Near the Elmore No. 1 well aqueous species activity ratios of $a(Na^+)/a(H^+)$ and $a(K^+)/a(H^+)$ vary several tenths of a log unit with increasing depth and temperature from ~0.6 km and ~250°C to ~2.2 km and ~350°C, whereas $a(Ca^{2+})/a^2(H^+)$ decreases ~2 orders of magnitude for a comparable range in depth and temperature. The fugacity of CO_2 gas is ~1.5-6 bars at ≤310°C. Calculated values of $a(SiO_2(aq))$, $a(Na^+)/a(K^+)$, $a(Ca^{2+})/a(Mg^{2+})$, and $f(CO_2(g))$ in the fluid phase coexisting with observed mineralogic phase relations are in remarkably close agreement with measured solute concentrations in geothermal fluids produced from deep drillholes near the Salton Sea.

Hydrolysis reactions representing observed phase relations and written with alkali and alkaline earth cations as products have negative standard molal enthalpies ($\Delta H^o(P,T,r)$ and volumes ($\Delta V^o(P,T,r)$) of reactions; consequently, $a(Na^+)/a(H^+)$, $a(K^+)/a(H^+)$, $a(Ca^{2+})/a^2(H^+)$, and $a(Mg^{2+})/a^2(H^+)$ decrease with increasing temperature at constant pressure, but increase with increasing pressure at constant temperature. An approximate linear relationship exists among these activity ratios and the reciprocal of absolute temperatures because $\Delta H(P,T,r)$ varies only slightly with increasing temperature at ~≤250 to 300°C. However, at ~≥300°C, $\Delta H^o(P,T,r)$ and $\Delta V^o(P,T,r)$ decrease dramatically as a consequence of extrema in the thermodynamic and electrostatic properties of the solvent near the critical region of H_2O. Hence empirical solute geothermometers based on linear regressions of geothermal fluid compositions at ~≤250-300°C cannot be confidently extrapolated to higher temperature systems. (Authors' abstract)

BISCHOFF, J.L., 1980, Geothermal system at 21°N, East Pacific Rise: physical limits on geothermal fluid and role of adiabatic expansion: Science, v. 207, p. 1465-1469. Author at Pacific-Arctic Br. of Marine Geol., U.S. Geol. Survey, Menlo Park, CA 94025.

Pressure-volume-temperature relations for water at the depth of the magma chamber at 21°N on the East Pacific Rise suggest that the maximum subsurface temperature of the geothermal fluid is about 420°C. Both the chemistry of the discharging fluid and thermal balance considerations indicate that the effective water rock ratios in the geothermal system are between 7 and 16. Such low ratios preclude effective metal transport at temperatures below 350°C, but metal solubilization at 400°C and above is effective even at such low ratios. It is proposed that the 420°C fluid ascends essentially adiabatically and in the process expands, cools, and precipitates metal sulfides within the upper few hundred meters of the sea floor and on the sea floor itself. (Author's abstract)

BLANKENBURG, H. and BERGER, H., 1981, Crystallite size in volcanic agates: Chemie der Erde, v. 40, no. 2, p. 139-145 (in German). Authors at Mozartplatz 4, Freiberg 9200, DDR.

Volcanic agate was found to have formed at >375°C, using the Rösler (1978) silica crystallite size thermometer. Authors believe "SiO_2 melt drops relatively rich in H_2O were present in the magma..." (E.R.)

BLATTNER, Peter, 1981, "Halogen geothermometry" and case for post-Devonian granolite in Fiordland, New Zealand: Bull. Minéral., v. 104, p. 811-816. Author at New Zealand Geol. Survey, P.O. Box 30368, Lower Hutt, New Zealand.

Unusually high chlorine levels in minerals genetically tie the Pembroke Granolites of Milford Sound to (1) the nearby but undated Darran Leucogabbro, and (2) the 500 km distant Riwaka Complex of Nelson. The Riwaka rocks occur at a more shallow crustal level than the upthrown (as well as southward shifted) Milford Sound basement, and their relations to fossiliferous and other well dated rocks suggest a post Devonian age of emplacement. A tie between Darran Leucogabbro and Pembroke Granolite seems already probable on the basis of field evidence and petrography. After consideration of halogen distributions between minerals, and "halogen geothermometry," it is shown how a stage of dehydration jointing in the granolite has led to concentration of the chlorine in apatite, which thereby became an indicator of high original whole rock chlorine, capable of surviving subsequent amphibolite facies metamorphism. (Author's abstract)

BLOOM, M.S., 1981, Chemistry of inclusion fluids: stockwork molybdenum deposits from Questa, New Mexico, and Hudson Bay Mountain and Endako, British Columbia: Econ. Geol, v. 76, p. 1906-1920. Author at Dept. Geol. Sci., Univ. British Columbia, Vancouver, British Columbia V6T 2B4, Canada.

Molybdenum mineralization and coextensive alteration in the Questa, Hudson Bay Mountain, and Endako stockwork molybdenum deposits occur in single and composite veinlets which exhibit an ordered sequence of emplacement. Fluid inclusions in the deposits can be classified as liquid-rich types A (liquid + vapor), C (liquid + vapor + halite), D (liquid + vapor + halite + sylvite), and E (H_2O-rich liquid + CO_2-rich liquid + CO_2 vapor) and as a vapor-rich type B. Study of these inclusions in the evolving fracture-controlled alteration-mineralization shows that type D inclusions are found with potassic alteration assemblages and type C inclusions occur with phyllic alteration assemblages.

Salinities are divided into three compositionally distinct groups. Early fluorine-rich biotite-stable alteration at Questa and Hudson Bay

Mountain is associated with hypersaline (40-70% NaCl + KCl) type D inclusions which homogenize most frequently by halite dissolution. Homogenization temperatures uncorrected for pressure range from 320° to >600°C. Type D inclusions from both deposits fall along similar linear compositional trends in the NaCl-KCl-H_2O system regardless of temperature or behavior of homogenization. The bulk of the molybdenite deposition coincides with quartz-sericite-pyrite alteration and with either moderate to high salinity (30-60% NaCl equivalent) type C inclusions, which homogenize by halite dissolution or vapor disappearance, or with low to moderate salinity (5-15% NaCl equivalent) type A inclusions. Evidence for local, intermittent boiling is present throughout the Questa and Hudson Bay Mountain, but not the Endako, hydrothermal systems. Homogenization temperatures for type A and C inclusions vary from 300° to >600°C with definite modes at about 390°C.

The inclusion data are accepted as evidence for evolution from magmatic to meteoric hydrothermal conditions. Hypersaline (type D) solutions were precursors to the actual ore-forming fluids and evolved directly from granitic source intrusions. Fluid reequilibration with the granitic intrusions and/or dissolution of NaCl precipitated by earlier hypersaline solutions along the halite trend are possible origins of the saline type C inclusion fluids. Salinity enhancement by boiling or mixing of hypersaline with meteoric fluids is not supported by the data. Pressures appear to have fluctuated between lithostatic and hydrostatic load, and intermittent overpressures with adiabatic decompression are suggested. (Author's abstract)

BOBROV, A.B., KICHURCHAK, V.M. and BERZENIN, B.Z., 1981, Peculiarities of mineralogy and formation conditions of rare-metal pegmatites: Mineralog. Sbornik, v. 35, no. 1, p. 38-44 (in Russian, English abst.). Authors at the Industrial-Geological United Enterprise "Yluzhukrgeologiya."

Ukrainian Archean amphibole-biotite and biotite gneisses and amphibolites bear veins of gabbroids, diabases, aplite-pegmatoid granites and pegmatites. The pegmatites consist of microcline, oligoclase, albite, quartz and rarer muscovite, tourmaline, spodumene and holmquistite. Inclusions in spodumene are always elongated; the highest T variety is filled by crystals (salts and silicates 45-50 vol. % or more) LH_2O, LCO_2 and G, Th 540-620°C, but some inclusions decrepitated at T $\geqslant$600°C before complete homogenization. Other inclusions in spodumene homogenized at 470-500°C and (S) at 200-310°C. Albite bears similar inclusions, Th 550-620°C and 300-460°C. In quartz G+L ± salt dms inclusions have Th 380-450°C and 120-340°C. Hence, the evolution of the pegmatites probably is as follows: magmatic stage (pegmatitic silicate-salt melts-solutions) T 540-640°C and more; microclinization + formation of secondary spodumene - 470-500°C, albitization 200-460°C, silicification + sericitization - 100-340°C. (Abstract by A.K.)

BODNAR, R.J., 1981, Use of fluid inclusions in mineral exploration: comparison of observed features with theoretical and experimental data on ore genesis (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 412. Author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Ore horizons in epithermal gold-silver deposits are characterized by inclusions trapped from immiscible fluids that generally contain carbon dioxide. Inclusions below the ore zone are water-rich and exhibit uniform phase ratios suggesting entrapment in the one-phase field; those above the ore zone may also have uniform phase ratios or may yield a wide range in homogenization temperatures, indicating entrapment from boiling solutions. Inclusions from above the ore zone are distinguished from similarly-trapped inclusions from below the ore zone by their mode and temperature of carbon dioxide homogenization and complete homogenization and provide a simple method of determining vertical position within the mineralized system.

Favorable characteristics in exploration for porphyry copper mineralization are the presence of halite and chalcopyrite daughter minerals and inclusions which homogenize to the vapor phase. Homogenization temperatures and salinities (other than noting presence or absence of halite daughter minerals) are unimportant from an exploration viewpoint. A quantitative rating system based upon these inclusion features provides highest values in the phyllic zone, lowest values at the outer edge of the propylitic zone and intermediate values in the potassic core, similar to the distribution of copper mineralization within these different alteration zones. Vertical position within the porphyry system is determined from the temporal relations of the various inclusion types. Early, chalcopyrite-bearing, vapor-rich inclusions ± coeval halite-bearing inclusions occur near the fluid source or pluton. Early, vapor-rich inclusions coexisting with low or moderate salinity liquid-rich inclusions ± later halite-bearing inclusions identify samples from a considerable distance above the heat source as predicted by numerical simulation of two-phase flow in one dimension. (Author's abstract)

BOETTCHER, A.L., 1981, Source regions of alkaline volcanoes: a review (abst.): EOS, v. 62, p. 1078. Author at Inst. Geophys. and Planet. Physics, and Dept. Earth and Space Sci., UCLA, Los Angeles, CA 90024.

In the same sense that the origins of anorthosite plutons and komatiites are generally restricted to certain geologic ages and structural settings, the various types of explosive volcanoes can be categorized in terms of provenance and, broadly speaking, age. An obvious example is the association of calc-alkaline volcanism with Cenozoic subduction of oceanic crust. Such associations yield clues to the chemistry of the source regions of the magmas. Alkali basalts and kimberlites occur in regions of epeirogenic doming, but the latter clearly are associated with deep-seated rifting and continental breakup, the former commonly with high-angle faults and possibly related to crustal warping, as in the eastern Mojave Desert. Although alkali flood basalts (low-alkali) have erupted throughout the Phanerozoic, explosive, mantle-xenolith-bearing basalts are largely restricted to the Cenozoic era. With several exceptions, known kimberlites are restricted to post-Jurassic time. The decline in the production of the tholeiitic basalts, reflecting the decrease in terrestrial heat production, is counter to the apparent trend of alkaline magmatism, which reflects increased effects of metasomatism of the mantle by fluids (magmas or aqueous solutions). This is supported by chemical and isotopic studies of the magmas and entrained xenoliths. The nature of these fluids is uncertain, largely because of our ignorance of oxygen fugacity in the mantle. However, studies of the roles of H_2O, CO_2, and other components at high pressures place constraints on the conditions of these processes, and the near absence of magnesian carbonates in deep-seated rocks and the presence of carbon and native metals in kimberlites suggest that CH_4 and other chemically reduced species are important components of metasomatizing solutions. (Author's abstract)

BORAK, Barry and FRIEDMAN, G.M., 1981, Textures of sandstones and carbonate rocks in the world's deepest wells (in excess of 30,000 ft. or 9.1 km): Anadarko Basin, Oklahoma: Sediment Geol., v. 29, p. 133-151. Authors at Dept. Geol., Rensselaer Polytechnic Inst. Troy, NY 12181, U.S.A.

Accelerated exploration in the deep Anadarko Basin has resulted in the need to understand the effects of deep burial at depths in excess of 30,000 ft. (9.1 km) on the textural characteristics of carbonate rocks and sandstones. The textures are not significantly different from diagenetic textures found in similar strata buried to shallower depths within the same basin.

Mean vitrinite reflectance (R_0) values from the Lone Star Bertha Rogers well were plotted versus depth as a means of developing a ranking parameter to characterize the thermal history of the deep Anadarko Basin. Temperatures of 200°C and higher had no apparent effect on the development of diagenetic textures or formation of new minerals, even though these temperatures approach those found in the zone of greenschist facies metamorphism.

Diagenetic textures which developed formed in response to increases in stresses and strains that accompany deep burial. Textures related to the effects of strains in carbonate rocks of the Hunton Group include the development of various kinds of twinning, and the mechanical and multiple displacement along twin planes within single crystals, as well as cataclastic textures, such as granulation and mortar structure.

Among sandstones of the Simpson Group only the development of concavo-convex and sutured boundaries and undulose extinction of quartz grains can be directly related to stresses and strains developed during deep burial.

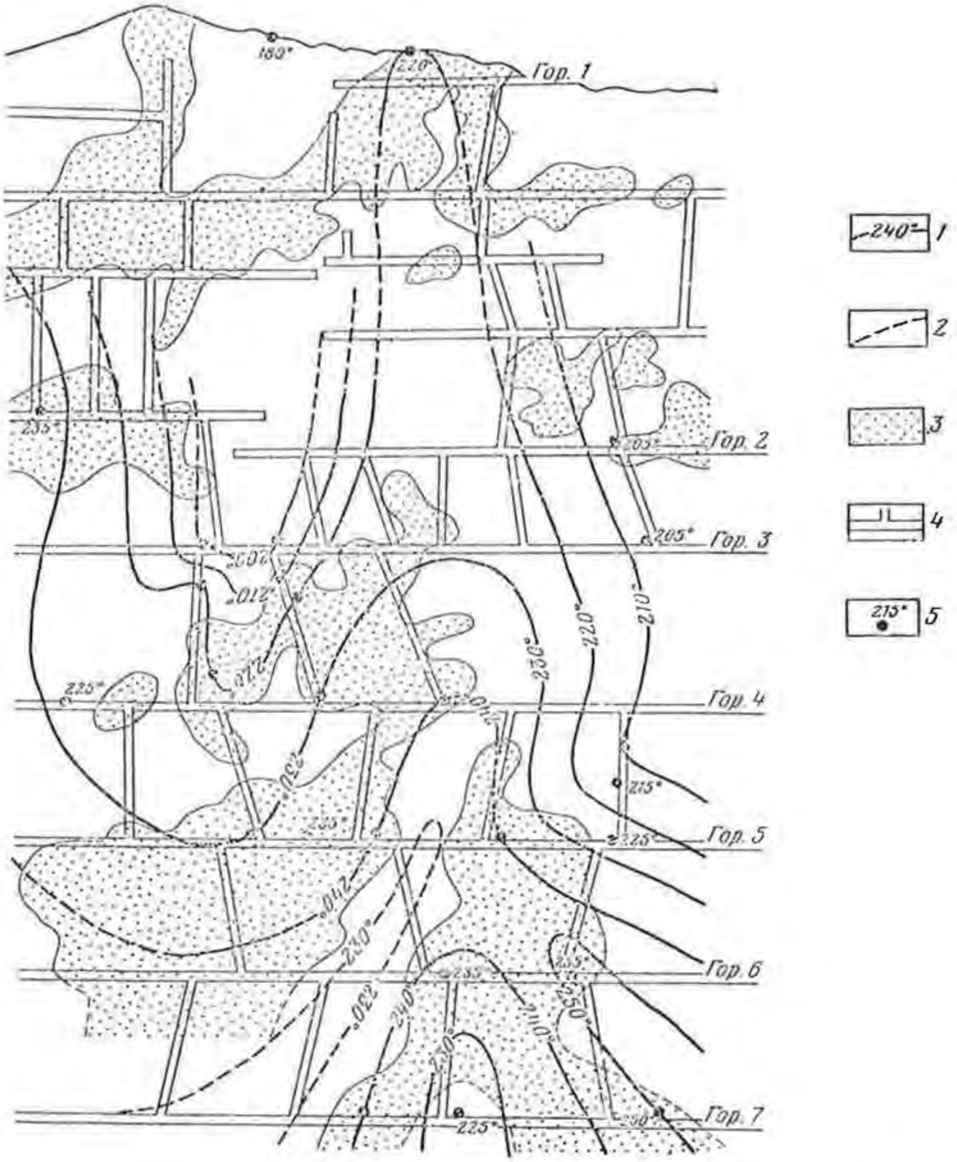
Mechanical adjustment occluded pores. Both limestones and sandstones are tight. (From the authors' abstract)

BORDET et al. - See Appendix

BORTNIKOV, A.Ya., 1981, Temperature regime of formation of quartz-sulfide-huebnerite veins of the deposit Kholoston (Western Transbaikalia): Geol. Rudn. Mest., v. 23, no. 5, p. 115-118 (in Russian). Author at Moscow Geol.-Prosp. Inst., Moscow, USSR.

The deposit occurs as a series of veins in the Dzhida ore field, in Paleozoic intrusion of quartz diorites. Gangue minerals consist of quartz, gilbertite, microcline, fluorite, and ore minerals - huebnerite, pyrite, sphalerite, galena, chalcopyrite, tetrahedrite. The general Th range from 200 to 300°C. The author tried to detect the local variations of mineral formation T; Th were measured mostly in quartz (Th 200-250°C, Td also 200-250°C), plus some determinations in huebnerite (Th 300-350°C) and sphalerite (Th 180-200°C). Sometimes Th in the same vein varies as much as 100°C between hanging and footwalls. Average Th were put in the vertical projection of the vein and isotherms of Th were drawn (Figure 2). Th increases slightly in lower levels of the veins; Th also decreases commonly from the center to the side of the vein. (Abstract by A.K.)

Figure 2. Isotherms of Th of G/L inclusions placed on a vertical projection of vein No. 47; 1 - isotherms found, 2 - isotherms supposed, 3 - vein parts with thickness >1 m, 4 - mining pits, 5 - sampling places. (Continued)



BOSWORTH, William, 1981. Strain-induced preferential dissolution of halite: in G.S. Lister et al, eds., The effect of deformation on rocks: Tectonophysics, v. 78, p. 509-525. Author at Dept. Geol. Sci., State Univ. of New York at Albany, Albany, NY 12222, USA).

Previous experiments on the effect of a fluid phase in deforming rock and rock analogue systems have failed to differentiate between the relative roles of stress and permanent strain in controlling preferential dissolution at fluid-grain boundary interfaces. Experiments are described here in which halite single crystals were loaded under dry conditions, followed by removal of load and immersion of the crystals in brine. A correlation between net dissolution rate and plastic strain of the adjacent crystalline material was then observed at free crystal surfaces. Calculation of the increase in free energy of the solid phase due to deformation indicates that plastic strain should play a greater part in controlling dissolution than elastic strain in the experimental design reported here.

Although pressure gradients or differences in normal stress may dominate over strain energy terms in producing solution transfer or diffusion through disordered phases in natural rock systems, these halite-water experiments demonstrate that caution must be used in interpreting mechanisms from petrographic and other observations of the phenomena now commonly referred to as "pressure solution." (Author's abstract)

BOTTINGA, Y. and RICHET, P., 1981, High pressure and temperature equation of state and calculation of the thermodynamic properties of gaseous carbon dioxide: Am. J. Sci., v. 281, p. 615-660. First author at Univ. de Nice, Parc Valrose, 06030 Nice, France.

A Redlich-Kwong type of equation of state for gaseous CO_2 with a and b being functions of molecular volume is proposed. This equation fits observed PVT data for gaseous CO_2 from -50° to 1000°C and from 1 bar to 10 kb and predicts quite well observed heat capacity values. Geochemically important decarbonation reactions are discussed. Thermodynamic properties of carbon dioxide are calculated and tabulated for temperatures between 400° and 2100°K and pressures up to 50 kb. (Authors' abstract)

BOUCHER, M., BOULANGER, D., SAINTIVES, J.P. and KUNTZ, P., 1980, Lacunae and inclusions in the halite from Valence and Bresse saliferous basins: 5th Symp. on Salt, A.H. Cougan and L. Hauber, eds., Cleveland, The Northern Ohio Geol. Soc., Inc., v. 1, p. 21-30.

To deepen knowledge of the behavior of rock salt used in storage cavities, investigations were carried out on halite crystals. The study is essentially concerned with discontinuities in the rock, that is, with intra- and intercrystalline lacunae and inclusions, their distribution, size, and contents. Study of the contents includes identification of the constituent mono-, bi- or triphase with chlorides, sulphates, sulfides, clays etc. Next a study was undertaken of samples which were tested under different experimental stresses with respect to the existence of these lacunae and inclusions. (Authors' abstract)

BOURCIER, W.L. and BARNES, H.L., 1981, Stabilities of hydrothermal zinc complexes (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 414.

BOURRAT, X., 1980, Fluid inclusion studies and RE analysis in vein fluorites from Beaujolais and Tarn (France): Unpublished mémoire de DEA, Dépt. des Sci. de la Terre, Univ. d'Orléans, 103 pp. (in French).

Thermometric and cryoscopic investigation of fluid inclusions; determination of REE patterns by neutron activation. The data establish differences between the two districts where ore deposition is probably different in age (Trias-Lias in Beaujolais, late Hercynian in Tarn). (Abstract courtesy J.-C. Touray)

BOWERS, T.S. and HELGESON, H.C., 1981, Thermodynamic and geochemical consequences of immiscibility in the system H_2O-CO_2-NaCl (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 414. Authors at Dept. Geol. and Geophy., Univ. California, Berkeley, CA 94720.

Fluid inclusion analyses leave little doubt that solutions containing large concentrations of water, carbon dioxide, 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 addition of 6 wt.% NaCl (relative to NaCl + H_2O) extends the region of immiscibility in the system H_2O-CO_2-NaCl to ~700°C at 500 bars, but only at low CO_2 concentrations. In contrast, addition of 20 wt.% NaCl extends the miscibility gap to ~600°C at 2 kb, even at high concentrations of CO_2. Intrusion of the immiscible region into this high-pressure/temperature environment may have a profound effect on temperatures of equilibration for metamorphic mineral assemblages. 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 PVT data along pseudobinaries for which X_{NaCl}/X_{H_2O} is constant. Isochores were then generated to aid in the interpretation of fluid inclusion data reported by Hendel and Hollister (1981), Crawford and Sisson (1981), and others. Calculated fugacity coefficients were used to assess the compositions of the coexisting immiscible phases. Preliminary calculations indicate that in certain instances intersection of divariant equilibrium curves with the miscibility gap in the system H_2O-CO_2-NaCl may cause the predicted equilibrium temperatures for a given pressure and X_{CO_2}/X_{H_2O} to be more than 50°C lower than would be true if no miscibility gap were encountered by the curves. However, intersection of divariant curves which have steep slopes with the miscibility gap may lower equilibrium temperatures for either H_2O-rich or CO_2-rich fluids by several hundred degrees. In addition, the geometry of both temperature-mole fraction and logarithmic activity diagrams may be altered significantly by the presence of the miscibility gap. (Authors' abstract)

BOYARKIN, A.P., 1981, Thermobarogeochemical studies of the mineral composition of ores and enclosing rocks in siderite and magnesite deposits of the Bashkir meganticlinorium (South Urals): Litol. Polezn. Iskop. 1981, no. 6, p. 118-122 (in Russian). Author at Inst. Geol., Ufa, USSR.

The primary-sedimentary and hydrothermal-metasomatic ore deposits of siderite and magnesite exhibit a vertical thermal zoning in relation to the age of the country rocks. Th of the gas-liq. inclusions is used to det. Tt (120-300°) of ores and the host rocks. Barogeochem. studies indicate that the ores were formed at 4-60 bars. The mineralogical compn. of the ores is described. Recrystn. of the primary-sedimentary material occurred at moderate depths in a reducing medium, with the participation of weakly mineralized metamorphosing NaCl-dominant solns. (C.A. 96,55555x)

BRAME, Simon, 1979, Mineralization near the northeast margin of the Nelson Batholith, southeast British Columbia: Master's thesis, Univ. of Alberta, Edmonton, AB, Canada.

Indexed under fluid inclusions. (E.R.)

BRATUS', M.D., DANISH, V.V. and SVOREN', Y.M., 1981, Hydrocarbon compounds of the Carpathian hydrothermal rock minerals: Dopovidi Akad. Nauk Ukrains'koy RSR, Ser. B: Geol. Khimi. ta Bilogichni Nauki, v. 1981, no. 7, p. 3-6 (in Ukrainian; English summary).

On the basis of studying the thermobaric conditions of trapping, behavior and composition of hydrocarbons in inclusions of hydrothermal minerals it is considered to be possible to find hydrocarbon accumulations in Mesozoic and Cenozoic Carpathian rocks. (Authors' abstract)

BRAY, C.J., 1981, Mineralization, greisenization and kaolinization at Goonbarrow china clay pit, Cornwall, U.K. (abst.): Inst. Mining and Metal., Trans., Sect. B, v. 90, p. 135, 1981.

Goonbarrow, a china clay pit situated within the St. Austell granite china clay region, is the subject of a varied goechemical and isotopic study to determine the mode of genesis of the kaolinite and associated tin/tungsten mineralization. Detailed geological mapping in conjunction with a geochemical study of the micas indicated that Goonbarrow is situated at the junction of two petrographically distinct phases of the St. Austell granite. An unusual asymmetric curved feldspar-crystal pegmatite is found at the junction. Elvans at Goonbarrow and three other locations within the St. Austell granite are shown to be intruded during hydrothermal activity and in some cases after major vein formation. Three main types of vein were recognized in Goonbarrow, the major ones being spatially associated with zones of kaolinized granite. A potassium/argon age study showed that the granites, pegmatite and greisens (and by inference tin/tungsten mineralization) were formed at about 280 ± 10 m.y. Four elvans, including Goonbarrow, were dated at around 272 m.y. Three of these elvans crosscut major vein swarms. Age determinations on fine grained muscovite produced predominantly during kaolinization and several kaolinized potassium feldspars also gave Hercynian ages. Scanning-electron microscopy studies on daughter minerals in fluid inclusions indicated the presence of Al, As, Ca, Cl, Cu, Fe, K, Mg, Mn, Na, S, Sn and Zn, although many of these elements were not present in minerals in the pit. Temperatures, pressures and salinities of vein fluids were determined by conventional fluid inclusion studies, which also indicated that the veins were boiling. Hydrogen and oxygen iosotope studies on vein quartz and greisen muscovites coupled with a reinterpretation of previous work and the fluid inclusion study produced a new model for the genesis of Cornish china clay. Kaolinite genesis from the vapor phase of hot boiling fluids intimately associated with greisen bordered quartz/tourmaline veins of Hercynian age is favored. (Author's abstract)

BRAY, C.J., SPOONER, E.T.C. and WESOLOWSKI, David, 1981, Sheeted vein Sn-W mineralization and greisenization associated with economic kaolinization, Goonbarrow china clay pit, St. Austell, Cornwall, England (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 416. First author at Dept. Geol., Univ. Toronto, Toronto, Ontario, Canada, M5S 1A1.

The Goonbarow china clay pit contains elongate zones of intensely kaolinized S-type granite (~12 wt.% kaolinite) which occur spatially associated with 50-150m wide swarms of steeply dipping, sub-parallel greisen bordered quartz-tourmaline ± cassiterite ± wolframite veins. Typical vein widths and inter-vein spacings are 1-20 cm and 1-8m respectively.

Aqueous liquid and vapor phases coexisted during mineralization either through boiling or condensation since highly saline (6-48 wt.% equiv. NaCl) inclusions containing up to 6 optically visible daughter crystals, which homogenize into the liquid phase, coexist with vapor rich inclusions which homogenize into the gaseous phase. Microthermometry indicates that hydrothermal activity occurred at 140°C - 480°C at a depth of 1.7-2km. Energy dispersive electron probe analysis of daughter crystals in opened inclusions detected Cu, Zn, As and S as well as Na, K, Mg, Ca, Al, Mn, Fe, Sn and Cl. The first 4 elements do not occur in the Sn-W zone observed, but are characteristic of higher levels of the vertical mineral zonation which occurs in S.W. England. H and O isotope ratios of vein quartz, greisen muscovite and kaolinite suggest that the hydrothermal liquid and coexisting vapor had a significant magmatic component. An unusual finding is that the δD values (16) of the H_2O released from inclusions in vein quartz span a large range from -14 to -34‰, whereas fluid $\delta^{18}O$ values (8) calculated from quartz define a tight range of 0.8‰. The combined information suggests that kaolinization resulted from interaction of highly penetrative, low salinity steam, and condensate, with the feldspars in the enclosing granite. (Authors' abstract)

BROOKS, J., ed., 1981, Organic maturation studies and fossil fuel exploration: Academic Press (London), 441 pp.

Contains 25 articles covering many aspects of organic maturation and the analysis of organic materials pertinent to organic inclusion studies. (E.R.)

BROWNE, P.R.L., 1981, Hydrothermal alteration of rocks at the Ngawha geothermal system, New Zealand: Chapter in New Zealand D.S.I.R. Geothermal Report, Number 7.

The active geothermal system at Ngawha, New Zealand occurs in Tertiary and Mesozoic greywackes and argillites. Alteration of the sediments is of two types: a) veining, which comprises quartz, calcite, chlorite, illite, K-feldspar, pyrite, pyrrhotite, hematite, epidote-clinozoisite, prehnite and pumpellyite and (b) phyllosilicate alteration, in which "fresh" rock chlorite and illite are altered in a retrograde manner by hydration and the development of interlayering, producing randomly interstratified illite-montmorillonite, montmorillonite-chlorite, montmorillonite, interlayered chlorite-illite and a more hydrated type of illite.

Borehole discharged fluids are mainly of a neutral, dilute (~2000 ppm) NaCl type with high B (up to 1000 ppm). Gases comprise about 1.0 wt % of the total discharge and are predominantly CO_2 (>90%) with trace CH_4, H_2S, H_2, NH_3 and N_2. Hg occurs as a precipitate in surface hot springs.

Fluid inclusion Th from primary and secondary inclusions in quartz and platy calcite crystals range between 190-240°C from depths of 500-1000 m.

Comparison with measured borehole temps suggest that some areas are now hotter than when the inclusions were trapped while other areas have cooled since inclusion formation. Some zones contain primary vapor-rich inclusions in quartz and suggest that boiling has occurred. (Abstract by J.W. Hedenquist)

BUBACK, M., 1981, Spectroscopic investigations of fluids, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 345-360. Author at Inst. für Physikalische Chemie, Univ. Goettingen, D-34 Goettingen, FRG.

BUCHANAN, L.J., 1981, Precious metal deposits associated with volcanic environments in the southwest, in Relations of tectonics to ore deposits in the southern Cordillera, Dickinson, W.R. and Payne, W.D., eds.: Arizona Geol. Soc. Digest Volume 14, p. 237-262. Author at Fischer-Watt Mining Co., Inc., 550 E. Plumb, Suite 203, Reno, Nevada 89502.

A comparative study of over 60 precious metal vein deposits hosted by volcanics indicates that ubiquitous physico-chemical features relate to the genesis of, and exploration for, these deposits. Host rocks are largely Tertiary calc-alkaline extrusions with hypabyssal intrusions. Andesites are the more common host to ore shoots, however most districts have preore felsic tuffs, volcanogenic sediments, dikes, sills, and plugs. The deposits fill fractures often related to a caldera environment. The veins are vertically zoned from agate and clay near the paleosurface, passing with depth into barren calcite; then quartz and calcite; then quartz, calcite, adularia and precious metals; then in deeper levels to quartz, adularia and base metals. The interface between the upper precious metals and the lower base metals is a level of episodic boiling of the fluids. At this level, CO_2 and H_2S are released to the vapor phase, pH rises in the remaining fluid, temperature drops slightly, and $f(O_2)$ increases. These results of boiling cause first the base metals, then the silver sulfide, and later the gold to deposit in a well-recognized temporal and vertical sequence. Episodic sealing of the fracture system, followed by episodic refracturing causes episodic boiling and mineral deposition at depths greater than hydrostatic conditions would allow, and yields the intra-mineralization brecciation and banded vein fillings so often observed in epithermal deposits. A low pH alteration assemblage, genetically related to the precious metal deposition, is nearly always present. This assemblage extends from the base of the precious metal ore horizon to the paleosurface, thus it serves as an excellent guide to non-outcropping ore shoots. (Author's abstract)

Contains an extensive (13-page) table (1), including fluid inclusion data for boiling in many. (E.R.)

BUCHANAN, L.J. de VIVO, B., KRAMER, A.K. and LIMA, A., 1981, Fluid inclusion study of the Fiumarella barite deposit (Catanzaro - S. Italy): Mineral Deposita, v. 16, p. 215-226. First author at Colorado Sch. of Mines, Geol. Dept., Golden, CO 80401, USA.

Samples from a barite vein deposit, located in the Catanzaro Fiumarella (Calabria) were examined by fluid inclusion and ore minerographic techniques. The barite vein occurs in plutonic rocks of the Stilo Unit, where some Mo mineralizations were reported. The purpose of the study was to determine the characteristics of the fluid inclusions and to compare them to those of typical porphyry Cu/Mo systems. The ore minerographic study shows that the sulfides, associated to the barite, are clearly post-barite. The fluid inclusion results indicate that the average minimum temperature of the barite formation can be assumed to be about 210°C, with a range of 190-235°C. The salinity of the barite forming solutions is in the range 0-19.5 wt% NaCl and the average minimum pressure on the system was of 18.04 bars equivalent to a minimum depth of 201 m of barite formation below the paleowatertable. No genetic link is suggested to exist between the fluid inclusions of the Fiumarella barite deposit and those characteristic of typical porphyry Cu/Mo systems, whereas a close relation with epithermal precious metal (with base metals) vein deposits or with their distant cousins, the Kuroko deposits, is suggested to exist. (Authors' abstract)

BUNTIKOVA et al. - See Appendix

BURNHAM, C.W., 1981, The nature of multicomponent aluminosilicate melts, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 197-230. Author at Dept. Geosci., The Pennsylvania

State Univ., University Park, PA 16802, USA.

BURRUSS, R.C., 1981, Hydrocarbon fluid inclusions in studies of sedimentary diagenesis, Chapter 6, pp. 138-156, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 6 Contents

BURRUSS, R.C., 1981, Analyisis of phase equilibria in C-O-H-S fluid inclusions, Chapter 3, pp. 39-74, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology, Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 3 Contents

BURRUSS, R.C., 1981, Analysis of fluid inclusions: phase equilibria at constant volume: Am. J. Sci., v. 281, 1981, p. 1104-1126. Author at Gulf Sc. and Tech. Co., P.O. Drawer 2038, Pittsburgh, PA 15230.

The assumption that a fluid inclusion has constant volume allows the composition and density of the inclusion to be deduced from univariant phase transitions observed with a cooling and heating stage microscope. The analysis of phase transitions is based on a generalized thermodynamic framework employing the Helmholtz free energy variables: volume, temperature, and composition. The technique is illustrated with the phase behavior of the CO_2-CH_4 and CO_2-H_2O binary systems. Observations of inconsistencies between the behavior of model binary systems and natural inclusions allow deduction of the presence of additional components. With judicious use of experimentally determined PVT properties and phase equilibria, inclusions as complex as the quaternary CO_2-CH_4-H_2O-NaCl system can be analyzed. (Author's abstract)

BURRUSS, R.C., CERCONE, K.R. and HARRIS, P.M., 1981, Timing of fracturing and oil migration, Oman Foredeep: evidence from fluid inclusions and burial history analysis (abst.): Geol. Assoc. Canada/Mineral. Assoc. Canada Abstracts, v. 6, p. A-7.

Shuaiba (lower Aptian) and Mauddud (upper Aptian-lower Cenomanian) reservoir limestones in Oman and the United Arab Emirates are bioturbated, argillaceous foraminiferal-peloidal wackestones and packstones. Shallow water deposition ceased in the Late Cretaceous as the Oman Foredeep rapidly subsided and filled with pelagic sediments. Burial history analysis indicates diagenesis, fracturing, and fluid migration occurred in five stages: (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 0-800 m, Coniacian to early Campanian: fractures crosscutting Stage 2 fractures are healed with cloudy, cleaved and sometimes twinned calcite containing dull-blue fluorescent, hydrocarbon fluid inclusions; (4) rapid subsidence and filling with 600-3400 m 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 Mtns. after 3900+ m burial by early Tertiary: fractures crosscutting all diagenetic features are filled with clear untwinned and uncleaved calcite containing only non-fluorescent, aqueous fluid inclusions. Correlation of earliest stylolite formation with minimum burial load of ~800 m requires hydrocarbon inclusions in Stage 2 fractures to predate all of Stage 4 and most of Stage 3. This limits oil migration (yellow fluorescent inclusions) to late Turonian-early Campanian time. The necessary depths of burial for potential source rocks to generate and expell oil during Stage 2 time requires them to be pre-Cretaceous in age. (Authors' abstract)

BURT, D.M., SHERIDAN, M.F. and CHRISTIANSEN, E.H., 1981, The relation of topaz-rhyolite lavas to porphyry molybdenum deposits (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 420.

BYLINO, L.V., NESTEROVA, T.Ya. and EVTUSHENKO, E.A., 1981, Gas content of evaporite rocks of a second potassium horizon of a mine field IV RV of the Starobinsk deposit: Deposited Doc. 1981, SPSTL 256 khp-D81, 9 pp. (in Russian).

H_2, He, N_2, CH_4, and CO contents are given of microinclusion gases in sylvinite and halite beds of the 2nd K-salt horizon in the Starobinsk deposit. In zones of replacement of sylvinite by halite, the rock salt beds have gases distinctly different in compn. from those of primarily pptd. halite beds. High H_2 and He contents are characteristic for the upper and lower sylvinite beds. These sylvinite beds contain microinclusion CH_4 contents of 0.012-0.0674 mL/kg, whereas microinclusion gases of intermediate and underlying halite beds have only traces of CH_4. (C.A. 97,166363y) (Authors' abstract)

BYRNE, P.A. and STOESSELL, R.K., 1981, Methane solubilities in chloride and sulfate brines (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 421.

CANDELA, P.A. and HOLLAND, H.D., 1981, Cu and Mo in silicate melt-aqueous fluid systems (abst.): EOS, v. 62, p. 413. Authors at Dept. Geol. Sci., Harvard Univ., Cambridge, MA 02138.

Coefficients for the partitioning of Cu and Mo between simple silicate melts and Cl-bearing aqueous fluids have been measured. The experiments were conducted at 750°C and 1.4 kb in a 1/2 inch ID, rapid quench, cold seal pressure vessel. The concentation of Cu and Mo in the final glasses is between 5 and 100 ppm. The aqueous and glass phase run products were analyzed by AAS and ion microprobe, respectively. The preliminary data show that Cu is chloride complexed and Mo is not. The Mo is probably present as a molybdate species. The ratio (D) of the concentration of Cu in the aqueous phase to Cu in the melt is given by $D = 2m_{Cl}^2$ and $D_{Mo} = 3$. Equations have been derived which express the Mo/Cu ratio of a fractionating aqueous phase as a function of such parameters as the initial chloride and water content of the melt and the fractionation of ore metal bearing minerals. The calculations suggest that the Mo/Cu ratio in the aqueous phase: 1) increases in later fractions of this phase at high initial water contents of the melt; 2) decreases at low initial water contents; and 3) decreases as the initial chloride content of the melt increases. As a melt with a higher water content saturates with an aqueous phase at a deeper level, the Mo/Cu ratio of the aqueous phase should be related to depth of water saturation of the melt. Other factors include the degree of fractionation of the parental magma, and the fraction of the melt crystallized before saturation with an aqueous phase. (Authors' abstract)

CANDELA, P.A. and HOLLAND, H.D., 1981, The effect of fluorine on the partitioning of molybdenum between a magma and a hydrothermal fluid (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 422.

CAO, Junchen, WU, Daqing, SHI, Jixi and LI, Benchao, 1981, The genesis and crystallization properties of the gypsum miarolitic cavity in Qing Long Sb mine, Guizhou Province, China: Geochimica, 1981, no. 4, p. 373-380 (in Chinese; English abstract).

A hugh interformational gypsum miarolitic cavity has been found in an antimony mine. Four crystallization steps are recognized for mineral crystals in the miarolitic cavity. Gypsum crystals seem to have been formed through two forms of crystallization. The data on fluid inclusions and hydrogen isotopes show that this cavity is the product of a hypergene process, the orebearing solution is derived from meteoric water, and the compositional material comes from the oxidized ore zone.

During the formation of the miarolitic cavity, the pH-value was in the range 4-5, i.e., weakly acidic solution, and the formation temperature less than 50°C. It can be clearly seen from the crystallization behavior of gypsum crystals and the mineral association that there have taken place significant changes in the pH-value of mineralization solution. (Authors' abstract)

CAPUANO, R.M. and COLE, D.R., 1981, Fluid-mineral equilibria in a hydrothermal system, Roosevelt Hot Springs, Utah (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 422.

CARSWELL, D.A., 1980, Mantle derived lherzolite nodules associated with kimberlite, carbonatite and basalt magmatism: A review: Lithos, v. 13,

p. 121-138.

All lherzolite nodules yield sub-solidus P/T equilibration estimates and are interpreted as fragments of upper mantle wall rocks incorporated during the volatile charged eruptions. Depths of derivation increase from <60 kms for most nodules in alkali basaltic magmas to >150 kms for some nodules in kimberlites. (From the author's abstract)

CASADEVALL, Tom, GREENLAND, Paul and FURUKAWA, Bruce, 1981, Gas studies of the March 10-12, 1980, intrusion of Kilauea Volcano, Hawaii (abst.). EOS, v. 62, p. 1072.

CASADEVALL, T., ROSE, W., Jr., GREENLAND, P., EWERT, J. and WUNDERMAN, R., 1981, Gas emissions from Mount St. Helens, Washington: constraints on a model for behavior of magma in the near-surface environment (abst.): EOS, v. 62, p. 1088. Authors at U.S. Geol. Survey, Vancouver, WA 98663.

Analyses of gas samples from fumaroles (temp. = 450-830°C) within the crater at Mount St. Helens indicate that the ratio of CO_2 to CO has increased from 170±30 during September 1980-January 1981 to 550±100 in August 1981. Also, whereas H_2S exceeded SO_2 in the same samples in September 1980, the reverse was true in sample collections made during May-August 1981.

Maximum emissions of SO_2 and CO_2 as detected by airborne measurements occurred in July 1980. During July 1980-August 1981 the average daily emissions have steadily decreased from 1,500 to 160 t/d (tons per day) SO_2 and from 12,000 to 800 t/d CO_2. We suggest that this decrease reflects the degassing of a magma body intruded during March-June 1980 at shallow depth, probably within the volcanic edifice itself.

Rates of gas emissions have changed before both explosive and nonexplosive eruptions. Prior to explosive eruptions CO_2 emission has decreased significantly whereas SO_2 emission has remained essentially constant. This pattern is interpreted to reflect an increase of gas pressure due to temporary sealing of the magma chamber. Before nonexplosive eruptions the rate of SO_2 emission has increased. This pattern is interpreted to reflect increased outgassing of a slowly rising magma body.

The volume of magma (0.3 km^3) required to produce the volume of sulfur outgassed through August 1981 is more than three times the volume of magma erupted since May 18, 1980 (0.1 km^3). Changing chemistry and volume of gas emissions suggest that the magma remaining in the edifice is largely outgassed, at least with respect to sulfur. The magma body which has fed the eruptions since June 1980 is probably a remnant from an intrusion during March-June 1980 located at shallow depth (0.5 to 2 km) within the volcanic edifice. Large increases in gas emissions such as might accompany a freshly outgassing pod of magma ascending toward the surface from greater depth have not been seen. (Authors' abstract)

CATHLES, L.M. and SMITH, A.T., 1981, The effects of compaction-driven fluid flow on the thermal history of basins (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 424.

CHAMPIGNY, N., 1981, A geological evaluation of the Cinola (Specogna) gold deposit, Queen Charlotte Islands, B.C.: M.S. thesis, Univ. of British Columbia, Vancouver, BC, Canada, 199 pp.

Indexed under fluid inclusions. (E.R.)

CHAMPNESS, P.E., CLIFF, Graham and LORIMER, G.W., 1981, Quantitative analytical electron microscopy: Bull. Minéral., v. 104, p. 236-240. First author at Dept. Geol., Univ. Manchester, Manchester, M13 9PL, Great Britain.

For a thin specimen X-ray absorption and fluorescence in the specimen can, to a first approximation, be ignored and observed characteristic X-ray intensity ratios, I_A/I_B, can be converted into weight fraction ratios, C_A/C_B by multiplying by a constant, $k_{AB}:C_A/C_B = k_{AB}I_A/I_B$. k_{AB} values can be calculated or determined experimentally. X-ray absorption within the sample must be considered when there is a significant difference in the energy of the characteristic X-rays. Fluorescence effects due to continuum X-rays can be ignored in thin specimens and characterisitc fluorescence is much less than that observed in bulk specimens. Expressions are given for both the absorption and fluorescence corrections.

Beam spreading in an orthopyroxene at 100 kV is calculated using a model based on Rutherford scattering, and this is compared with experimental results. (Authors' abstract)

CHEN, C.-T. A., 1981, Geothermal system at 21°N: Science, v. 211, p. 298.

A critique of Bischoff (1980; this volume) for his assumption that the P-V-T relations of seawater are the same as those for pure water. (E.R.)

CHI, GoGin, 1981, Symposium on the composition of fluid inclusions in minerals: Geochimica, 1981, v. 6, no. 2, p. 184 (in Chinese; translation courtesy Dr. H.-Z. Lu).

A symposium on fluid inclusion composition was held from December 25th to the 30th, 1980, in Peiking. The 86 participants came from the Acadamy of Sciences, the Ministry of Geology, the Ministry of Metallurgy, the Second Ministry of Mechanics, the Ministry of Education, the Ministry of Chemical Industry and others, a total representing 46 administrative units. 48 papers were presented by 31 participants at the meeting. The reports cover the state of fluid inclusion composition research in PRC and abroad, the analytical methods of inclusion composition (gaseous, liquid and solid phases), research on the freezing methods for gaseous, liquid and solid phases, the application of the results of stable isotopes and fluid inclusion composition to diagenesis, mineral and ore formation, and geological prospecting.

The future tasks of fluid inclusion composition research were discussed during the meeting are as follows:

1. to strengthen the research of the fundamental theories of fluid inclusion composition;
2. to apply the results of inclusion research to diagenetic, mineral and ore formation and geological prospecting;
3. to develop microscopical techniques of fluid inclusion research and to develop research techniques related to stable isotopes and glass inclusion composition;
4. to establish a series of fluid inclusion standard samples.

Note - See also Acad. Sinica, 1981, this volume. (E.R.)

CHIVAS, A.R., 1981, Geochemical evidence for magmatic fluids in porphyry copper mineralization: Part I. Mafic silicates from the Koloula Igneous Complex: Contrib. Mineral. Petrol., v. 78, p. 389-403. Author at Res. Sch. Earth Sci., The Australian Natl. Univ., Canberra, ACT 2600, Australia. (Continued)

The Koloula Igneous Complex comprises 26 different intrusive phases that have been divided into two major magmatic episodes - cycle 1 intrusions (≥4.5 Ma) and cycle 2 intrusions (2.4 to 1.5 Ma). The cycle 2 intrusions are further divided into the Inamumu Zoned Pluton (IZP) which is composed of 6 concentrically disposed quartz diorite and tonalite units; and several satellite intrusions. The IZP is host to porphyry-copper mineralization, whereas the cycle 1, and cycle 2 satellite intrusions are barren. Presently exposed mineralization in the IZP (A system) represents the deeply eroded core of a porphyry copper system, where widely-spaced veinlet alteration envelopes (≤1 mm thick) are separated by large volumes of unaltered rock.

Compositional trends in biotites and amphiboles from both individual grains and throughout the differentiation series of the IZP, indicate fluctuating but generally increasing $f(O_2)$ existed through the sequence from early magmatic → late magmatic → early hydrothermal conditions. In amphiboles, compositional domains (Mg-rich) that are indicative of high $f(O_2)$ are correlated with episodes of fluid exsolution, independent evidence of which is provided by multiple generations of fluid inclusions in quartz phenocrysts. These high $f(O_2)$ domains in amphiboles have higher Si, Mn, and Ca contents, but are depleted in Fe, Ti, Na, K, and Cl relative to the less "oxidizing" domains. The latter elements are those that are known from veinlet alteration assemblages and fluid-inclusion evidence to have been preferentially partitioned into the co-existing fluid phase (≈"late magmatic" hydrothermal solution).

By contrast, amphiboles from barren rock types that are slightly older than, and of the same age as the IZP, exhibit restricted compositional ranges, and are more Fe-rich. Some individual grains and two cycle 2 satellite intrusions indicate Fe-enrichment during progressive crystallization. Siliceous deuteric amphiboles are commonly as Mg-rich as the high $f(O_2)$ amphibole domains from the IZP, but are easily distinguished from them by their lack of smooth compositional trends versus Si, and by their highly variable Mg and Fe contents.

Biotites from the IZP also indicate progressive oxidation, whereas biotites from the barren rock types show either little compositional variation or progressive Fe-enrichment. Biotites from the barren intrusions are richer in Cl, Li and Rb and poorer in Ba than those of the mineralizing intrusions. fHF was very low (~0.003 bars) in both barren and mineralizing intrusions. During progressive differentiation, Rb content decreased and Ba content increased in IZP biotites, which is atypical, yet explicable owing to the former presence of a competing fluid phase during biotite crystallization.

Because $f(O_2)$ is a function of degree of fluid exsolution, then in igneous systems with sufficient Cu, Cl, and ultimately S, progressively higher $f(O_2)$ should potentially lead to more mineralized intrusions. Higher $f(O_2)$ is reflected by steeper ΣFe versus Si gradients in amphibole domains. Indeed, such a graph for amphiboles from 5 igneous complexes indicates that two economically mineralized units produced steeper ΣFe:Si than those from weakly mineralized intrusions. Steep ΣFe:Si trends that do not continue to amphibole domains more siliceous than Si=7.3 (atoms per 23 oxygens) are unlikely to have resulted from subsolidus crystallization and these intrusions are unlikely to be strongly mineralized. (Author's abstract)

CHOU, I.-M. and EUGSTER, H.P., 1981, DTA studies of the phase relations in the system H_2O-NaCl-KCl at elevated P and T (abst.): EOS, v. 62, p. 410.

First author at U.S. Geol. Survey, 959 National Center, Reston, VA 22092.

The phase relations in the system H_2O-NaCl-KCl have been studied at P-T conditions as high as 2Kb-850°C by differential thermal analysis (DTA). A sample of fixed composition was sealed in a reentrant Pt capsule and placed in conventional cold-seal pressure vessel (fig. 1). The sample temperature (T) and the differential temperature (ΔT) were monitored during heating and cooling cycles, while constant total pressure was maintained by connecting the pressure vessel to a large reservoir. The relationship between phase boundaries and ΔT signals was established by using published data on 1-atm phase equilibria for the NaCl-KCl binary system. The results indicate no significant effect of supercooling or superheating in our experiments. The liquidus temperatures for the compositions of 66.62, 82.26, and 90.41 wt% NaCl in the H_2O-NaCl system have been measured at 1 (562, 678, 744°C), 1.5 (568, 687, 754°C), and 2 (579, 690, 761°C) Kb. The isopleths of these liquidus temperatures in P-T space, when extrapolated to the halite-liquid-vapor surface, do not agree with Keevil's (J. Am. Chem. Soc. 64, 1942) data. The discrepancies might be due to corrosion problem in Keevil's experiment.

DTA has proved to be an efficient and accurate method for determination of phase equilibria in H_2O-salts systems. The information on phase relations in the H_2O-NaCl-KCl system will make it possible for ore quantitative interpretations of the physico-chemical conditions for mineral deposition through the fluid-inclusion studies. (Authors' abstract)

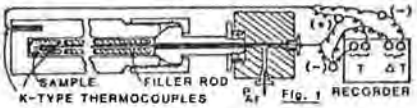


Fig. 1

CHRISTIE, A.B., 1981, Geochemistry of precious and base metal mineralizations of Great Barrier Island and the Coromandel Peninsula: Abstracts from 1981 New Zealand Geochem. Group Conf., Inst. Nuclear Sci., Lower Hutt, New Zealand, 23 Sept. 81, p. 13-14. Author at Geol. Dept., Victoria Univ. of Wellington.

The Cenozoic vein type mineralizations of Great Barrier Island and the Coromandel Peninsula exhibit a time-depth-temperature mineral zonation as follows: (1) Cu, (2) Pb-Zn-Cu, (3) Pb-Zn-Cu-Au-Ag, (4) Cu-Sb, (5) Au-Ag, (6) Ba, (7) Sb and (8) Hg.

Fluid inclusions trapped in quartz and calcite gangue minerals, at the time of mineralization, contain 0-1 molal mixed sodium and potassium chloride solutions and up to 2 mole percent CO_2. Potassium concentrations determined by fluid inclusion analyses together with vein and wall rock mineralogical evidence are used to determine the pH, sulphur fugacity and oxygen fugacity at the time of mineralization. From this data it is evident that in most deposits main stage mineralizations were precipitated from fluids containing approximately equal proportions of oxidized and reduced sulphur species.

Sulphur isotope ratios of sulphide and sulphate minerals suggest two sources of sulphur: magmatic SO_2 and Mesozoic sedimentary sulphate.

The hydrogen isotope ratios of fluid inclusion waters analyzed from a few deposits are similar to present day meteoric and geothermal waters of the area. (Author's abstract)

CLARK, M.E. and PHILLIPS, G.N., 1981 Conditions of gold deposition, Mt. Charlotte, Kalgoorlie, Western Australia (abst): Geol. Soc. Australia, Abstracts, no. 3, p. 69-70. First author at Western Mining Corp., Ltd., Kambalda, Western Australia.

The Mt. Charlotte deposit, Kalgoorlie, Western Australia, is a stockwork of quartz veins with gold-bearing alteration selvages, in an Archaean greenstone belt. Fluid flow during mineralization and the properties of the ore fluid have been investigated from a study of vein structures, fluid inclusions in vein quartz and alteration assemblages.

Mineralized veins developed as extension fractures during oblique faulting and post-date regional folding and metamorphism. Veining is restricted to an Fe-rich granophyric zone of a differentiated tholeiitic metadolerite, the Golden Mile Dolerite. Vein structures indicate fractures were produced by hydraulic fracturing which was limited to the relatively brittle granophyric zone.

Three stages of vein development are recognized. Relative volumes and mineralogy of these stages are: Stage 1 (2%), quartz-ankerite-calcite-pyrite; Stage 2 (97%), quartz-pyrite (pyrrhotite)-sericite-calcite-scheelite; Stage 3 (1%), quartz-pyrite chlorite-calcite. Stages 1 and 2 are associated with gold-bearing alteration assemblages of quartz-pyrite-sericite-ankerite-siderite-calcite.

Stages 1 and 2 were deposited from a supercritical fluid containing 20-30 mol % CO_2 and less than 4 wt % dissolved salts. Homogenization temperatures for Stage 1 inclusions are 340-360°C and 295-320°C for Stages 2 and 3. Indicated fluid pressures of 1.2-2 kb imply that Stages 1 and 2 were deposited at 360-440°C. The ore fluid was near-neutral to slightly acid (pH = 5.3 ± 0.6) and relatively reduced ($m(\Sigma s) = 0.02$ molal, $a(O_2) \sim 10^{-27}$, $a(S_2) \sim 10^{-7}$).

The data are consistent with an ore fluid derived during low- to medium-grade metamorphism of a dominantly mafic pile. Gold transport as chloride complexes would be negligible under the indicated conditions but gold thio-sulphide complexes ($Au(HS)_2^-$) could account for significant gold transport.

It is proposed that increasing pore-fluid pressure during rapid post-metamorphic uplift induced hydraulic fracturing during faulting. Cooling of the ore fluid during uplift to temperatures around 400°C would tend to saturate the fluids in $Au(HS)_2^-$. Oxidation of the ore fluid by the wall-rock assemblages is the most likely mechanism for precipitation of gold. (Authors' abstract)

CLAYTON, W.F., 1981, The petrology and geochemistry of the Ben Lomond Granite and associated tin-tungsten mineralization: Unpubl. Hons. Thesis, Univ. Tasmania, 134 pp.

The Rossarden Sn-W deposit (N.E. Tasmania) is a system of quartz veins in metasediments above an aplite cupola of the Ben Lomond Granite. In the quartz cap or contact vein of the cupola, fluid inclusions with the following properties occur:

Inclusion Type	Salinity of aqueous phase, eq.wt.% NaCl	Tm clathrate °C	Th CO_2 °C	Th L °C
Aqueous L + V	0 to 7			210-260
Low density $LCO_2 + LH_2O + V$	0 to 3.4 (?)	8.4 to 11.6	17 to 31 (mode 21 to 24)	350 (to V)
High density $LCO_2 + LH_2O + V$				310-370 (to L)

(Continued)

The quartz has trapped immiscible H_2O- and CO_2-rich fluids, probably coexisting. A pressure estimate from isochores of brine and CO_2-rich fluid is 1.1 to 1.8 kbar. The study also deals with regional geology, granite petrology, petrography and geochemistry and geology of local Sn-W prospects. (Abstract courtesy C.J. Eastoe)

CLOCCHIATTI, Robert, MASSARE, Dominique and JEHANNO, Celestine, 1981, Hydrothermal origin of Zabargad (St. Johns) Red Sea peridot gemstone as proved by their inclusions: Bull. Mineral., v. 104, p. 354-360 (in French with English abstract). First author at ER 45 du C.N.R.S. Lab. de Petrogr. et Volcanol., bat. 504, Univ. Paris XI, 91405 Orsay, France.

The conditions of deposition and nature of the fluid inclusions in olivine gems from Zabargad prove that all the minerals have crystallized by an hydrothermal process which affected the island's principal peridotite body.

Circulation of hypersaline fluids at high temperature (750°-900°C) with abundant volatile elements (CO_2, N_2, Cl, S, H_2O), with low pressure (partial pressure of CO_2 between 0.4 to 0.8 kbar) caused mobilization of the major elements contained in the peridotite; the chemical composition of dms demonstrates this. The same fluids as well as CO_2-saturated silicate liquids, with chemical composition similar to basaltic andesites, characterized "normal" olivines of peridotite. By comparison to fluid inclusions in olivines from Assab peridotite nodules (Erythrea), untouched by hydrothermal processes, we note, in olivines from Zabargad, the absence of carbonic fluids with high filling density (Assab pCO_2 = 7.5 to 8.3 kbar).

Hydrothermal process responsible for olivine crystallization seems to be associated with the tectonic and magmatic events connected with the first stages of the Red Sea opening. (Authors' abstract)

CLOKE, P.L., 1981, Prediction of NaCl-KCl solvus; ΔH(mixing), (Na,K)Cl and ΔH(mixing) diopside-clinoenstatite (abst.): EOS, v. 62, p. 1069.

CLYNNE, M.A., CHOU, I.-M. and HAAS, J.L., Jr., 1981, $SrCl_2$ solubility in complex brines: Sci. Basis for Nuclear Waste Management, v. 3, J.G. Moore, ed.: Plenum Press, N.Y., p. 499-506. First author at U.S. Geol. Survey, Menlo Park, CA 94025.

Work done because of significance of nuclear waste Sr solubility in brines from repository sites in salt, but also pertinent to the geochemistry of natural Sr in brine inclusions. (E.R.)

CLYNNE, M.A., POTTER, R.W., II and HAAS, J.L., JR, 1981, Solubility of NaCl in aqueous electrolyte solutions from 10 to 100°C: J. Chem. Eng. Data, v. 26, p. 396-398. First author at U.S. Geol. Survey, Menlo Park, CA 94025.

The solubilities of NaCl in aqueous KCl, $MgCl_2$, and mixed $CaCl_2$-KCl solutions have been determined from 10 to 100°C. The data were fit to an equation, and the equation was used to calculate values of the change in solubility of NaCl, $\delta[NaCl]/\delta T$. These values are required for calculations of the rate of migration of fluids in a thermal gradient in rock salt. The data obtained here indicate that the values of $\delta[NaCl]/\delta T$ are 36-73% greater for solutions containing divalent ions than for the NaCl-H_2O system. (Authors' abstract)

CLYNNE, M.A., POTTER, R.W., II and WHITE, L.D., 1981, Analytical results of tagged synthetic brine migration experiments at Avery Island, Louisiana: U.S. Geol. Survey Open File Rept. 81-1137, 16 p.

Vapor condensates were collected during experiments attempting to measure brine migration in a thermal gradient in rock salt. From variations in the deuterium concentrations measured in the condensates it is concluded that deuterium from a tagged synthetic brine emplaced in the salt migrated to the heater hole. (Authors' abstract)

COBB, J.C., 1981, Geology and geochemistry of sphalerite in coal: Illinois State Geol. Survey, Contract/Grant Rept. Series 1981-3, May 1981, 204 pp.

Middle Pennsylvanian (Desmoinesian) coals of certain areas of the Illinois and Forest City Basins contain epigenetic sphalerite and associated minerals in veins, clastic dikes, collapse structures, and other small-scale structural features. The mineral assemblage in the sphalerite veins consists of silicates, sulfides, and carbonates. The paragenesis is kaolinite-(quartz?)-pyrite-sphalerite-pyrite-calcite.

The morphology of sphalerite vein walls indicates that banding in the coal had achieved nearly its present stage of development at the time of sphalerite deposition. Sphalerite veins postdate cleats and are often developed in cleats. Some sphalerite deposition was contemporaneous with subsidence of coal into sinkholes. Compactional features in the coal show that from 8 to 14 percent of the compaction in the coal occurred after sphalerite deposition commenced. A relationship between porosity, inherent moisture, and compaction of the host coals suggests that the sub-bituminous (B) rank had been achieved at the time of sphalerite deposition.

Homogenization temperatures for the sphalerite fluid inclusions are nearly identical for the sphalerite from the Illinois and Forest City Basins and range from 75° to 113°C. There is a moderately high correlation coefficient ($r=.75$) between the vitrinite reflectance of the host coals and homogenization temperatures. This data may eliminate the possibility of fluid flow initiated by thermally-produced convection and raises the possibility of convection by compaction and loading of basin sediments. This data and a paleogeothermal gradient of 2.35°C per 100m suggest a maximum depth of sphalerite deposition of 3.9 kilometers and a minimum depth of 2.2 kilometers.

The chemical and isotopic composition of the fluid inclusions are nearly the same for the six coal beds and two coal basins represented suggesting a similar fluid depositing the sphalerites. They are also similar to fluids observed in inclusions from nearby Mississippi Valley-type ore deposits, and bear close resemblance to basinal brines.

The occurrence of sphalerite in coal may record basinal processes that contribute to the genesis of Mississippi Valley-type ore deposits. (Author's abstract)

COLLINS, P.L.F., 1981, The geology and genesis of the Cleveland tin deposit, western Tasmania: fluid inclusion and stable isotope studies: Econ. Geol., v. 76, p. 365-392. Author at Tasmania Geol. Survey, Dept. Mines, G.P.O. Box 124B, Hobart, Tasmania 7001, Australia.

The Cleveland tin-copper deposit comprises several lenses of pyrrhotite-cassiterite-stannite-chalcopyrite mineralization represented by a series of interlayered chert-shale beds and mineralized units occurring within an Early Cambrian succession of spilitic basalt, mafic pyroclastic, argillite, chert, and limestone overlain by a sequence of micaceous turbiditic graywacke and argillite. South and east of the deposit is the Late Devonian Meredith Granite.

Ore paragenesis is divided into four stages with a superimposed mineralogical zonation: (I) quartz + fluorite + wolframite + molybdenite + (cassiterite) as stockwork veins in the footwall rocks; (II) quartz + tourmaline + fluorite + chlorite + pyrrhotite + chalcopyrite + cassiterite + stannite as stratabound lenses parallel to the host rocks, with sphalerite and arsenopyrite common at the extremities of the sulfide lenses and quartz veins with sphalerite, arsenopyrite, chalcopyrite, and galena surrounding the deposit; (III) quartz + arsenopyrite + (stannite) as veins; and (IV) fluroite + carbonate + quartz filling veins and vugs. An extensive alteration halo in the hanging wall of the sulfide lenses is defined by increased replacement of pyroxene by actinolite nearer to the ore, accompanied by an increase in K, Rb, Sn, and Zn and a decrease in Na, but is not reflected by the whole-rock $\delta^{18}O$ values.

Fluid inclusion and stable isotope data reveal a systematic trend in depositional temperatures and a marked consistency in composition of the hydrothermal fluid. Fluids of stages I and II were low to moderately saline (8-14% NaCl), but while stage I fluids were of low CO_2 content, the CO_2 content of stage II fluids was locally high. The CO_2 in stage II fluids was probably derived from dissolution of limestone. The salinity of the fluid decreased slightly to 7 to 11 percent NaCl and was very low in CO_2 during stage IV. Fluid temperatures are estimated at about 480°C for stage I and 500°C for stage II, and 250° to 300°C during stage IV. The calculated $\delta^{18}O$ composition of the water in the hydrothermal fluid was about 8.7 per mil for stage I, 10.2 per mil for stage II, and 9.5 per mil for stage IV. The $\delta^{34}S$ values of the sulfides were near to 0 per mil (-0.2 to +5.5 per mil) throughout the mineralization. The consistent salinity and the isotopic compositions indicate a magmatic source for the mineralizing fluid and a lack of mixing with meteoric water.

The Cleveland deposit originated from the metasomatic replacement of limestone beds by tin-bearing, low to moderately saline fluids of initially low CO_2 content derived from a granitic source related to the Meredith Granite. (Author's abstract)

COOK, S.J. and BOWMAN, J.R., 1981, Fluid inclusion studies of contact Ca-Al-(Fe)-Si skarns at Alta, Utah (abst.): EOS, v. 62, p. 1059. Authors at Dept. Geol. and Geophys., Univ. Utah, Salt Lake City, UT 84112.

Fluid inclusion studies have been made on early stage garnet (Gn) and late stage quartz (Qz) from several multistage contact skarns associated with the Alta stock. Matrix Gn from early Gn + pyroxene (Px) + Qz assemblages typically contain fluid dominated (<30% vapor) multiphase inclusions, with daughter minerals halite, magnetite, hematite, and anhydrite (?). Dissolution temperatures for halite give NaCl salinities from 32 to 39 wt. % with liquid homogenization temperatures ranging from 417 to 481°C. Qz from later stage Qz + epidote + actinolite + calcite assemblages ± magnetite ± chalcopyrite contains predominately two-phase inclusions with vapor <30% by volume. Measured freezing point depressions yield a range of NaCl equivalent salinities from 1.9 to 10.5 wt %, with liquid homogenization temperatures ranging from 267 to 348°C. Pressure corrections of 1.5 kb based on observed Andalusite + Cordierite + K-feldspar assemblages in associated contact metamorphosed pelitic rocks yield mean formation temperatures of 457 ± 25 and 598 ± 30°C for late Qz and early Gn bearing rocks respectively. These values are in good agreement with temperature limits set independently by application of phase equilibria to the observed skarn assemblages. The fluid inclusion data indicate decreasing temperature and fluid salinity during evolution of the contact skarns. Additional fluid inclusion and stable isotope studies are underway to further constrain fluid evolution paths and fluid sources. (Authors' abstract)

COOLEN, Marc, 1981, Carbonic fluid inclusions in granulites from Tanzania; a comparison of geobarometric methods based on fluid density and mineral chemistry (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Inst. voor Aardwetenschappen, Vrije Univ., 1007 MC, Amsterdam The Netherlands.

Granulite facies rocks from the Upper-Proterozoic Furua Granulite Complex of southern Tanzania contain high-density carbonic fluid inclusions with well-developed negative crystal shape in host quartz, plagioclase and garnet. The inclusions are mainly of isolated type and their size is up to 15 µm. They are most abundant in metapelites which are intercalated in pyroxene granulites of assumed volcanic origin. Samples of intermediate scapolite-garnet-hornblende-two-pyroxene granulite and associated kyanite-biotite-garnet granulite from one locality were selected for the purpose of a detailed comparison of pressure estimates of metamorphism, based on the fluid density and the solid phase chemistry.

The results of the microthermometric measurements on the fluid inclusions show a characteristically narrow range of homogenization temperatures between -30 and -55°C for both rock types. The Th histograms give well-defined peaks at -50°C for plagioclase in the px granulite and at -43°C for quartz in the metapelite. The data for garnet vary around -35°C. Tm values between -58.5°C (plag) and -57°C (gar) indicate that the carbonic fluid consists of nearly pure CO_2. The peaks observed correspond with CO_2 densities of 1.14, 1.11 and 1.08 g/cc, respectively.

The chemistry of the host phases and associated solids, as studied by electron microprobe, reveals all characteristics of intermediate- to high-pressure granulite-facies metamorphism. Temperature estimates of 770 to 870°C are based on the element partitioning among garnet-biotite, garnet-clinopyroxene, and orthopyroxene-clinopyroxene. Associated pressures of 9 to 13 kbar are calculated from the orthopyroxene (2.25 wt% Al_2O_3)-garnet and kyanite-plagioclase (An_{27})-garnet(Gro_{10}) assemblages.

The combined geobarometric data show that the fluid density isochores nearly touch the lower P limit set by the solid phases. However, a pressure gap of 1 to 3 kbar remains apparent. This difference may be related to the partial H_2O pressure which must have been substantial in order to explain the presence of the hydrous phases biotite and hornblende. The high-density carbonic inclusions are believed to be representative of a pervasive fluid present during peak metamorphic conditions in the volcano-sedimentary pile. A deep seated and essentially juvenile origin of the CO_2 is suggested by the low $\delta^{13}C$ value (-14.3). The rather widespread preservation of these "primary" inclusions indicates that the rocks were hardly affected by major disturbances during later events. The studied rocks are part of an extensive granulite complex (>2000 km^2) which probably acted as one coherent tectonic unit during its emplacement in the upper crust from a depth of more than 40 km. (Author's abstract)

CORADOSSI, N. and MARTINI, M., 1981, Fluorine, chlorine and lithium distribution in igneous rocks of Lipari and Vulcano (Aeolian Islands, Italy): Bull. Volcanol., v. 44, no. 3, p. 565-571. Authors at Instituto di

Mineral., Petrogr. e Geochimica, Univ. Florence, Italy.

Fluorine and chlorine have been determined in samples of lavas and pyroclastic products from the islands of Lipari and Vulcano, which form the southernmost portion of the Aeolian arc, because their present distribution may provide additional information for a better understanding of the differentiation and eruptive mechanisms affecting these volcanoes.

On the basis of previous data which did not reveal a significant presence of Cl- and F-bearing minerals, these two elements are expected to concentrate in the residual melt during differentiation, following a distribution pattern similar to that of lithium that is a typical residual constituent.

The analytical results are in good agreement with the hypothesis which attributes a positive role to potassium in the solubility of volatiles in the melt phase, while silica would favor their escaping in a gaseous form.

For rocks representing the last stages of differentiation a sharp increase in lithium concentration is observed, and the relative loss of fluorine and chlorine is attributed to their releasing as constituents of fumarolic fumes. If the system is to a certain extent sealed, a "normal" passive enrichment for all the considered elements may occur. (Authors' abstract)

COVENEY, R.M. and GOEBEL, E.D., 1981, Fluid inclusion geothermometry of sphalerite from minor occurrences in Kansas, northern Missouri and eastern Nebraska (abst.): Geol. Soc. Am. Abstracts with Programs, v. 13, p. 274. Authors at Dept. Geosci., Univ. Missouri-Kansas City, Kansas City, MO 64110.

The finding of high homogenization temperature for fluid inclusions preserved in sphalerite specimens from widespread minor occurrences in both surface and deep subsurface Paleozoic rocks in Kansas, northern Missouri and eastern Nebraska expands the geographical area known to have been affected by Mississippi-Valley-type ore fluids. Leach's (1979) work on fluid inclusions in three major ore districts first brought attention to the probably genetic relationship between the major deposits known as the Central Missouri Barite district, the northern Arkansas district and the Tri-State district and minor sphalerite occurrences commonly found geographically between major ore districts in central and southern Missouri and in northern Arkansas. The study by Leach et al. (1975) using fluid inclusion data and other observations suggested a genetic relationship between the northern Arkansas and the Tri-State districts. Additional fluid inclusion works by Leach in 1979 suggested that the same ore fluids responsible for those two ore districts may also have been responsible for the central Missouri district, some several hundred Km to the north. Homogenization temperatures measured in our work range from ca. 60°C in northwest Kansas and eastern Nebraska, 70-80°C in northern Missouri, and 100-110°C in east central Kansas. Our preliminary data indicate a general decrease in temperature away from the known major ore districts, including the Upper-Mississippi-Valley deposits. Because known ore districts characteristically have homogenization temperatures greater than 100°C, it seems probable that similarly high temperatures found in minor occurrences of sphalerites between major ore deposits may indicate the proximity of undiscovered ore grade deposits. (Authors' abstract)

COVENEY, R.M., Jr., 1981 Gold quartz veins and auriferous granite at the Oriental mine, Alleghany district, California: Econ. Geol., v. 76, no.

8, p. 2176-2199. Author at Dept. Geosciences, Univ. Missouri-Kansas City, Kansas City, MO 64110.

In the vicinity of serpentinite wall rocks, the three fissure veins at the Oriental mine, Alleghany district, California, contain small high-grade ore shoots carrying hundreds of troy ounces of gold per ton. In addition, minable zones of albitized wall-rock granite ore contain an average of 0.2 ounces of gold per ton. In the veins most native gold is associated with arsenopyrite, but in the granite it occurs as microscopic inclusions within the pyrite. Various geothermometers and paragenetic relations suggest that vein gold deposition occurred during the end stages of mineralization at temperatures between approximately 200° and 300°C, at pressures between 670 and 2500 bars, and at depths exceeding 2.5 km. During the early stages of mineralization, when most hydrothermal alteration and gold deposition in granite probably occurred, temperatures were above 340°C and possibly as high as 491°C.

Muscovite, paragonite, calcite, dolomite, dawsonite, and albite fluid inclusion daughter minerals have been identified in situ by refractive index measurements and by X-ray powder diffraction. The near neutral to alkaline character of the mineralizing fluids, implied by the presence of 0.34 M dissolved dawsonite, and the low equivalent NaCl contents of fluid inclusions suggest that gold may have been complexed with sulfur or arsenic, rather than occurring as chloride complexes.

Wall-rock alteration effects include envelopes of intense carbonatization and desilication, surrounding the principal gold quartz veins but also occurring along splits and fractures emanating from the main vein structures. For example, in granite the main alteration effects, dissolution of original quartz and formation of albite, occur along nearly flat-lying fractures, chiefly in the footwall of the Oriental vein. Chemical analyses suggest that desilication of granite and removal of silica during ankeritization of mafic minerals in the other rock types liberated sufficient amounts of silica to form the vein quartz at the Oriental mine. Beyond the fringes of the main alteration envelopes is an outer essentially pervasive alteration zone, characterized by sericitization and chloritization, which grades into greenschist-facies country rocks and may predate mineralization. Gold in high-grade ore shoots may have been precipitated by reactions involving reducing fluids derived from the wall-rock serpentinite near which all high-grade vein ores occur. Limited fluid inclusion data for ore shoot quartz, however, seem to be consistent with the alternative possibility of temperature controls for ore deposition. (Author's abstract)

COX, D.P., CZAMANSKE, G.K. and BAIN, J.H.C., 1981, Mineral-rich fluid inclusions in the root zone of a porphyry copper system, Ajo, Arizona (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 433. First author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

Abundant 10-micron fluid inclusions occur in primary interstitial quartz grains in all compositional variants of the Cornelia Quartz Monzonite (Tertiary) at Ajo, Arizona. Both mineral-rich and vapor-rich inclusions are present and vary in proportion from sample to sample. The mineral-rich inclusions may contain halite, sylvite, iron chloride, complex K, Na, Ca, and Fe chlorides, Ca sulfate, hematite, and chalcopyrite.

The Cornelia pluton previously has been recognized as a fault block uplifted with respect to the Ajo porphyry copper deposit to the east and possibly representing the root zone of the deposit. Rock textures are predominantly hypidiomorphic granular, silicate minerals typically are fresh, and biotites have igneous compositions in the ranges: Fe_2O_3, 1.5-2.3; FeO, 11.8-13.6; MgO, 13.8-16.2; TiO_2, 4.0-4.5 weight percent. These factors illustrate the unaltered nature of the rocks hosting the fluid inclusions and indicate that high-salinity metal-bearing fluids were part of the late magmatic history of the pluton.

Rocks within the Ajo ore body have a classic microaplitic groundmass, contain abundant chlorite and sericite, and are cut by closely spaced quartz veins containing abundant small secondary inclusions and rare mineral-rich inclusions in the range of 1-2 micron. These contrasts reflect critical differences between the root-zone and ore-depositional environments. (Authors' abstract)

CRAWFORD, M.L., 1981, Phase equilibria in aqueous fluid inclusions, Chapter 4, pp. 75-100, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 4 Contents

CRAWFORD, M.L., 1981, Fluid inclusions in metamorphic rocks - low and medium grade, Chapter 7, pp. 157-181, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 7 Contents

CRAWFORD, M.L. and SISSON, V.B., 1981, CO_2-brine immiscibility in high-grade metamorphic rocks: Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-11.

Studies of fluid inclusions in mica- and clinozoisite-rich metamorphic rocks show that aqueous brines, containing over 20 wt. % dissolved salt (NaCl equivalent), are immiscible with CO_2 at temperatures of 620 ± 20°C and moderate to high pressures. Synmetamorphic quartz pods and veinlets contain separate inclusions of brine and CO_2; where trails of the two types of inclusions cross no mixing of the fluids is seen. In contrast, later, less saline brines (10 wt. % salts) do mix with CO_2 where the trails containing these inclusions intersect. The presence of a high temperature solvus between saline brine and CO_2 is supported by other fluid inclusion and experimental studies. The fluid inclusion population in the quartz segregations apparently records the compositions of fluids evolved during the metamorphic reactions. These fluids escape from the host rock along discrete channelways and are trapped there by the precipitation of quartz. In the country rocks which contain abundant hydrous mineral phases the quartz is devoid of CO_2 inclusions. The few inclusions which are present represent the remnants of the thin film of aqueous fluid which remains in contact with the metamorphic minerals. The compositions of these fluid inclusions apparently are modified by incipient retrograde metamorphic reactions, changing the salinity and possibly eliminating residual CO_2 through formation of retrograde calcite. (Authors' abstract)

CROSBIE, T.R., 1981, Polished wafer preparation for fluid-inclusion and other studies: Trans. Inst. Min. Metall., Sec. B, Appl. Earth Sci. (London), v. 90, no. 5, p. B82-B83.

DABITZIAS, S. and HAMILTON, D.L., 1981, The interaction of forsterite with $NaCl-CO_2$-bearing aqueous fluids at pressures to 1 kbar and temperature to 300°C: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 11-13.

DADZE, T.P., SOROKIN, V.I. and NEKRASOV, I.Ya., 1981, Solubility of SnO_2 in water, water solutions of HCl, HCl+KCl and HNO_3 at 200-400°C and pressure 101.3 MPa: Geokhimiya, no. 10, p. 1482-1492 (in Russian, English abst.). Authors at Inst. Exper. Mineral., Chernogolovka, USSR.

Partly pertinent to studies of inclusion fluids. (A.K.)

DAHANAYAKE, K. and RANASINGHE, A.P., 1981, Source rocks of gem minerals: Min. Deposita, v. 16, p. 103-11. Authors at Dept. Geol., Univ. Peradeniya, Peradeniya, Sri Lanka.

Field and laboratory studies on the geology and mineralogy of gem sediments and associated rocks reveal that gem minerals occur both in garnetiferous gneisses and granulites. It has been observed that PT conditions characteristic of granulite facies had favored the formation of gem minerals such as topaz, corundum, beryl, spinel, tourmaline and zircon. (Authors' abstract)

DARIMONT, Anne and DUCHESNE, J.-C., 1981, Fluid inclusions in spathic calcites from Pb-Zn vein deposits in carbonate environment (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Authors at Géol. appliquée and Géol., Pétrol., Géoch., Univ. de Liège, B-4000 SART TILMAN par Liège 1.

The present investigation, which is part of a research program supported by the CEE on Belgian Pb-Zn deposits in carbonate environments, has been on fluid inclusions in spathic calcites associated with vein deposits, in order to assess the usefulness of the method as a prospecting tool and also to determine some of the physico-chemical parameters of the ore-forming process.

A recent drilling campaign around a Pb-Zn deposit in Dinantian rocks near Poppelsberg (E. Belgium) provided the samples in which three types of calcite can be distinguished: (1) gangue minerals from the main vein; (2) calcite from veinlets at various distance from the main vein; (3) geode calcites from some dolomitic strata.

The data obtained on more than 300 samples can be summarized in the following points: (1) Th varies from 30°C to more than 300°C; frequency diagrams for the three types show several peaks; (2) Te is lower than -60°C; (3) freezing points (Ed. Tm ice?) vary from -35°C to 2°C with peaks at -21°C, -15°C and -3°C; (4) CO_2 has been detected by crushing and compared with quantitative measurements obtained by Dr. Shepherd (IGS-London) with mass spectrometry analysis; the contents are variable but remain low (from 0.07 to 0.25 mol.%); (5) gas/liquid volume ratios can vary considerably in a given specimen.

The statistical study of the frequency diagrams of Th shows that the different peaks have little significance: the distributions can hardly be distinguished from a Gaussian one, except for gangue calcites, where the population appears tri-modal.

Several possible mechanisms can be invoked to justify the dispersion of Th: boiling, mixing and necking. Though boiling of the CO_2-rich vapor phase is appealing, because it can precipitate calcite in a cooling solution, it is however difficult to admit because the CO_2 content of the inclusions is low and inclusions homogenizing in the gas phase have not been observed. The clustering of the freezing points around three discrete values tends to indicate that three different solutions have played a role in the process. The difference in temperature of the fluids could have been blurred by necking of the inclusions during subsequent recrystallization of the calcite. The variation in a single crystal of the gas/liquid volume ratios is in agreement with such an hypothesis.

Geode calcites seem to have a more complex history. They could have been initially precipitated through a diagenetic reaction with anhydrite and later partially replaced by a veinlet-type calcite.

From a methodological stand point, it is concluded that the best constraints which can be obtained to determine a genetic model seem to come from Tm experiments and not from Th, which appear difficult to interpret unless coupled with freezing temperatures on each individual inclusion. (Authors' abstract)

DAROT, Michel and GUEGUEN, Yves, 1981, Dislocations in forsterite experimentally deformed at high temperature: Bull. Minéral., v. 104, p. 261-266. Authors at Lab. de Tectonophys., 2, Chemin de la Houssiniere, 44072 Nantes Cedex, France.

A thorough analysis of dislocations has been conducted in eighteen forsterite single crystals deformed at high temperatures (1400-1650°C) and moderate stresses (80-800 bars). Two complementary techniques have been used for this purpose. One is a decoration technique particular to olivine and forsterite, the other is transmission electron microscopy (TEM). The use of both techniques together allow (one) to appreciate which microstructure is representative of the whole sample and to characterize completely these microstructures from a crystallographic point of view. It is concluded that the most important glide system is (010) [100] and that edge segments in the (010) glide plane are largely dominant. (Authors' abstract)

DAVYDOV, 1981 - See Appendix

DAVYDOV, DAVYDOV and LESKOVA - See Appendix

DEBBAH, B., 1981, Fluid inclusion studies in fluorite from the El Hammam district (central Morocco): Unpublished mémoire de DEA, Dépt. des Sci. de la Terre, Univ. d'Orléans, 47 pp. (in French).

Microscopic and thermometric investigations complementing earlier data (Lezier and Yajima, Yajima and Touray 1970; COFFI abstracts no. 3, p. 42 and 81) and underlining a zonal pattern in the El Hamman district. (Abstract courtesy J.-C. Touray)

de BÉTHUNE, Stanislas, 1981, The effect of the composition of the interstitial fluid phase on metamorphic decarbonation reactions: Comptes Rend. Acad. Sci. (Paris) Ser. II, v. 293, p. 593-596 (in French).

DEICHA, Georges, et al., 1981, Advances in physico-chemical studies of mineral cavities using electron microscopy (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated).

This abstract addresses some new results on mineralogical discontinuities studied by scanning electron microscopy (SEM). These observations lead to a better understanding of the complex interactions of non-equilibrium crystallographic factors in the formation of the cavities which enclose fluid inclusions. Such SEM studies could lead to a more critical approach to the problem of boiling of hydrothermal solutions as the cause of disparities in the degree of filling of cogenetic aqueous inclusions. (M. Logsdon)

DELANEY, J.R. and KARSTEN, J.L., 1981, Ion microprobe studies of water in silicate melts: concentration-dependent water diffusion in obsidian: Earth and Planet. Sci. Letters, v. 52, p. 191-202. Authors at Dept. Oceanogr., WB-10, Univ. Washington, Seattle, WA 98195, U.S.A.

The ion microprobe at Johnson Space Center has been calibrated for in situ water determinations on a 10-μm scale over the range 0.2 wt.% H_2O to 1.8, 6.8, and 3.7 wt.%, for basaltic, albitic, and rhyolitic glasses, respectively. The basalt glass calibration curve differs substantially from those of albite and rhyolite glasses, indicating a need to carefully match composition and/or melt structure between H_2O standards and unknowns.

A value for the diffusivity of water as a function of concentration and time has been calculated from water diffusion profiles measured in rhyolite glasses prepared at 850°C and 700 bars $P_t(H_2O)$. (From the authors' abstract)

DELOULE, E. and ELOY, J.F., 1981a, Improvements of laser probe mass spectrometry for the chemical analysis of fluid inclusion in ores (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). First author at Bureau de Recherches Geol. et Miniere, Orleans La Source.

In order to obtain analytical information on geological fluids, we have performed laser probe mass spectrometry. This process permits us to analyze directly each selected micro fluid inclusion inside the crystals. This microprobe uses the laser beam interaction to erode into the material thickness over the inclusion site as far as the cavity. As the fluid comes out, the components of fluid inclusion are partly ionized during the laser time of interaction. The ions are accelerated in an ionic source, separated by a magnetic sector and detected by a photographic plate detector.

By means of the Saha equation applied to the plasma obtained by laser interaction we studied a theoretical model of fluid ionization. We calculated the ionization yeilds of different chemical species. With this method, we obtained semi-quantitative results for the determination of atomic ratio Na/K and (Na+K)/Cl in the case of fluid components in quartz, fluorine and dolomite samples. (Authors' abstract)

DELOULE, E. and ELOY, J.F., 1981b Quantitative analyses of individual fluid inclusions in geologic materials; application to metallogeny: Bur. Rech. Geol. Min. Rept. No. DGRST78 7 0927; available from CNRS-AR 8647, France, 55 pp. (in French). First author at Bur. Rech. Geol. et Minieres, Orleans, France.

Semi-quantitative analysis of Na, K, and Cl ions present in quartz, fluorite and dolomite inclusions, using an ion probe, and a mass spectrometer with a laser source which uses the interaction of the laser phase with the sample for a micro-sampling of the material and for its ionization. (Authors' abstract)

DEMIN, Yu.I. and SERGEEVA, Nat.Ye., 1981, Sulfide-polymetallic ores in the near-contact zone of diabase dike at the Shemonaikhin deposit (Rudnyi Altai): Geol. Rudn. Mest., v. 23, no. 2, p. 119-124 (in Russian). Authors at Moscow State Univ., USSR.

Hyalophanes from the Talovo-Turgusun ore field bear inclusions with Th 480°C; quartz associated with hyalophanes from Karagayly deposit (Kazakhstan) - 430°C; phase ratios in fluid inclusions in hyalophanes from the deposit Shemonaikhin indicate Th about 420-450°C. (A.K.)

DERGACHEV and MELENEVSKIY, 1981 - See Appendix

DERGACHEV, A.L., STAROSTIN, V.I. and DOROGOVIN, B.A., 1981, Dependence of Debye temperature of quartz crystals on the quartz-formation pressure: Akad. Nauk SSSR Doklady, v. 257, no. 4, p. 992-993 (in Russian).

DES MARAIS, D.J., STALLARD, M.L., NEHRING, N.L. and TRUESDELL, A.H., 1981, Molecular and carbon isotopic variations of geothermal hydrocarbons as a function of their depth of production (abst.): EOS, v. 62, p. 1061. First author at Ames Res. Center, NASA, Moffett Field, CA 94035.

Higher molecular weight hydrocarbons commonly occur in geothermal emanations, and these compounds derive from the thermal decomposition of sedimentary or groundwater organic matter. For example, hydrocarbons in the fluids of the Cerro Prieto, Mexico, geothermal field originate largely from coaly material in the sedimentary reservoir. Thermal decomposition of coal and shale organic matter was performed in the laboratory in a vacuum at 400°C for periods ranging from 2 to 256 hours. With longer heating, the ^{13}C contents of the light hydrocarbons generally increased, and the concentrations of methane, ethane and benzene increased relative to other hydrocarbons. These experimental trends resemble the trends observed for geothermal hydrocarbons produced at increasing depths and temperatures. An example is provided by the hydrocarbons from Cerro Prieto wells M-5 (production depth = 1300m; temperature = 290°C) and M-120 (production depth = 2000m; temperature = 340°C). (Continued)

	M-5		M-102	
Compound	Abundance[a]	$\delta^{13}C$(PDB)	Abundance[a]	$\delta^{13}C$(PDB)
Methane	460,000	-31.2±0.2	500,000	-27.4±0.2
Ethane	7,550	-20.6±0.2	3,100	-16.6±0.3
Propane	1,600	-21.8±0.2	420	-21.9±0.2
Butane	400	-22.2±0.2	60	-27 ±0.5
Benzene	1,200	-24.1±0.2	1,150	-21.9±0.1

[a] Abundance is in parts per million by volume in residual gases collected over NaOH solution.

Conceivably such information could help to define the extent of sedimentary geothermal reservoirs. (Authors' abstract)

DIEHL, Peter and KERN, Hartmut, 1981, Geology, mineralogy, and geochemistry of some carbonate-hosted lead-zinc deposits in Kanchanaburi Province, western Thailand: Econ. Geol, v. 76, no. 8, p. 2128-2146. First author at Geostat Systems Internl. Inc., 626 West Pender St., Suite 809, Vancouver, British Columbia V6B 4V9 Canada.

During the last years several small- to medium-sized Pb-Zn deposits have been explored in the western mountain chains of the Province of Kanchanaburi, Thailand. Sulfide mineralization is stratbound and closely related to the development of reeflike algal crinoidal buildups which are incorporated in a thick Ordovician limestone sequence. Fine-grained galena-sphalerite-pyrite ores prevail with accessory fahlore and various Sb-Ag sulfosalts in a gangue of barite, silica, and carbonate. Sulfides are usually intimately intergrown, grain boundaries of the impingement type. Sphalerite has a low Fe content whereas galena is notably argentiferous. Sulfide precipitation was mainly controlled by primary porosity and permeability of the host rocks; however, in some places cavern fillings and collapse breccias of a paleokarst are also mineralized. Relationships between carbonate cementation and ore structures indicate an Ordovician ore emplacement at shallow depth. Homogenization temperatures of fluid inclusions range from 107° to 174°C. The lack of major replacement structures and the fact that carbonate gangue and sulfides have often coprecipitated show that the ore-bearing solutions were almost neutral in pH. The freezing temperatures of fluid inclusions near 0°C, the high contents of Ag, Sb, and Hg, and a zonal pattern of these elements are unusual for most carbonate-hosted lead-zinc deposits. The origin of the metal-bearing solutions is uncertain, but chemical characteristics and mineralized tuff breccias near the deposits possibly indicate a relationship to an igneous source. (Authors' abstract)

DIMROTH, Erich, 1981, The carbon-oxygen system at present and in the Precambrian, in R.J. O'Connell and W.S. Fyfe, eds., Evolution of the Earth, Geodynamics Series, v. 5, p. 69-74. Author at Sci. de la Terre, Univ. du Québec à Chicoutimi, 930 est, rue Jacques-Cartier, Chicoutimi, Qué., Canada G7H 2B1.

The geochemical cycle of carbon and oxygen can be considered to be a complex feedback system; rates of transfer from one reservoir to the other in general are functions of reservoir levels. Oxygen and organic matter are produced and consumed in the biologic subsystem. Small fractions of the oxygen and organic matter are withdrawn from the biologic subsystem and enter the exoxenic subsystem where they are used in various redox reactions and from where they return to the biologic subsystem in form of CO_2. A small fraction of oxygen and organic matter entering the exogenic subsystem is subduced and, thus, is withdrawn to the mantle. It reappears in form of mantle-derived CO_2 exhaled by volcanos.

Preserved reservoirs of oxidized species, of organic matter, and reduced species provide the evidence for the state of the carbon-oxygen system in the distant past. Large exogenic reservoirs of oxidized species (Fe^{3+}, SO_4^{2-}) existed since Archean time. The oldest well documented red beds are 2750 m.y. old. The oldest sulfate evaporites have an age of 3300 m.y. Oxidized, palagonitized volcanic glass, and ferric oxide crusts on basalt pillows exist since at least 2750 m.y. and must have constituted a huge reservoir of oxygen. Reservoirs of carbon, and of reduced species (Fe^{2+}, S^{2-}) also are similar to present reservoirs, neither excessively large, nor particularly small.

It is not likely that the feedback relations in the carbon-oxygen system changed with time. Consequently, the sedimentary evidence suggests that the state of the carbon-oxygen system has remained stable since the Archean. (Author's abstract)

DING, Biying, YANG, Yianzheng and LIAO, Fengxian, 1981, Fluid inclusion study of W-Sb-Au ore deposits in western Hunan province: J. of Central-South Inst. of Mining and Metal., no. 2, 1981;, p. 114-120 (in Chinese; abstract courtesy Dr. Huan-Zhang Lu.

There are four mineralization stages in this mine: early quartz-carbonate, quartz-wolframite-scheelite, quartz-sulfide-native gold-stibnite, and later quartz-carbonate.

Three types of fluid inclusions were found: type I, liquid-rich fluid inclusions, type II, daughter-mineral-bearing, and type III, liquid fluid inclusions. The most common one is the liquid-rich fluid inclusions. The average Th of different mineralization stages as follows: The early quartz-carbonate stage; 343°C, quartz-wolframite-scheelite stage; 254°C, quartz-sulfide-native gold stage; 207-162°C, and the later quartz-carbonate stage; 121°C. The fluid inclusions are rich in K, Na, Ca, Mg, F, Cl, CO_2, N_2, CO, CH_4. The ratio K/Na ranges from 0.49 to 1.48, of Ca/Mg ranges from 2.8 to 20.0. The trace elements Fe, Sb, Pb, Au, Cu, Ni, Mn, Co, and Cr were also found in the fluid of fluid inclusions. Gas-chromatography was used, with a vacuum decrepitation extraction technique. The value of sulfur isotopes was determined. These data indicate that the ore-forming fluids of the western Hunan W-Sb-Au ore deposits were low temperature, low salinity (about 11 wt.% NaCl equivalent) brines. (Authors' abstract)

DOBSON, D.C., 1981, The relationship between skarn and greisen alteration - an example from the Lost River tin deposit, Alaska (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 440. Author at Dept. Geol., Stanford Univ., Stanford, CA.

The Lost River tin deposit provides an excellent opportunity to examine the relationship of the hydrothermal processes responsible for the formation of skarn and greisen. The spatial and temporal evolution of the alteration system has been defined by detailed mapping, core logging, electron microprobe and fluid inclusion studies. Mineralization occurs in skarn and greisen above and within the cupola of a Late Cretaceous granite stock which intrudes a thick section of Ordovician limestone.

Earliest stages of alteration at Lost River were characterized by relatively anhydrous stockwork calcic skarns dominated by idocrase, garnet, magnetite and fluorite with tin both as cassiterite and within silicate lattices. Replacement of the early silicates by hydrous minerals -- phlogopitic mica and hornblende -- accompanied the deposition of sulfides (sphalerite, galena, pyrite), fluorite, cassiterite and scheelite in the skarns at the same time the plug was undergoing greisenization. Greisen, which therefore postdates most skarn, destroys igneous textures in the granite and is composed primarily of quartz, with topaz, tourmaline, arsenopyrite, base metal sulfides and cassiterite.

Skarn occurs worldwide in association with intrusive rocks over a range of compositions, from diorite, which typically has Fe-Cu skarns, to granite (W, Mo, Sn skarns). The granitic intrusions related to greisenization and tin mineralization are, in general, the most evolved and highly differentiated in this sequence; their associated skarns likewise represent a near end-member in a continuum of similar deposits. Relative to Fe, Cu and even W skarns, Lost River, and probably many tin skarns, is characterized by high activities of F and B, by low Fe/Al ratios, low total metal content, and by generally lower total S and fugacities of O_2 and S_2. Field occurrence also tends to be distinctive -- tin skarns frequently form at some distance from their source intrusive contact and with little metamorphic skarn or endoskarn. Variations among deposits are a function of XCO_2, depth and host lithology. (Author's abstract)

DOLGOV and BAKUMENKO, 1981 - See Appendix

DOLGOV and GIBSHER, 1981 - See Appendix

DOLGOV and SHUGUROVA, 1981 - See Appendix

DOLGOV et al., 1981 - See Appendix

DOROFEYEVA, V.A. and KHODAKOVSKIY, I.L., 1981, Calculation of equilibrium composition of multicomponent systems by minimization method using equilibrium constants: Geokhimiya, no. 1, p. 129-135 (in Russian, English abst.). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The results of calculations are shown for water solution of KCl under P-T conditions exceeding critical parameters of water. Pertinent to fluid inclusion studies. (A.K.)

DOROSHENKO, Yu.P. and PAVLUN', N.N., 1981, Physico-chemical peculiarities of genesis of the deposit Akchatau (from inclusions in minerals): Mineralog. Sbornik, v. 35, no. 2, p. 44-51 (in Russian, English abstract). Authors at the L'vov Univ., L'vov, Ukrainian SSR.

The deposit Akchatau belongs to Mo-W formation and quartz-vein-greisen type and genetically and spatially it is connected with the Akchatuy pluton of alaskite granites of late Variscan (Permian) age, occurring in the NW part of the Dzhungarian-Balkhash geosynclinal area. Veins and greisens bear over 100 minerals (60 hypogene ones), ore minerals are mostly wolframite, pyrite, molybdenite plus rarer bismuthinite, sphalerite, galena, scheelite, chalcopyrite; quartz, fluorite, muscovite, topaz and calcite are the main gangue minerals. Molybdenite-quartz association bears PS inclusions: essentially G (LH_2O 10-15 vol.%), Th in G 440-405°C, L/G (LH_2O 20-30 vol.%) and G/L (LH_2O 60-70 vol.%) Th in G or L 405-390 and 395-340°C, respectively, at 395-390°C critical phenomena were observed, G/L + dms (halite ± sylvite ± ore dm) Th 400-280°C, P for this association $1.2x10^5$-$1.1x10^5$ Pa max. total salt concentration 40-40 wt.%; rare-metal-molybdenite-wolframite-quartz association - G, L/G and G/L ± dms, Th 480-450°C, 460-445°C, 445-320°C (445-440°C-critical phenomena), 450-300°C (with dms), P 0.5x10^4 Pa-1.5x10^5 Pa, maximum total salt concentration 35-49 wt.%, frequent boiling of solutions, Td of wolframite 330-440°C; pyrite-wolframite-quartz association, inclusion types as in previous association, Th 415-395°C, 405-385°C, 400-280°C (with dms), P 0.65x10^4 Pa-0.45x10^4 Pa, maximum total salt concentration 38-48 wt.%; galena-sphalerite-quartz association - G/L inclusions, sometimes with LCO_2 (from 20 to 90 vol.%), Th 310-150°C and 28.1-30.5°C for LCO_2 inclusions, P 0.55x10^4 Pa-0.35x10^4 ± 0.2x10^3 Pa; fluorite-quartz and zeolite-calcite associations, G/L inclusions with Th 180-60°C. Main ions are Cl, Na, K, $HSiO_3$, F, subordinate ones - Ca, Mg, HCO_3, SO_4. (Abstract by A.K.)

DOROSHENKO, Yu.P., PAVLUN', N.N. and SIMKIV, Zh.A., 1981, Chemical composition of mineral-forming solutions of the deposit Akchatau (from fluid inclusions in minerals): Mineralog. Sbornik, v. 35, no. 1, p. 77-81 (in Russian, English abstract). Authors at L'vov Univ., L'vov, Ukrainian SSR.

Mineral associations of Mo-W ores of the deposit Akchata formed during polystage process from solutions of variable composition. Inclusions in minerals of the commerical stage commonly bear more dms (halite, sylvite and other salts) and post commercial stage (with galena and sphalerite) - ususally LCO_2. Salt components from water leachates were determined in inclusions: Na, K, Ca, Cl, F, $HSiO_3$, Mg, Sr, ΣFe, HCO_3, SO_4, Mo. In the triangular plot K-Na-Ca+Mg+Sr the solutions fall along the K-Na side between 50 and 100% Na, in the plot F-Cl-$HSiO_3$ along the Cl-$HSiO_3$ side between 50 and 100% Cl, in the plot N_2-CO_2-CH_4+C_nH_{2n+2} essentially in its part 100% CO_2 - 50% N_2 - 50% CH_4+C_nH_{2n+2}. Total salt concentration exceeded 65 wt.% and became lower in the later stages. (Abstract by A.K.)

DRUMMOND, S.E., Jr., 1981, Boiling and mixing of hydrothermal fluids: chemical effects on mineral precipitation: Ph.D. thesis for The Pennsylvania State Univ., Graduate School, Dept. Geosciences, University Park, PA, 397 pp.

The solubilities of CO_2 and H_2S in 0-6 m aqueous sodium chloride solutions between 25° and 400°C have been measured via a pressure-volume-temperature mass-balance technique. This method was used for 506 CO_2 and 474 H_2S solubility determinations. K_H (Henry's law constant) is expressed in terms of fugacity (atm). Solubility data from the literature for CH_4, H_2, and SO_2 have been evaluated in order to assemble a consistent set of solubilities for important gases in high-temperature aqueous sodium chloride solutions. These solubility data show a systematic and linear temperature dependence when correlated to the gas volatility ratios. The volatility ratio (VR) is related to Henry's constant such that: $VR = (K_H^\circ \cdot V_W^V)/(\Phi \cdot Z \cdot R \cdot T)$, where V_W^V is the specific volume (liter/kg) of H_2O in the vapor, Φ is the fugacity coefficient for the gas, Z is the gas compressibility factor, R is the ideal gas constant (liter · atm/deg · mole), and T is temperature in Kelvin. This relationship is used as a convenient means for extrapolating the low-temperature solubility data for SO_2 to high temperatures.

The gas solubility data for CO_2, H_2S, CH_4, and SO_2 are used in a quantitative numerical model of the chemistry of boiling hydrothermal solutions. This model considers the critical physical and chemical variable which must be defined before the chemistry of a boiling solution can be determined: heat budget, open or closed nature of the system, redox-controlling equilibria, and the extent of mineral-solution equilibration.

Isoenthalpic solutions with initial temperatures of 350°, 250°, and 150°C cool to about 120°C after 50%, 25%, and 5% water loss to the vapor phase respectively. Gases partition from liquid to vapor much more rapidly from open than closed systems, particularly at low temperatures. Open boiling tends to oxidize solutions by removing reduced components (H_2S, CH_4, H_2, etc.) from solution more rapidly than their less volatile counterparts (SO_4^{2-}, SO_2, CO_2, etc.). This effect is most pronounced at low temperatures and when the equilibrium oxygen fugacity is controlled by the rapidly changing CO_2/CH_4 ratio. Closed boiling has little effect on the oxidation state of the solution since all of the redox components are confined within the liquid-vapor system.

Boiling tends to increase pH by removing acid volatile species (i.e., H_2CO_3, H_2S) from solution. This pH increasing mechanism is most effective for low-temperature (<300°C) solutions with an initial pH > 4.0 and a high acid-volatile content. At higher temperatures (e.g., 350°C) the volatility ratios are low, causing the acidic gases to partition into the vapor phase at a reduced rate. Consequently, 350°C isothermal solutions undergo only moderate pH changes during boiling.

Boiling is generally a favorable process for depositing oxides, native metals, sulfides quartz, and to a lesser extent for carbonates and sulfates. Boiling is most effective in depositing these mineral groups when the process is isoenthalpic (i.e., boiling is accompanied by cooling) and for initial conditions amenable to pH increases. Most of the well-studied ore deposit systems associated with liquid-vapor fluids fall within the realm of conditions most conductive to mineralization by boiling. This correlation combined with numerous examples of an intimate spatial association between mineralization and the boiling horizon is compelling evidence that boiling is an important ore-forming process.

The same numerical techniques used for the boiling model were used to determine the effects of mixing hot and cold fluids on solution chemistry and mineral deposition. Redox and pH changes during mixing hot and cold solutions are generally subordinate to the cooling effect which usually results in quantitative deposition of sulfides, native metals, and oxides. The cold solution acts primarily as a coolant and reduces the solubility of most metallic minerals dissolved in the hot solution. Sulfate deposition is contingent on the sulfate content in the cold solution. Carbonates tend to dissolve unless the mixing process is accompanied by significant pH increases. The mixing model predictions are consistent with field evidence in ore deposit systems where fluid mixing is thought to be responsible for the mineralization (e.g., Kuroko and other volcanogenic massive sulfide deposits and the Mississippi Valley-type deposits). (Author's abstract)

DUBROVSKIY - See Appendix

DUDYREV et al., 1981 - See Appendix

DZIEDZIC, A. and RYKA, W., 1981, Carbonatites from Tajno: Post-magmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, p. 8-9, Wydawnictwa Geologiozne, Warsaw (in Polish). Authors at Geol. Inst., 00-975 Warsaw, Rakowiecka 4, Poland.

Post-Carelian anorogenic magmatism yielded pyroxenite, gabbro and syenite intrusions in the Precambrian East-European Platform. Carbonatites were reported in the Etk syenite massif and Tajno pyroxenite massif. The latter were found in the borehole Tajno IG1. Under Mezozoic sedimentary rocks at a depth of 600m, medium- and fine-grained pyroxenites, sometimes cut by foyaite veins, were found. At a depth of 616-814m several zones of pyroxenite breccias up to 20m thick were cemented by carbonatite. The carbonatite veinlets are up to 10-20 cm thick. 1. The oldest stage is represented by partially brecciated veins consisting of albite and pyrite; they formed at Th 400-340°C. 2. Middle stage is formed by carbonatites of main generation. They consist of calcite, burbankite and bastnaesite plus fluorite; subordinate minerals are dolomite, barite, strontianite, apatite, chlorite, titanite, ilmenite, pyrite, pyrrhotite, galena and sphalerite. Albite, microcline and quartz are very rare. Carbonatites formed at Th 310-250°C. 3. The youngest calcite veins with quartz, sulfides and pseudochalcedony formed at T<200°C. The content of the rare earth oxides in carbonatites reaches 10%. The rare earth oxides consist of La_2O_3 up to 6.1%, Ce_2O_3 up to 3.1%, Nd_2O_3 up to 0.4% and traces of Sm, Pr, Y etc. Rare earths occur in carbonates and hydrous carbonates. (Authors' abstract, translated by A.K.)

EADINGTON, P.J. and WILKINS, R.W.T., 1980, The origin, interpretation, and chemical analysis of fluid inclusions in minerals: CSIRO Inst. of Earth Resources (North Ryde, NSW, Australia) Tech. Commun. 69, 45 pp.

A review (76 references), based in part on two separate contributions to a workshop on fluid inclusions in minerals held at LaTrobe Univ. in February 1979. (E.R.)

EDMOND, J.M., VON DAMM, K.L., McDUFF, R.E. and MEASURES, C.I., 1981, Chemistry of hot springs on the East Pacific Rise and their effluent dispersal (a review): Nature, v. 297, no. 5863, p. 187.

EFIMOVA, M.I., BLAGODAREVA, N.S., FEDCHINA, G.N. and NAUMKIN, P.A., 1981, Post-magmatic alterations in the porphyry rocks of the ore fields in Sikhote-Alin': Post-magmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, Wydawnictwa Geologiozne, Warsaw, p. 1 (in Russian). Authors at Far East Geol. Inst. of Far East Sci. Center of Acad. Sci. USSR, Vladivostok, USSR.

Magmatic formations of the folded system of Sikhote-Alin' consist of volcanic-plutonic and intrusive complexes of Upper Cretaceous-Paleogene age and they are characterized by various metallogenic specializations. Ore mineralization frequently occurs in the marginal parts of the volcanic-plutonic structures and necks of paleovolcanoes, connected with deep faults. Development of very complex dike assemblages is typical of most of the ore fields. The dikes are pre-ore, syn-ore and post-ore. Pre-ore dikes and small intrusions consist mostly of acid porphyries: granite, granodiorite, felsite, and quartz porphyries, which crystallized (thermobarogeochemical data) under active fluid regime at Th 1400-1200°C.

Postmagmatic alterations of porphyry rocks preceding ore formation and coeval with it caused the origin of metasomatites of various compositions. For tin and tungsten deposits these are characteristically high- and moderate-T (450-380°C) greisens and greisen-like metasomatites with topaz; for lead-zinc and partly tin-lead-zinc deposits - moderate- to low-T (320-180°C) propylites. Analyses of water leachates from quartz of metasomatic zones showed that post-magmatic solutions that formed greisen associations were of Cl-(F)-Na or Cl-(F)-K type and propylitizing solutions - of HCO_3-SO_4-Ca-Mg type. Existence of various types and zones in metasomatites may be explained by evolution of acidity-alkalinity and pH of those solutions, fluctuation of T regime and periodic boiling of the hydrotherms. (Authors' abstract, translated by A.K.)

EGGLER, D.H. and BAKER, D.R., 1981, Effect of methane on melting of peridotite: EOS, v. 90, p. 421. First author at Dep. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Although there are many indications that the terrestrial upper mantle is only mildly reduced (fO_2 above MW), intrinsic fO_2 measurements on olivines and presence of CH_4 in diamonds indicate that at least some portions are more reduced. Calculations with the modified-Redlich-Kwong EOS indicate that at mildly reduced conditions, volatiles will be CO_2 and H_2O. At more reducing conditions, in the presence of graphite or diamond, CH_4 will become a significant species and at very reducing conditions (IW) is dominant.

The effect of CH_4 on melting of two silicate compositions, diopside, $CaMgSi_2O_6$, and DP65, diopside35pyrope65, have been determined in the P-T range 20-40 kbar, 1500-1600°C. Breakdown of anthracene in sample capsules produced a mixture of graphite, CH_4(ca.90%), and H_2(ca.10%). At 21 kbar, the solidus of diopside is depressed about 140°C, suggesting a sustantial effect due to solution of CH_4. The melting interval is about 50°C, presumably due to dilution of CH_4 by H_2. For the DP65 composition, primary phase fields of olivine and garnet are expanded upwards in pressure, suggesting that solution of CH_4 has a depolymerizing effect on the melt.

These results suggest two scenarios for volatile-influenced, near-solidus melting above about 25 kbar: at mildly reducing conditions, carbonated peridotites produce carbonate-CO_2-H_2O-rich alkalic melts; at reducing conditions, carbonates are unstable, and CH_4-rich melts are probably alkalic only at considerable depths. (Authors' abstract)

EHARA, Sachio, YUHARA, Kozo and NODA, Tetsuro, 1981, Hydrothermal system and the origin of the volcanic gas of Kuju-Iwoyama volcano, Japan, deduced from heat discharge, water discharge and volcanic gas emission data: Bull. Volcanological Soc. of Japan, v. 26, no. 1, p. 35-56 (in Japanese; English abstract).

EICKHOFF, K.-H. and HESS, M., 1981, Microthermometrical investigations on post-diagenetic mineralizations in Mesozoic sediments of the Lipper Bergland (Lower Saxonian Tectogene): Dipl. Arb., Göttingen, 176 pp. (in German).

Fluid inclusion investigations in quartz, calcite, barite. (E. Horn)

EIMON, Paul, 1981, Exploration for epithermal gold and silver deposits: the epithermal model: Paper presented at The First International Symp. on Small Mine Economics & Expansion, Taxco, Mexico, May 17-21, 1981, 15 pp.

A good general review of epithermal deposits. (E.R.)

ENGI, Martin, 1981, Electron probe microanalysis of fine grained mineral powders and inclusion-rich solids (abst.): EOS, v. 62, p. 1056. Author at Dept. Geol. Sci., Univ. British Columbia, Vancouver, B.C. Canada V6T 2B4.

Spatial resolution limits frequently do not permit the complete separation of fine-grained phases in the analysis by electron probe or SEM techniques. A general correction procedure has been developed, which removes the effects of such contamination and results in good approximations of the pure phase compositions. The method involves recognition that each spot analyzed may emit X-radiation generated in several phases. Hence, each activated volume will have different proportions of the same phases and the total emission from each spot can be regarded approx. as a linear combination of the emissions of each of the phases present. Simultaneous consideration of a large number of spots permits distinguishing the proportions of phases in each spot and, by iterative linear regression, approximation of the pure phase compositions. Initial estimates for the iterative refinement can usually be obtained by Gram-Schmidt orthogonalization of the raw data matrix.

Potential and limits of the method will be illustrated. Applications include products from experimental mineralogy and petrology, precipitates in metallurgical and fluid inclusion studies, as well as clastic fragments in sedimentology. (Author's abstract)

ENGLISH, P.J., 1981, Gold-quartz veins in metasediments of the Yellowknife supergroup, Northwest Territories; a fluid inclusion study: M.S. thesis, Univ. Alberta, Edmonton, AB, Canada.

ENIKEEVA, 1981 - See Appendix

ENJOJI, Mamoru and SHOJI, Tetsuya, 1981, Fluid inclusion study on the Tsumo skarn-type deposit, southwestern Japan: Mining Geol., v. 31, no. 5, p. 383-396 (in Japanese; English abstract). First author at Institute of Geoscience, The Univ. of Tsukuba, Ibaraki 305, Japan.

The Maruyama orebody of the Tsumo mine belongs to the skarn type copper-zinc-tungsten deposit. Skarns are mainly classified into the following three types judging from their modes of occurrence and the mineral assemblages; banded skarn, massive skarn (vesuvianite-garnet-clinopyroxene skarn, wollastonite-garnet-clinopyroxene skarn, and garnet-clinopyroxene skarn) and vein skarn (hedenbergite skarn). A copper-zinc mineralization took place in wollastonite-garnet-clinopyroxene skarn and garnet-clinopyroxene skarn, while a tungsten (scheelite) one is recognized not only in hedenbergite vein skarn, but also in the part of wollastonite-garnet-clinopyroxene skarn.

Skarn minerals contain fluid inclusions, some of which are evidently primary in origin. Many of fluid inclusions contains solid phases, such as halite, sylvite, carbonate and metallic minerals. The variable volume ratio of the solid phases to the whole vacuole may suggest that the skarn minerals of the deposit were formed from saline solution of various concentrations. On the contrary, fluid inclusions in scheelite do not contain any solid phase. This implies that the mineral precipitated from a solution whose salinity was lower than 26 wt.% NaCl. Small grains of chalcopyrite are included in a sphalerite crystal. The fact that they array along a particular plane may suggest that some of them are not exsolution products, but minerals trapped during the growth of host mineral.

Most of fluid inclusions in garnet, clinopyroxene and wollastonite are homogenized into liquid phase at about 300°-350°C. When the temperature correction is made considering salinity of the inclusion fluid and the formation pressure on the basis of the sphalerite geobarometer, it is concluded that the formation temperature of the skarn minerals was about 400°-350°C.

In general, fluid inclusions in skarn minerals have no liquid CO_2 phase at room temperatures. This turns out to be true of those in the

Tsumo deposits. This fact agrees well with the conclusion derived from the solubility data of CO_2 for NaCl solution and the calculated data of the stability field of the skarn minerals. However, the presence of gaseous inclusion, though the abundance is few, may suggest that two phase locally appeared during the skarn mineralization. (Authors' abstract)

ERCEG, M.M., 1981, The Te Ahumata fossil geothermal system, aspects of its geology, geochemistry and mineralogy: M.Sc. thesis, Univ. Auckland, New Zealand. Author at Amoco Minerals, Auckland, New Zealand.

Te Ahumata in south central Great Barrier Island is the site of an epithermal gold-silver deposit of Pliocene to Pleistocene age. The 1.5 x 2 km area consists of an upstanding, remanent, trapezoidal shaped plateau of Pliocene pyroclastic flow units separated by airfall tuffs, underlain by a sequence of occasionally carbonaceous volcanogenic sediments unconformably overlying a basement of porphyritic andesite of Miocene age. A period of geothermal activity, possibly continuing to the present day, although further north, centered on Te Ahumata closely followed the deposition of the rhyolitic pyroclastic units.

Fluid movement initiated by the intrusion of a suspected granitic stock at depth was restricted in the andesite to the major fault zones, now infilled with quartz veins, that surround and generally dip beneath the plateau. A main stage of hydrothermal alteration within the initially permeable pumiceous pyroclastic units developed a strong zonal alteration pattern about fluid channelways of an inner adularia/illite zone, a central interlayered illite-montmorillonite zone and an outer Ca-montmorillonite zone. Late stage boiling, possibly induced by a lowering of the watertable, initiated a phase of acid oxidative leaching of the pyroclastics to a mineral assemblage of quartz and kaolinite.

The present plateau surface corresponds closely to the paleosurface; fluid inclusion studies of quartz crystals taken from a paleo-depth of 200 m suggest a temperature of 210-220°C for the main stage of activity with low fluid salinities of 2.5 to 4.1 wt. percent NaCl and relatively high fluid densities of 0.8 to 0.9 g/cm^3. Mineral equilibria diagrams indicate a fluid acidity of pH6 for the main stage alteration and a higher acidity ($pH \approx 3$) for the late stage.

Geochemical data show that Au, Ag, Co, Hg, Sb, Si and Li are enriched in the quartz veins that represent fluid channelways. Within the hanging wall Au, Ag, As, B, Cd, Co, Cr, Cu, Hg, Ni, Sb and V are enriched usually showing an increase in concentration towards the vein. Au, Sb, Hg and Ag are enriched in both geochemical environments but Ag and Sb are more abundant in the hanging wall and Au and Hg in the vein. The geochemical separation of Au and Ag is confirmed by statistical analysis.

Detailed mineralogical investigations of sulphides precipitated in two different environments, the fault breccia and the quartz vein, are undertaken. The minerals marcasite, pyrite, pyrrhotite, argentian tetrahedrite, famatinite, miargyrite and stibnite are developed in the fault breccia and electrum, polybasite, acanthite and proustite in the quartz veins. The late stage acid oxidative phase of hydrothermal alteration affected mainly the fault breccia association producing secondary minerals such as kermesite and covellite. The late stage fluids were capable of carrying Ag suggesting that leaching of primary sulphide accumulations occurred probably to secondary enrichment zones beneath the plateau.

The above features suggest that the Te Ahumata area was the focus of a now extinct Pliocene to Pleistocene geothermal system. (Author's abstract)

ERMOLAEV, N.P., KOLENTSEV, V.V. and SALAZKIN, A.N., 1981, Redistribution of substance during formation of stratiform ores in metamorphic schists Geol. Rudn. Mest., v. 23, no. 2, p. 86-96 (in Russian). (Authors' institution not given.)

The deposit (name or location not given) contains ores of U, V, Ag and Sb occurring in coal-bearing microquartzites. Length of the mineralized tectonic zones varies from tens of meters to 1 km and thickness from few cm to 1.5 m. Vein dolomite has Td 310-400°C, calcite - from 150°C, quartz in central part of veins - Td from 120°C. (Abstract by A.K.)

EUGSTER, H.P., 1981, Metamorphic solutions and reactions, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 461-508. Author at Dept. Earth and Planet. Sci., Johns Hopkins Univ., Baltimore, MD 21218, USA.

The composition of metamorphic solutions can be estimated from mineral assemblages, provided the appropriate reaction partners are present and the necessary laboratory calibrations are available. However, fH_2O buffers or indicators are not common and this represents a severe handicap, since solubilities and dissociation equilibria depend strongly on the density of the aqueous fluid, pH_2O. It might be possible in the future to estimate fO_2 and then measure the intrinsic hydrogen fugacity of natural assemblages.

Mineral growth and dissolution can be understood only if the necessary information is available on solute speciation. Dissociation constants are available for H_2O, NaCl, KCl, $MgCl_2$, HCl, but little information is available on speciation in H_2O-CO_2 fluids.

A review of solubility data in mineral-H_2O, mineral-H_2O-HCl and mineral-H_2O-CO_2 systems reveals that data are available for surprisingly few minerals and this hampers our ability to predict solute concentrations and hence compositional gradients in the supercritical fluid. Quartz, albite, magnetite, Mg-silicates and calcite are used as examples.

Experimental techniques for studying mineral reactions in supercritical mixtures include a variety of fugacity buffers, all based on hydrogen diffusion and two types of hydrogen sensors, one based on the Ag-AgCl buffer and the other on a modified Shaw bomb.

Two examples of equilibrium applications are discussed. The first is concerned with properties of KCl-H_2O and NaCl-H_2O mixtures and the second with speciation in an aqueous solution in equilibrium with K-feldspar + muscovite + quartz. Chloride concentration and temperature are shown to affect dissociation equilibria and species distribution most.

Metasomatism can occur either by diffusion or fluid flow or both. A sufficiently detailed theoretical framework is available to model diffusional transport, but fluid flow and hence infiltration metasomatism are still not well understood. The effect of combining convecting fluids with chemical reactions can be illustrated in processes of ore formation such as magnetite and sulfide deposits.

We can best summarize the state of the art by listing a number of key areas where progress is essential for a better understanding of metamorphic fluids. (Author's abstract)

EUGSTER, H.P. and GUNTER, W.D., 1981, The compositions of supercritical metamorphic solutions: Bull. Minéral., v. 104, p. 817-826. First author at Dept. Earth and Planet. Sci., Johns Hopkins Univ. Baltimore, Maryland 21218 USA.

Mineral assemblages can be used to estimate the compositional range of supercritical metamorphic solutions. Abundances of the major solutes SiO_2, Na, K, Ca, Mg and Fe in OH-Cl solutions are obtained from solubility data on quartz, albite + paragonite + quartz, K-feldspar + muscovite + quartz, wollastonite + quartz, talc + quartz and magnetite. Without taking solid solution effects into account, the relative abundance sequence is SiO_2>Na>K>Ca>Fe>Mg. At high chloride molalities K and Ca are reversed and the importance of silica is diminished. Solid-fluid fractionation has been evaluated for alkali feldspar, plagioclase and biotite solid solutions. For fluids in equilibrium with K-feldspar, Na is very strongly enriched in the fluid, with Na>K for Or-contents as high as 95. Similarly, Na is enriched in fluids in equilibrium with plagioclase with Na>Ca for An-contents of 95 and more. Biotites have a corresponding effect on Fe-Mg separation with Fe>Mg for biotites with a phlogopite content of 90 or more. These fractionation effects can change the general abundance sequence to SiO_2>Na>Fe>K>Ca>Mg, depending upon the nature of the solids present. (Authors' abstract)

FAHLEY, M.P., 1981, Fluid inclusion study of the Tonopah district, Nevada: Master's thesis, Colorado School of Mines, Golden, CO.

The Tonopah mining district, Nye County, Nevada, has produced over 170 million ounces of silver and 1.8 million ounces of gold from quartz veins in rhyolitic to andesitic late Oligocene to early Miocene volcanic rocks. Mineralization occurs along the shallow, northwest-dipping normal Tonopah fault and along steeply-dipping hanging wall fractures containing high grade ore shoots. Rhyolite sills and dikes, which were intruded along the deeper segments of the Tonopah fault, are closely related in time to the main episode of mineralization.

Wall rock alteration zones adjacent to veins consist of an inner potassic (adularia) zone which grades outward into argillic and propylitic alteration. With increasing depth, phyllic (quartz-sericite-pyrite) alteration predominates over potassic and argillic alteration.

Vein filling consists of three stages: early barren stage (quartz + sericite + adularia + pyrite), silver stage (quartz + base metal sulfides + gold + adularia + sericite + pyrite + agentite + pyrargyrite + polybasite), and late barren stage (quartz + calcite + barite). Fluid inclusion filling temperatures indicate that early barren stage fluids were between 290°C and 240°C, silver stage fluids between 280°C and 220°C, and late barren stage fluids between 260°C and 140°C. Variable liquid to vapor ratios in primary fluid inclusions suggest boiling of the hydrothermal fluids occurred at higher elevations above the Tonopah fault. Freezing temperature determinations indicate the salinity of the hydrothermal solutions averaged between 1 and 3 wt.% NaCl equivalent, suggesting a meteoric origin for the fluids. This conclusion is in close agreement with stable isotope data.

Preliminary theoretical considerations at 250°C suggest that mineralizing fluids were in equilibrium with sericite + adularia + quartz (pH=6.2) and were dilute, meteoric waters with log fO_2 values in the range -32 to -34.

A model in which meteoric waters circulated to substantial depths below the surface and became heated by shallow-seated igneous intrusions is proposed. As these solutions became heated, metals were leached from the Paleozoic-Mesozoic basement and Tertiary wall rocks. Dilute, metal-bearing solutions then travelled along the Tonopah fault and were deflected into hanging wall fractures where periodic boiling and mineral precipitation occurred at depths between 2,000 and 1,000 feet below the surface. A drop in temperature, an increase in pH and fO_2, and a decrease in fS_2 accompanying boiling are believed to be the primary mechanisms for metal precipitation. (Author's abstract)

FANDERLIK, Ivan and DUBSKÝ, František, 1981, Angular distribution of scattered luminous flux by inhomogeneities in quartz raw materials: Sbornik Geologickych Ved., v. 17, p. 127-136 (in Czechoslovakian; English abstract).

The various angular distribution of a scattered luminous flux measured by means of a photogoniodiffusometer is due to mineral, liquid-gas and gas inclusions in vein and crystal quartz of various geological provenance. These inclusions represent diffusion centers responsible for the characteristically different course of indicatrix curves shown as the relationship between luminous flux and measuring angle. They are an aid in distinguishing between the quality and provenance of vein quartz and crystal used in the manufacture of fused silica.

The diffusion centers conformable to Rayleigh scattering condition are present in the quartz raw material produced by the firm Thermal Syndicate and those of Rayleigh-Gans type can especially be found in Czechoslovak vein quartz. The Soviet material MBK Svetlorecensk is the one showing a transition between both types mentioned above. Finally, the Soviet material Kystym, an African material from Angola, the American material Arkansas I, and a Brazilian crystal contain diffusion centers of Mie type.

The courses of the dependence correlate with grain size microscopic studies. (Authors' abstract)

FAYZIYEV et al. - See Appendix

FAYZIYEV, A.R., YURGENSON, G.A. and KOZACHENKO, A.A., 1981, Infrared spectra of fluorite from deposits of Central Kazakhstan: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 2, p. 37-43 (in Russian). First author at Tadzhik State Univ.

Fluid inclusion components: H_2O, CO_2 and organic matter were found by IR spectroscopy in fluorite crystals. (A.K.)

FELDMAN, M.D. and PAPIKE, J.J., 1981, Metamorphic fluid compositions from the Notch Peak aureole, Utah (abst.): EOS, v. 62, p. 435. Authors at Dept. Earth and Space Sci., SUNY, Stony Brook, NY 11794.

Upper Cambrian dolomitic limestones and interlayered argillites were contact metamorphosed during emplacement of the Jurassic Notch Peak quartz monzonite stock. Garnet porphyroblasts from high grade non-graphitic assemblages are generally fluid inclusion bearing. Fluid inclusions in high-grade minerals are particularly significant, as they are more likely to represent fluids trapped at or near peak metamorphic conditions, and thus may provide constraints on both the composition of peak metamorphic fluids and on the evolution of metamorphic fluid composition.

Optical study of over 1000 fluid inclusions and preliminary microthermometric data collected at Stony Brook on a single pass gas flow heating/freezing stage (described in Werre et al., 1979) have shown the following:

1. Fluids coexisting with garnet-bearing assemblages have very high

H_2O/CO_2 ratios;

2. Fluids have variable but high bulk salinities, ranging from ~20 to ~40 wt.% total salts;
3. Na^+, K^+ and CL^- are probably the most important dissolved constituents;
4. Ca^{++} is present in small but detectable quantities;
5. Fluids are compositionally complex, saturated with sulfides and several unidentified insoluble minerals at 25°C.

These data are consistent with experimental results of Gordon and Greenwood (1971), indicating that grossular is stable only at high H_2O/CO_2. The high solute concentrations in the fluid phase show that metamorphic fluids in non-graphitic carbonate rocks may depart strongly from the binary H_2O-CO_2 system, and point out the need to consider metamorphic fluid-rock interaction from the standpoint of high temperature solution chemistry. (Authors' abstract)

FENOGENOV, A.N. and EMEL'YANENKO, P.F., 1981, Finding of allanite in ore-bearing trap intrusives of the Noril'sk group of the North-West of Siberian Platform: Akad. Nauk SSSR Doklady, v. 256, no. 4, p. 939-941 (in Russian). Authors at Moscow State Univ., Moscow, USSR.

Experimental melting of basalts in a hydrogen atmosphere showed that the presence of fluid under reducing conditions basalt melts easily and produces two immiscible melts of contrasting composition. Olivine from the Noril'sk intrusives bears magmatic inclusions consisting of amphibole and biotite. (A.K.)

FERRELL, R.E., 1981, Clay mineral evidence for movement of high temperature subsurface fluids (abst.): Am. Assoc. Petro. Geol. Bulletin, v. 65, no. 7, p. 1360.

FILIPISHIN, F.L. and GROMOV, A.V., 1979, Inclusions of mineral-forming media in principal minerals of magnesian skarns in the Katalakh and Tsvetkova phlogopite deposits: Izv. Vyssh. Uchebn. Zaved., Geol. Razved, v. 22, no. 3, p. 62-66 (in Russian; trans. in Int. Geol. Review, v. 25, 1981, p. 927-930).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 12, 1979, p. 55-56. (E.R.)

FINCH, C.B., BALL, F.L. and BATES, J.B., 1981, Czochralski growth of single-crystal gehlenite ($Ca_2Al_2SiO_7$): J. Cryst. Growth, v. 54, p. 482-484. First author at Metals and Ceramics Div., Oak Ridge Nat'l. Lab., Oak Ridge, TN 37830, USA.

Single-crystal boules of gehlenite ($Ca_2Al_2SiO_7$) were grown from even- and off-stoichiometry melts under differing conditions of oxygen fugacity (fO_2). Growth was accomplished by the Czochralski method at 1600°C and 10^5 Pa (1 atm) total pressure, using inductively heated Ir or Pt - 20%Rh crucibles. The supra melt gas ambients included air ($fO_2 = 0.2x10^4$ Pa), Ar (10 Pa), Ar-50%CO_2-2%H_2 (10^{-2} Pa), and Ar-4%H_2-1.5%H_2O (10^{-4} Pa). Colorless, transparent material up to 8 mm diam. by 15 mm long was obtained from the evenly stoichiometric melt composition under Ar at growth rates of 1.5 mm/h or less. Growth at rates exceeding 2 mm/h or growth at a high fO_2 (e.g., air), led to the formation of bubbles and elongated voids or inclusions, predominantly in the core regions of boules. Optical, X-ray diffraction, and electron-induced X-ray fluorescence data are included. (Authors' abstract)

FLEET, M.E., MacRAE, N.D. and OSBORNE, M.D., 1981, The partition of nickel between olivine, magma and immiscible sulfide liquid: Chem. Geol., v. 32, p. 119-128.

FLEURY, P.A., 1981, Phase transitions, critical phenomena, and instabilities: Science, v. 211, no. 4478, p. 125-131. Author at Materials Res. Lab., Bell Laboratories, Murray Hill, NJ 07974.

Transformations among many of the diverse states of matter arise from microscopic interactions involving very many (approximately 10^{23}) constituent particles and result in dramatic changes in macroscopic properties. The values of some physical parameters vanish, while others approach infinity. These changes and their evolution are strikingly similar in systems as apparently different as liquids, magnets, superconductors, ferroelectrics, and liquid crystals, which suggests that there is an underlying unity to phase transition phenomena. The basis and extent of this unity are reviewed for many-body systems in equilibrium, and analogies with instability phenomena in systems far from equilibrium (such as lasers, fluid flows, and avalanche electronic devices) are pointed out. (Author's abstract)

FLORKE, O.W., MIELKE, H.G., WEICHERT, Jurgen and KULKE, Holger, 1981, Quartz with rhombohedral cleavage from Madagascar: Am. Mineralogist, v. 66, p. 596-600. First author at Institut fur Mineralogie, Ruhr-Univ. Bochum, Postfach, D-4630 Bochum, Germany.

Anhedral quartz slabs from a vein deposit in Madagascar showing smooth cleavage planes parallel to positive rhombohedra r {1011} are described. Only two of the three equivalent pairs of the form {1011} show cleavage, although of different quality (smoothness). The best developed planes lie parallel to Brazil-twin lamellae; the less well developed planes do not. We presume small tectonically induced thermal shocks to be the releasing mechanism for rhombohedral cleavage fractures. In combination with hydrolytic weakening and directed stress, large smooth cleavage planes were formed. Since the r-faces of quartz are F-faces, they have a minimum of free surface energy. We assume this to be the reason for cleavage parallel to positive rhombohedral faces. (Authors' abstract)

FORD, M.M., 1981, A fluid inclusion and petrographic study of barren and gold-mineralized quartz veins in the central and southern Carolina slate belt, North Carolina: M.S. thesis, Univ. North Carolina, Chapel Hill, NC, U.S.A., 72 pp.

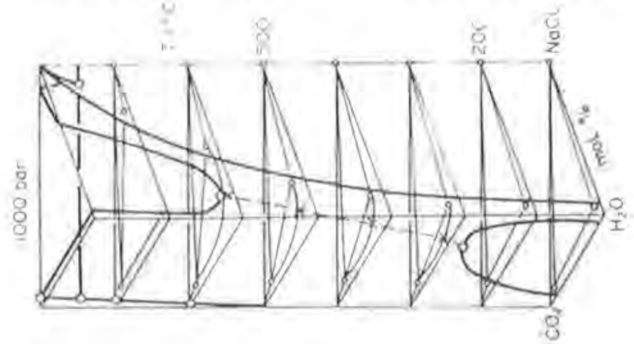
FRANCK, E.U., 1981, Survey of selected non-thermodynamic properties and chemical phenomena of fluids and fluid mixtures, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 65-88. Author at Inst. für Physikalische Chemie der Univ. Karlsruhe, D-75

Karlsruhe, FRG.

Water, aqueous solutions and mixtures, other polar fluids and fused salts are emphasized. The special qualities of these fluids, which are of interest in geochemisty, are always so closely related to thermodynamic properties that these have to be discussed together. The present knowledge of PVT-data of water and water-sodium-chloride solutions to 600°C and 4 kbar is shown. Examples of spectroscopic investigations of hydrothermal, dense solutions by u.v., i.r. and Raman methods are given. The viscosity and the dielectric constant of dense supercritical polar fluids are discussed. The electrolytic conductivity of dilute, concentrated and of ternary aqueous phases up to 1000°C is surveyed. Finally, phase boundaries and critical curves in binary systems with new results for the water-hydrogen system are presented and the ternary system water-carbon dioxide-sodium chloride is discussed. (Author's abstract)

Note: In the discussion of this paper (p. 86), Franck presents a tentative polythermal diagram (Fig. 4.20) for the important system H_2O-CO_2-NaCl, as shown below. (E.R.)

Fig. 4.20. Supplement to the previous Fig. 4.19 with additional details. Tentative "isobar" of the ternary system water-carbon dioxide-sodium chloride. The isothermal triangular planes at 300 to 600°C show estimated coexistence curves for two fluids, one rich in CO_2, and one rich in aqueous NaCl solution. The extrema of these coexistence curves are points on the critical curve, which is also qualitatively indicated on Fig. 4.19.



FRAPE, S.K. and FRITZ, P., 1981, Comments on origin and genesis of saline waters and brines found at depth in the Canadian Shield (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-19.

A research consisting of groundwater sampling and literature reviews has been undertaken to determine the chemical and isotopic composition of deep waters found in the crystalline rocks of the Canadian Shield. Results of these studies have shown most groundwaters sampled above 2000 feet to be relatively fresh, to be derived from meteoric waters and in mining environments to be often less than 30 years old. However, at a number of widely separated locations groundwaters sampled below 3000 feet were saline or brines with dissolved loads of 10,000 to 260,000 mg/L. Evidence from flow rates and length of flow and groundwater pressures would indicate that at some sites the reservoir for these brines is quite large and extensive. Chemically the brines were Ca-(Na)-Cl waters which contained little or no Mg-K-HCO_3. Isotopically (^{18}O and ^{2}H) these waters plot above and to the left of the global meteoric waterline, indicating ^{18}O depletion, ^{2}H enrichment or some combination of both. All Canadian Shield brines which have been sampled and analyzed to date, are isotopically and chemically different from any sedimentary, magmatic or thermal saline brine waters that the authors have found reported in the literature. The Canadian brines are also different from any groundwaters reported from other crystalline environments. Analyses have shown that these brines are not simple evaporated seawater, sedimentary basin brines, hydrothermal solutions or residual ore-forming fluids. Any of these sources may have provided an original water which was then trapped and highly modified by rock water interactions. Combinations of processes such as chloritization, albitization, the hydration of primary silicates and the neoformation of clay minerals modified not only the primary chemistries but also influences the isotopic composition of these brines. (Authors' abstract)

FREESTONE, I.C. and HAMILTON, D.L., 1981, The role of liquid immiscibility in the genesis of carbonatites - an experimental study: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 27-29.

FREUND, Friedemann, 1981, Charge transfer and O^- formation in high and ultrahigh pressure phase transitions: Bull. Minéral., v. 104, p. 177-185. Author at Mineralog. Institut der Univ., Zülpicher Str. 49, D-5000 Köln 1, Fed. Rep. Germany.

It is firmly established that in oxide crystals containing no transition metal cations molecular hydrogen can form from OH^- by oxidation of the O^{2-} state to O^- according to: $2\ OH^- \rightleftharpoons 2O^- + H_2$. The O^- in an O^{2-} matrix represents a defect electron and is symbolized by O•. A high thermal stability of O^- is anticipated due to resonance stabilization. The partial molar volume of O^- is about 20% smaller than that of O^{2-}. At high pressures and high degrees of H_2O saturation when nearly stoichiometric amounts of "water" are dissolved in, for instance forsterite, this postulated charge transfer (CT) between the hydroxyl O^{2-} and the hydroxyl H^+ leads to a new formula expression for forsterite under mantle conditions:

$$Mg_2SiO_4 + H_2O \rightleftharpoons Mg_2SiO_3(OH)_2 \rightleftharpoons Mg_2SiO_3O_2^{-}/H_2$$

A 7-10% zero-pressure volume decrease is anticipated for the phase on the right hand side which has undergone full charge transfer and consists of O^- and O^{2-}. Similarily the occurrence of atomic carbon in solid solution in MgO and mantle-derived olivines leads to the assumption that charge transfer processes also occur between $4\ O^{2-}$ and C^{4+} state of the CO_2 or CO_3^{2-} yielding $4\ O^- + C$ or, written in the CT formalism, $[CO_4]^{4-}$. Evidence is presented that charge transfer between atoms of different electronegativity is not restricted to the rather special cases of H_2O and CO_2. More examples of pressure-induced CT phases which probably consist of O^- are: (1) stishovite which, from partial molar volume considerations, should contain divalent Si^{2+} and two O^-, hence $Si''O_2^{-}$ and (2) the high-pressure polymorph of goethite, I-FeOOH where the trivalent Fe may be reduced to the divalent state concommittantly with the O^- formation; hence $Fe^{2+}O_2^{-}/(H_2)_{0.5}$. Applying this CT principle to olivines in the mantle of the earth leads to a novel concept for high and ultrahigh pressure phases which embrace also the final stage of CT transitions leading to the metallic state in the core of the earth. (Author's abstract)

FRIEND, C.R.L., 1981, Charnockite and granite formation and influx of CO_2 at Kabbaldurga: Science, v. 214, no. 4527, p. 550-552.

FUKUYAMA, Hiro, SYKES, M.L. and HOLLOWAY, J.R. 1981, Pre-eruption H_2O content of 1980 Mt. St. Helens dacite (abst.): EOS, v. 62, p. 1084. First author at Geol. Inst., Univ. Tokyo, Hongo, Tokyo 113, Japan.

Experimentally determined pre-eruption magmatic H_2O content and temperature of May 18, 1980, Mt. St. Helens dacite have been obtained from experiments determining pyroxene (px) and plagioclase (plag) phase relationships. Starting material was crushed May 18 pumice from which crystals were separated and 1-3 wt% H_2O added. This was heated to 1050°C at 3 kbar to form a homogeneous glass. To promote nucleation, 5 wt% of separated plag crystals were added back to the ground glass starting material before final welding in Ag-Pd capsules. Experiments at 0.5-2 kbar, 850-1050°C, fO_2 at NNO, were run in an internally heated pressure vessel equipped with a Shaw hydrogen membrane. Mounted and polished run products were anlayzed optically and by electron microprobe.

Results show inverse stability relationships with respect to temperature at constant pressure at 1 and 3 wt% H_2O for px and plag. At 1 wt% H_2O, px-out occurs at 1000±15°C and plag-out at 1100°C. At 3 wt% H_2O, plag-out occurs at 850°C and px-out at 900°C. The intersection of these stability curves at constant P yields a crystallization temperature of 1000±15°C at 2.5±.5 wt% H_2O. Composition of Fe-Ti oxides separated from crushed pumice indicate temperatures of 950±50°C and $-\log(fO_2)$ of 10±1.5; these values are consistent with the experimental results. (Authors' abstract)

FUZIKAWA, K., 1981, Fluid inclusions of several generations in metamorphogenic quartz: an example from Caetité, Bahia: Soc. Bras. Geol. - Núcleo Minas Gerais, Bull. no. 2, p. 71-91 (in Portuguese with English abstract).

Unlike fluid inclusions in idiomorphic minerals, the paragenetic distinction of secondary fluid inclusions in minerals from metamorphic rocks is less obvious, and in many cases quite impossible.

In the present case, five different quartz grains, from a vein-like structure of a gneissic rock, were selected for study. These grains contained various groups of different types of fluid inclusions. The manner of occurrence of these inclusions, in addition to 499 microthermometric measurements, and several crushing tests allowed the paragenetic differentiation of five types of fluid inclusions. This fact made possible the visualization of a possible evolution of the fluids during the onset of the Na-metasomatism on gneissic rocks of the Caetité area in centra-southern Bahia. (Author's abstract)

GAFFNEY, E.S., 1981, Possible terrestrial volcanic occurrences of gas clathrate hydrates: Geophys. Res. Letters, v. 8, no. 1, p. 51-54. Author at Los Alamos Sc. Lab., Los Alamos, NM 87545.

On the basis of the thermodynamic stability of hydrates of SO_2, H_2S and CO_2, it is suggested that those compounds may be found in some terrestrial volcanic environments. Hydrates of SO_2 and H_2S may be found in low-temperature fumaroles, especially where surrounding rocks are below 0°C. Such situations could occur at high altitudes and/or high latitudes. Hydrates of H_2S, SO_2, and CO_2 may be found on grain surfaces and in pore spaces of pyroclastic or other material overlying gas sources where proper conditions prevail, such as pore pressure equal to overburden pressure. For H_2S, such deposits can occur with mean surface temperatures as high as 20°C. Submarine volcanism could give rise to stable submerged hydrate occurrences analogous to both the above occurrences. (Author's abstract)

GALABURDA, Y.A. and KROCHUK, V.M., 1981, The crystal morphology and crystallization conditions of titanite from hydrothermal formations of the Ukrainian Shield: Mineral. Zh., v. 3, no. 1, p. 93-97 (in Russian; English summary).

Fluid inclusions in associated quartz are highly saline, with much CO_2. (E.R.)

GAT, J.R. and GONFIANTINI, R., eds., 1981, Stable isotope hydrology; deuterium and oxygen-18 in the water cycle: Intl. Atomic Energy Agency Tech. Repts. Series No. 210, 340 pp.

A thorough review, consisting of 13 chapters by various authors, of all aspects of isotopic fractionation and its measurement in samples from various types of geologic environments, including atmospheric, surface, ground, geothermal and paleowaters. (E.R.)

GEGUZIN, Ya.E. and DZYUBA, A.S., 1981, The role of open inclusions of supercooled melt in the formation of gas bubbles in the rear of a crystallization front: Kristallografiya, v. 26, p. 577-581 (in Russian; translated in Sov. Phys. Crystallogr., v. 26 no. 3, p. 325-327, 1981; pub. 1982). Authors at State Univ., Khar'kov.

The authors investigate the generation of gas bubbles during crystallization of a gas-saturated melt. They elucidate the contribution made by inclusions of supercooled melt to the formation of gas bubbles at the rear of the crystallization front. They estimate the velocity of gas bubbles in liquid layers separating elements of the crystal structure. They experimentally observe the yield of gas bubbles from the bulk of the solid phase during crystallization of a melt. (Authors' abstract)

GEGUZIN, Ya.E., DZYUBA, A.S. and KONONENKO, N.V., 1981, Concentration of impurities at the boundary of the moving crystallization front of a melt: Kristallografiya, v. 26, p. 571-576 (in Russian; translated in Sov. Phys. Crystallogr., v. 26, no. 3, p. 322-325; pub. 1982). Authors at State Univ., Khar'kov.

The authors suggest a "test bubble" method for investigating the distribution of gas during crystallization of a gas-saturated melt. They have measured the distribution of a gaseous impurity (air) ahead of a moving ice front. They discuss the experimentally observed process of periodic emission of gas bubbles. They determine the distribution coefficient ($K = 0.12$). They find the critical supersaturation ($\delta = 6.8$) at which gas bubble nucleation is observed during the crystallization of water saturated with air at 0°C. (Authors' abstract)

GEHRIG, M., LENTZ, H. and FRANCK, E.U., 1981, Phase equilibria and pVT of binary and ternary mixtures of water, carbon dioxide and sodium chloride up to 3 kb and 550°C (abst.), in Anniversary meeting of the Mineralogical Soc., Jan. 15-16, 1981, London: Mineral. Soc. Bull., 1980, no. 49, p.6.

In a vessel sealed with a movable piston and a sapphire window phase equilibria and pVT of binary and ternary joins consisting of water, carbon dioxide, and sodium chloride have been measured. The components have been chosen with regard to geochemical applications: knowledge of the solubility and mixing properties of such systems and their temperature and pressure dependence may help to evaluate liquid inclusion data. Especially, binaries from water and carbon dioxide, water and sodium chloride, and ternary mixtures have been investigated up to higher temperature and pressure conditions. Phase equilibria of such systems are represented and the influence of the salt is discussed. (Authors' abstract)

GELETIY, V.F., CHERNYSHEV, L.V. and PASTUSHKOVA, T.M., 1981, Study of equilibria of solid phases of the system PbS-CdS with water-salt solutions at elevated temperatures and pressures: Geokhimiya, no. 10, p. 1463-1481 (in Russian, English abst.). Authors at Inst. Geochem. of Siberian Branch of Acad. Sci. USSR Irkutsk.

Solubility of PbS and CdS was determined in NaCl, NH_4Cl, HCl+NaCl and NH_4Cl+NaCl water solutions at T 300-430°C and P 1000 atm. Pertinent to fluid inclusion studies. (A.K.)

GERLACH, T.M., 1981, Restoration of new volcanic gas analyses from basalts of the Afar region: further evidence of CO_2-degassing trends: J. Volcanol. Geotherm. Res., v. 10, p. 83-91. Author at Sandia Lab., Albuquerque, NM 87185 USA.

The restored compositions for approximately 70 new analyses reported recently for Erta'Ale lava lake (LeGuern et al., 1979) are in good agreement with restored compositions (Gerlach, 1980a) based on previously published data. The results confirm earlier indications that gas collections taken at different times from the lava lake are related principally by variations in CO_2 content. Restored compositions for gas samples collected in the final stages of a November 1978 Ardoukoba eruption along the Asal Rift spreading axis resemble the Erta'Ale gases except for a much lower CO_2 content. The Ardoukoba gases fall close to a CO_2-decreasing control line for gases with initial compositions similar to the 1971-1973 Erta'Ale gases. These results suggest that gases released from basaltic lava along zones of crustal spreading follow compositional trends dominated by changes in CO_2 content. (Author's abstract)

GERLACH, T.M., 1981, Characterization of magmatic volatiles (abst.): EOS, v. 62, p. 1057. Author at Sandia Natl. Labs., Albuquerque, NM 87185.

Existing high-temperature (>950°C) volcanic gas analyses are mainly restricted to samples from erupting tholeiitic and alkaline lavas. Detailed studies of 150 such analyses revealed several modifications superimposed on the samples during and after collection and causing erratic compositions. Computational methods were developed to correct the reported data. The restored analyses showed limited evidence of short-term variations. The principal species are H_2O, CO_2, SO_2. Minor species included H_2, CO, H_2S, S_2, HCl and HF. O_2 fugacities ranged from NNO to a half-order of magnitude below QMF. Regular compositional trends exist and are characterized by decreasing CO_2 with progressive outgassing; no evidence was found of a unique magmatic gas composition. The total sulfur (SO_2, S_2, H_2S) of the gases showed a positive correlation with lava O_2 fugacity. All restored analyses were significantly depleted in H_2O and enriched in sulfur and CO_2 compared to "excess volatiles." Simple models for the outgassing of sea floor basalts with change in depth (pressure) are consistent with the chemical trends observed in the restored data. The models indicate that CO_2 rich vesicle gases of sea floor basalts and H_2O rich volcanic gases approach end members in a spectrum of gas compositions evolved during the outgassing of tholeiitic basalts. These studies provided a data base for materials compatibility investigations relevant to magma energy extraction. (Author's abstract)

GIARDINI, A.A. and MELTON, C.E., 1981, Experimentally-based arguments supporting large crustal accumulations of non-biogenic petroleum: J. Petro. Geol., v. 4, no. 2, p. 187-190. First author at Dept. Geol., Univ. Georgia, Athens, GA 30602 USA.

The evolution of the Earth's atmosphere has been explained by a diffusion model that obeys first order kinetics. By assuming that the same rate law governs the diffusion of petroleum compounds that are known to exist in the upper mantle, we find that 1.5×10^{15} tons have diffused out during the past 3.1 billion years. If 0.1% of this primordial petroleum has undergone crustal migration and entrapment, deposits totalling 1.5×10^{12} tons are now present in the Earth's crust. Assigning a 0.3 recovery factor, this is equivalent to about 3 trillion barrels. (Authors' abstract).

The basis for the arguments is the analysis of gases evolved from crushing or graphitizing diamonds. (E.R.)

GIORDANO, T.H. and BARNES, H.L., 1981, Lead transport in Mississippi Valley-type ore solutions: Econ. Geol., v. 76, p. 2200-2211. Authors at Ore Deposits Res. Sect., The Pennsylvania State Univ., University Park, PA 16802.

The environment of base metal transport in Mississippi Valley-type ore solutions has been evaluatd thermodynamically. The average ore solution has at 100°C: $\Sigma m_S = 10^{-1}$ to 10^{-3}. $\Sigma m_C = 10^{-2}$ to 10^{-4}, $\log aO_2 = -54$ to -58 and $pH = 6.8$ to 7.8; and at 200°C: $\Sigma m_S = 10^{-1}$ to 10^{-3}, $\Sigma m_C = 10^{-2}$ to 10^{-4}, $\log ao_2 = -41$ to -46 and $pH = 6.2$ to 7.2. Under these conditions, chloride and bisulfide complexing together provide maximum galena solubilities of only 10^{-3} and 10^{-2} ppm lead at 100° and 200°C, respectively. Bisulfide complexes are predominant over chloride complexes. However, these concentrations are three to four orders of magnitude too low to form an ore deposit. Additional complexes involving the ligands SO_4^{-2}, CO_3^{-2}, HCO_3^-, NH_3, Br^-, and $S_2O_3^{-2}$, and the ion pairs $NaPbCl_3^0$ and $NaPbCl_4^-$ are also insufficiently stable to account for minimum concentrations of 10 ppm lead in the average ore solution. Thus, inorganic complexes are apparently inadequate mechanisms of lead transport in Mississippi Valley-type ore solutions.

As an alternative to inorganic complexing, the intimate association of organic material with Mississippi Valley-type mineralization suggests that organometallic complexes of lead were important in Mississippi Valley-type ore solutions. In the average ore solution at maximum feasible ligand concentrations, complexes with acetate, citrate, and oxalate cannot account for significant lead transport. However, lead in salicylate complexes could reach concentrations of roughly 3 to 30,000 ppm at 100° and at 200°C, respectively. Concentrations of saliclylate as small as 10^{-4} to 10^{-5} m may result in sufficient lead transport to form a Mississippi Valley-type ore deposit. (Authors' abstract)

GIGGENBACH, W.F., 1981, Geothermal mineral equilibria: Geochim . Cosmo. Acta, v. 45, p. 393-410. Author at Chem. Div., Dept. Scientific and

Indus. Res., 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 $\log PCO_2 = 15.26 - 7850/(t + 273.2)$, 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 aluminium-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)

GIZE, A.P. BARNES, H.L. and HOERING, T.C., 1981, The organic geochemistry of three Mississippi Valley-type deposits (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 459-460. First author at Ore Deposits Res. Sec., The Pennsylvania State Univ., University Park, PA 16802.

For three districts (Shullsburg, Wisc., Elmwood, Tenn., and Gays River, Nova Scotia), mineralized and unmineralized samples were analyzed for saturated and polycyclic aromatic hydrocarbons, metallo-porphyrins, and fatty acids, and the stable carbon isotopic compositions of the kerogens and extracts were also determined.

The organic material differs markedly between the three localities, reflecting differences in the source and post-diagenetic histories of the organic matter, and in the tectonic histories of the deposits. Differences within a deposit are less noticeable. There was no marked increase in aromaticity at the ore-bodies relative to the unmineralized localities. Metallo-porphyrins were detected only in Wisconsin, and the ratio of the nickel to vanadyl porphyrin increased at the ore-body. The occurrence of nickel porphyrins, either indigenous to the host-rocks, or introduced with the ore-forming solutions, may account for trace millerite (NiS) and siegenite ($(Ni,Co)_3S_4$) in these deposits.

The thermal maturity of the extractable organic matter and the kerogens differs between the deposits. In the Shullsburg mine, the thermal maturity is compatible with temperatures of 100°-220°C from primary fluid inclusions in the sphalerites of McLimans and others. This level of thermal maturity is in agreement with a calculated time of 0.25 my to form a major ore-body (using zinc dispersion data).

Genesis of these deposits involved the derivation of the ore-forming solutions from evolving sedimentary basins, with the inevitable incorporation of organic matter into the brines. In the Wisconsin deposit, the introduced organic matter has been diluted and masked by the high concentrations of indigenous organic matter. By contrast, the thermally more mature material at Elmwood shows clear evidence of having been introduced during the ore-forming process. (Authors' abstract)

GOEBEL, E.D. and COVENEY, R.M., 1981, High "homogenization" temperatures for sphalerite fluid inclusions from southwestern and southern Kansas (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 460. Authors at Univ. Missouri-Kansas City, Kansas City, MO 64110. (Continued)

Minor occurrences of metallic sulfides are common and widespread in Paleozoic carbonate rocks in the Mid-Continent area (Goebel 1966). As shown by Coveney and Goebel (1981), where specimens of these are recovered as insoluble acetic acid residues from carbonate rock cores, or from unheated cuttings, they are useful (especially clear sphalerite) in fluid inclusion homogenization temperature determination.

Homogenization temperatures measured in sphalerite specimens from D.L. Evans' (1962) Ordovician occurrences in southwest Kansas are uniformly high, but extremely erratic, ranging mostly from 150-270°C. As far as can be determined, after the cuttings from which these specimens were recovered, the cuttings were washed, then dried in gas ovens at extremely high temperatures. Our observed high temperatures, are most likely artifacts, caused by induced leakage and stretching of the fluid inclusions during the drying operation. Therefore, fluid inclusion workers should be aware of the post-recovery heating history of specimens from oil and gas explorational borehole drilling.

Known ore districts characteristically have homogenization temperatures greater than 100°C. We have measured filling temperatures of from 90-120°C from unheated surface samples of sphalerite from Pennsylvanian-aged rocks located in southern Kansas far to the west of the Tri-State District. Our measured temperatures are well within the range of temperatures common in the Tri-State District. This area of high temperatures in Elk and Montgomery Counties, Kansas, may be indicative of nearby undiscovered ore-grade deposits. (Authors' abstract)

GOGISHVILI and CHKHEIDZE, 1981 - See Appendix

GOLD, Thomas and SOTER, Steven, 1980, The deep-earth-gas hypothesis: Sci. Amer., v. 246, p. 154-161.

A hypothesis that primary methane is leaking out of the earth's interior and may yield some of the hydrocabon deposits now generally considered to be biogenic. Pertinent to the analyses of gas inclusions from mantle rocks (which have CO_2 and no methane). (E.R.)

GOLDING, L.Y. and KEAYS, R.R., 1981, Problems of ore genesis at Kalgoorlie (abst.): Geol. Soc. Australia, Abstracts, no. 3, p. 70. First author at Electrolytic Zinc co. of Australasia Ltd., Bentley, Western Australia.

The gold-telluride lodes at Kalgoorlie show characteristics of both epigenetic and modified syngenetic mineralization.

The main host rock, the Golden Mile Dolerite (G.M.D.), is a tholeiitic unit which, at least in part, extrusive and which is overlain by a sequence of shallow-water to subaerial sediments and pyroclastics called the Black Flag Beds (B.F.B.). Mineralization is localized about a synclinal infold of the B.F.B. into the G.M.D., known as the Boulder Dyke or Kalgoorlie Syncline, and also within interflow sediments associated with volcanic rocks underlying the G.M.D.

Gold, Ag, Te, Se, As, Sb, S, K and CO_2 have been introduced into the lodes and stockworks. Anomalous levels of these elements in some interflow sediments and B.F.B. shales suggest that the volcanic-sedimentary pile which hosts the ore deposits was the source of the ore constituents. As a tentative model, it is suggested that the interaction of active volcanism with the shallow-water to subaerial environment of the B.F.B. in which organic-rich black shales, carbonates and evaporite-bearing sediments were accumulating, provided ideal conditions for substantial localized concentration of metals. Deformation, thermal fluids and changes in physio-chemical conditions were probably instrumental in the transport and deposition of the ore-metals into their present sites. (Authors' abstract)

GOLDING, S.D. and WILSON, A.F., 1981, Geochemical and stable isotopic studies of the No. 4 Lode, Kalgoorlie, Western Australia (abst.): Geol. Soc. Australia, Abstracts, no. 3, p. 70.

GOLDSMITH, J.R., 1981, The join $CaAl_2Si_2O_8$-H_2O (anorthite-water) at elevated pressures and temperatures: Am. Mineralogist, v. 66, p. 1183-1188.

GOLYSHEV, S.I., PADALKO, N.L. and PECHENKIN, S.A., 1981, Fractionation of stable oxygen and carbon isotopes in carbonate systems: Geokhimiya, 1981, no. 10, p. 1427-1441 (in Russian).

GORBATYI and DEM'YANETS, 1981 - See Appendix

GORCHAKOV, P.N., KHOMYAKOV, A.P. and SHATSKAYA, N.S., 1981, Karpatite and typomorphic minerals of the tungsten-mercury ores of the Tamvatnei deposit (Chukotka): Akad. Nauk SSSR Doklady, v. 257, no. 2, p. 432-435 (in Russian). Authors at Inst. Mineral., Geochem. Crystallochem. of Rare Elements, Moscow, USSR.

Pertinent to organic compounds trapped in minerals. (A.K.)

GOROVOY, A.F., 1981, Deformation of cinnabar in ores from Nikitovskoe ore field: Geol. Rudn. Mest., v. 23, no. 1, p. 90-93 (in Russian). Author at Kommunarsk Mining-Metallurgical Inst., Kommunarsk, Ukrainian SSR.

Thermometric studies (Th?) showed that mercury sulfide crystallized at 115-135°C and dickite at 60-70°C. (A.K.)

GORYAINOV, I.N., 1981, Ratios (Fe+Mn)/Ti and (Fe+Mn)/Al in products of volcanic exhalations: Akad. Nauk SSSR Doklady, v. 256, no. 2, p. 457-458 (in Russian). Author at the North Marine Sci.-Production Geol. Geophys. Trust "Sevmorgeo," Leningrad, USSR.

Pertinent to the composition of hydrotherms. (A.K.)

GRAF, D.L., 1981, Hydraulic potential differences required in nature to drive salt filtration (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 462.

GRAF, J.L. and RICHARDS, Bill, 1981, Rare earth elements in hydrothermal carbonates associated with breccia-filling and replacement, Pb-Zn-Cu sulfide deposits in dolomite host rock, Viburnum Trend, Missouri (abst.): Geol. Soc. Am. Abstracts with Programs, v. 13, p. 279. Authors at Dept. Geol., Kansas State Univ., Manhattan, KS 66506.

In the Pb-Zn deposits of the Viburnum Trend, sulfide and carbonate minerals were deposited in a number of episodes. Isotopic and fluid inclusion studies have suggested that the ore solutions changed with time. The REE patterns of hydrothermal minerals should reflect these changes unless the solution REE pattern was overwhelmed by release of REE from the host rock. If rock REE dominate, however, all REE patterns should be the same regardless of the mineral's position within the paragenetic sequence.

Samples of hydrothermal (open space filling) calcite (OSC) and dolomite (OSD), recrystallized dolomite (RD), and dolomite host rock (DHR) from the Buick and Milliken (Sweetwater) mines were analyzed for REE using INAA. Late, OSC are depleted in light REE relative to OSD and RD (La/Sm = 0.6-0.96 for OSC and 2-2.2 for dolomites) and all of these carbonates are strongly depleted in LREE relative to DHR (La/Sum = 8.7 for DHR). All samples have negative Eu anomalies (Eu/Sm = 0.17-0.27).

The observed patterns for hydrothermal minerals might have been generated when a hydrothermal solution which was depleted in LREE reacted with DHR. The difference between the patterns of OSC and OSD may have been produced by two solutions with different REE patterns or by larger water/rock ratios in the solutions which deposited OSD and RD. (Authors' abstract)

GRAHAM, C.M., 1981a, Kinetics of hydrogen isotope exchange between hydrous minerals and water: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 175-178.

GRAHAM, C.M., 1981b, Diffusion of hydrogen in micas. Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 178-180.

GRAHAM, C.M., 1981c, Diffusion of hydrogen in epidote group minerals: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 180-182.

GRAHAM, C.M., 1981d, Closure temperatures for cessation of hydrogen isotope exchange during water-rock interactions: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 182-183.

GRAHAM, C.M., 1981e, Mechanisms of hydrogen and oxygen isotope exchange in mineral-fluid systems: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 183-185.

GRAHAM, C.M., 1981f, Stable isotope equilibrium and the fluid phase in cooling metamorphic rocks: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 185-187.

GRAHAM, C.M., BORTHWICK, J. and GRAHAM, A.M., 1981, A vacuum extraction technique for manometrical determination of the composition of the H_2O-CO_2 fluid phase in "mixed volatile" experiments: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 103-105.

GRANOVSKIY, A.G. and TRUFANOV, V.N., 1981, Typomorphic peculiarities of minerals of polymetal deposits of Gornaya Osetiya as criterion of depth of ore formation: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razv., no. 11, p. 51-56 (in Russian). Authors at Rostov State Univ., USSR.

The data were obtained during studies of deposits: Sadon, Zgid, Arkhon, Kholst, Fasnal, Levoberezhnoe. Vertical extent of polymetal mineralization is 2.5-3 km. Number of fluid inclusions in ore quartz is 9.5×10^4 to 8.5×10^6 per 1 mm^3. Solutions are of Na-K-Mg-Ca-SO_4-Cl-HCO_3 type, pH 6.2-8.4, total salt concentration 8-10 wt%, Th 380-60°C, P 74-12 MPa, paleotemperature gradient 4.8-15°C/100 m. (Abstract by A.K.)

GREENWOOD, H.J., ROSS, J.V., KLEPACKI, D. and GETSINGER, J., 1980, Cariboo Mountains project: Geol. Field work 1979, Prov. of Brit. Columbia, Min. of Energy, Mines and Petrol. Resources, Paper 1980-1, p. 151-155. Authors at Dept. Geol. Sci., Univ. British Columbia.

Specimens were collected from 16 localities in the Cariboo Mountains. Of these 27 specimens, 17 were taken from large and small quartz veins folded with and crosscutting the metamorphic and sedimentary structures. The remaining specimens have been studied petrographically and broadly confirm results of Campbell, Mountjoy, and Young (1973), who indicate a steadily increasing metamorphic grade from chlorite and biotite schists in the northwest to staurolite, kyanite, sillimanite schists in the southeast. The quartz veins have been examined for fluid inclusions and without exception all specimens are rich in fluid inclusions. The inclusions are small, ranging from 10 to 60 microns in diameter, and all have at least two fluid phases. Most inclusions consist of two fluids, a water-rich liquid and a carbon dioxide-rich gas, the gas amounting to 5 to 10 per cent by volume of the inclusions. One specimen contains three fluids, a water-rich liquid, a carbon dioxide-rich liquid, and a carbon dioxide-rich gas. This inclusion is approximately 60 per cent carbon dioxide overall, while the others range up to a maximum of 10 per cent. No inclusion was seen to contain solid daughter minerals and to date it has not been possible to determine homogenization temperatures due to the small size of the inclusions. The present limited sampling gives no clear indication of gradient in proportions of CO_2/H_2O in the metamorphic fluid, but it is hoped that more extensive sampling coupled with measurements on the heating/cooling stage will show good correlation between the properties of the fluids and the conditions indicated by the metamorphic mineral assemblages. (Authors' abstract)

GRIBANOV, A.P. and BELOZEROV, N.I., 1981, Some features of the electrophysical properties of pyrites of gold-containing districts in the central Amur River region: Metallog. Priamur'ya, 1981, p. 34-39 (in Russian). Edited by E.A. Kulish, Akad. Nauk SSSR, Dal'nevost. Nauchn. Tsentr, Vladivostok, USSR.

The type of elec. cond. (p and n type), the thermal emf, and the concn. of Co, Ni, Pb, Cu, and As were determined in pyrites. Homogenization and decrepitation studies showed a formation temp. 155-400° for pyrites. (Modified from C.A., 98: 164109S)

GRIGORIEV, D.P., EVZIKOVA, N.Z., ZIDAROVA, B., KOSTOV, I., KUZNETSOV, S.K., MALEEV, M., MINEEV, D.A., POPOV, V.A., TCHESNOKOV, B.V., SHAFRANOFSKIY, I.I. and YUSHKIN, N.P., 1981, The crystallomorphological evolution of minerals: Scientific Papers, USSR Acad. Sci. Komi Branch, Issue 76, 28 pp. (in Russian).

The investigation is devoted to the problem of crystallomorphological evolution of minerals. Examples of crystal form alteration in time and space are given. It is shown that these alterations are in conformance with laws. The regularity consists in the existence of evolutionary habits of crystals of minerals. It is expressed in crystallomorphological zoning of ore bodies and mineralization fields. The main factors of morphogenesis of crystals are discussed. The foundations of search and exploration crystallomorphology are given. (Authors' abstract)

GRIGORYAN, S.S., ROZERENKO, S.V. and MANUCHARYANTS, B.O., 1981, Thermal conditions for the formation of some gold ore deposits of Armenia:

Izvest. Akad. Nauk Armyanskoy SSR, Nauki o Zemle, v. 34, no. 2, p. 65-73 (in Armenian; English summary).
Indexed under fluid inclusions. (E.R.)

GRIGOR'YEV, Iv.F. and DOLOMANOVA, Ye.I., 1981, Thermobarogeochemistry of main minerals of tin ore deposits: Izv. Vyssh. Uchebn. Zav.-Geol. i Razv., no. 8, p. 33-43 (in Russian). First author at Moscow Geol.-Prospecting Inst., USSR.

The authors describe typical inclusions in cassiterite and accompanying minerals and give the list of elements found in precipitates from solutions in inclusions (by microprobe method): Na, K, Mg, Ca, Al, Si, Ti, Nb, W, S, Cl, Mn, Fe and rarer Sc, P, Ta, Zn, Cu. As trapped minerals in inclusions by electron microprobe were determined: Tapiolite, ilmenite, sphalerite, quartz, rutile, corundum, hematite, scheelite, fluorite, halite, sylvite, galenite. Chlorides usually exceed sulfates. Silicates and aluminosilicates of K, Ca, Fe and Na are common; rarer are oxides and carbonates of W, Ti, Al, Zn, Fe, Ca. Also CO_2 (determined in optical microscope) occurs very frequently. Similar characteristics of inclusions is given for quatrtz, beryl, topaz, tourmaline from tin deposits. A number of trapped minerals was determined by microdiffraction method (muscovite, halite, sylvite sulfohalite, jacobsite, etc.). Methods of analyses of L and G phase are also presented, as well as methods of measurement of Th and Td and the work of interpretation. (Abstract by A.K.)

GRIGOR'YEVA, T.A. and SUKNEVA, L.S., 1981, Effects of sulfur and of antimony and arsenic sulfides on the solubility of gold: Geokhimiya, 1981, no. 10, p. 1534-1540 (in Russian).

GRJOTHEIM, Kai, 1981, Characteristics and thermodynamics of fused salts, <u>in</u> Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 231-248. Author at Dept. Chem., Univ. Oslo, Norway.

GROMOV, A.V. and FILIPISHIN, F.L., 1979, The temperature regime of crystallization of post-phlogopite mineral associations in magnesian skarns of Central Aldan region: Vyssh. Ucheb. Zavedeniy Izv., Geol. i. Razvedka, no. 7, p. 52-58 (in Russian; translated in Internatl. Geol. Rev., v. 23, no. 6, 1981, p. 695-699). First author at Ordzhonikidze Moscow Geol.-Explor. Inst. (MGRI).

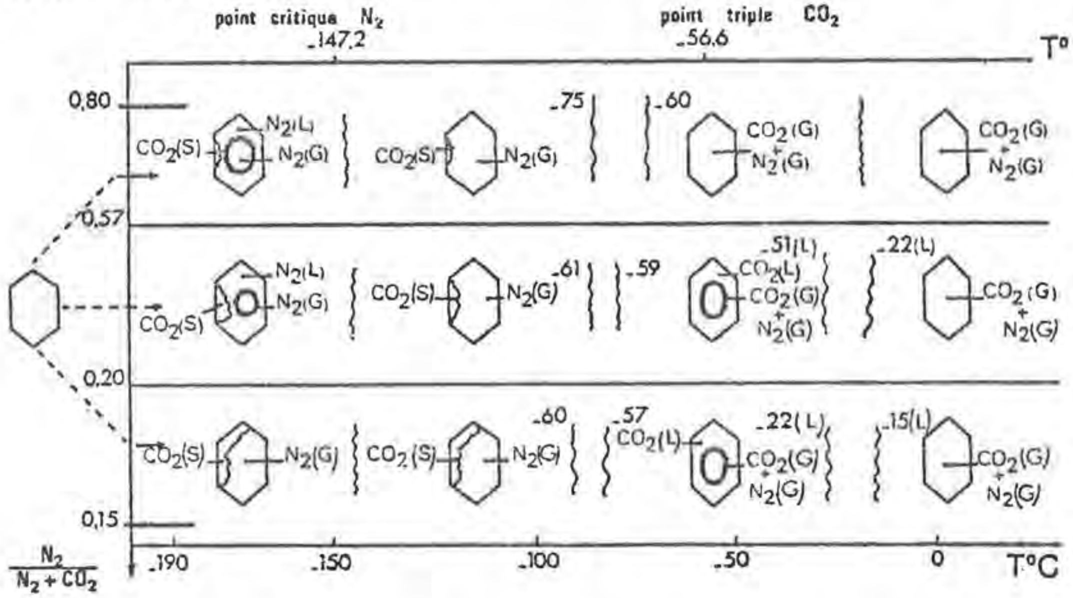
Th of inclusions in post-phlogopite minerals were as follows (°C): in rhombohedral calcite 40-300, and fluorite 60-200, from the calcite-fluorite-silicate association; in quartz 80-260 and in scalenohedral calcite 20-180, from the quartz-calcite-hematite association. An attempt was made to relate the relative concentrations of Cl, Na and K in a series of such deposits to the total gas "saturation" (e.g., Cl(in unstated units)/gas(ml/gm) ranged from 9 to 62). (E.R.)

GUILHAUMOU, N., DHAMELINCOURT, P. and TOURAY, J.C., 1981, Fluid inclusions in the N_2-CO_2 system composition and behavior on freezing (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). First author at ER no. 224 du CNRS, Lab. Geol. de l'Ecole normale superieure 46 rue d'Ulm, 75230 Paris Cedex 05, France.

N_2 + CO_2 inclusions may be divided into three classes of composition:

a) $N_2/(N_2+CO_2)$ > 0.57. Liquid nitrogen is always visible at very low temperature and Th occurs in the range -151°C to -147°C (nitrogen critical temperature); solid CO_2 sublimates between -75°C and -60°C. b) 0.20 < $N_2/(N_2+CO_2)$ < 0.57. Liquid nitrogen is visible at very low temperature, solid CO_2 melts on heating, liquid and gas CO_2 homogenize to liquid phase betwen -51°C to -22°C. c) $N_2/(N_2+CO_2)$ < 0.20. Liquid nitrogen is not visible even at vey low temperature (-195°C), liquid and gas CO_2 homogenize to liquid phase between -22°C and -15°C.

The $N_2/(N_2+CO_2)$ mole ratio have been determined using two different nondestructive and punctual techniques: Raman microprobe and optical estimation of the volume ratios of the different phases at low temperature. (Authors' abstract)



GUILHAUMOU, N., DHAMELINCOURT, P., TOURAY, J.-C. and TOURET, J., 1981. A study of fluid inclusions in the system nitrogen-carbon dioxide of dolomites and quartz from northern Tunisia. Results of microcryoscopy and Raman microprobe analyses: Geochim. Cosmochim. Acta, v. 45, no. 5, p. 657-673 (in French; English abstract). First author at ER No. 224 du C.N.R.S., Lab. de Géol. de l'Ecole normale supérieure, 46 rue d'Ulm, 75230 Paris Cedex 05, France.

Optical and analytical studies were performed on 400 $N_2 + CO_2$ gas-bearing inclusions in dolomites and quartz from Triassic outcrops in northern Tunisia. Other fluids present include brines (NaCl- and KCl-bearing inclusions) and rare liquid hydrocarbons. At the time of trapping, such fluids were heterogeneous gas + brine mixtures. In hydrocarbon-free inclusions the $N_2/(N_2 + CO_2)$ mole ratio was determined using two different non-destructive and punctual techniques: Raman microprobe analysis, and optical estimation of the volume ratios of the different phases selected at low temperatures. In the observed range of compositions, the two methods agree reasonably well.

The $N_2 + CO_2$ inclusions are divided into three classes of composition: (a) $N_2/(N_2 + CO_2) > 0.57$: Liquid nitrogen is always visible at very low temperature and homogenization occurs in the range -151°C to -147°C (nitrogen critical temperature), dry ice (solid CO_2) sublimates between -75°C and -60°C; (b) $0.20 < N_2/(N_2 + CO_2) \leqslant 0.57$: liquid nitrogen is visible at very low temperature but dry ice melts on heating; liquid and gas CO_2

homogenize to liquid phase between -51°C to -22°C; (c) $N_2/(N_2 + CO_2) \leq 0.20$: liquid nitrogen is not visible even at very low temperature (-195°C) and liquid and gas CO_2 homogenizes to liquid phase between -22°C and -15°C. The observed phase changes are used to propose a preliminary phase diagram for the system CO_2-N_2 at low temperatures.

Assuming additivity of partial pressures, isochores for the CO_2-N_2 inclusions have been computed. The intersection of these isochores with those for brine inclusions in the same samples may give the P and T of trapping of the fluids. (Authors' abstract)

GUIRAUD, Michel, SAUNIAC, Sophie and BURG. J.-P., 1981, Precise determination of P-T conditions during emplacement of the Pardailhan Nappe (Montagne Noire), using inclusions: C.R. Acad. Sci. Paris, v. 292, Ser. II, p. 229-232 (in French).

Fluid inclusions in quartz veins along the basal contact of the Pardailhan nappe (Montagne Noire, southern french Massif Central) have been analyzed. They are distributed in two families; the latter lead us to precisely determine P-T conditions of the epizonal metamorphism during which this nappe was emplaced: P = 1850 bar, T = 275°C. (Authors' abstract)

GUNTER, W.D. and GIRSPERGER, S., 1981, The halite saturation surface in supercritical brines (abst.): Terra Cognita, 1981 Spring, Special Issue, p. 40. Authors at Inst. fur Kristal. und Petrog., ETH-Zentrum, CH-8092 Zurich, Switzerland.

Thermal analysis of the halite liquidus in the binary system NaCl-H_2O was made at NaCl concentrations greater than $X_{NaCl}=0.25$ (i.e. >50 wt.% NaCl) at pressures between 1 and 4 kilobars. A chromel/alumel thermocouple, seated within a well inside a gold capsule containing ~300mg of a NaCl/H_2O mixture, was used. Temperatures were digitally recorded (to within 1 μ volt) over linear heating and cooling scans across the halite liquidus. Although mathematical analysis of the cooling runs produced a definitive DTA peak, the heating scans (particularly at the lower concentrations) did not. Consequently reversals of the liquidus were possible only at the more concentrated end of the binary.

This data when extrapolated to lower pressures than 1 kilobar lies at lower temperatures than that found for equivalent compositions on the three phase curve, halite-liquid-vapor determined from PVT measurements by other workers. (Authors' abstract)

GUTSALO, L.K., 1981, On the constancy of the world ocean water salinity and the argon concentration in the earth's atmosphere during the Phanerozoic era: Akad. Nauk SSSR Doklady, v. 257, no. 6, p. 1457-1460 (in Russian).

GUTSALO and PLOTNIKOV, 1981 - See Appendix

HAAPALA, I. and KINNUNEN, K., 1981, Fluid inclusion evidence on the genesis of Sn deposits (abst.): J. Geol. Soc. (London), v. 138, no. 2, p. 213.

Based on published data on fluid inclusions in cassiterite and associated minerals, a synthesis was presented on the temperature and other characteristics of the mineralizing fluids in different genetic types of Sn deposits. (Authors' abstract)

HAAS, J.L., Jr., LORENZ, J., CLYNNE, M.A., POTTER R.W., II, SCHAFER, C.M.

and GEVANTMAN, L.H., 1981, Geology, mineralogy, and some geophysical and geochemical properties of salt deposits: Physical properties data for rock salt, Natl. Bureau of Standards Monograph 167, p. 3-43. First author at U.S. Geol. Survey, Reston, VA.

A review of many aspects of salt, including fluid inclusions; 76 references. (E.R.)

HAMANN, S.D., 1981, Properties of electrolyte solutions at high pressures and temperatures, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 89-112. Author at Commonwealth Sci. and Ind. Research Org., G.P.O. Box 4331, Melbourne, Victoria 3001, Australia.

HANOR, J.S., 1981, The solubility of methane in sedimentary pore waters: effect of other dissolved gas species (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 467. Author at Dept. Geol., Louisiana State Univ., Baton Rouge, LA 70803.

Knowledge of the solubility of methane in sedimentary pore waters is of critical importance in evaluating problems ranging from bubble formation and sediment stability in shallow marine sediment to the resource potential of deeply buried brines. Methane solubility is generally evaluated or predicted on the basis of temperature, total pressure, and pore water salinity. An additional factor, usually neglected, but also significant, is the presence of other dissolved gas species. At a fixed T, total P, and brine salinity, the aqueous solubility of CH_4 is limited by its fugacity in a coexisting, water-saturated gas phase. The addition of other volatile gas components to the system lowers the fugacity of CH_4 and, hence, its aqueous solubility. Gases of relatively low solubility, such as N_2, Ar, and He, will have a greater effect on CH_4 solubility than will highly soluble gases, such as CO_2 and H_2S.

An evaluation of available analyses of dissolved gases in shallow marine sediments shows that many pore waters containing low absolute concentrations of CH_4 are actually saturated with respect to a binary CH_4-N_2 gas phase. Less information is available on dissolved gases in deep waters. However, the potential magnitude of effects of other gases on CH_4 solubility can be calculated. For example, take a brine containing 70,000 ppm NaCl at 120°C and 300 bars total P. As little as 8 mM/l dissolved N_2 would lower CH_4 solubility by 10%. The presence of this small amount of N_2 has the same effect on CH_4 solubility as lowering P by 30 bars, lowering T by 20°C, or increasing salinity to 90,000 ppm NaCl. (Author's abstract)

HANOR, J.S., 1981, Composition of fluids expelled during compaction of Mississippi Delta sediments: Geo.-Marine Letters, v. 1, p. 169-172. Author at Dept. Geol., Louisiana State Univ., Baton Rouge, LA 70803.

Fluids discharged from subaerial springs along faults on a sediment diapir near the mouth of the Mississippi River are derived from buried marine pore waters which have been extensively altered chemically by processes of bacterial respiration, mineral precipitation and, possibly, by fractionation due to the presence of clays of high exchange capacity.

Vertical mass transport of dissolved components in many shallow marine sediments is controlled by long-term compaction, diffusion, and bioturbation. In areas of rapid sediment deposition, however, these processes can be overwhelmed by catastrophic episodes of sediment failure, vertical mixing and upward discharge of water, gas and dissovled species. (Author's abstract)

HANSON, G.N., 1981, Geochemical constraints on the evolution of the early continental crust: Phil. Trans. R. Soc. Lond., v. 201, p. 423-442. Author at Dept. Earth and Space Sci., State Univ. New York, Stony Brook, NY 11794, U.S.A.

The most important process affecting both major and trace-element concentrations in the mantle and crust is melting producing silicate liquids which then migrate. Another process whose effects are becoming more apparent is the transport of elements by CO_2- and H_2O-rich fluids. Due to the relatively small amounts of fluids involved they have but little effect on the major-element abundances but may severely affect minor- and trace-element abundances in their source and the material through which they travel. (From the author's abstract)

HARRIS, D.M., 1981a The microdetermination of H_2O, CO_2, and SO_2 in glass using a 1280°C microscope vacuum heating stage, cryopumping, and vapor pressure measurements from 77 to 273 K: Geochimica et Cosmo. Acta, v. 45, p. 2023-2036. Author at Dept. Geol., The Univ. Alberta, Edmonton, Canada T6G 2E3.

A new microscope vacuum heating stage and gas analyzer has been developed for measurement of H_2O, CO_2, SO_2, and noncondensable gas (H_2, CO, N_2, Ar, CH_4, etc.) evolved from samples, particularly natural glass, at temperatures up to 1280°C. The gas evolved upon heating to 1280°C is collected in a liquid nitrogen cold trap. Gas components are identified by the characteristic vapor pressure and temperature ranges over which solid and vapor are in equilibrium during sublimation of individual components. The masses of CO_2, SO_2, and H_2O derived from samples and blanks are calculated using the ideal gas law, the molecular weights of the components, and the gauge constant (i.e., the ratio of the number of moles of gas to its partial pressure in the constant volume). Results obtained by repeated determinations of H_2O, CO_2, and SO_2 evolved from a submarine basaltic glass from Kilauea volcano, Hawaii, (average sample mass = 3×10^{-3}g) gave probable errors for the determinations of H_2O (0.23%), CO_2 (0.025%), and S (0.071%) equal to 4, 10, and 8% respectively, of the concentrations. Determinations of H_2O in smaller samples of H_2O-poor basaltic pumice show a linear proportionality (0.063%) between the measured H_2O and the sample mass over the range 0.1×10^{-6} to 1.7×10^{-6}g H_2O. Comparisons of H_2O determinations by this technique with those obtained by Penfield, gas chromatic, microcoulometric, and vacuum fusion techniques used elsewhere show reasonably good agreement. Determinations of SO_2 by this technique agree reasonably well X-ray fluorescence and electron microprobe determinations of sulfur. Determinations of CO_2 by the present technique are reproducible but cannot be compared directly to measurements made in other labs because of differences in samples analyzed. The principle advantages of this analytical technique are the very small sample required, the simultaneous determination of H_2O, CO_2, SO_2 and noncondensable gas, the avoidance of calibration procedures dependent on chemical standards, and the visual observations that can be made during sample outgassing. (Author's abstract)

HARRIS, D.M., 1981b Vesiculation and eruption of a subduction zone basalt (abst.): EOS, v. 62, no. 45, p. 1084. Author at Dept. Geol., The Univ.

Alberta, Edmonton, Canada, T6G 2E3.

The 1974 eruption of Fuego produced an ash blanket with a dense magma volume of >0.1 km^3. The tephra are vesiculated, high-Al basalt with abundant phenocrysts of plagioclase and olivine, and lesser amounts of magnetite, augite, and oxyhornblende. The compositions of melt inclusions within olivine vary in a systematic way and reflect the continuously changing liquid composition due to crystallization of plagioclase (up to 23% by mass), olivine (4%), magnetite (3.5%), and augite (8%) from a basaltic liquid similar in composition to the erupted ash. Pre-eruption crystallization increased the concentration of H_2O dissolved in the residual melt from 1.6 ± .3% (51% SiO_2, Fo77 host) to about 3.5% (54% SiO_2, Fo71 host) such that its partial pressure just before eruption was about 1250 bars. I speculate that, due to increase of $P(H_2O)$, fractures developed in the rock surrounding the magma body and the increased volume allowed vesiculation of the magma. However, a calculated energy budget for th PdV work that can be performed during ascent by stepwise isothermal exsolution of the H_2O (3.5%) dissolved in the pre-eruption liquid and decompression of the steam is less than the energy required to move the magma (60% liquid, 40% crystals) toward the surface from an assumed depth of 3 km. Detailed analyses of the conditions within the Fuego magma body, inferred from melt inclusions, show that an explosive eruption would have occurred only if the magma became very significantly enriched in H_2O by accumulation of vapor, or the magma ascended to the surface by some means other than expansion of gas. Because large amounts of H_2O are required as propellants for explosive magmatic eruptions and exceed the amounts dissolved in the liquid just before eruption, enrichment of the upper portions of magma bodies with a free vapor phase seems to be a necessary and sufficient condition for such eruptions. (Author's abstract)

HARRIS, Gene and KOSTER VAN GROOS, A.F., 1981, Liquid immiscibility in the system $NaAlSi_3O_8$-Na_2CO_3 at pressures of 30 kilobars (abst.): Geol. Soc. Am. Abstracts with Programs, v. 13, p. 280. Authors at Dept. Geol. Sci., Univ. Illinois, Box 4348, Chicago, IL 60680.

Phase relationships in the system $NaAlSi_3O_8$-Na_2CO_3 have been determined at temperatures of 1000°-1450°C and 30 kbar pressure. The liquid miscibility gap occurring between Na_2CO_3-rich liquids and silicate rich liquids at 1 kbar (Koster van Groos and Wyllie, AJS:264, 1966) persists at 30 kbar. The eutectic in the pseudobinary system $NaAlSi_3O_8$-Na_2CO_3, consisting of sodium carbonate+jadeite+quartz+liquid, lies at 1080°C and 80% $NaAlSi_3O_8$-20% Na_2CO_3. The two-liquid field is present at 1150°C over a range of compositions. The albite→jadeite+quartz transition seems to have little effect on the phase relations compared to those at 1 kbar. The presence of the two-liquid field at geologically reasonable temperatures and pressures lends support to the possibility of the origin of alkaline carbonatite complexes by liquid immiscibility. (Authors' abstract)

HAYASHI, M., TAGUCHI, S. and YAMASAKI, T., 1981, Activity index and thermal history of geothermal systems: 1981, Geothermal Resources Council, Transactions, v. 5, p. 177-180. Authors at Res. Inst. Industrial Sci., Kyushu Univ. 86 Hakozaki, Fukuoka City 812, Japan.

An activity index which indicates the degree of potential of a geothermal system or a geothermal well is proposed here as follows: $AI = 1-(Tb-Tm)/(Tb-Tg)x100$, where Tm is the maximum temperature measured or estimated, Tb is the saturated temperature corresponding to the integrated hydrostatic pressure at the depth yielding the highest temperature, and Tg is the assumed temperature at the above depth when the geothermal gradient is the same as the average value for the world, 3°C/100m. Based on this activity index, a geothermal system or a geothermal well can be objectively evaluated and classified in one of the following seven categories: AA above 100, A 100-80, B 80-60, C 60-40, D 40-20, E 20-0 and F below 0. Very active fields belong to Type A, whereas less active ones to Type B or C. However, the fluid inclusion study has revealed that some of the latter were of Type A in the past, and their thermal histories have been traced by a combination of the fission track data. (Authors' abstract)

HE, Luqing and DIAO, Peiliang, 1981, A study of the reliability of (analyses of) gases extracted from inclusions in minerals by the heating decrepitation method: J. Central-South Inst. Mining and Metal., no. 2, p. 107-113 (in Chinese; English abstract).

In order to improve on the reliability of analyses of gases in mineral inclusions that are extracted by the heating decrepitation method, the specific effects of extracting temperature on dynamic characteristics of water, carbon dioxide, nitrogen, hydrogen and methane extracted from inclusions in minerals are investigated in this paper. Chemical reactions between gases, and between gas and solid are also studied through tests of gas mixtures.

The investigations of dynamics and thermodynamics show that the gas phase of inclusions in examined quartz from gold veins consists mainly of N_2, H_2O and CO_2. However, a considerable part of the H_2 and CH_4 found by the heating decrepitation method is probably due to chemical reactions and the decomposition of organic matter. In accordance with the calculations of chemical thermodynamics, it is possible that chemical reactions such as $CO + H_2O \rightleftharpoons CO_2 + H_2$, $CH_4 + H_2O \rightleftharpoons CO + 3H_2$ and $2FeO + H_2O \rightleftharpoons Fe_2O_3 + H_2$ can take place under the circumstances of heating decrepitation method. It is demonstrated that these chemical reactions depend on extraction temperature, concentration of gases and presence of water.

The authors have designed a vacuum extraction device for the heating decrepitation method. It can avoid chemical reactions. It is possible to extract gases in mineral inclusions reliably. (Authors' abstract, modified by E.R.)

HE, Luqing, DIAO, Peiliang, LIU, Jie and LIAO, Fengxian, 1981, Determination and study of the compositions of gases in fluid inclusions: J. Central-South Inst. of Mining and Metallurgy, 1981, no. 3 (in Chinese; English abstract).

The extraction and determination of the compositions of gases in fluid inclusions have been investigated. The authors have designed a simple device for vacuum heating explosive extraction. It is proposed to use vacuum heating explosive extraction - gas chromatography for determining water, carbon dioxide, hydrogen, oxygen, nitrogen, carbon monoxide and methane simultaneously in fluid inclusions. Better results are obtained by this method. (Authors' abstract)

HEDENQUIST, J.W., 1981, Geological and geochemical evidence for cyclic variations in temperature and gas chemistry at Waiotapu geothermal system, N.Z.: implications for epithermal-type Au-Ag mineralization: Abstracts from 1981 New Zealand Geochem. Group Conf., Inst. Nuclear Sci., Lower

Hutt, New Zealand, 23 Sept. 81, p. 12-13. Author at Geothermal Inst., Univ. Auckland, New Zealand.

The active geothermal systems of the Taupo Zone, N.Z., bear many similarities in their setting, rock type, hydrothermal alteration and mineralization, fluid chemistry and temperature - pressure regime to the Miocene epithermal volcanic Au-Ag and Cu-Zn-Pb vein deposits of Japan and the Tertiary Au-quartz-adularia vein deposits of Nevada, USA. Hydrothermal alteration of the silicic volcanics of Japan by dilute (<2 wt. % NaCl equiv.), near-neutral pH fluids in a near surface zone at temperatures from 200 to 280°C results in deposition of adularia, pyrite, chlorite, white-mica and silica.

At Waiotapu there are anomalous Au-Ag-As-Sb(-Hg-Tl) concentrations in surface sinter and Zn-Pb-Cu sulfides at depth with alteration and mineral deposition comprising albite, adularia, white-mica, pyrite, chlorite, epidote, zeolites, and calcite and silica at temperatures of 180 to 295°C. Deep fluids are of near-neutral pH and contain 0.2 wt. % NaCl, 0.05 molal CO_2 and 0.003 molal H_2S.

Integration of mineralogy, present subsurface fluid chemistry and fluid inclusion data indicate changes in fluid chemistry, pH and temperature, possibly of a cyclic nature. These changes may be related to hydrothermal explosion activity, of which there is much evidence in the Waiotapu area, with some events dated at ~900 years B.P. Metal concentration in the Champagne Pool sinter is presently occurring, although there is good evidence that this is also cyclic.

Seward (1973) has experimentally demonstrated how temperature, pressure, total sulfur and, particularly, pH affect Au solubility under geologically reasonable conditions for epithermal mineralization, with sulfur content and temperature decreases and pH shifts from near neutrality resulting in decreased Au solubility.

It will be demonstrated how buildup of gas pressures in a sealed system can contribute to the mechanism of hydraulic fracturing and hydrothermal explosions, with subsequent boiling, gas loss, temperature drop and mineral deposition, resulting in a resealing of the system. This gas loss will result in an increase in fluid pH, with both of these coupled factors causing Au thio complexes to be destabilized and Au to precipitate. Therefore, it is hypothesized that fluctuations in gas content (possibly related to volcanic events), which may be detectable in ore deposits by fluid inclusion studies, are of prime importance in controlling the stratigraphic position of Au concentration in these types of convective systems, particularly those with evidence of catastrophic change in the system (hydraulic fracturing and hydrothermal explosions). (Author's abstract)

HEIN, U.F., 1981, Relationships between fluorine anomalies and fluorite geochemistry in the carbonate-hosted Zn-Pb-F-Ba mineralizations of Alpine Triassic formations: Mem. Soc. Geol. Ital., v. 22, p. 83-99 (in Italian; abstract courtesy P. Lattanzi). Author at Inst. f. Angewandte Geol. der Freie Univ., Wichernstrasse 16, D-1000 Berlin 33, FRG.

The author quotes unpublished data which he obtained on fluid inclusions in fluorite from the Paglio Pignolino deposit, province of Bergamo. Th is between 80° and 110°C, while freezing temperatures range from -12.8° to -16.7°C. The data are considered to be very similar to values typical for Mississippi Valley deposits.

HELGESON, H.C., 1981, Prediction of the thermodynamic properties of electrolytes at high pressures and temperatures, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 133-178. Author at Dept. Geol. and Geophy., Univ. California, Berkeley, CA 94720, USA.

HELGESON, H.C., KIRKHAM, D.H. and FLOWERS, G.C., 1981, Theoretical prediction of the thermodynamic behavior of aqueous electrolytes at high pressures and temperatures: IV. Calculation of activity coefficients, osmotic coefficients, and apparent molal and standard and relative partial molal properties to 600°C and 5 kb: Am. J. Sci., v. 281, no. 10, p. 1249 (whole number).

HELZ, R.T. and THORNBER, C.R., 1981, Geothermometry of Kilauea Iki lava lake (abst.): EOS, v. 62, p. 1073. First author at U.S. Geol. Survey, Menlo Park, CA 94025.

Kilauea Iki lava lake, formed in 1959, has been cored repeatedly, down to its molten interior. The lowest core recovered in most holes is partially molten before drilling and is quenched by the cooling water used during drilling. These deep core samples are potentially an excellent set of natural crystallization experiments if we can determine their temperatures prior to quenching.

Temperatures have been estimated by measuring downhole temperatures after drilling and by analyzing coexisting magnetite and ilmenite in the cores and applying the goethermometer of Buddington and Lindsley. The results show that measured downhole temperatures are lower than Fe-Ti oxide temperatures by 50-250°C, except in one hole. As the discrepancy is larger where more cooling water was used, it seems that most holes did not recover thermally after drilling. T-fO_2 values for the first appearance of magnetite in 1967-1979 core from Kilauea Iki are consistently higher (1080-1100°C, fO_2 near the NNO buffer) than in Makaopuhi and Alae lava lakes (1030-1050°C, fO_2 near the QFM buffer). Initial compositions in Kilauea Iki were more reducing: Fe-Ti oxides from the earliest (1960-62) core give fO_2-T values more like those of Makaopuhi and Alae.

To establish quenching temperatures for core from above magnetite-in, melting experiments were performed on a sample of core from near the base of the crust in KI75-1. The runs were made by holding the sample in a loop of thin Pt wire; fO_2 was maintained on the NNO buffer using CO_2-H_2 mixtures. Glass in runs at 1130°C is identical in composition to glass in the core at the crust/melt interface in KI75-1. This temperature (1130°C) is much higher than the temperatures of 1060-1060°C observed at the crust/melt interface in both Makaopuhi and Alae lava lakes, and reflects the higher olivine content of Kilauea Iki. (Authors' abstract)

HENDEL, E.M. and HOLLISTER, L.S., 1981, An empirical solvus for CO_2-H_2O-2.6 wt% salt: Geochim . Cosmo. Acta, v. 45, p. 225-228. Authors at Dept. Geological and Geophys. Sci., Princeton Univ., Princeton, NJ 08544, USA.

The solvus in the system CO_2-H_2O-2.6 wt% NaCl-equivalent was determined by measuring temperature of homogenization in fluid inclusions which contained variable CO_2/H_2O but the same amount of salt dissolved in the aqueous phase at room temperature. The critical point of the solvus is at 340 ± 5°C, at pressures between 1 and 2 kbar; this is about 65°C higher than for the pure CO_2-H_2O system. The solvus is assymetrical, with a steeper H_2O-rich limb and with the critical point at mole fraction of water between 0.65 and 0.8. (Authors' abstract)

HENDRY, D.A.F., CHIVAS, A.R., REED, S.J.B. and LONG, J.V.P., 1981, Goechemical evidence for magmatic fluids in porphyry copper mineralization. Part II. Ion-probe analysis of Cu contents of mafic minerals, Koloula Igneous Complex: Contrib. Mineral. Petrol., v. 78, p. 404-412. First author at Dept. Geol. and Geophysics, Univ. Sydney, NSW 2006, Australia.

The Cu contents of biotites (av. 880 ppm), amphiboles (16 ppm) and magnetites (160 ppm) from barren intrusions of the Koloula Igneous Complex are significantly greater than the Cu contents of the same minerals from unaltered mineralizing intrusions (av. 23, 6 and 20 ppm respectively). The Cu content of amphiboles from mineralizing intrusions is strongly domain-dependent, with Cu (and chlorine) being depleted in compositional domains that formed during intermittent boiling of hydrothermal fluids. The conversion of pyroxene to amphibole is an unlikely process for the release of Cu.

Owing to the differences in Cu contents of biotite, amphibole, and magnetite, mineralizing rock types from the Koloula Igneous Complex are depleted in Cu compared to barren intrusions by 60 ppm, of which 57 ppm is attributable to biotite, 0.5 ppm to amphibole, and 2 ppm to magnetite. Partitioning of the amount of Cu measured here into the fluid phase during boiling is potentially large enough to produce porphyry copper orebodies. The high Cu-contents of minerals from barren rocks suggest that igneous complexes that are hosts for porphyry copper deposits may be anomalously enriched in that metal. (Authors' abstract)

HESSE, R. and HARRISON, W.E., 1981, Diagenetic effects of gas-hydrates (methane-clathrates) (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-25.

The wide-spread occurrence of gas-hydrates under the deeper parts of continental margins predicted from seismic profiles has recently been confirmed by the recovery of "frozen" volcanic ash from DSDP drill holes 496 to 498 on the Pacific continental slope (2064 to 5497 m water depth) off Guatemala. If the pressure is high enough, hydrates form in organic-matter rich terrigenous sediments which produce early diagenetic methane in excess of pore water solubility. In deep marine sections hydrate zones may be more than 1 km thick. However, the base of the hydrate zone has not been penetrated on the Guatemalan margin.

In hydrate bearing sediments the most noticeable diagenetic effect is the downward decrease in salinity of the pore fluids (to about half the salinity of sea water). This observation (e.g. Guatemalan margin; Blake Outer Ridge) cannot be attributed to the influx of meteoric water from the continent, because of greater water depth, long distance from the coast and positive oxygen isotopes (reaching maximum δ-values of approx. +2.50‰ at the bottom of the holes near 400 m sub-bottom). Isotopic fractionation by hydrates is known to concentrate light isotopes in the fluids. Partial separation of the solids (sedimentary particles and hydrates) from the pore fluids during compaction leads to heavy isotope enrichment when the hydrates thaw and remix with the remaining pore fluids. Exclusion of salts from the crystal structure of hydrates similarly explains the downward freshening of the pore fluids. This may significantly affect diagenetic reactions in marine sediments at depth which may behave more like fresh-water sediments. In the clay fraction no mineralogic changes have been observed from top to bottom of the holes. Furthermore, thawing at the base of the hydrate zone may cause anomalously high fluid pressures and development of gas reservoirs. (Authors' abstract)

HEYEN, Georges, RAMBOZ, Claire and DUBESSY, Jean, 1981, Simulation of fluid phase equilibria in carbonic systems: Application to the study of fluid inclusions (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). First author at Univ. de l'Etat à Liège, LASSC, 2, rue A. Stévart, B-4000, Liège, Belgium.

Both RAMAN spectroscopy and microthermometry are now available to analyze carbonic inclusions. Their combined use has created the need for (1) more accurate interpretative diagrams relative to binary mixtures, and (2) new models for interpreting phase equilibria in multicomponent systems.

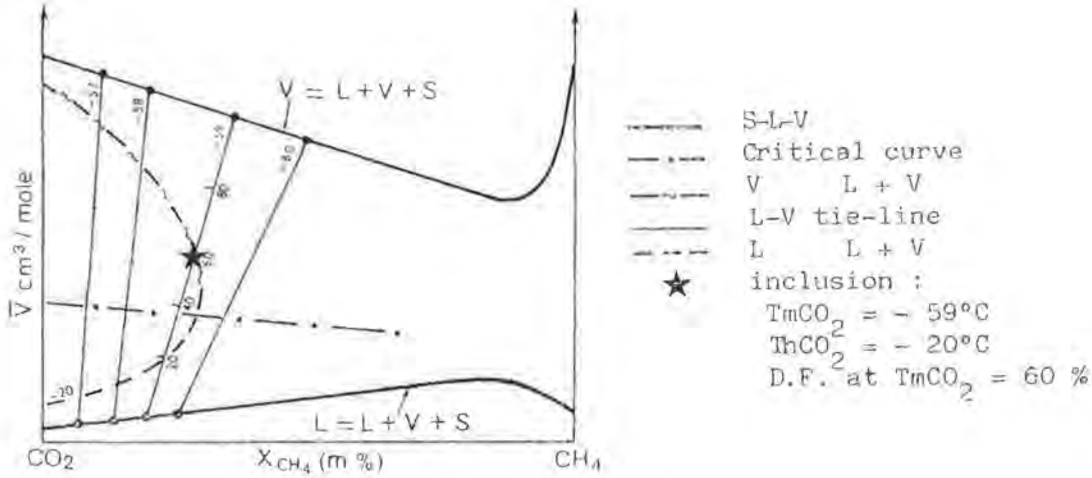
The liquid-vapor and solid-liquid-vapor equilibria in the CO_2-CH_4-C_2H_6 system and related subsystems have been simulated using the three-parameter equation of state and the mixing rules proposed by Heyen (1980). In particular:

1) a model for the $\underline{CO_2\text{-}CH_4}$ system has been adjusted using the P, T, X, $\overline{V}$ data in the two-phase region. Its validity to reproduce the available P, T, X data along the solubility curve are considered as a proof of the validity of the predictions of the volumes along the solubility curve.

Summarizing the analyses of Burruss (1977) and Swanenberg (1979), a unique $\overline{V}$, X diagram is proposed: a) to compare the $TmCO_2$-$ThCO_2$-degree of filling of an inclusion to the properties of the binary CO_2-CH_4 system, and determine its composition and density if binary. b) To interpret $TmCO_2$-degree of filling in terms of composition and density of the mixtures considered as a binary one (case where no carbonic liquid visible under microscope).

2) An equation of state for the CO_2-CH_4-C_2H_6 system below 31°C is constructed after an adjustment on the three binary subsystems.

It enables us to determine the density of any mixture composed of CO_2-CH_4-C_2H_6 provided that the bulk composition expressed in mole fraction is analyzed with the Raman microprobe M.O.L.E. and that a phase equilibrium is observed. (Authors' abstract)



Schematic $\overline{V}$,X projection in the CO_2-CH_4 system.

HITCHON, Brian, 1981, Genetic links between shales, formation fluids and ore deposits -- example for zinc from Alberta, Canada (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 473. Author at Alberta Res. Council, 11315 - 87th Ave., Edmonton, Alberta, Canada T6G 2C2.

Previous studies by the author, using statistical factor analysis, have shown that zinc in Alberta formation waters occurs as a separate factor with a weak opposed loading for the partial pressure of carbon dioxide in the associated natural gas, and that zinc in Alberta crude oils also occurs as a separate factor but with a small opposed loading for sulphur in the crude oil.

In the table below, the average content of zinc in Cretaceous and Devonian shales from Alberta (previously unpublished data) is compared with the average content of zinc in Alberta formation waters and crude oils (based on the above-cited studies), and the partial pressure of carbon dioxide and hydrogen sulphide in the associated natural gases, for the same stratigraphic units.

	Shales	Formation Water	Crude Oil	pCO_2	pH_2S
Cretaceous	187 ppm	0.27 mg/ℓ	332 ppb	13 psi	6 psi
Devonian	66 ppm	1.43 mg/ℓ	470 ppb	94 psi	211 psi

Contents of zinc up to 90.7 mg/ℓ have been found in some Middle Devonian formation waters (unpublished data).

Based on the conclusions from the statistical factor analyses and known basinal hydrodynamics, the data in the table suggest that the generation of both carbon dioxide and hydrogen sulphide in the Devonian shales through maturation is a possible mechanism for releasing zinc from these shales, with subsequent accumulation in the liquid phases. Further, such a suggestion is consistent with the presence of scattered occurrences of zinc minerals in several Devonian carbonate reefs and the commercial zinc ore body in Middle Devonian rocks at Pine Point in the Northwest Territories, Canada. (Author's abstract)

HO, Lu-qing and DIAO, Pei-liang, 1981, Determination and study of the composition of gases in fluid inclusions of Xiang-Xi gold ore deposit: Geol.-Geochem., v. 9, p. 37-39 (in Chinese; abstract courtesy Dr. Huan-Zhang Lu).

Water, carbon dioxide, methane, nitrogen, hydrogen, carbon monoxide, ethylene and acetylene in fluid inclusions of Xiang-Xi gold ore deposit were determined by vacuum decrepitation extraction - gas chromatography technique. The sensitivities in the determinations of water, carbon dioxide, methane, carbon monoxide, nitrogen, hydrogen, ethylene and acetylene were 10, 1.4, 0.1, 0.5, 0.3, 0.001, 0.002 and 0.001 μg respectively. The relative standard deviations ranged from 1.2 to 10.5% except methane for which it was 13.9%. The amounts of water and volatiles (gases) determined in inclusions of quartz from different locations are listed in following table.

The origins of these gases have been investigated as well. The experimental results show that water, carbon dioxide, nitrogen and carbon monoxide, etc. come from the fluid inclusions, while methane may also come from other sources. The possibility that hydrogen comes directly from the fluid inclusions is questionable. (Authors' abstract)
(Continued)

Anal. No.	Material	Sample Wt. (g)	Total no. of samps. anal.	Average amounts of evolved gases (μg/g)*							
				H_2O	CO_2	CH_4	CO	H_2	N_2	C_2H_4	C_2H_2
1	quartz-sulfide vein #1	5	8	3020	114.0	3.2×10^{-1}	trace	8.0×10^{-2}	13.8	N.d.	N.d.
2	quartz-sulfide vein #2	5	9	2740	82.0	2.2×10^{-1}	trace	1.6×10^{-1}	9.4	1.68×10^{-1}	8.0×10^{-3}
3	quartz-sulfide vein #3	5	10	2820	97.0	5.6×10^{-1}	1.4	2.4×10^{-1}	15.2	1.68×10^{-1}	6.4×10^{-3}
4	quartz-sulfide vein #4	5	7	2340	102.0	2.4×10^{-1}	trace	2.6×10^{-1}	19.4	N.d.	N.d.
5	quartz-sulfide vein #5	10	7	1710	53.0	2.1×10^{-1}	trace	1.1×10^{-1}	7.1	N.d.	N.d.
6	quartz-sulfide vein #6	5	9	2680	170.0	5.6×10^{-1}	1.4	2.6×10^{-1}	21.0	1.78×10^{-1}	3.2×10^{-3}
7	quartz-sulfide vein #7	5	7	3420	86.0	5.6×10^{-1}	1.4	2.6×10^{-1}	16.0	N.d.	N.d.
8	quartz-sulfide vein #8	5	8	2680	74.0	4.0×10^{-1}	trace	2.8×10^{-1}	12.0	N.d.	N.d.
9	quartz-carbonate vein	5	9	1240	47.0	5.6×10^{-1}	2.0	2.6×10^{-1}	5.6	1.04×10^{-1}	3.2×10^{-3}
10	upper quartz vein of profile	5	9	1040	21.0	7.6×10^{-1}	trace	1.6×10^{-1}	7.0	1.34×10^{-1}	3.2×10^{-3}
11	quartz-porphyry	2.5	9	2920	20.8	1.2	trace	2.8×10^{-1}	9.6	N.d.	N.d.
12	meidum-grit	5	9	1600	48.0	1.5	3.4	5.4×10^{-1}	3.4	N.d	N.d.
Relative standard deviation				1.5	1.2	13.9	10.5	5.9	1.4	7.4	9.8

*Micrograms per gram of sample, i.e., p.p.m. N.d. = not determined.

HOEFS, J., 1981, Isotopic composition of the ocean - atmospheric system in the geologic past, in R.J. O'Connell and W.S. Fyfe, eds., Evolution of the Earth, Geodynamics Series, v. 5, p. 110-119. Author at Geochem. Inst., Goldschmidtstrasse 1, 3400 Göttingen, Germany.

One of the most promising tools in tracing back the history of the ocean - atmosphere system seems to be the analysis of stable isotope ratios of suitable samples, having preserved their primary isotope ratios since formation and deposition. Besides the oxygen isotopic composition of ocean water this review concentrates on the sulfur isotopic composition of ocean sulfate, the carbon isotope composition in the system ocean - atmosphere - biosphere and the strontium isotopic composition of ocean water. It is shown that there are definite fluctuations in the isotopic composition of these elements during the earth's history, especially during the Paleozoic. These changes cannot be seen as isolated phenomena and have far-reaching implications not only for the ocean - atmosphere system. They can only be explained if very important geologic parameters have fluctuated, two of which are a) the distribution of land and sea (due to changes in tectonic and volcanic activity), b) the atmospheric oxygen concentration, may be due to varying rates of photosynthesis or carbon burial and sulfide oxidation. (Author's abstract)

HOEFS, J., COOLEN, J.J. and TOURET, J., 1981, The sulfur and carbon isotope composition of scapolite-rich granulites from southern Tanzania: Contrib. Mineral. Petrol., v. 78, p. 332-336. First author at Geochemisches Institut, Goldschmidtstrasse 1, D-3400 Göttingen, Federal Republic of Germany.

Sulfur and carbon isotope data are presented of 15 granulite samples from the Furua Complex, southern Tanzania, in which scapolite is a primary and major rock-forming constituent (up to 30 vol%). From these data, the isotopic composition is deduced of the sulfate and carbonate group in the scapolite structure. Subsequently, the composition and origin is discussed of the volatile species that are present in the deep crustal environment in which these scapolites formed.

The δ^{34}S-values show a narrow range from 0.3 to 3.6‰, consistent with a deep-seated (mantle) origin of the sulfur; the mean value of 1.9‰ is slightly higher than usually found in rocks of assumed mantle provenance. The results of the carbon isotope analyses are more difficult to interpret; they suggest that the granulites contain two different carbon components with different isotopic compositions. Firstly, one component, liberated by phosphoric acid at room temperature has δ^{13}C-values between -3.8 and -11.2‰ and a mean value of -6.7‰. This carbon component is assumed to occur as finely dispersed, submicroscopic carbonate inclusions. The second carbon fraction is liberated by phosphoric acid treatment at temperatures between 200 and 400°C and has considerably lower δ^{13}C-values with a mean value of -14.1‰. This seems to represent the carbon isotope composition in the scapolite structure. Such low δ^{13}C-values do not agree with the generally accepted value of 7‰ for "juvenile" carbon, but they are comparable to those found in early, primary carbonic inclusions from various granulite regions. It is argued that these low δ^{13}C-values are typical for granulite-facies metamorphism and that they may characterize an important fluid phase of the lower crust. (Authors' abstract)

HOHLFELDER, J.J., BEATTIE, A.G. and SHEFELBINE, H.C., 1981 Water release and a mechanical failure in heated geologic salt: Sandia Natl. Labs., Albuquerque, NM, Sandia Report SAND-81-1488, 23 p.

The rate of water release and the acoustic emission rate were measured in heated specimens of geologic salt. These measurements show that changes in thermal power applied to the salt cause increased acoustic emission from the salt. The acoustic emission is caused by the salt's cracking. The salt's cracking enhances its prompt release of water. (Authors' abstract)

HOLLISTER, L.S., 1981a Information intrinsically available from fluid inclusions, Chapter 1, pp. 1-12, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

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Conclusions
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HOLLISTER, L.S., 1981b Techniques for analyzing fluid inclusions, Chapter 11, pp. 272-277, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

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References

HOLLISTER, L.S. and CRAWFORD, M.L., eds., 1981, Fluid inclusions: applications to petrology: Mineralog. Assoc. Canada Short Course Handbook, Vol. 6, 304 pp. Available from Business Mgr., MAC, Dept. Mineralogy, Royal Ont. Museum, 100 Queen's Park, Toronto, Ont., Canada M5S 2C6.

This book stems from a short course sponsored by the Mineralogical Assoc. Canada and held in Calgary, Alberta, Canada, May 1981. It consists of 12 chapters, by various authors, covering many aspects of inclusion research pertinent to petrology (but excluding melt inclusions) as follows:

1. Hollister: Information intrinsically available from fluid inclusions.
2. Holloway: Compositions and volumes of supercritical fluids in the Earth's crust.
3. Burruss: Analysis of phase equilibria in C-O-H-S fluid inclusions.
4. Crawford: Phase equilibria in aqueous fluid inclusions.
5. Roedder: Origin of fluid inclusions and changes that occur after trapping.
6. Burruss: Hydrocarbon fluid inclusions in studies of sedimentary diagenesis.
7. Crawford: Fluid inclusions in metamorphic rocks - low and medium grade.
8. Touret: Fluid inclusions in high grade metamorphic rocks.
9. Spooner: Fluid inclusion studies of hydrothermal ore deposits.
10. Weisbrod: Fluid inclusions in shallow intrusives.
11. Hollister: Techniques for analyzing fluid inclusions.
12. Hollister et al.: Practical aspects of microthermometry.

Additional details on the contents of each of these chapters will be found in this volume under the individual authors. (E.R.)

HOLLISTER, L.S., CRAWFORD, M.L., ROEDDER, E., BURRUSS, R.C., SPOONER, E.T.C. and TOURET, J., 1981, Practical aspects of microthermometry, Chapter 12, pp. 278-304, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralogy. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 12 Contents

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HOLLOWAY, J.R., 1981a Compositions and volumes of supercritical fluids in the Earth's crust, Chapter 2, pp. 13-38, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology, Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 2 Contents

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HOLLOWAY, 1981b - See Appendix

HOLSER, W.T. and WILGUS, C.K., 1981, Bromide profiles of the Röt salt, Triassic of northern Europe, as evidence of its marine origin: Neues Jahrb. für Mineralogie-Monatshefte, no. 6, p. 267-276.

HOWE, S.S., 1981, Mineralogy, fluid inclusions, and stable isotopes of lead-zinc occurrences in central Pennsylvania: Master's degree thesis, The Pennsylvania State University, University Park, PA.

Widely scattered, noneconomic lead-zinc occurrences are located within a 5000 square km region in central Pennsylvania, in the western portion of the highly folded and thrust-faulted Valley and Ridge province of the Appalachian Mountains. The mineralization occupies fractures, joints, and breccias of Late Pennsylvania to Early Permian age in lower Paleozoic carbonates, shales, and sandstones; it also occurs as disseminations in sandstones and sandy laminae of shales. Epigenetic mineralization can be divided into six paragenetic stages, each separated by an episode of tectonic distrubance: (1) pyrite + arsenopyrite ± pyrrhotite; (2) quartz; (3) barite + celestite + dolomite + calcite ± fluorite ± hematite; (4) sphalerite, in three substages; (5) chalcopyrite + galena ± jordanite ± bournonite (?); and (6) quartz + barite + calcite ± pyrite ± hematite. The paragenesis is consistent throughout the region.

Fluid inclusions generally contain a vapor phase and one liquid phase at room temperature, although petroleum is also present in some inclusions. Homogenization temperatures of 192 fluid inclusions in minerals deposited during stages 2, 3, and 4 range from 84° to >400°C, with most homogenizing around 160° ± 60°C. Fluid inclusion temperatures vary most widely in stage 3 minerals and least widely in stage 4 sphalerite. Sulfur isotope temperatures from the two most intimately intergrown sphalerite-galena pairs are 137° and 175°, in good agreement with homogenization temperatures of fluid inclusions in sphalerite. This suggests that the pressure correction on the homogenization temperatures of inclusions in sphalerite is small. The salinities of fluids in 85 inclusions range from 1 to 29 wt % NaCl equiv., although half have salinities between 24 and 25 wt % NaCl equiv. Salinities also vary most widely in stage 3 minerals and least widely in stage 4 sphalerite.

The $\delta^{18}O$ values of 6 samples of stage 2 quartz range between +20.0 and +25.7‰ (SMOW), yielding calculated $\delta^{18}O$ values of the mineralizing fluids of +5.1 to +11.6‰ at T + 175° ± 40°C. The $\delta^{34}S$ values of 82 samples of epigenetic sulfide minerals range between +1.2 and +33.6‰, although most values are between +19 and +30‰; 12 samples of sulfate minerals have $\delta^{34}S$ values that range from +30.0 to +43.2‰. The $\delta^{34}S$ values of H_2S in the fluids, calculated from the $\delta^{34}S$ of minerals and the temperature data, remained between +20 and +30‰ throughout most of the mineralization sequence except for a very marked decrease to about +1‰ during the latest substage of sphalerite deposition during stage 4.

The mineralogical, fluid inclusion, and stable isotope data suggest that the mineralizing fluids originated as connate or formation water brines, similar to mid-continent oilfield waters, and contained sulfur of latest Precambrian to Early Silurian age. Deformation during the Late Pennsylvanian-Early Permian Alleghanian orogeny likely mobilized these fluids from a deep sedimentary basin(s). Fluid flow was probably controlled by structural features, such as thrust faults and cross-structural lineaments, or by porous clastic aquifers. Changes in the redox state of the mineralizing fluids, probably caused by different proportions of sulfides and sulfates in the solutions, appear to be responsible for the observed mineral paragenesis and for banding of sphalerite during stage 4. Deposition of sulfates, carbonates, and fluorite during stages 3 and 6 was probably caused by the influx of an oxidized fluid and/or by mixing of the sulfide-rich brine with sulfate-rich meteoric waters at the sites of deposition. The lead-zinc occurrences in central Pennsylvania show a strong similarity to Mississippi Valley-type lead-zinc deposits with regard to temperature, chemistry, and isotopic composition of the mineralizing fluid. (Author's abstract)

HUA, Yongfeng, 1981, Preliminary study on the origin of mercury deposits in Guizhou and vicinity: Acta Geologica Sinica, v. 55, no. 2, p. 139-148. Author at Guizhoou Metal. Geol. Brigade No. 1.

The following aspects of the origin of mercury deposits are discussed.

Having given the general geological features and the paleotectonic and paleogeographic environments of the mercury deposits in the Southwestern Platform Regions of China, the author analyses the source materials and ore-forming geological age, and briefly sums up the modes of transportation and concentration of mercury under superficial conditions by means of lead and sulfur isotope data. It is concluded that the mercury deposits might be of sedimentary origin at an early incipient stage. Studies of the fluid inclusions and some geological conditions of the deposits suggest that the mercury mineralization has undergone a late, low-temperature hydrothermal solution stage probably in the nature of heated confined groundwater action. Consequently the mercury deposits concerned should be considered as of a "sedimentary-nonmagmatic hydrothermal" type. (Author's abstract)

HUNTER, R.H. and TAYLOR, L.A., 1981, Rusty Rock 66095: a paradigm for volatile-element mobility in highland rocks: Proc. Lunar Planet. Sci., v. 12B, p. 261-280.

HUNTER, R.H. and TAYLOR, L.A., 1981, Rust and schreibersite in Apollo 16 highland rocks: manifestations of volatile-element mobility: Proc. Lunar Planet. Sci., v. 12B, p. 253-259.

HURST, V.J. and STORCH, S.P., 1981, Regional variation in the cell dimensions of metamorphic quartz: Am. Mineralogist, v. 66, p. 204-212. First author at Geol. Dept., Univ. Georgia, Athens, GA 30602.

Precision unit-cell measurements of eighteen quartz samples from one rock type within a region of classic Barrovian metamorphic zones show variations that correlate with metamorphic grade. Although different samples within each metamorphic zone may show cell-size variations of about 0.01% (ten times the measurement uncertainty), the regional variation is twice as great, and there is a clear trend of increasing cell size with decreasing metamorphic grade. This general increase in cell parameters is consistent with the greater total impurity content and more numerous lattice defects of quartz formed at lower temperatures and pressures. (Authors' abstract)

IGNATOV et al., 1981 - See Appendix

IKIN, N.P. and HARMON, R.S., 1981, D/H and $^{18}O/^{16}O$ ratios and mineralogy of serpentinites from the highland border fracture zone, Scotland: Bull. Minéral, v. 104, p. 795-800. First author at Dept. Geol., Univ. College, Cardiff, Wales, U.K.

Serpentines separated from fault-bounded serpentinites found in the Highland Border Fracture Zone, Scotland, have been studied by combined mineralogical and stable isotope techniques. The ultramafic rocks have been involved in two major hydration events. The first involved meteoric waters at low temperatures and produced pseudomorphic lizardite serpentinites from the parent harzburgites and dunites, the second metamorphosed the lizardite serpentinites and through progressive recrystallization and new mineral growth ultimately produced antigorite serpentinites with a non-pseudomorphic texture. The latter metamorphism involved a fluid source of metamorphic origin. (Authors' abstract)

INOUE, T., KOMATSU, H., HOSOYA, S. and TAKEI, H., 1981, Defect structures of synthetic olivine: J. Crys. Growth, v. 55, p. 307-316. Authors at The Res. Instit. for Iron, Steel and Other Metals, Tohoku Univ., Sendai 980, Japan.

The defect structures of the synthetic olivine crystal ($Fo_{92}Fa_8$) grown by the floating zone (FZ) method were investigated by means of (i) chemical etching, (ii) dark-field illumination and (iii) decoration technique. The results obtained were summarized as follows; (1) Reliable dislocation etchants were established on the (010), (100) and (001) surfaces. (2) A banded structure was observed in the planes parallel to the growth axis, which was formed by the periodic variation of the dislocation density along the growth axis at the intervals of 0.3-1 mm. (3) A number of helical dislocations and dislocation loops were observed only in the high dislocation density regions. The number of helices and loops increased towards the tail of the boule. (4) The densities of dislocation and subboundary in the FZ olivine were much smaller than in natural crystals, although larger than in the forsterite grown by the Czochralski method. (Authors' abstract)

IONE et al., 1981 - See Appendix

ISHKOV, Yu.M. and REYF, F.G., 1980, Laser-excited spectrographical analysis of liquid phase in individual inclusions: Geokhimiya, no. 9, p. 1407-1412 (in Russian; translated in Geochem. Int'l., v. 17, no. 5, p. 76-79, 1981).

Abstract in Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 106 (1980). (E.R.)

ISUK, E.E. and CARMAN, J.H., 1981 The system $Na_2Si_2O_5$-K_2SiO_5-MoS_2-H_2O with implications for molybdenum transport in silicate melts: Econ. Geol, v. 76, p. 2222-2235. First author at Dept. Comprehensive Sci., Morgan State Univ., Baltimore, Maryland 21239.

The behavior of molybdenite in the system $Na_2Si_2O_5$-K_2SiO_5-MoS_2-H_2O has been investigated from 340 bars to 1.36 kb in the temperature range 450° to 850°C. Phase relations in the system show enhanced molybdenite solubility in the alkali silicate liquids and coexisting vapors. MoS_2 solubility is up to 10 wt percent in vapor-saturated $Na_2Si_2O_5$ melt and 12.5 wt percent in vapor-saturated $K_2Si_2O_5$ melt at 680 bars and 650°C. There is a positive pressure dependence of solubility, but retrograde solubility is indicated as a function of temperature above about 650°C at the pressures investigated.

The experimental data combined with published data on structure of silicate melts (Mysen and Virgo, 1980) suggest that Mo silicate and/or Mo-hydroxylated silicate complexes such as $MoSi_2O_5^{+2}$, $MoSi_2O_6$ and $MoSi_2O_4(OH)^{+3}$ may account for the observed molybdenite solubility. If these results can be extrapolated to nature, it seems likely that geologically significant quantities of molybdenum may be transported in hydrous alkalic silicic melts as Mo silicate complexes for eventual fractionation into the vapor phase during vapor generation. Such a transport mechanism would be consistent with the commonly observed association of Mo with silica-rich rocks. (Authors' abstract)

IVANOV, I.P., POKROVSKIY, V.A. and BORISOV, M.V., 1981, Studies of solubility phase diagrams with computers: Akad. Nauk SSSR Doklady, v. 256, no. 6, p. 1481-1483 (in Russian). Authors at Inst. Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka near Moscow, USSR.

The systems: Al_2O_3-SiO_2-H_2O-HCl and CaF_2-MgF_2-H_2O at T 25-300°C under P of saturated vapor were used as examples. (A.K.)

IVANOV, Miroslav, 1981, Nickel-cobalt ores of liquation-magmatic type in amphibole gabbro bodies along the contact zone of the Gemeric and Veporic units (Eastern Slovakia): Mineralia. slov., v. 13, no. 3, p. 193-208 (in Slovenian; English abstract). Author at Geologický ústav D. Štúra. Mlynaká dolina 1. 809 40 Bratislava.

A hitherto unknown genetic type of nickel-cobalt (copper) ore has been found to occur in amphibole gabbro body at the contact zone of the Gemeric and Veporic units in Eastern Slovakia. Results of detailed mineralogical and geochemical analysis of samples from the KV-3 (Rochovce) borehole show that the mineralization concentrates at the lower part of amphibole gabbro bodies and that it is of liquation-magmatic nature. Ore concentrations originated in basic intrusive bodies of Carboniferous age emplaced along the contact of the Veporic (lower) and Gemeric (upper) units. Accordingly, perspective areas for further investigation may be delimited. (Author's abstract)

IVANOVA, N.I., KOGAN, B.S. and PERTSOV, N.V., 1981, The influence of liquid phase on the formation of fractured structures in mechanically stressed quartz diorite: Akad. Nauk SSSR Doklady, v. 259, p. 1423-1427 (in Russian).

IVANOVSKAYA, I.N., SHTERNBERG, L.Ye., MAKHOV, S.F., MUSINA, A.R. and FILONENKO, V.P., 1981, Carbon isotope fractionation in solid-state diamond synthesis: Geokhimiya, 1981, no. 9, p. 1415-1417 (in Russian).

IZAWA, Eiji, YOSHIDA, Tetsuo and SAKAI, Takafumi, 1981, Fluid inclusion studies on the gold-silver quartz veins: Mining Geol. Special Issue, v. 10, p. 25-34. First author at Dept. of Mining, Kyushu Univ., Hakozaki, Fukuoka 812, Japan.

Filling temperatures of 294 fluid inclusions in quartz and calcite from 79 locations in the Kushikino district were measured. The salinities of 7 inclusions were also estimated. The results show that the environment of formation for the Kushikino No. 1 vein (L0-L14) had: (1) a temperature range from 133° to 268°C, (2) pressure range from 4 to 7 MPa, (3) fluid salinity of 0.6 to 1.1. wt.% NaCl equivalent, and (4) a depth varying from 450 to 850 m below the Pliocene surface.

Temperature varies with depth and along the strike of the Kushikino No. 1 vein. The temperature distribution in the veins of the Kushikino district suggests that the quartz was deposited from ascending solutions in a convective geothermal system and that the temperature range from 210° to 250°C favored the precipitation of quartz with gold and silver in ore grade. Calcite precipitation resulted from the boiling of ascending hydrothermal solutions and from the heating of local decending ground water.

The high temperature zones (>210°C) within the unexplored parts in and adjacent to the Kushikino district are potential areas for gold-silver deposition, hence it will not be out of place to prospect for these minerals. (Authors' abstract)

JACKOWICZ, E., 1981, Secondary alterations of Permian effusive rocks from the Foresudetic monocline: Post-magmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, p. 4, Wydawnictwa Geologiozne, Warsaw (in Polish). Author at Geol. Inst., 00-975 Warsaw, Rakowiecka 4, Poland.

Samples were taken from drill cores. Post-magmatic alterations: albitization, carbonatization, chloritization, silicification, zeolitization, metasomatosis by iron oxides and hydroxides, by sulfates and sulfides developed at 500-300°C, as appears from Td. (A.K.)

JACKSON, N.L, HALLIDAY, A.N., SHEPPARD, S.M.F. and MITCHELL, J.G., 1981, Isotopic and fluid inclusion evidence bearing on the polyphase metallogenic evolution of the St. Just district, Cornwall: J. Geol. Soc. (London), v. 138, no. 2, p. 213.

Fluid inclusion data, Rb-Sr, K-Ar and ^{40}Ar-^{39}Ar ages and $^{18}O/^{16}O$, D/H stable isotope data indicate the following chronology of metallogenesis and alteration in the St. Just district: (1) Land's End granite emplaced >280 Ma. (2) Metasomatic skarns developed at 274 ± 8 Ma. Meteoric fluids entered system. (3) Barren pegmatites, dominantly from meteoric fluids, formed in joints. (4) Sheeted, steep, NW-trending, greisen-bordered, cassiterite-bearing vein swarms developed in pluton roof at 279 ± 5 Ma from moderately saline meteoric fluids yielding Th = 400-450°C. (5) Main stage, polymetallic, NW- or WNW-trending, fracture-controlled vein and replacement mineralization from meteoric fluids about 270 Ma, comprising: (i) cassiterite without sulphides, Th = 310-380°C, moderately saline fluids, (ii) cassiterite with sulphides, Th - 280-320°C, more variably saline fluids, (iii) sulphide without cassiterite, Th = 200-270°C, low saline fluids. (6) Hydrothermal rejuvenation of event 5 fracture systems 225-215 Ma, 170-160 Ma and in Tertiary times, probably at progressively lower temperatures and from meteoric fluids. Development of N-trending Pb-Zn-Fe-U-bearing veins. (7) Deep kaolinization in pluton roof during weathering by low temperature meteoric fluids. (Authors' abstract)

JACOBS, G.K. and KERRICK, D.M., 1981, Devolatilization equilibria in H_2O-CO_2 and H_2O-CO_2-NaCl fluids: an experimental and thermodynamic evaluation at elevated pressures and temperatures: Am. Mineralogist, v. 66, p. 1135-1153. First author at Rockwell Hanford Operations, P.O. Box 800, Richland, WA 99352.

Experimental equilibrium brackets have been obtained in H_2O-CO_2 and H_2O-CO_2-NaCl fluids for several decarbonation equilibria. Using available thermodynamic data and activities for H_2O and CO_2 calculated from the modified hard-sphere Redlich-Kwong (HSMRK) equation of Kerrick and Jacobs (1981), thermodynamic extrapolations in P-T-XCO_2 space of devolatilization equilibria yield close agreement with the experimental equilibrium brackets, implying that the experimental and thermodynamic data are internally consistent, and that the activities of H_2O and CO_2 predicted by the HSMRK equation of Kerrick and Jacobs (1981) are quite reasonable. The significance of assuming ideal vs. nonideal mixing of H_2O and CO_2 for the calculation of T-XCO_2 topologies is demonstrated for a portion of the system CaO-Al_2O_3-SiO_2-H_2O-CO_2. Experiments in H_2O-CO_2-NaCl mixtures at P = 6 kbar show that, compared to binary H_2O-CO_2 fluids, the presence of small (5-10 wt.%) amounts of NaCl in the fluid phase significantly increase the activity of CO_2 for H_2O-rich compositions. At 2 kbar, however, little difference in the activity of CO_2 in H_2O-CO_2-NaCl vs. H_2O-CO_2 mixtures is implied by the experiments. (Authors' abstract)

JACOBS, G.K. and KERRICK, D.M., 1981, Methane: an equation of state with application to the ternary system: Geochimica et Cosmo. Acta, v. 45, p. 607-614. First author at Dept. Geol., Grand Valley State Colleges, Allendale, MI 49401, U.S.A.

A hard-sphere modified Redlich-Kwong (HSMRK) equation of state was obtained by least squares fitting to available P-V-T data for methane. For the P-T range of experimental data used in the fit (50 to 8600 bars and from 320 to 670 K), calculated volumes and fugacity coefficients for CH_4 relative to experimentally determined volumes and fugacity coefficients have average percent deviations of 0.279 and 1.373, respectively. The HSMRK equation, which predicts linear isochores over a wide P-T range, should yield reasonable estimates of fugacity coefficients for CH_4 to pressures and temperatures well outside the P-T range of available P-V-T data. Calculations for the system H_2O-CO_2-CH_4, using the HSMRK equations for H_2O and CO_2 of Kerrick and Jacobs (1981) and the HSMRK equation of CH_4 of this study, indicate that compared to the binary H_2O-CO_2 system, small amounts of CH_4 in the ternary system H_2O-CO_2-CH_4 slightly increases the activity of H_2O, and significantly decreases the activity of CO_2. (Authors' abstract)

JARRELL, J.A., KING, J.G. and MILLS, J.W., 1981, A scanning micropipette molecule microscope: Science, v. 211, p. 277-279. First author at Res. Lab. Electronics and Dept. Physics, Massachusetts Inst. Tech., Cambridge 02139 and Lab. Renal Biophysics, Medical Services, Massachusetts Gen. Hospital, Boston, MA 02114.

A movable quartz micropipette, whose tip is sealed with a polymer plug, is used as a liquid-vacuum interface to a mass spectrometer. A light microscope allows observation of, and positioning of, the micropipette tip on the surface of a sample mounted in a perfusion chamber. This forms the basis of an instrument which enables one to study, in vitro, the localization of transepithelial transport of water and other molecules. Some preliminary results from the use of this instrument are presented. (Authors' abstract)

Possibly pertinent instrumentation for some inclusion studies. (E.R.)

JEBRAK, Michel, 1981, Study of barite, fluorite, and galena veins of the French central Massif, Ussel district: Bull. Bur. Rech. Geol. Min., Sect. 2, Géol. Gites Minér., no. 3, p. 205-221 (in French).

The veins were formed from low salinity fluids at ~130°C. (E.R.)

JEFFERIS, R.G. and VOIGHT, Barry, 1981, Fracture analysis near the mid-ocean plate boundary, Reykjavik-Hvalfjördur area, Iceland: Tectonophysics, v. 76, p. 171-236. First author at Shell Oil Co., P.O. Box 92047, Worldway Center, Los Angeles, CA 90009, U.S.A.

The geometry and thermal history of fractures have been determined at 59 stations from Reykjavik to Hvalfjördur in southwestern Iceland. The data provide information on crustal stress regimes in the vicinity of mid-ocean ridges. (From the authors' abstract) (Continued)

Fluid inclusions in calcite and quartz from boreholes (2-phase, no daughter crystals, no evidence of boiling) were used to estimate pressure of formation, geothermal gradients, and fracture and thermal history of the area. (E.R.)

JENATTON, Liliane, 1981, Fluid inclusions thermometry in crystals related to the opening of alpine veins. An approach of T-P variations during tectonic deformation: Unpublished thesis, doctorat de 3ème cycle, Univ. sci. et méd. de Grenoble, France (in French).

Quartz crystals were collected from a tarditectonic tension vein outcropping in the western Alps, between Belledonne and Les Grandes Rousses. Trapped solutions are nearly pure water (1 to 2 wt.% NaCl equiv.). From about 900 determinations, Th are very well grouped, with limited evolution of the mean Th (+4°C) between the first and second quartz generation. There is no indication of late reequilibration of inclusions.

Syntectonic quartz and calcite samples were collected from recrystallization zones in belemnites guards and cut into sections. They occurred in a folded zone (western Alps, Pelvoux cover) and were picked up on the normal and on the inverse flank of the same fold. Trapped solutions are nearly pure water. From about 700 determinations, Th are more scattered than in the previous case. Nevertheless, mean Th are well defined and identical in associated quartz and calcite. From the beginning of the breaking of the belemnites guards until the completion of the folds, mean Th increases by steps from 131°C to 139°C.

Some neo-inclusions, possibly related to late reequilibration after trapping are present. (Abstract courtesy J.-C. Touray)

JOCKWER, Norbert, 1981, Laboratory investigation of water content within rock salt and its behavior in a temperature field of disposed high-level waste, in Scientific Basis for Nuclear Waste Management, J.G. Moore, ed., v. 3., p. 35-42. Author at Gesel. für Strahlen- und Umweltforschung mbH Inst. für Tieflagerung, Wiss. Abt. Theodor-Heuss-Str. 4, D-3300 Braunschweig, FRG.

Studies were made of the loss in weight vs temperature for various salt samples in order to try to identify the forms of the water present. Hydrous minerals evolve their water at rates that vary widely over a range of temperature, depending on the humidity. The behavior of fluid inclusions in single crystals remains ambiguous. (E.R.)

JOHANNES, W. and SCHREYER, 1981, Experimental introduction of CO_2 and H_2O into Mg-cordierite: Am. J. Sci., v. 281, no. 3, p. 299-317.

JOHNSON, B.D. and COOKE, R.C., 1981, Generation of stabilized microbubbles in seawater: Science, v. 213, p. 209-211. Authors at Dept. Oceanogr., Dalhousie Univ., Halifax, Nova Soctia, Canada B3H 4J1.

Bubbles of less than 1 micrometer and as large as 13.5 micrometers in diameter, stabilized by an apparent compression of substances sorbed onto their surfaces, were examined to determine their physical and temporal stability. Their ease of formation is related to the qualities of the water in which they are formed. Their presence in the water column must now be considered when interpreting acoustic data gathered to determine marine bubble populations. (Authors' abstract)

Possibly pertinent to some fluid inclusion studies. (E.R.)

JOHNSON, K.S. and PYTKOWICZ, R.M., 1981, The activity of NaCl in seawater of 10-40% salinity and 5-25°C at 1 atmosphere: Marine Chem., v. 10, p. 85-91. First author at Marine Sc. Instit., Univ. California, Santa Barbara, CA 93106, USA.

The activity of NaCl in artificial seawater was measured potentiometrically with Na^+- and Cl^--sensitive electrodes. The salinity of the solutions, examined at 25°C, ranged from 10-40‰ salinity. The change in the activity from 5-25°C was measured at 35‰ salinity.

The molal mean activity coefficient of NaCl in 35‰ seawater at 25°C is 0.667. The relative partial molal enthalpy of NaCl in 35‰ seawater is -130 ± 50 cal mol^{-1}. This value is in good agreement with the value measured in pure 0.72 M NaCl.

The results were compared with activity coefficients predicted by a specific interaction model and by an ion association model. Good agreement was found in both cases. (Authors' abstract)

KADIK et al., 1981 - See Translations.

KALININ, A.S., SOTNIKOV, V.I., KOLONIN, G.R. and BERZINA, A.P., 1981, Model of geochemical temperature threshold of copper-molybdenum deposit (modelling with use of computer): Akad. Nauk SSSR Doklady, v. 259, no. 4, p. 962-966 (in Russian). First author at Irkutsk State Univ., USSR.

Useful for comparison with reconstructions made on the basis of fluid inclusion studies. (A.K.)

KALYUZHNYI, V.A., BRATUS, M., ZINCHUK, I. and REMESHILO, B.G., 1981, Geochemistry of carbon-containing fluid in magmatic and hydrothermal-metasomatic processes according to data from a study of inclusions in minerals: Deposited Doc., 1981, VINITI 882-81, p. 118-124 (in Russian).

CO_2, N_2, CH_4, and traces of CH_4-homologs were detected in gases from magmatogenic minerals in kimberlites. The gases in inclusions in minerals from andesite-basalts of Iturup Island (Kurils) suggest that N_2 was the predominant gas in basaltic magmas; CO_2 and CH_4 were present in lesser amt. Segregated CO_2, N_2, and, in subordinate amts., CH_4 and H_2O were found in assocn. with magmatic glass in an olivine nodule from the Hawaiian islands. Basic plagioclase and olivine from basalts erupted by Kamchatkean volcanoes had inclusions contg. CH_4 and higher homologs of CH_4. Both solid and liq. hydrocarbons occur as inclusions in the Hg deposits of Trancarpathia; the $\delta^{13}C$ values of various hydrocarbons were -2.00 to -2.80‰. Petroleum-type oils as well as CH_4 and higher homologs of CH_4 occur in inclusions in calcite and quartz from hydrothermal veins in the Carpathians. The CH_4-H_2O fluids widespread in quartz veins of the Donets Basin formed at 130-180° and 400 bars. The fluid inclusions in the minerals studied support the idea that hydrocarbons, H_2O, and CO_2 are present in the mantle and also that petroleum can originate at mantle depth. (C.A., 96: 165913v)

KAMINSKIY, F.V., GALIMOV, E.M., GENSHAFT, Yu.S., IVANOVSKAYA, I.N., KLYUEV, Yu.A., ROVSHA, V.S., SANDOMIRSKAYA, S.M. and SMIRNOV, V.I., 1981, Bort with garnet from the pipe "Mir" (Yakutia): Akad. Nauk SSSR Doklady, v. 256, no. 3, p. 674-676 (in Russian). First author at Central Sci.-Research Geol.-Prosp. Inst. of Color and Precious Metals, Moscow, USSR.

The paper bears Laue photos, IR spectra, $\delta^{13}C$ values and chemical composition data for garnet and pyroxene inclusions and host diamond.(A.K.)

KANEOKA, Ichiro and TAKAOKA, Nobuo, 1980, Rare gas isotopes in Hawaiian ultramafic nodules and volcanic rocks: constraint on genetic relationships: Science, v. 208, p. 1366-1368. First author at Geophy. Inst., Univ. Tokyo, Bunkyo-ku, Tokyo 113, Japan.

Differences in the rare gas isotopic ratios, especially the ratios of helium-3 to helium-4 and of argon-40 to argon-36, in Hawaiian ultramafic nodules and phenocrysts in volcanic rocks indicate that the nodules and phenocrysts were derived from different sources. The isotopic ratios in ultramafic nodules are similar to those in oceanic tholeiites. The phenocrysts seem to have formed in equilibrium with source materials richer in primordial components than those of the oceanic tholeiites. Mixing between the sources is quite likely. (Authors' abstract)

KARWOWSKI, Ł. and WŁODYKA, R., 1981, Conditions of formation of drusy minerals at Michatowice (Karkonosie Mts.): Post-magmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, Wydawnictwa Geologiozne, Warsaw, p. 10-11 (in Polish). Authors at Silesian University, Sosnowiec, Poland.

The studied bodies occur in coarse-grained granite, in aplites and in a "pegmatoid" variety of granite. The "pegmatite" druses are irregular, of small dimensions and not connected with tectonics. Among the minerals in those druses, tourmaline, fluorite, zeolites, calcite and bavenite were found. Th was measured mostly for inclusions in quartz, plus individual determinations in cleavelandite and epidote. The earliest phase (formation of feldspars, quartz and micas) occured at 450-400°C from heterogeneous solutions due to boiling of mineral-forming fluid. Below 400°C the fluid was dilute LH_2O solution. Following minerals crystallized in three essential phases: 360-270°C, 170-140°C and <120°C; during the latter carbonates, epidotes, cleavelandite, chlorites and zeolites crystallized. (Authors' abstract, translated by A.K.)

KAWAMOTO, Y. and TOMOZAWA, M., 1981, Prediction of immiscibility boundaries of ternary silicate glasses: Phys. and Chem. of Glasses, v. 22, no. 1, p. 11-16.

A simple and reliable method of predicting the immiscibility boundary of a ternary silicate glass system, knowing the immiscibility boundaries of binary silicates, is presented. The method is based upon the similarity in shape of immiscibility boundaries of silicate systems and the pseudobinary regular mixing equation. The immiscibility boundaries estimated by the prediction method for the Li_2O-Na_2O-SiO_2, Na_2O-BaO-SiO_2, and Na_2O-CaO-SiO_2 systems agree extremely well with the experimental data. (Authors' abstract)

KAY, E.A. and STRONG, D.F., 1981, A fluid inclusion and geochemical study of gold-bearing sulphide-quartz veins, Moretons Harbour, Newfoundland (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-30.

Mineralized veins of three main types are found in the Moretons Harbour area of central Newfoundland, namely:

I Au-bearing arsenopyrite + quartz;
II Stibnite + quartz + carbonate;
III Au-bearing base-metal sulphides + quartz.

They occur largely within a pyroclastic unit of a thick (8 km) sequence, dominated by tholeiitic pillow lavas, which exhibit a lower greenschist facies mineral assemblage. The veins are oriented perpendicular to bedding in cross fractures, commonly related to felsite dykes and are associated with carbonate alteration. Mineral chemistry and fluid inclusion data suggest that the gold-bearing minerals were deposited from a fluid of low salinity, high temperature and enriched in CO_2. These are most comparable to fluids related to metamorphic dehydration, although a genetic relation to the felsic magma cannot be ruled out. (Authors' abstract)

KEKULAWALA, K.R., PATERSON, M.S. and BOLAND, J.N., 1981, An experimental study of the role of water in quartz deformation: Mechanical Behavior of Crustal Rocks, Geophys. Monograph 24, Am. Geophy. Union, p. 49-60. First author at Dept. Physics, Univ. Sri Lanka, Colombo 3, Sri Lanka.

Basic equilibrium and kinetic properties of water in quarz are elucidated in a combined mechanical, infrared absorption, and electron microscope study on a hydroxyl-bearing synthetic quartz crystal. Changes in yield strength and nature of infrared absorption observed after heating specimens at 900°C and various pressures are correlated with the precipitation and redissolution of water in bubbles visible in the electron microscope. From these observations it is concluded that the solubility of water in quartz at 900°C and 300 MPa pressure is between 200 and 400 H per 10^6Si and that the diffusivity of the dissolved hydroxyl-bearing species is very low, probably less than 10^{-19} m^2s^{-1} at 900°C in initially dry quartz but increasing significantly with hydroxyl concentration. These results explain the sluggishness and associated experimental difficulties in studies on hydrolytic weakening in this pressure range. They indicate that equilibrium may not be attained in many such experiments and pose pertinent questions concerning extrapolation to geological conditions. (Authors' abstract)

KELLER, Jörg, 1981, Carbonatitic volcanism in the Kaiserstuhl alkaline complex: evidence for highly fluid carbonatitic melts at the earth's surface: J. Volcanol. Geotherm. Res., v. 9, p. 423-431. Author at Mineralogisches Institut der Univ., D 7800 Freiburg, Federal Republic of Germany.

Extrusive carbonatites are described from the Miocene alkaline complex of the Kaiserstuhl, Rhinegraben, Western Germany. Agglutinated carbonatitic lapilli form pyroclastic rocks in which all components show forms acquired when a highly fluid melt was sprayed into the air by an explosive eruption: droplets, spherical and elliptical lapilli, rods, dumb-bell and pear-shaped forms.

Complete morphological analogies suggest a mechanism similar to the formation of "Pele's tears," basaltic droplets formed by the eruption of the most fluid Hawaiian basaltic magmas. Evidence is provided by this example that $CaCO_3$-carbonatitic magmas can exist in nature under surface conditions displaying extremely low viscosity. (Author's abstract)

KENDRICK, G.C. and EDMOND, C.L., 1981, Magma immiscibility in the Shonkin Sag and Square Butte laccoliths: Geology, v. 9, p. 615-619. First author at Utah Int'l. Inc., 2110 Reserve, Missoula, MT 59801.

The Shonkin Sag and Square Butte laccoliths of central Montana differentiated in place from single alkalic magmas to produce syenite and shonkinite through a gravity-controlled differentiation mechanism. The absence of rhythmic and cryptic layering and a lack of definite cumulate textures suggest that crystal settling did not produce syenite from shonkinite in either laccolith. Field relations strongly suggest coexistence of a mafic and a felsic magma. Both field relations and chemical trends, which are incompatible with a fractional crystallization model, can, on the other hand, be explained by magma immiscibility. During or following intrusion, immiscible syenite globules separated from a mafic shonkinite magma, coalesced, and rose to form a homogeneous upper layer of syenite. An increase in host viscosity, due to cooling, trapped late-rising syenite globules. These are preserved as isolated syenite segregations as much as 10 m in diameter enclosed in the lower shonkinite. (Authors' abstract)

KEPEZHINSKAS, K.B., SOBOLEV, V.S. and TOMILENKO, A.A., 1981, Sharp change of the PCO_2 gradient near the source of its release during high-temperature metamorphism: Akad. Nauk SSSR Doklady, v. 258, no. 3, p. 732-734 (in Russian). Authors at Inst. Geol. and Geophysics of Siberian Branch of Acad. Sci. USSR, Novosibirsk, USSR.

Minerals of the studied Archean migmatites from Khan-Khukhey Ridge (Mongolia) bear mostly metamorphic one-phase inclusions of liquid CO_2 (Th in quartz and garnet are 0 to +18°C, specific volume 1.08-1.26 cm^3/g), but calciphyre intercalations in gneiss contain quartz with inclusions of low Th (-46 to -22°C, specific volume 0.877-0.96 cm^3/g). P of fluid evaluated from the above specific volumes of CO_2 at T 600-700°C (garnet-biotite geothermometer) was 4.5-5.0 kbar in gneisses and 7.5-8.5 kbar in calciphyres. These data prove the sharp change of PCO_2 gradient in the neighborhood of the CO_2 source and indicate that CO_2 during regional metamorphism is mostly of local, not mantle origin. (Abstract by A.K.)

KERRICH, R., 1981, Archean gold-bearing chemical sedimentary rocks and veins: a synthesis of stable isotope and geochemical relations, *in* E.G. Pye and R.G. Roberts, eds., Genesis of Archean, Volcanic Hosted Gold Deposits, Symp. at Univ. Waterloo, March 7, 1980: Ontario Geol. Survey Misc. Paper 97, p. 144-175. Author at Dept. Geol., Univ. Western Ontario, Canada.

Studies of lode gold deposits in 'greenstone' belts reveal a number of common chemical and hydrodynamic features. The following data have been obtained from the Timmins, Yellowknife, Red Lake and Val d'Or-Malartic areas. All gold-bearing chemical sedimentary rocks have $\delta^{18}O$ quartz of 18‰ to 25‰, implying initial low-temperature equilibrium with fluids at the seafloor. REE distribution in such sedimentary rocks are typical of patterns for Archean chemical sedimentary rocks. Locally, auriferous sedimentary rocks (e.g. Timiskaming) exhibit REE distributions which parallel abundances in neighboring subvolcanic-extrusive felsic porphyries. Basic volcanic rocks with background precious metal abundances (<2 ppb Au) have $\delta^{18}O$ whole rock of 7‰ to 10‰, compared to 5.5‰ to 6.5‰ for fresh basalt. The enrichment in ^{18}O is attributed to seawater interaction at temperatures of <150°C. Enrichments in ^{18}O are also present in some felsic igneous rocks.

Hydrothermal veins within given regions have a narrow range of $\delta^{18}O$ quartz (12‰-Yellowknife; 14‰-Timmins) and constant Δ (quartz-muscovite) implying fluids of metamorphic origin at 400-500°C - probably derived by outgassing at the greenschist-amphibolite transition. Wall-rocks are in oxygen isotope equilibrium with veins. Vein geometry requires hydraulic pressure ⩾ lithostatic pressure for fluid discharge along hydraulic fractures. This stress condition is consistent with a reservoir of ponded metamorphic fluids. Filling temperature determinations on primary fluid inclusions are in the range 300 to 360°C; significant CO_2 is present.

Wall-rocks of veins have a strong iron reduction anomaly ($Fe^{2+}/\Sigma Fe = 0.92$) compared to background ($Fe^{2+}/\Sigma Fe = 0.7$), requiring the introduction of large volumes of reductant in the hydrothermal solutions. Hydrogen is probably the reductant involved, derived by dissociation of H_2O inequilibrium with the QFM system at high temperatures. REE distribution in veins, plus positive Eu^{2+} anomalies, confirm the reducing environment of ore deposition, and imply fluids at source in equilibrium with rocks of mafic to ultramafic composition. Redox and oxygen isotope anomalies correlate: both parameters give estimates for the water/rock ratio along conduits of >3:1. High-temperature reducing solutions may be critical for aqueous transport of Cr, Ni, W, Pd, and Pt which are all present at 10 times to 500 times background abundances in gold-bearing veins.

In both vein and stratiform deposits, Au, Ag, and Pd average 20, 2, and 0.1 ppm respectively, compared to background abundances of 2, 100, and 8 ppb in mafic igneous rocks. This represents concentration factors of 10,000 for Au, 20 for Ag, and 10 for Pd relative to background. The relatively immobile elements Cr, Ni, and W may be significantly enriched in lodes, whereas the abundant and mobile base metals Cu, Zn, Pb, and Co are concentrated by only 1 times to 5 times. This separation may be accounted for if fluids are generated under conditions of low water/rock such that the absolute abundance of rare elements in solution is not constrained by solubility, whereas base-metal solute concentration is. Metamorphic outgassing, where water/rock may be ~1:20, satisfies this condition. For the Timmins area simple calculations give estimates for hydrothermal fluid volumes of ~90 km^3, transport distances of ~12 km, and Au solute concentrations of ~20 ng/ml.

From these data, it is believed that the distinctive suites of metals in lode gold deposits versus massive base-metal sulphides reflect fundamentally different properties of the hydrothermal systems in terms of source, temperature, ratio of hydraulic to lithostatic pressure, water/rock ratio in source regions, and abundance of CO_3^{2-}. The predominance of lode gold deposits in Archean 'greenstone' belts may be accounted for if geothermal gradients were higher such that outgassing and ponding of metamorphic fluids were more efficient, and if Hargraves model of an early globe-encompassing hydrosphere is correct, such that metamorphic fluids debouched onto the seafloor. (Author's abstract)

KERRICH, R. and FYFE, W.S., 1981, The gold-carbonate association: source of CO_2, and CO_2 fixation reactions in Archaean lode deposits: Chem. Geol., v. 33, p. 265-294. Authors at Dept. Geol., Univ. Western Ontario, London, Ont. N6A 5B7, Canada.

Abundant carbonate is a ubiquitous feature of Archaean lode gold deposits - both in domains of alteration enveloping veins, and in rocks enclosing auriferous sediments. Detailed studies of chemical mass balance in metabasalts, progressively altered towards gold-bearing quartz carbonate veins disposed within shear zones at Yellowknife, reveal massive additions of CO_2, K, Si and Fe accompanying mineralization, with concomitant depletions of Na. Coherent behavior of Al, Sc, Zr (also V and Nb) provides a reference for constraining the volume relations during hydrothermal alteration. In the peripheral regions of alteration, depletions of Ca and Mg result in overall volume reduction, but these elements are added to veins and their immediate alteration envelopes where there is a large positive volume change. Precious metals, together with Cr, Ni, Cu, Zn, Pb, Rb, Cd and Ba, have been added to the veins and altered wall rocks.

Whereas quartz, noble metals and other trace elements have been precipitated from hydrothermal fluids, solution of Ca, Mg (and some Fe), indigenous to peripheral alteration regions, combining with CO_2 from the mineralizing reservoir, appears to be the process for forming the abundant ferri-dolomite gangue. Observations of many Archaean Au deposits reveals that carbonate chemistry reflects the nature of wall rocks, with wall rocks donating the bivalent metal cations, and hydrothermal fluids the CO_2. Alteration reactions at Yellowknife involved hydrolysis of albite accompanied by fixation of $K_{aqueous}$ to produce muscovite, with Na loss; and hydrolysis of chlorite + epidote with CO_2 fixation to form ferri-dolomite.

Studies of oxygen isotopes, $Fe^{2+}/(Fe^{2+} + Fe^{3+})$, and structure reveal that Au, quartz and carbonate were precipitated in the presence of fluids of probable metamorphic origin ($\delta^{18}O$ + 8-9‰), at low redox potential, and at ambient temperatures of 400-450°C, during episodes of hydrofracturing.

The abundant CO_2 and K, required for extensive carbonate-muscovite replacement alteration, could be supplied by fluids released during prograde metamorphism under greenschist or greenschist-amphibolite facies conditions, where the relative proportion of CO_2/H_2O is in the order of 0.2 to 0.5, and $K/Na \simeq 1$. Given high CO_2-CO in the hydrothermal reservoir, these molecules may act as complexing agents for transport of Au and other rare elements (e.g., W, Pd, Ni, Cr). (Authors' abstract)

KERRICH, Robert and WALKER, S.D., 1981, Auriferous metamorphic fluid venting with peripheral seawater convection; Chadbourne gold mine, Noranda, Quebec (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 486. Authors at Geol. Dept., Univ. Western Ontari, London, Ontario, Canada, N6A 5B7.

At the Chadbourne Mine, Noranda, Quebec, gold mineralization is confined to a subconically shaped domain of intense hydrofracturing, within Archaean andesites of the Blake River group (~2.8 Ga). Calculations of chemical mass balance (method of Gresens, 1966), in which the coherent behavior of Al, Sc and Zr are used to define volume change, reveal 2 domains of alteration. Firstly, an outer zone ~250 m wide peripheral to the mineralized breccia, characterized by additions of Na_2O and H_2O, with concomitant loss of K_2O, MgO, MnO, SiO_2 and some transition metals. Secondly, in the Au-breccia, massive fixation of outer zone is oxidized ($Fe^{2+}/\Sigma Fe = 0.46 \pm 0.23$), and the inner zone reduced ($Fe^{2+}/\Sigma Fe \sim 0.9$) relative to background ($Fe^{2+}/\Sigma Fe = 0.7$). The presence of hydrofractures in all orientations signifies $P_{fluid} \geqslant P_{load}$ during mineralization. In the outer alteration zone the $\delta^{18}O$ of quartz (8.9 to 12‰), albite (6 to 8.6‰), and chlorite (0.4 to 1.7‰) corresponds to a T_{fluid} of 220-280°C and fluid $\delta^{18}O$ of 0 ± 1‰. Within the domain of gold mineralization the $\delta^{18}O$ of quartz (12 to 13.5‰), chlorite (6.1 to 6.9‰) and magnetite (-0.8 to +1.9‰) define a T_{fluid} of 380-450°C and a $\delta^{18}O$ fluid of 8 ± 1‰.

The data are interpreted in terms of forceful discharge of a low redox, auriferous metamorphic fluid reservoir at lithostatic pressure, in which K>Na such that muscovite is stabilized over albite, and in which elevated CO_2 contributes to the hydrolysis of Fe, Mg, Ca-silicates to Fe, Mg, Ca-carbonates. The thermal anomaly arising from heat transport upwards in the metamorphic plume forced local, shallow convection of oxidized marine water under hydrostatic pressure, in which Na>K such that albite was stabilized. Pressure differentials between the two reservoirs appear to have limited mixing. (Authors' abstract)

KERRICK, D.M. and JACOBS, G.K., 1981, A modified Redlich-Kwong equation for H_2O, CO_2, and H_2O-CO_2 mixtures at elevated pressures and temperatures: Am. J. Sci., v. 281, p. 735-767. First author at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Carnahan and Starling's (1972) hard-sphere Redlich-Kwong equation was modified to include an attractive term (a) that is a function of pressure and temperature. The modified equation is superior to those that assume a to be independent of pressure. Calculated molar volumes and fugacity coefficients for H_2O and CO_2 are in good agreement with those obtained from P-V-T data; furthermore, this equation yields reasonably accurate fugacities for H_2O and CO_2 at P-T conditions beyond the range of experimental volumetric measurements. Using standard mixing rules for calculating a_{mix} and b_{mix}, this equation yields Z_{mix} values that are consistent with those of Greenwood's (1969) P-V-T measurements. Calculated activities show significant positive non-ideality of mixing at elevated pressures ($P \geqslant 1$ kb) and T = 400° to 800°C. Unmixing of H_2O and CO_2 is implied at lower temperatures (400°C) and at higher pressures ($\bar{P}$>10 kb). (Authors' abstract)

KESLER, S.E., RUSSELL, N., SEAWARD, M., RIVERA, J., McCURDY, K., CUMMING, G.L. and SUTTER, J.F., 1981, Geology and goechemistry of sulfide mineralization underlying the Pueblo Viejo gold-silver oxide deposit, Dominican Republic: Econ. Geol., v. 76, p. 1096-1117. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

The large Pueblo Viejo oxide gold deposit was developed by weathering of a gold-quartz-pyrophyllite deposit that formed during sedimentation in a small basin in the upper part of the Los Ranchos Formation, one of the oldest volcanic units in the Greater Antilles. The basin is floored by conglomerates and agglomerates, which grade upward into sandstones and carbonaceous sediments that include chert with thin pyrite layers. Plant fossils, which are common in the carbonaceous sediments, indicate that the basin was near a land mass.

The mineralized zone is roughly funnel shaped and expands to its maximum horizontal dimensions in the carbonaceous sediments. The lower part of the funnel tube contains alunite and diaspore. Pervasive pyrophyllite alteration makes up most of the overlying tube and upper part of the zone, and locally extensive silicification makes up the top of the funnel. Supergene kaolinite is present in the upper part of the funnel.

Metallic minerals, consisting mostly of pyrite, are found as disseminations, layers, and veins, with base and precious metal values being highest in the veins. Veins are most common in the carbonaceous sediments and diminish in abundance downward into the coarser clastic units. The veins contain abundant pyrite, sphalerite, and quartz; minor barite, enargite, and pyrophyllite; and traces of electrum, argentite, colusite, tetrahedrite-tennantite, geocronite, galena, and tellurides containing gold, silver, and copper. There is a stong correlation between Au and Zn in the upper parts of the mineralized zone and the Au:Ag ratio, which averages 1:7, decreases slightly with depth. Au is in electrum in the lower part of the mineralized zone and partly in tellurides in the upper part. Fluid inclusions indicate that fluids in the veins were very dilute, boiled at least locally, and reached temperatures of 130° to 190°C. Pyrophyllite stability requires minimum temperatures of about

260°C for the hydrothermal system. Isotopic data indicate that most of the sulfur in the mineralization was derived from seawater, whereas the strontium and lead came from the Los Ranchos Formation, which probably also supplied the precious metals.

The Pueblo Viejo system is similar to other gold-quartz-pyrophyllite deposits except that it contains no known mineable vein orebodies and, instead, contains numerous, narrow, closely spaced, irregular veins that can be mined by bulk methods. These veins are thought to have formed by hydraulic fracturing of the carbonaceous sediments caused by fluid pressures as the hot spring system developed. The size and shape of the mineralized system at Pueblo Viejo resemble active hot spring systems such as Wairakei, New Zealand, and its environment of formation probably resembled that of the Quaternary volcano chain which crosses Lake Managua in Nicaragua. (Authors' abstract)

KESSEN, K.M., WOODRUFF, M.S. and GRANT, N.K., 1981, Gangue mineral $^{87}Sr/^{86}Sr$ ratios and the origin of Mississippi Valley-type mineralization: Econ. Geol, v. 76, p. 913-920. First author at Geophys. Svc., Inc., 1440 Canal St., Suite 2020, New Orleans, LA 70112.

The $^{87}Sr/^{86}Sr$ ratio measurements in Mississippi Valley-type gangue minerals, and host marine carbonates ranging in age from upper Cambrian to Mississippian, show that in northwestern Ohio, where the mineralization is sparse, the minerals precipitated from fluids in local isotopic equilibrium with the host carbonates in which the minerals were emplaced. In contrast, most gangue minerals from districts of major mineralization in Illinois, Kentucky, Virginia, and Tennessee contain strontium with higher $^{87}Sr/^{86}Sr$ ratios than the carbonate hosts and appear to have crystallized from fluids containing strontium from silicate minerals in the sedimentary succession. No evidence has been found for a magmatic component in the ore fluid strontium.

Data from Elmwood, Tennessee, show that the early ore fluids, like those of northwestern Ohio, were in isotopic equilibrium with the host carbonates but that they were mixed with and displaced by introduced fluids containing more radiogenic strontium.

These findings are consistent with the two-fluid mixing model for the Mississippi Valley mineralization, where a fluid indigenous to the host carbonates and containing reduced sulfur was mixed with introduced fluids analogous to metal-bearing and low sulfide oil field brines, with an extensive history of chemical exchange with clays and other silicate minerals in the sedimentary succession. (Authors' abstract)

KESTIN, Joseph, 1981, Experimental determination of the viscosity and thermal conductivity of fluids, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 295-320. Author at Brown Univ.. Providence, RI 02912, USA.

KHARLAMOV, Ye.S. et al, 1980, Origin of carbonatites of the Kovdor deposit: Geologiya Rudnykh Mestorozhdeniy, 1980, v. 22, no. 4, p. 3-20 (in Russian; translated in Int'l. Geol. Rev., v. 23, no. 8, p. 865-880, 1981).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 13, p. 116-117, 1980. (E.R.)

KHODAKOVSKIY, I.L. and DOROFEYEVA, V.A., 1981, Dielectric constants of water and values of their derivatives from temperature and pressure in the range 0 to 300°C and 1 to 50,000 bars: Geokhimiya, no. 8, p. 1174-1185 (in Russian, English abst.). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Pertinent to properties of inclusion fluids. (A.K.)

KHODAKOVSKIY, I.L., DOROFEYEVA, V.A., MEL'NIKOVA, G.L., GARANIN, A.V. and RYZHENKO, B.N., 1981, Thermodynamic properties of liquid water in the temperature range 0-300°C and pressure up to 10,000 bars: Geokhimiya, no. 2, p. 208-220 (in Russian; English abst.). First author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The P-V-T properties of liquid water at T 0-300°C and P 1-10,000 bars may be described correctly within experimental limits by the new equation of state $V=A+C \lg [(B_0 + B_2P^2) + P]$. The paper bears tables of specific volume (table 3), volatility (table 4), coefficient of isothermal compressibility (table 5), coefficient of isobaric expansion (table 6), $(\partial^2V/\partial T^2)_P$ (table 7) and $(\partial^2V/\partial P^2)_T$ (table 8) for water in the above P and T ranges. (A.K.)

KHODAKOVSKIY, I.L. and SHIKINA, N.D., 1981, The role of carbonate complexes in mercury transport in hydrothermal solutions (experimental studies and thermodynamic analysis): Geokhimiya, 1981, no. 5, p. 671-682 (in Russian).

KIM, M.Y., 1981, Fluid inclusion studies relating to tungsten-tin-copper mineralization at the Ohtani mine, Japan: J. Geosci., Osaka City Univ., v. 24, Art. 4, p. 109-162. Author at The Korea Inst. Energy and Resources (KIER), 219-5, Garibong-Dong, Youngdeungpo-Gu, Seoul, Korea 150-06.

The ore deposits of the Ohtani mine are genetically related to the late Cretaceous granitic activity. The vein fractures are tension and shear fractures in the Ohtani granitic body. The vein-filling formed by the multiple ascent of ore-forming fluids, consisting of three major stages separated by a tectonic break. The mineral assemblages of the three major stages of mineralization may be briefly defined as follows: Stage I: hexagonal pyrrhotite plus sphalerite, stannite, chalcopyrite and quartz; Stage IIA: chalcopyrite and pyrrhotite plus small amounts of stannite, sphalerite, cubanite, galena, native bismuth, bismuthinite, arsenopyrite and pyrite. The gangue minerals consist of quartz and calcite; Stage IIB: cassiterite, scheelite, muscovite, pyrrhotite, sphalerite, chalcopyrite, arsenopyrite, pyrite. The gangue minerals are quartz, muscovite, fluorite and calcite; Stage III: scheelite, quartz, and muscovite, plus pyrrhotite, sphalerite, chalcopyrite, arsenopyrite, pyrite, fluorite and calcite.

Fluid inclusion data are summarized as follows:

(a) Stage I associated with chloritization shows high temperature (320-260°) and high salinity (7.8-5.1 equivalent wt. % NaCl), depositing hexagonal pyrrhotite, sphalerite, stannite, and chalcopyrite.

(b) Stage IIA shows moderate temperature (320-194°C) and low salinity (6.8-2.1 equivalent wt. % NaCl), depositing chalcopyrite, monoclinic pyrrhotite and other sulfide minerals. In particular the mineral paragenesis shown by sphalerite, stannite and chalcopyrite may be formed above 250°C, and bismuthinite deposition was formed above 235°C.

(c) Stage IIB associated with muscovitization shows moderate temperature (308-214°C) and moderate salinity (9.0-2.1 equivalent wt. % NaCl), depositing tin and tungsten minerals. The precipitations of cassiterite and scheelite are below 310°C in temperature and 9.0 equivalent wt. %

NaCl in salinity. Drusy quartz of stage IIB shows low temperature (267-172°C) and low salinity (4.1-1.7 equivalent wt. % NaCl).

(d) Stage III associated with intensive muscovitization shows low temperature (276-190°C) and moderate salinity (5.9-2.6 equivalent wt. % NaCl), depositing scheelite, muscovite, monoclinic pyrrhotite and other sulfide minerals. Drusy quartz of stage III shows low temperature (240-164°C) and low salinity (3.9-1.5 equivalent wt. % NaCl).

(f) Correlating the variations of temperature and salinity in each stage to pyrrhotite occurrences, it is considered that stage I associated with hexagonal pyrrhotite shows higher temperature and higher salinity than stage II or stage III which is associated with monoclinic pyrrhotite.

(g) Stage IIB associated with scheelite and muscovite shows slightly higher temperature than stage III which is also associated with scheelite and muscovite. (From the author's conclusions)

KINNUNEN, K.A., 1981, Summary: comparison of fluid inclusion assemblages of Outokumpu-type ore outcrops and boulders in eastern Finland: Geol. Survey of Finland, Rept. of Investigation No. 51, 40 pp. (in Finnish with 2-page English summary).

The applicability of fluid inclusion studies to boulder tracing was tested with chrome diopside and quartz from the Outokumpu ore outcrops (Kumpu B and Kaasila), several Outokumpu-type ore outcrops (Luikonlahti, Mihkali, Riihilahti and Hietajärvi) and 17 Outokumpu-type ore boulders. The chrome diopside contained workable primary fluid inclusions, but the phase volume composition was practically the same in all samples. The abundance of different types of secondary fluid inclusion planes in quartz, by contrast, characterized the Outokumpu-type ore mineralizations. With this inclusion data the Outokumpu-type ore boulders could be classified into three boulder fans. In fact, the composition of the fluid inclusion plane assemblages in quartz seems to characterize ore boulders in such detail that inclusion studies can provide an additional tool for boulder examination. (Author's abstract)

KIRBY, S.H. and GREEN, H.W., II, 1980, Dunite xenoliths from Hualalai Volcano: evidence for mantle diapiric flow beneath the island of Hawaii: Am. J. Sci., v. 280, p. 550-575. First author at U.S. Geol. Survey, 345 Middlefield Road, Menlo Park, CA 94025.

The work of Jackson (1968) has shown that the dunite xenoliths in the 1800-1801 Kaupulehu flow of Hualalai Volcano, Hawaii, originated in the mantle and that the metamorphic textures are due to syntectonic recrystallization. We have applied an oxidation decoration technique and transmission electron microscopy to the study of CO_2-filled bubbles and dislocation substructures. We show that the textural variations among the dunite tectonite xenoliths are due to progressive deformation and recrystallization of an originally coarse-grained dunite (~5 mm size). The recrystallized grain size (400 ± 200 microns), subgrain size (45 ± 5 microns), and free dislocation density $(3 \pm 2) \times 10^4$ mm^{-2} do not vary systematically with the extent of recrystallization, suggesting that the degree of recrystallization is a function of the total strain, not the tectonic shear stress. Many of the free dislocations and dislocation arrays in the first generation olivine grains are decorated with CO_2 bubbles, whereas these features are not decorated in the recrystallized grains. We believe that these observations point to the slow depressurization of the dunites during early deformation, leading to precipitation from solid solution of free CO_2 from the original grains along dislocations and that subsequent syntectonic recrystallization segregated CO_2 at grain boundaries, leaving the recrystallized grains undecorated by CO_2 bubble precipitates. The coupling of slow depressurization and flow may be accounted for in the simplest way by a diapiric origin for these rocks. (Authors' abstract)

KIRKPATRICK, R.J., 1981, Kinetic theory of nucleation in silicate melts (abst.): EOS, v. 62, p. 1064

KIRKPATRICK, R.J., KUO, L.-C. and MELCHIOR, John, 1981, Crystal growth in incongruently-melting compositions: programmed cooling experiments with diopside: Am. Min., v. 66, p. 223-241. First author at Dept. Geol., Univ. Illinois, Urbana, IL 61801.

Programmed cooling experiments using a synthetic diopside glass and constant cooling rates of from 10° to 300°C/hr first crystallize forsterite and then with decreasing temperature clinopyroxene + wollastonite. The forsterite grows as hopper-shaped crystals which then develop dendrites from external corners. The morphological development can be qualitatively explained by a model involving diffusion in the melt and interface attachment kinetics. Microprobe traverses across forsterite-glass interfaces show that the magnitude of the MgO depletion in the melt near flat interface segments varies from 1.72 to 4.28 percent and increases with increasing run time for a given cooling rate and with increasing value of the product of the cooling rate times the run time for all cooling rates. The results are in qualitative agreement with theoretical predictions. Near a particular crystal MgO depletion is least at corners and greatest in reentrants. The clinopyroxene is more magnesian than diopside (solid solution towards enstatie) and grows as dendrites. The wollastonite occurs between the clinopyroxene dendrite arms. The clinopyroxene first appears at nominal undercoolings (1391 T_{quench}) of from 182° to 240°C, depending on the cooling rate. Unlike other sets of programmed cooling experiments which show a continual increase in nominal undercooling with increasing cooling rate, these experiments show a maximum in clinopyroxene undercooling at 50°C/hr. The undercooling is actually least for the 300°C/hr runs. (Authors' abstract)

KISH, L. and CUNEY, M., 1981, Uraninite-albite veins from the Mistamisk Valley of the Labrador Trough, Quebec: Mineralog. Mag., v. 44, p. 471-483. First author at Ministère de l'Energie et des Ressources, 1620 boul. de l'Entente, Quebec G1S 4N6, Canada.

The uraninite-albite veins of the Mistamisk area occur in the argillite member of the Dunphy Formation, which is near the base of the slightly metamorphosed Lower Proterozoic sequence of the central Labrador Trough. The vein minerals are albite, uraninite, dolomite, and chlorite, and minor quantities of quartz, tellurides, sulphides, gold, and organic material. Pitchblende and calcite are related to late remobilization.

The veins were deposited in fractures by hydrothermal solutions, and metasomatism caused albitization of wall rocks. Fluid inclusions have an unusual composition, described here for the first time in connection with soda-metasomatism; the aqueous solution of the inclusions is oversaturated in NaCl and contains Ca^{2+} and Mg^{2+}, and the gas phase mostly consists of N_2, CO and CO_2. The presence of hematite and absence of hydrocarbons indicates that the vein-forming solution was oxidizing.

The temperature and pressure of vein formation, estimated from fluid inclusion data, was 300°-350° and 2.5 kbar respectively consistent with the composition of the phengite which is a common metamorphic mineral of the host rock. Vein emplacement occurred in the waning stages of the Hudsonian Orogeny, the hydrothermal solution possibly originating by metamorphism of sodic schists of the Mistamisk area, which are possibly of evaporitic origin. (Authors' abstract)

KITA, Itsuro, 1981, A new type ball mill made of pyrex glass: Geochemical J., v. 15, p. 289-291. Author at Res. Instit. of Underground Resources, Mining College, Akita Univ., 1-1, Tegata Gakuen-cho, Akita 010, Japan.

A ball mill made of pyrex glass with an alumina ball was devised. The features are as follows, 1) quartz and rocks can be powdered manually in a short period of time, 2) pulverization is possible in the pressure range from 10^{-3}torr to about 3 atm and the temperature up to about 300°C, 3) interior of the mill is visible, and 4) the mill is handy to manipulate and easy to repair. The mill may be useful for varieties of crushing experiments. (Author's abstract)

KLOSTERMAN, M.J., 1981, Applications of fluid inclusion techniques to burial diagenesis in carbonate rock sequences: Applied Carbonate Research Program Tech. Series Contribution #7, modified from M.S. thesis, Lousiana State Univ.

Carbonate cement formed during diagenesis of sedimentary rocks frequently entraps samples of diagenetic fluid as fluid inclusions, which record the pressure and temperature of the fluid at the time of formation. Homogenization of liquid-gas inclusions yields an estimate of the minimum temperature of inclusion and crystal formation; freezing point depressions of liquid inclusions can provide a close approximation of the salinity of the trapped liquid. Homogenization temperatures (Th) and final melting temperatures (Tf) were determined for 222 small (4-15 micron), primary and pseudosecondary, aqueous liquid-gas fluid inclusions in coarse (0.25-3.0 mm) poikilotopic calcite cement. The cement is from the moderately buried (2.4-3.3 km) Smackover Formation (Upper Jurassic, Oxfordian), which was sampled from wells in Walker Creek and Mount Vernon oil fields in southern Arkansas. Th values, uncorrected for excess ambient pressures during inclusion entrapment, range from 58° to 158°C. This large range is interpreted as resulting largely from gradual precipitation of calcspar and entrapment of inclusions during changing temperature conditions. Depressed freezing temperatures (-15° to -32°C) and low initial melting temperatures (-51° to -68°C) indicate that the fluid in the inclusions is a very saline, complex calcium chloride brine containing the equivalent of between 19 and 31 wt percent NaCl. The elevated Th values, high fluid salinity and apparent presence of $CaCl_2$ suggest precipitation of the calcite cement in the subsurface from a hot, concentrated calcium chloride brine. (Author's abstract)

KLOSTERMAN, M.J., 1981, Fluid inclusions in carbonate reservoir rock, Smackover Formation (Upper Jurassic), southern Arkansas, USA (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts v. 6, p. A-32.

Carbonate cement formed during diagenesis frequently entraps diagenetic fluid as fluid inclusions. Homogenization of liquid-gas fluid inclusions produces estimates of the minimum temperatures during entrapment; freezing temperatures of liquid inclusions can provide a close approximation of the salinity of the trapped liquid. Homogenization (Th) and freezing temperatures (Tf) were determined for small (4-15μ) primary, aqueous liquid-gas fluid inclusions in coarse (.25-3 mm) poikilotopic calcite cement from a deeply buried (2.4-3.3 km) oolitic grainstone sampled from Walker Creek and Mount Vernon oil fields in southern Arkansas. Th values, uncorrected for high pressures, range from 59° to 159°C, with a mode from 95°-105°C, Tf values from -15° to -32°C, with a mode from -24° to -26°C.

Many of the measured Th values are higher than the current bottom hole temperatures of 80°-108°C. The elevated Th values can be explained by one or more of the following: 1) a higher paleogeothermal gradient; 2) the inclusion has leaked, stretched, or contains a system other than saltwater; 3) in situ production of gas. Tf values correspond to salinities of 19-28 wt% equiv. NaCl. Observed first melting temperatures occur between -51° and -68°C, suggesting the presence of $CaCl_2$ in the trapped brine.

The elevated Th values, high salinity, and apparent presence of $CaCl_2$ suggest precipitation of the poikilotopic cement in the deep subsurface, at temperatures greater than currently exist at that depth, and from a concentrated $CaCl_2$-brine. (Author's abstract)

KOBAYASHI, Nobuyuki, 1981, Effect of fluid flow on the formation of gas bubbles in oxide crystals grown by the Czochralski method: J. Crys. Growth, v. 54, p. 414-416. Author at Faculty of Engrg., Toyama Univ., Takaoka, Toyama 933, Japan.

The inclusion of bubbles in oxide crystals is analyzed. The primary determinant of bubble formation is the growth rate of the crystal. Fluid flow in the melt considerably influences the bubble entrapment in the crystal. Crystals with bubbles are grown if free convection is dominant in the melt, while those without bubbles are grown if forced convection caused by crystal rotation is dominant. This result is also confirmed by observing the interface shape. The critical Reynolds number of the rotating crystal above which crystals without bubbles are grown is theoretically given if growth parameters and material properties of molten oxides are known. (Author's abstract)

KOCHETKOVA, K.V., KOVALEV, K.R., BORISENKO, A.S. and PAVLYUCHENKO, V.S., 1981, Composition and properties of the zinc-bearing staurolite from the Kholodninskoe deposit (West Forebaikalia): Zapiski Vses. Mineral. Obshch., v. 110, no. 3, p. 310-318 (in Russian). Authors at Inst. Geol. and Geophys. of Siberian Branch of Acad. Sci. of the USSR, Novosibirsk, USSR.

The minerals of the quartz-staurolite-zinc-bearing staurolite-gahnite-garnet-plagioclase paragenesis bear inclusions of two types: 1) inclusions of very dense gases (methane), in gahnite and quartz, homogeneous at room T, heterogenize at -160 to -150°C to G and L phases, freezing at T of LN_2 (-196°C), Tm at -180 to -185°C, Th at -125 to -135°C, specific vol. at -125 to -135°C is 2.60 to 2.73 cm^3 per g, hence P at 570-575°C (determined by Perchuk's garnet-staurolite geothermometer) is 4.7-5.5 kbar. 2) S inclusions in quartz and staurolite, filled by LH_2O+LCO_2 or LH_2O+LCO_2+halite dm yield Th 220-260°C. (Abstract by A.K.)

KOGARKO et al., 1981 - See Appendix

KOIVULA, J.I., 1981a, The hidden beauty of amber: new light on an old subject: Gems & Gemology, v. 16, p. 34-36. Author at Gemological Inst. Am., Santa Monica, CA.

A discussion, with 7 photographs, of inclusions of various types in amber. (E.R.)

KOIVULA, J.I.,b 1981, Carbon dioxide as a fluid inclusion: Gems & Gemology, v. 16, no. 12, p. 386-390. Author at Gemological Inst. of America, Santa Monica, CA.

Second only to water in abundance as a fluid inclusion filler, carbon dioxide in a liquefied form, because of its low critical temperature and extreme sensitivity to heating, is often and easily overlooked. Found in natural gem minerals, the explosive pressures CO_2 can generate in an inclusion chamber, even with only a slight rise in temperature, make it a type of fluid inclusion that all gemologists should be aware of. (Author's abstract)

KOIVULA, J.I., 1981c, Inclusions in andalusite; a comparison of localities: Gems & Gemology, v. 16, no. 12, p. 401-404.

A short review of solid (and fluid) inclusions in gem andalusite. CO_2 liq., H_2O, and occasionally N_2 are found. (E.R.)

KOIVULA, J.I., 1981d Photographing inclusions: Gems & Gemology, v. 17, p. 132-142. Author at Gem Ident. Dept., Gem Trade Lab., Inc., Santa Monica, CA.

Although the general principles of photomicrography are easily learned and applied, high-quality photomicrography is an art that is mastered only with time and great patience. The microscope must be kept scrupulously clean, and the effects of light on the subject inclusion must be fully understood in order to determine what method(s) of illumination will yield the most useful photographic image. Specialized techniques that can save film and time, while producing top-quality photomicrographs, are usually learned only through long hours of experience. This article discusses some of these techniques, such as the importance of a properly prepared microscope and photographic subject, as well as the control of vibrations and exposure time. In addition, the various methods of illumination that are adaptable to a standard binocular gemological microscope and introduced. (Author's abstract)

KOKIN, A.V., 1981, Thermobarometry of native gold and of its associated minerals from the south-eastern Yakutija: Akad. Nauk SSSR, Sib. Otdel., Geol. i. Geofis., no. 5, p. 74-80 (in Russian).

See Appendix

KOL'TSOV, 1981 - See Appendix

KONNERUP-MADSEN, Jens, 1981, Hydrocarbon gases associated with alkaline igneous activity in the continental Gardar rift province (south Greenland): Evidence from compositions of fluid inclusions (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Inst. Petrol. Univ. Copenhagen, Denmark.

Fluid inclusions in minerals from both Si-oversaturated and Si-undersaturated igneous complexes belonging to the Precambrian Gardar rift province in south Greenland have been examined. The results show that there is a distinction in fluid composition between the Si-oversaturated and the Si-undersaturated rock types: Granites and quartz syenites are characterized by CO_2 and only minor CH_4 whereas nepheline syenites are dominated by hydrocarbons (especially CH_4) and contain only small amounts of CO_2. Calculations suggest that the composition of gases in the nepheline syenites could well reflect equilibration with graphite at magmatic temperatures and at oxygen fugacity values below those corresponding to the QFM buffer curve.

Comparison of the gases in minerals from Gardar nepheline syenites with those of various other alkaline igneous complexes reveal a high degree of similarity and suggest the existence of a characteristic hydrocarbon-rich vapor phase associated with Si-undersaturated, peralkaline magmatic activity. The generation of these hydrocarbon-rich volatiles is considered mainly to reflect, 1) low oxygen fugacities, 2) a long temperature range of crystallization and a low-temperature solidus, and 3) retention of volatiles, during formation of these rock types. In general, however, CO_2 is the characteristic vapor phase associated with continental igneous activity. (Author's abstract)

KONNERUP-MADSEN, Jens, ROSE-HANSEN, John and LARSEN, Elfinn, 1981, Hydrocarbon gases associated with alkaline igneous activity: evidence from compositions of fluid inclusions: Rapp. Grønlands geol. Unders. 103, p. 99-108.

The importance of volatile components in the generation and crystallization of alkaline rocks has been emphasized by a number of authors (see review by Kogarko, 1974). One method of determining the character of the volatile components associated with natural magmatism is to study the volatiles trapped as fluid inclusions in minerals during formation of the rocks. Although there may often be difficulties in relating the volatiles observed in fluid inclusions in minerals to those present in the melt at the time of solidification, this approach is considered to provide a potential method for determining the characteristics of volatiles associated with formation of natural rocks.

Studies of fluid inclusions in minerals and rocks from various alkaline complexes have shown the presence of considerable amounts of hydrocarbon gases together with highly alkaline aqueous fluids (Petersilie and Sørensen, 1970; Sobolev et al., 1974). The relation between these two contrasting types of fluids is still somewhat uncertain. Microscopic observations, however, suggest that the hydrocarbon gases were entraped in the minerals by preferential enclosure of immiscible droplets of hydrocarbons within a saline aqueous fluid (Konnerup-Madsen et al., 1979). (Authors' abstract)

KONONENKO, V.G. and GEGUZIN, Ya.E., 1981, Movement of a foreign impurity in a crystal near the melting point of the latter: Kristallografiya, v. 26, p. 157-163 (in Russian; translated in Sov. Phys. Crystallogr., v. 26, no. 1, p. 85-89, 1981). Authors at State Univ., Khar'kov.

The authors experimentally investigate the motion of a small copper sphere in a crystal of naphthalene just below the melting point. They find anomalously high velocities and a sharp rise in velocity as the melting point is approached. They suggest and analyze three mechanisms of motion which are possible in the given conditions, and estimate the velocities due to each. By comparing the observed and theoretical velocities, they find that to explain the anomalously high values and the anomalously rapid rise as the melting point is approached, it is necessary to assume that in the vicinity of the sphere there is spontaneous generation of dislocation loops at premelting temperatures. This leads to a fall in the effective shear modulus. (Authors' abstract)

KONOVALOV, I.V., 1981, Stages of development of metamorphic-deformation cycles and accompanying mineralization: Akad. Nauk SSSR Doklady, v. 258, no. 5, p. 1172-1174 (in Russian). Author at Inst. of Earth's Crust of

Siberian Branch of Acad. Sci. USSR, Irkutsk, USSR.

In the beginning of geosyncline inversion in the Badaybo area, Asian USSR, the earlier-formed sulfide ores recrystallized with formation of lenticular bodies and individual metacrysts at T >400°C. In the stress zones quartz (±sulfides) veinlets formed during decreasing temperature from 400 to 360°C. In apical zones of the anticlinal folds the quartz-gold ores formed in the middle of the geosyncline inversion at T ~400°C. All Th are for inclusions in quartz. (A.K.)

KOROBEYNIKOV, A.F., 1981a Fractionation of gold in magmatic melt during its crystallization: Akad. Nauk SSSR Doklady, v. 258, no. 5, p. 1200-1204 (in Russian). Author at Tomsk Polytechnical Inst., Tomsk, USSR.

The remnant portions of silicate melt and volatiles become enriched in gold during magma crystallization 5-190 times (compared with initial melt) and this explains the geological position of gold ore deposits. Pertinent to melt and G/L inclusions. (A.K.)

KOROBEYNIKOV, 1981b - See Appendix

KORYTOV, F.Ya., KHRAPOV, A.A. and KANDINOV, M.N., 1981, Phenakite-fluorite mineralization of Mongolia: Doklady Akad. Nauk SSSR, 1978, v. 242, no. 1, p. 190-191 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sects., v. 242, p. 148-149, 1981).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 11, p. 111. (E.R.)

KORZHINSKIY, A.F. and MAMCHUR, G.P., 1978, Isotope composition of graphitic and carbonate carbon from Archean gneisses of the Ukrainian Shield as an indicator of graphite formation conditions: Mineralog. Obshch. Zapiski, 1978, no. 4, p. 442-448 (in Russian; translated in Internat. Geol. Rev., v. 23, no. 3, p. 337-342, 1981).

KORZHINSKIY, M.A., 1981, Apatite solid solutions as indicators of the fugacity of HCl^0 and HF^0 in hydrothermal fluids: Geokhimiya, 1981, no. 5, p. 689-706 (in Russian).

KOSHELEV et al., 1981 - See Appendix

KOSUKHIN, O.N., 1981, On the genesis of graphic textures: Akad. Nauk SSSR, Sib. Otdel., Geol. i Geofis., 1981, no. 4, p. 46-50 (in Russian). See Appendix

KOTELNIKOV, A.R., BYCHKOV, A.M. and CHERNAVINA, N.I., 1981, Experimental study of calcium distribution between plagioclase and water-salt fluid at 700°C and P = 1000 atm: Geokhimiya, 1981, no. 5, p. 707-721 (in Russian).

KOTOV, N.V., DOMNINA, M.I., VOROB'YEV, P.V., KOVNURKO, G.M. and GALIBIN, V.A., 1981, Experimental determination of composition of albitizing fluid during hydrothermal alteration of granite in presence of NaF: Geokhimiya, no. 9, p. 1353-1361 (in Russian, English abst.). Authors at Leningrad State Univ., Leningrad, USSR.

Experiments were made under conditions: P_{H_2O} 1 kbar, T 400-600°C, 1-6 M NaF solution, granite: water solution ratio equal 1:3; pertinent to studies of inclusion fluid composition. (A.K.)

KOTOV, N.V., DONSKIKH, A.V., GALIBIN, V.A. and VOROB'YEV, P.V., 1981, Reactions of granite and basalt with K-Na-chloride solutions at elevated PH_2O-T parameters: Akad. Nauk SSSR Doklady, v. 257, no. 3, p. 705-707 (in Russian). Authors at Leningrad State Univ., USSR.

Pertinent to the chemical composition of mineral-forming fluids. (A.K.)

KOVAL'SKIY, F.I., 1981, Halide formations of salt domes in the northern Caspian Depression, in The Structure and Formation Conditions of Salt-Bearing Horizons: A.L. Yanshin and M.A. Zharkov, eds.: Izd. Nauka, Sibirsk. Otdel., Novosibirsk, USSR, p. 131-134 (in Russian).

Indexed under fluid inclusions. (E.R.)

KOVAL'SKIY, F.I., MOSKOVSKIY, G.A., RUMYANTSEVA, O.P. and GILETIN, A.M., 1981, Sedimentation conditions of the Kungurian halide deposits in the Kuibyshev area of the Volga region, using results from a study of inclusions in minerals, in The Structure and Formation Conditions of Salt-Bearing Horizons: A.L. Yanshin and M.A. Zharkov, eds.: Izd. Nauka, Sibirsk. Otdel., Novosibirsk, USSR, p. 32-36 (in Russian).

See Appendix

KOWALIK, Joseph, RYE, R.O. and SAWKINS, F.J., 1981, Stable-isotope study of the Buchans, Newfoundland, polymetallic sulphide deposits: in The Buchans orebodies: fifty years of geology and mining: Geol. Assoc. of Canada Spec. Paper 22, 1981, p. 229-254. First author at Newmont Exploration Ltd., RFD #1, Box 263A, Brewer, ME 04412.

Mineralogical and stable-isotope studies of the Buchans orebodies, and particularly of the stockworks from the Lucky Strike orebody, provide paragenetic and temperature data which give some insight into the origin of the fluids involved in ore formation.

The host rocks for the Lucky Strike stockworks were first pervasively chloritized and pyritized. Pyrite was also deposited during a period of silicification, which in the Lucky Strike stockworks postdates most of the chloritization. Chalcopyrite, although it too is most commonly associated with silicification, appears to have been deposited later than the majority of the pyrite but before sphalerite and galena. Barite and calcite follow quartz in the paragenetic sequence and are the dominant gangue minerals of galena in the stockworks.

Stable-isotope data indicate a temperature range of 243° to 371°C for quartz-chlorite deposition and a range of 140° to 322°C for sphalerite-galena mineralization, with temperatures decreasing away from the major plumbing system. Much of the $\delta^{34}S$ data are nearly identical to those observed for the Japanese Kuroko deposits and suggest that all of the sulphur in the deposit was derived from seawater. In general, δD and $\delta^{18}O$ data indicate that the ore fluids were predominantly, if not entirely, seawater, and that the water:rock ratio in the system was large. (Authors' abstract)

KOZLOWSKI, A., 1981, Cryometry of inclusions in fluorite from the Strzegom pegmatites: Post-magmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, p. 13-14, Wydawnictwa Geologiozne, Warsaw (in Polish). Author at Inst. Geochem., Mineral. Petrogr. of Geol. Fac. of Warsaw Univ., 02-089 Warszawa, al. Zwirki i Wigury 93, Poland.

Drusy fluorite from granite quarry No. 18 at Strzegom, Lower Silesia, bears large (0.2-0.4 mm) G/L inclusions. Cryometric studies showed that during rapid cooling down to -130°C the liquid remained supercooled and metastable, but crystallization of this solution may be achieved at -60 to -70°C using proper cooling rate. Te of inclusions was -54 to -58°C, similar to Te of $NaCl-CaCl_2-H_2O$ (-55°C); Tm equals -21.1°C. Starting from one or few ice crystals in inclusions, on freezing it is possible to grow ice and hydrohalite crystals occupying at -72°C about 60 vol.% of inclusion. The remaining solution is metastable liquid down to -130°C and that metastability has not been overcome. At about -50°C the difference of refractive indices of remaining solution and fluorite disappears (n of fluorite at 20°C = 1.434). The only reasonable salt that may appear in hydrothermal solutions in sufficient concentrations to raise the value of refractive index to that of fluorite is $CaCl_2$ (40 g $CaCl_2$ per 100 ml of solution gives n at 20°C equal 1.434). The above data indicate that hydrothermal solutions in the Strzegom pegmatites for Th about 200°C had chloride-sodium-calcium character and high concentration. (Author's abstract)

KOZLOWSKI, Andrzej, 1981, Melt inclusions in pyroclastic quartz from the Carboniferous deposits of the Holy Cross Mts., and the problem of magmatic corrosion Acta Geologica Polonica, v. 31, no. 3-4, p. 273-284.

Pyroclastic quartz from Carboniferous clayey sediments of the Holy Cross Mts. bears silicate glass inclusions, frequently altered or refilled by pneumatolytic and hydrothermal solutions. Homogenization and crushing stage studies have yielded the quartz crystallization and probably eruption temperature 790-810°C, cooling rate, and have evaluated changes of pressure of volatiles. The invalidity of common interpretation of the so-called "magmatic corrosion" phenomena is presented. (Author's abstract)

KOZLOWSKI, A. and NOWAKOWSKI, A., 1981, Origin and formation conditions of albite in pegmatites of the Karkonosie and Strzegom granites: Postmagmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, p. 12-13, Wydawnictwa Geologiozne, Warsaw (in Polish). Authors at Inst. Geochem. Mineral. Petrogr. of Geol. Fac. of Warsaw Univ., 02-089 Warszawa, al. Zwirki i Wigury 93, Poland.

Albite as almost pure sodium feldspar is very common in veins and pegmatitic nests in granites of Karkonosie and Strzegom. Origin of this feldspar, frequently twinned after albite and pericline laws is either primary or secondary. Primary are cleavelandite and bluish-white albite. Cleavelandite forms epitaxial crystals on older feldspars, bluish-white albite occurs as parallel or radial compact aggregates of fine plates, or as granophyric intergrowths with quartz. Orientation of pericline composition plane (RS) is similar in both albite varieties, because the angle s equals ~37°, which indicates that those feldspars grew in almost maximum ordered structural state.

Plates of secondary albite are usually milky-white. They formed either from potassium feldspar (chess albite) or from primary plagioclase (normal twinning). Chess albite did not inherit albite and pericline twins after potassium feldspar, but albite normally shows inherited twins after primitive plagioclase. The relic plane RS preserved in such albite pseudomorphs has the angle s = 8-10° ("chemical memory") and indicates the composition of the primitive, now-vanished plagioclase was An12-An16; this was confirmed by finding the same composition for rarely preserved relics of primitive plagioclase in albite pseudomorphs. Hence, such albite has great similarity to the Alpine periclines, as was evident during comparative studies of Polish and Alpine feldspars.

Pegmatitic paragenesis consisting of quartz, microcline and primitive plagioclase formed from pneumatolytic and next hydrothermal solutions at Th 580-400°C. Cleavelandite, probably finishing the albitization process, crystallized at 330-130°C from hydrothermal solutions, thus albitization may be connected with T range from ~400 to ~300°C. Representative composition of solution at this T 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. Total salt concentrations ranged from 13.0 to ~25 wt.% (cryometric and calculated data), pressures may be estimated to be 50-80 MPa. (Authors abstract, translated by A.K.)

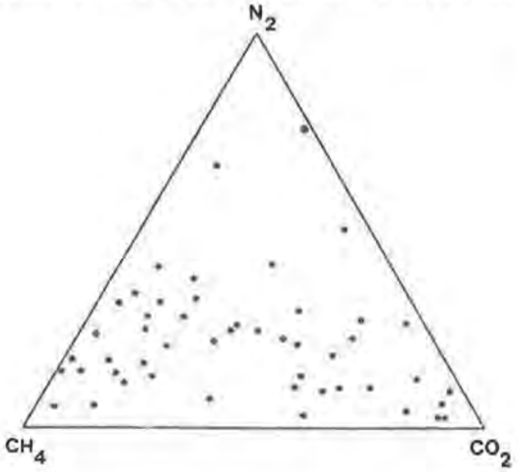
KRASNOBAEV - See Appendix

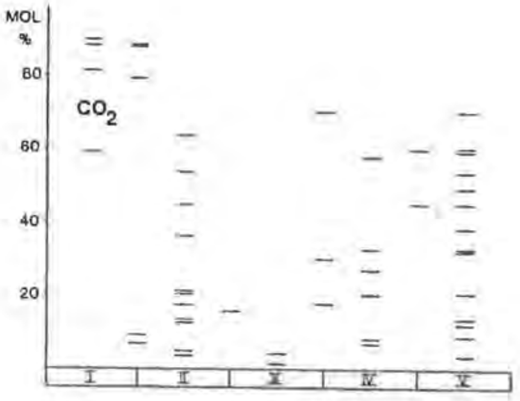
KRAUSE and GNIRK, 1981 - See Appendix

KRAYNOV and RYZHENKO, 1981 - See Appendix

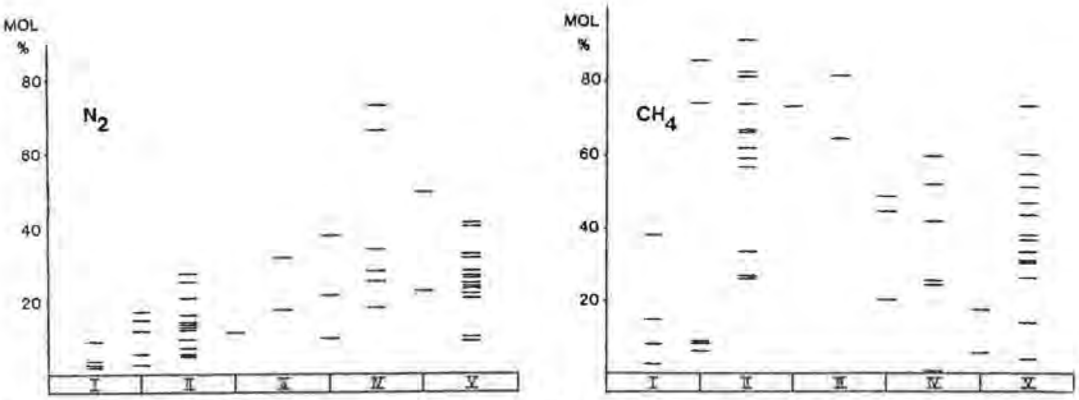
KREULEN, R., 1981, N_2-CH_4-CO_2 fluids during formation of the Dôme de l'Agout, France (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated).

The Dôme de l'Agout consists of an ellipsoidal mass of gneisses and migmatites emerging from a large area of chlorite-sericite schists. Fluid inclusions in syn-metamorphic quartz segregations are typically monophase at room temperature. Analyses by gas chromatography indicate that their main constituents are N_2, CH_4 and CO_2; such compositions are confirmed by freezing studies on individual inclusions. Nitrogen contents of the inclusions show a gradual increase with metamorphic grade. CH_4 and CO_2, however, show an erratic distribution with the exception of low grade samples, which invariably have very high CO_2 contents. The origin of the nitrogen remains unsolved; however, it seems likely that the nitrogen was not produced by mineral reactions in the presently exposed rocks but came from an external source and moved from the centre of the dome outwards. (Author's abstract)





(Continued)



KRIVOSHLYK, I.N. and BOBRIYEVICH, A.P., 1981, Globules of immiscible carbonatites in kimberlite rocks: Akad. Nauk SSSR Doklady, v. 260, no. 4, p. 986-988 (in Russian).

Pertinent to immiscibility in melt inclusions. (A.K.)

KUDELSKII, A.V. and SHIMANOVICH, V.M., 1981, Viscosity of underground brines: Akad. Nauk SSSR Doklady, v. 259, p. 450-452 (in Russian).

KUHLIBAKINA and CHAYKOVSKAYA - See Appendix

KULIKOV, 1981a, 1981b - See Appendix

KULIKOV, I.V., 1981c Genesis of high-temperature calcite of the deposit Tyrnyauz: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 8, p. 118-121 (in Russian). Author at Moscow Geol.-Prosp. Inst., USSR.

Calcite of the scheelite-sulfide-fluorite stage at the W-Mo deposit Tyrnyauz consists of coarse-grained post-fluorite aggregates. It bears P inclusions of concentrated solutions with 10-20 dms, Th 550-600°C, inclusion size up to 1.5 mm. S inclusions are two-phase with G>L or G<L in coeval inclusions, that proves boiling of solutions healing fractures in calcite. (Abstract by A.K.)

KUMAR, C., ESTRIN, J. and YOUNGQUIST, G.R., 1981, Crystal growth under nonuniform conditions; experimental observations in $MgSO_4 \cdot 7H_2O$-water system: J. Crys. Growth, v. 54, p. 176-184. Authors at Dept. Chem. Engrg., Clarkson College of Tech., Potsdam, NY 13676, USA.

A characteristic feature of crystals is their tendency to maintain spatially uniform growth despite adverse conditions in the surrounding fluid. This is strikingly demonstrated when the (110) face of $MgSO_4 \cdot 7H_2O$ is grown from aqueous solution under the influence of an impinging jet. In this case, despite the solute concentration variation at the interface, uniform growth is maintained by incorporating solvent inclusions. Based on classical theory, the boundary of the inclusion-free region is believed to indicate the attainment of the limiting Wilson-Frenkel growth locally. Accordingly, the adsorption coefficient of the solute is calculated from these data. (Authors' abstract)

KUMAR, M.B., 1981, Character of brine leaks at the Avery Island salt mine, Louisiana (abst.): Geol. Soc. Am. Abstracts with Programs, v. 13, p. 12. Author at Inst. Environ. Studies, Louisiana State Univ., Baton Rouge, LA 70803.

The present study is essentially based on the chemical analyses of twenty-two samples of the major active leaks at the 500-ft and 700-ft levels of the Avery Island salt mine. Five samples of ground water over the salt dome are also included in the study. The samples represent sodium-chloride brines with some concentrations of calcium, magnesium, and potassium. In ionic distribution, the mine leaks generally do not appear to be significantly different from the ground water. The chemical character of the mine leaks has been compared with that of modern sea water, oil-field brines of Louisiana, and brines of other salt mines. Numerous concentration plots of chloride and bromide against other constituents have been evaluated. An integration of all the pertinent data indicates a meteoric origin for most of the mine leaks at Avery Island. The conclusions of this study are appraised in light of similar studies completed on the sub-surface leaks of the Belle Isle and Weeks Island salt mines, for which nonmeteoric origins have strongly been suggested. The Avery Island mine leaks may be related to shallow fracture zones located near the top of the salt dome. (Author's abstract)

KUN, S., CHAMPIGNY, N. and SINCLAIR, A.J., 1981, Genetic implications of fluid inclusion studies Cinola gold deposit Queen Charlotte islands: Geol. Field work 1980, Brit. Columbia Min. of Energy, Miner. & Pet. Resources Paper 1981-1, p. 197-200. Authors at Dept. Geol. Sci., Univ. British Columbia.

Preliminary fluid inclusion studies provide important constraints on a genetic model for the Cinola deposit. The low salinities and low CO_2 content of the ore fluid are consistent with the suggestion that the fluid originated as pore water in the country rock. Filling temperatures, and the absence of textures resulting from boiling, suggest a minimum depth of formation of about 1100 meters and stratigraphic information suggests a maximum depth of formation of about 1800 meters. "Freezing temperatures" of +2 to +4°C are assumed to be from CO_2 hydrate. The two major peaks of filling temperatures (~155 and ~275°C) suggest that two principal temperature regimes existed during the depositional history. These peaks indicate an early period of high temperature deposition and a late period of lower temperature deposition. (From the authors' conclusions)

KURODA, Yoshimasu, SHIRAI, Hiroaki, SUZUOKI, Tetsuro and MATSUO, Sadao, 1981, Origin of water participated in the formation of the cupriferous iron-sulfide deposit, Hatachi mine, northeast Japan, based on hydrogen isotope study: J. Japan. Assoc. Min., Petr. Econ. Geol., v. 76, p. 156-162. First author at Dept. Geol., Shinshu Univ., Matsumoto 390, Japan.

Anthophyllite, biotite, cordierite and muscovite in the metasomatic rocks such as anthophyllite-cordierite rock closely associated with the copper-bearing iron-sulfide ores were separated to determine their δD and X_{Fe} values. The δD values of the ambient water in the process of formation of the metasomatic rocks can be estimated to be about -30‰ from these values. Coexisting biotite and hornblende from the Cretaceous granodiorite adjacent to the ore deposit showed the equilibrium relationship on δD-X_{Fe} diagram and the estimated δD value of the water equilibrated with both minerals is the same as the value for the metasomatic rocks. Two kinds of water participating in the ore formation and in the granodiorite intrusion seem to be derived from the same origin. On the other hand, δD values of hornblende from the amphibolites of normal chemical composition, which seem to be metamorphosed from basic tuffs and volcanic rocks without metasomatic change of composition are inferred to be in equilibrium to water with δD far lower than -30‰. (Authors' abstract)

KURZ, M.D. and JENKINS, W.J., 1981, The distribution of helium in oceanic basalt glasses: Earth and Planet. Sci. Letters, v. 53, p. 41-54. Authors at Dept. Chem., Woods Hole Oceanogr. Instit., Woods Hole, MA 02543, USA.

We have determined the concentrations and isotopic composition of helium in oceanic basaltic glass both by melting and by crushing in vacuo. A significant fraction of the helium is released by crushing, confirming that it resides within the vesicles. Comparison of volume percent vesicles to the fraction of helium contained in the vesicles gives qualitative agreement with experminental gas-melt partitioning studies. Measured concentrations are therefore, a function of original helium content, magmatic history, vesicle size and quantity, and grain size analyzed. Helium released by crushing is isotopically indistinguishable from that contained in the glass. Diffusion rates for helium in basaltic glass (in the temperature range 125-400°C) determined using the method of stepwise heating, yielded an activation energy of 19.9 ± 1 kcal/mole and in $D_0 = -2.7 \pm 0.6$ (cgs units). Extrapolation of these results to ocean floor temperature (0°C) gives a diffusivity of $1.0 \pm 0.6 \times 10^{-17}$ cm^3/s, indicating that diffusion is an insignificant mechanism for helium loss from fresh basaltic glasses. The $^3He/^4He$ ratios are remarkably constant (at $1.10 \pm 0.03 \times 10^{-5}$) for samples from the Mid-Atlantic Ridge (FAMOUS area and 23°N), the Juan de Fuca Ridge, the Galapagos spreading center, the Mid-Cayman Rise, and the Central Indian Ocean Ridge. This result is interpreted in terms of similar geochemical histories within the source regions for these samples. (Authors' abstract)

KURZ, M.D., JENKINS, W.J., HART, S.R. and CLAQUE D., 1981, Helium isotopic systematics of oceanic islands and the Loihi Seamount (abst.): EOS, v. 62, p. 1083.

KUZNETSOVA, S.V., GNATENKO, O.V., BEREZOVSKII, F.I. and KULIK, Zh.V., 1981, Organic matter from gaseous-liquid inclusions in radioactive quartz: Dopov. Akad. Nauk Ukr. RSR, Ser. B: Geol., Khim. Biol. Nauki, 1981, no. 12, p. 17-20 (in Ukrainian). Authors at Inst. Geokhim. Fiz. Miner., Kiev, USSR.

Org. matter occurs in gas-liq. inclusions in prismatic crystals of quartz from uraniferous metasomatic Proterozoic albitites. It has H/C ratio 0.57, with (O + N + S) 79.81% and played a role in the transport of U and subsequent deposition. A high-temp. hydrothermal origin is proposed for the organic matter. (C.A., 96: 72035v)

KUZNETSOVA, S.V. and LAZARENKO, E.E., 1981, Thermal conditions and fluid formation of accessory uranium mineralization in Precambrium potassium-silicon somatites: Dopov. Akad. Nauk Ukr. RSR, Ser. B: Geol., Khim. Biol. Nauki, 1981, no. 8, p. 27-29 (in Ukrainian). Authors at Inst. Geokhim. Fiz. Miner., Kiev, USSR.

Fluid inclusion studies of the U-bearing accessory minerals in potassic-silicic metasomatites indicate U mineral crystn. at 210-420° for Th- and rare earth-contg. varieties and at 110-360° for the oxides and silicates of U. Metasomatism was induced by a H_2O-CO_2 fluid of moderate salinity. (C.A., 95: 153997s)

KWAK, T.A.P. and ASKINS, P.W., 1981, Geology and genesis of the F-Sn-W(-Be-Zn) (wrigglite) at Moina, Tasmania: Econ. Geol., v. 76, p. 439-467. First author at Dept. Geol., La Trobe Univ., Bundoora, Victoria 3083, Australia.

The Moina skarn deposit, with its associated Sn-W-F veins and greisen, occurs at the margin of the Dolcoath leucogranite. The skarn occurs as a thick horizontal plate approximately one km in its longest dimension and up to 100 m thick and is separated from the granite's upper near-horizontal contact by approximately 200 m of the Moina sandstone. The necessary plumbing system for access of mineralizing fluids is probably a series of east-west-trending tension fractures, now Sn-W quartz veins, associated with a major northwest-southeast-trending fault known as the Bismuth Creek fault. Emplacement of the granite was at shallow depths (<3 km?).

The skarn unit section consists of: (a) a granular garnet-pyroxene-vesuvianite-fluorite skarn; (b) the main skarn ("wrigglite") consisting of fluorite-magnetite-vesuvianite (cassiterite-scheelite-adularia) and having a characteristic fine-grained, rhythmic, finely layered contorted structure; (c) a granular, pale green pyroxene skarn which occurs as thin units (<5 cm) within and near the base of unit (b) above; (d) a wollastonite-rich skarn (>80 vol % wollastonite); and (e) a granular garnet-pyroxene-vesuvianite-fluorite skarn overlying the other units. Unit (e) is relatively enriched in boron (≈600 ppm).

The skarn unit carries up to 25 weight percent F; 0.6 percent Sn, 0.5 percent W, 0.2 percent Be, 27.5 percent Zn, and 4.5 ppm Au. Sn, Be, and Fe values increase toward the upper part of the skarn sequence whereas Zn, Cu, and Mo values are erratic. Secondary Zn-Cu-In-Cd-Au sulfide-amphibole alteration of the primary F-Sn-Be oxide skarn is related to the Bismuth Creek fault. When the primary wrigglite skarn is altered, Sn is largely lost from that part of the skarn. (Authors' abstract)

Fluid inclusions in quartz from a vein show liquid CO_2 commonly, plus dm NaCl and fluorite (confirmed by SEM) and possibly hematite, plus numerous unidentified nonopaque dms. Th = 331 ± 12°C; some gas-rich inclusions also, suggesting boiling. Tm NaCl >Th L-V, but CaF_2 dm did not dissolve (kinetics?). Te -23.1°, Tm ice -15.3°C. Inclusions in CaF_2 vein have no CO_2, Th ~482°C (in V and in L). Inclusions in topaz had no CO_2, but two dms; Th 416 (in V and in L); Te -15°; Tm ice -6.4°C. (E.R.)

KWAK, T.A.P. and TAN, T.H., 1981a, The geochemistry of zoning in skarn minerals at the King Island (Dolphin) mine: Econ. Geol., v. 76, p. 468-497. Authors at Dept. Geol., La Trobe Univ., Bundoora, Victoria 3083, Australia.

Trends of chemical zoning in crystals of garnet, pyroxene, scheelite, and amphibole in 34 samples collected from the pluton's contact updip to 500 m from the contact in the main ore horizon at the King Island scheelite (Dolphin) mine show systematic variations. Garnet cores up to 400 m from the contact are the most andradite rich, reaching values of 98 mole percent nearest the contact. Andradite values decrease systematically both for a particular part of the garnet crystals away from the contact and across individual grains to the outer edges. The mole percent andradite in core and outer core zones decreases to the 500-m mark while in the midsection and edge zones the values decrease to 400 m and then increase. A similar relationship occurs in pyroxenes, which nearest the contact contain hedenbergite values of 98 mole percent. Scheelite occurring as inclusions in garnet reach values of scheelite_{65} powellite_{34} for core zones nearest the pluton while scheelite interstitial to garnet have maximum values of scheelite_{72} powellite_{27}. Powellite contents decrease both toward the edges of individual grains and along the traverse to the 400-m mark where a reversal of trend occurs continuing to 500 m from the contact. Amphibole compositions show a linear decrease of the ratio $Fe^{=2}/Fe^{=2}$+Mg+Mn from 98 nearest the contact to 88 at 390 m and then decreasing abruptly to 65 at 500 m.

Fluid inclusion filling temperatures vary systematically in time and distance from the pluton, with a maximum near 800°C for garnet midsections nearest the pluton to temperatures as low as 180°C for interstitial calcite and quartz. The salinities decrease from near 65 weight percent total dissolved salts in the early formed minerals (i.e., garnet) nearest the pluton to less than 3 weight percent for later formed minerals farthest from the contact (i.e., calcite). These decreases occur out from the contact and progressively toward the end of the paragenetic sequence. Scheelite initially crystallized at higher temperatures, but interstitial scheelite precipitation occurred from a concentrated Na-K(-Ca)-Cl solution (approximately 10 molal, total dissolved salts) at temperatures of approximately 500°C at the pluton's contact to 300°C at a distance of 500 m from the contact. Chemical variations of fluid compositions for all but garnet core zones beyond 400 m from the contact occurred due to mixing of solutions derived form the Northern Boundary fault. The interface between solutions which have permeated through and reacted with the developing skarn unit and those derived from the fault marks the maximum outward edge (from the pluton) of boiling of the solutions, the highest concentrations of W ore, reversals or inflection points in mineral composition profiles, and changes in the elemental ratios of constituents in the brine solutions.

Hot saline solutions initially cooled to approximately 380°C on entering the colder marble horizon. Flow along this horizon caused the loss of heat, dilution, and chemical change of the solution, this latter in response to both reactions with the marble and hornfelsic units as well as the precipitation of the skarn. Permeability was produced by the dissolution of $CaCO_3$ to produce $CaCl_{2(aq)}$ and faulting. With time, thermal equilibrium was reached between the evolving fluid and the contact rocks until boiling of the solution occurred with the loss of a CO_2-rich vapor. During this event the Northern Boundary fault was tectonically active so that primary fluid now entered the forming skarn both from the fault and the contact of the pluton. Mo-rich scheelite began to precipitate at the time of boiling. Subsequent to garnet + pyroxene crystallization, after the boiling event and contemporaneous with the crystallization of amphibole + some quartz, Mo-rich scheelite not "armored" in garnet was dissolved, redistributed, and redeposited as Mo-poor scheelite and molybdenite. This type of scheelite forms most of the ore being mined. (Authors' abstract)

KWAK, T.A.P. and TAN, T.H., 1981b, The importance of $CaCl_2$ in fluid composition trends-evidence from the King Island (Dolphin) skarn deposit: Econ. Geol., v. 76, p. 955-960. First author at Dept. Geol., La Trobe Univ., Bundoora, Victoria 3083, Australia.

The multiphase inclusions at King Island have much $CaCl_2$ in solution; if this $CaCl_2$ content is not considered, and the composition is assumed to be in the system NaCl-KCl-H_2O, some erroneous concepts can be formed. First melting temperatures should always be obtained on multiphase (i.e., NaCl+KCl) inclusions. (E.R.)

KYSER, T.K. and JAVOY, M., 1981, Stable isotope relations in the Loihi Seamount (abst.): EOS, v. 62, p. 1083. First author at U.S. Geol. Survey, Denver, CO 80225. (Continued)

Stable isotope compositions and water and carbon contents have been measured in tholeiitic and alkalic glasses from the Loihi Seamount. ^{13}C concentrations increase with the carbon content for each rock type, and this relation is attributed to loss of carbon dioxide which is enriched in ^{13}C relative to dissolved carbon. Prior to extensive outgassing near the surface, the $\delta^{13}C$ values of all the samples were probably -20 to -18, and the carbon concentrations were 150-250 ppm for tholeiitic magmas, 300 ppm for alkalic magmas, and >400 ppm for basanites.

Water contents of the glasses vary with potassium contents, are higher than most MORBs (0.10-0.20 wt %), and the lowest values (0.40 wt %) approach those of submarine tholeiites from the East Rift Zone of Kilauea. δD values are variable (-65 - -50), but many are in the range previously estimated for the primary values of ERZ tholeiites (-70 - -65). The more D-rich samples may reflect seawater contamination which would affect only the hydrogen and argon compositions.

$\delta^{18}O$ values vary from 4.5 to 6.0 with most values between 4.5 and 5.0. Unlike lavas from developed islands, there is no correlation between $\delta^{18}O$ and silica undersaturation. The low ^{18}O content of these lavas suggest formation from a source different from that which produces MORBs. The variable $\delta^{18}O$ values indicate that the source may actually represent a mixture of MORB mantle and a primitive, ^{18}O-rich source. The δD and $\delta^{13}C$ values, however, suggest that trace isotopes may reflect only one of the sources. (Authors' abstract)

LAGACHE, Martine and CARRON, J.-P., 1981, Influence of silica content on the partition coefficient of the elements Na, K, Rb, Cs and Sr between silicate melt and hydrothermal solution in the system quartz-albite-orthoclase-H_2O at 800°C and 2 kbar: C.R. Acad. Sci. Paris, v. 292, p. 1273-1276 (in French).

Distribution coefficients for Rb and Cs between hydrothermal solutions and silicate liquids increase by a factor of two depending upon the composition of the silicate melt in going from a feldspar to a composition containing 45% silica in excess. In contrast the coefficient for Sr decreases by a factor three for the same composition. The behavior of ions of large and small ionic radius leads one to believe that the average volume of the cavities in the Si-Al-O network increases with silica content. (Authors' abstract)

LAND, L.S. and MILLIKEN, K.L., 1981, Feldspar diagenesis in the Frio Formation, Brazoria County, Texas Gulf Coast: Geology, v. 9, p. 314-318. First author at Dept. Geol. Sci., Univ. Texas at Austin, Austin, Texas 78712.

Tremendous quantities of detrital feldspar have been dissolved or albitized below about 14,000 ft (4,267 m) in the Frio Formation (Oligocene), Chocolate Bayou Field, Brazoria County, Texas. Some sandstones no longer contain any unmodified detrital feldspar grains. Material transfer involved in these reactions is immense, affecting at least 15% of the rock volume. Thus, albitization has important implications for several other diagenetic processes that involve feldspars or their components. These processes include formation of secondary porosity, precipitation of quartz and carbonate cements, and the evolution of Na-Ca-Cl formation water. (Authors' abstract)

LAND, L.S. and PREZBINDOWSKI, D.R., 1981, The origin and evolution of saline formation water, Lower Cretaceous carbonates, south-central Texas, U.S.A., in W.Back and R. Létolle (Guest-Eds.), Symp. on Geochem. and Groundwater - 26th Int'l. Geol. Congress, J. Hydrol., v. 54, p. 51-74. First author at Dept. Geol. Sci., Univ. Texas at Austin, Austin, TX 78712.

Systematic chemical variation exists in formation water collected from a dip section through Lower Cretaceous rocks of south-central Texas. Chemical variation can be explained by an interactive water-rock diagenetic model.

The cyclic Lower Cretaceous shelf carbonates of the Edwards Group dip into the Gulf of Mexico Coast "geosyncline," and can be considered, to a first approximation, as part of a complex aquifer contained by Paleozoic basement beneath, and by relatively impermeable Upper Cretaceous clay and chalk above. The hydrodynamic character of this carbonate system is strongly controlled by major fault systems. Major fault systems serve as pathways for vertical movement of basinal brines into the Lower Cretaceous section. Formation water movement in this system has strong upfault and updip components.

The "parent" Na-Ca-Cl brine originates deep in the Gulf of Mexico basin, at temperatures between 200 and 250°C, by the reaction:
halite + detrital plagioclase + quartz + water → albite + brine.
Other dissolved components originate by reaction of the fluid with the sedimentary phases, K-feldspar, calcite, dolomite, anhydrite, celestite, barite and fluorite. Significant quantitites of Pb, Zn and Fe have been mobilized a well.

As the brine moves updip out of the overpressured deep Gulf of Mexico basin, and encounters limestones of the Stuart City Reef Trend (the buried platform margin), small amounts of galena precipitate in late fractures. Continuing to rise upfault and updip, the brine becomes progressively diluted. On encountering significant quantities of dolomite in the back-reef facies, the Ca-rich brine causes dedolomitization. Although thermochemical consideration suggests that small amounts of several authigenic phases should precipitate, most have yet to be found. Minor amounts of several kinds of calcite spar are present, however. As the brine evolves by dilution and by cooling, no systematic changes in any cation/Cl ratio occur, except for regular updip gain in Mg as a result of progressive dedolomitization. The formation water, highly diluted by meteoric water, eventually discharges along faults as hot mineral water. (Authors' abstract)

LAPIN - See Appendix

AVRENT'YEVA and PERCHUK, 1981 - See Appendix

AVRUKHINA, A.K., SAZHINA, N.K., KASHKAROVA, V.G., BARYSHNIKOVA, G.V., IGNATENKO, K.I. and STAKHEYEVA, S.A., 1981, Chemical compositions of olivines from L-group chondrites: Geokhimiya, 1981, no. 7, p. 947-169 (in Russian).

LAWLER, J.P., 1981, Fluid inclusion evidence for ore-forming solutions: Phoenixville, Audubon and New Galena mine disticts, PA: Master's degree thesis, Bryn Mawr College, PA.

The Audubon, Phoenixville and New Galena Pb-Zn-Cu vein deposits of southeastern Pennsylvania have been investigated by microthermometric analysis of fluid inclusions in sphalerite, dolomite and quartz. The results obtained from primary and pseudosecondary inclusions in sphalerite indicate that the ore was deposited by a sodium rich brine of moderate salinity (11-14 equivalent wt. % NaCl) at temperatures probably near 200°C. The Na-rich character of the fluid suggests that dissolved constituents in the fluids were derived from Na-rich sedimentary rocks of the Newark basin.

Local fluid-wallrock interaction may have produced slightly higher salinity fluids (15-16 equivalent wt. % NaCl) present at New Galena. The data obtained in this study suggest that igneous activity did not necessarily cause the development of the ore fluid as mineralogical evidence indicates that temperatures throughout the basin reached 200°C. Deposition of the ore occurred where connate, metal rich brines migrating through faults and fractures encountered temperature and chemical conditions, developed through wall rock interaction with the ore solution, which favored sulfide precipitation. (Author's abstract)

LAZARENKO, O.Je, KUZNETSOVA, S.V. and BELEVTSEV, R.Ya., 1981, Temperature conditions for crystallization of basalt from the rift zone of the Arabian-Indian Ridge: Dopovidi Akad. Nauk Ukr. RSR, Ser. B: Geol. Khimi. Biol. Nauki, 1981, no. 5, p. 14-16 (in Ukrainian; English summary).

The article deals with the investigation of melt inclusions in basaltic lavas from the Arabian-Indian ridge. The rocks were formed under active tectonic conditions at temperatures ranging from 1290 to 1170°C. (Authors' abstract)

LAZ'KO, Ye.M., 1981, Thermobarogeochemical zoning: Zapiski Vses. Min. Obshch., v. 110, no. 1, p. 16-25 (in Russian). Author at L'vov Univ., L'vov, Ukrainian SSR.

The detection of mineralogical-geochemical zoning in single minerals and objects of simple composition is impossible or difficult. Change of physico-chemical parameters of solutions in time causes the common occurrence of thermobarogeochemical zoning, detectable by studies of properties of fluid inclusions. Relations between the types of zoning is illustrated by example of the ore field Klichkinskoe (E. Transbaikalia). Paleotemperature (Th) analysis of mineral-forming solutions permits the prognosis of ore mineralization of deep levels, the outlining of ore bodies, correlation of the parts of ore bodies divided by faults etc. For solution of metallogenic problems and determination of the modes of prospecting it is important to establish the regional thermobarogeochemical zoning on the basis of fluid inclusions in minerals over a large area. In the Aldan such studies caused the outlining the area of possible occurrence of rock crystal and a new rock-crystal-bearing region was distinguished. The conclusion was made that essential mineralization of the E. Transbaikalian metallogenic province formed due to mantle solutions. (Author's abstract, translated by A.K.)

LeANDERSON, P.J., 1981, Calculation of temperature and $X(CO_2)$ values for tremolite-K-feldspar-diopside-epidote assemblages: Can. Min., v. 19, p. 619-630. Author at Dept. Geol. Engrg., Colorado Sch. Mines, Golden, CO 80401, U.S.A.

The middle Proterozoic rocks in the southern part of the Grenville Province, southern Ontario, were metamorphosed and deformed during the Grenvillian orogeny. A study of calc-silicate isograds based on model equilibria demonstrates that the rocks in west central Limerick Township were metamorphosed to a range of grade corresponding to the first appearance of tremolite and diopside in the calcareous units. Five samples have assemblages corresponding to the mutual intersection of the following equilibria: 1) 5 phlogopite + 6 calcite + 24 quartz = 3 tremolite + 5 K-feldspar + 2 H_2O + 6 CO_2, 2) tremolite + 3 calcite + 2 quartz = 5 diopside + H_2O + 3 CO_2, 3) 2 zoisite + CO_2 = calcite + 3 anorthite + H_2O. Calculated intersection temperatures at 4000 bars range from 15°C higher to 142°C lower than those obtained for the same samples using the two-feldspar geothermometer of Whitney & Stormer (1977). Temperatures for assemblages corresponding to the intersection of equilibria 2) and 3) are reasonable, but those based on intersections involving the calcite-anorthite equilibrium are low by 45 to 142°C. This may be due either to erroneously high estimates of the activity of $CaAlAl_2Si_3O_{12}(OH)$ in epidote or to uncertainty in the position of equilibrium 3) in isobaric T-X(CO_2) space. Assemblages in these samples and in those of Carmichael (1970) indicate that reaction 1) lies near the intersection of reactions 2) and 3). Based on this observation and the experimentally determined position of equilibria 2) by Hoschek (1973) and 3) by Skippen (1974), it is suggested that at temperatures greater than 400°C and pressures greater than 2 kbar, epidote is stable in metamorphic rocks if the X(CO_2) of the fluid phase is less than 0.10 to 0.20, in contrast to a value of 0.03, determined experimentally by Johannes & Orville (1972). (Author's abstract)

Le BAS, M.J., 1981, Carbonatite magmas: Mineralog. Mag., v. 44, p. 133-140. Author at Dept. Geol., Univ. Leicester, LE1 7RH.

Normal carbonatite magmas are characteristically associated with ijolites and produce extensive fenitization by alkali metasomatism, commonly feldspathization or phlogopitization. The sequence of carbonatites developed from this magma are characterized by igneous isotopic ratios, high contents of incompatible elements, their distinctive pattern of differentiation from sövite to beforsite, and a late-stage rare-earth element, baryte, fluorite mineralization. Carbonatite rock is composed mainly of calcite, but fluid inclusion and related data indicate that the original magma was highly alkaline and chemically similar to that known at Oldoinyo Lengai Volcano in Tanzania. It is suggested that this carbonatite magma is secondary magma produced from carbonated nephelinite magma by liquid immiscibility. Carbonatite magma can also occur associated with kimberlites but these carbonatites are alkali-poor and do not produce the characteristic fenitization. (Author's abstract)

LE BAS, M.J. and ASPDEN, J.A., 1981, The comparability of carbonatitic fluid inclusions in ijolites with natrocarbonatite lava: Bull. Volcanol., v. 44, no. 3, p. 429-438. First author at Dept. Geol., Univ. Leicester, LE1 7RH, UK.

The composition of carbonate, sulphate, halide and other phases trapped as fluid inclusions in apatite crystals in ijolite and urtite from sub-volcanic complexes in East Africa have been determined using the electron micro-probe. The bulk composition of these inclusions is alkali-rich and closely comparable to the natrocarbonatite lava from the active volcano of Oldoinyo Lengai in N. Tanzania. The inclusions are interpreted as having been originally immiscible alkali carbonate-rich droplets within a nephelinitic melt. The evidence suggests that magma of the composition of natrocarbonatite lava is that most likely for the parent magma during carbonatite petrogenesis. (Authors' abstract)

LEVITSKIY, V.V. and DEMIN, B.G., 1981, Gas composition of inclusions - indicator of degree of erosion of hydrothermal deposits: Sovetskaya Geologiya, no. 3, p. 104-112 (in Russian). Authors at East-Siberian Sci.-Res. Inst. of Geol., Geophy. and Mineral Raw Materials, USSR.

The samples were taken from various gold-ore deposits and in various fragments of ore-magmatic systems of various depths. Samples were ground under vacuum and gas volume was measured by mercury MacLeod pump; analyses were made by gas chromatography. Quartz, sulfides and rocks were analyzed. It was found that one of the most important parameters indicating depth and redox conditions is the ratio CO_2/hydrocarbons+H_2, whose values increase regularly from pegmatite to moderately deep hydrothermal (Zn, Pb, Mo, Au) and next to shallow (Sb, Hg, Ag-Au) deposits. However, this ratio may not always be used because hydrocarbons frequently are absent in inclusions in minerals from shallow deposits. Different ratios, such as O_2/N_2 and CO_2/N_2, or H/C/N/O, may be used for different levels. Several more deposits are characterized by this method, as well as ore minerals and magmatic rocks from Tadzhikistan, Mama region in the USSR, E. Africa, Karelia, Sayans, NE of the USSR and from seven kimberlite pipes of Yakutia. (Abstract by A.K.)

LEVY et al., 1981 - See Appendix

LI, Binglun, 1981, Some problems in the study of gas-liquid inclusion in minerals: Scientia Geologica Sinica, no. 2, 1981, p. 159-163 (in Chinese with English abstract). Author at Institute of Geol., Academia Sinica, Bijing, China.

On the basis of the characteristics of inclusions in synthetic minerals, the physical and chemical changes after trapping and the morphological and characteristic variations of inclusions in metamorphic process, this article discusses the application of the essential assumptions and the genetic criteria in studying gas-liquid inclusions in minerals. The results obtained indicate that some problems should be considered in the study, such as volume changes after trapping, the possibility that some "daughter minerals" actually formed before trapping, and that under metamorphism, the inclusions were changed in size, shape, and composition. Hence care is needed in fluid inclusion research. (Author's abstract, modified by the author)

LI, Yingyun and XING, Fengming, 1981, On hydration of quartz in metamorphic rocks: Scientia Geologica Sinica 1981, no. 1, p. 78-81 (in Chinese; English abstract). Authors at Inst. Geol. Sci., Geol. Bureau of Anhui, Hefei.

This paper discusses the hydration of quartz in metamorphic rocks and its genesis.

As a result of hydration, hydrous quartz consists usually of two parts: the inner part that is nothing but a residual anhydrous core and the outer part that is called the hydration rim. Because of the lower refraction index of the latter, a clear Becke line appears between the two parts. It seems that the hydration rim is similar to "quartz girdle." It frequently develops along the boundaries of fissures and intergranular spaces. With the development of hydration of quartz, the residual anhydrous core became small or even died away. Multi-layered hydration rim may be a reflection of polymetamorphism.

Simple experiments show that hydrous quartzes can be dehydrated at a certain temperature and normal pressure, and that the kind of water contained in hydrous quartzes is probably not crystalline water but absorption water.

The hydration of quartzes has been determined in the hydrous metamorphic rocks of greenschist facies and amphibolite facies, but so far it has not been found in the granulite facies rocks.

Confirmation of hydration of quartz will be of help to the study of metamorphism. In a certain sense, the hydration rim may be considered as a "facies indicator." (Authors' abstract)

Note: From this abstract, I suggest that these "hydration zones" may be optical artifacts. See Stringham and Roedder, Am. Mineralogist, v. 39, p. 384-386, 1954. (E.R.)

LI, Yinqing, RUI, Zongyao and CHENG, Laixian, 1981, Fluid inclusions and mineralization of the Yulong porphyry copper (molybdenum) deposit: Acta Geol. Sinica, 1981, no. 8, p 216-233 (in Chinese; English abstract).

By means of micro-heating stage, freezing stage, trace chemical analysis and polarizing microscope, the authors have studied the type, frequency, size, temperature, pressure, salinity, daughter minerals, ratio of gas to liquid, revivable boiling(sic) and composition of fluid inclusions in the Yulong porphyry copper (molybdenum) deposit. From the data acquired, a series of very interesting problems such as the character of thermal fluid, physico-chemical condition, alteration, mineralization and its possible mechanism have been suggested.

Various minerals of the Yulong porphyry copper (molybdenum) deposit, are rich in fluid inclusions. Inclusions of different types (gaseous, liquid and polyphase) are usually associated in the same sample or even the same mineral. In the monzonitic granite porphyry showing, biotite-potash feldspar alteration the inclusions are dominantly gaseous and polyphase; while in the porphyry with quartz-potash feldspar and quartz-sericitization alteration mainly polyphase and a few gaseous and liquid ones. In the altered argillic monzonite porphyry and the altered propylitic country rock liquid inclusions predominate while gaseous and polyphase ones are minor. Gaseous ones appear, however, to be more dominant in the country rock overlying the intrusive body. Th of the inclusions ranges from 600°C to 180°C; the deposition temperatures of Cu-Mo sulphides range from 420° to 250°C. From the center of the porphyry body to the wall-rocks the temperature of mineralization decreases gradually. The salinity of the fluid inclusions ranges from 6 to 56 wt.%, but the highly-saline polyphase inclusions are concentrated only in the region of economic mineralization. The Cu-Mo sulphides were deposited under the highly saline fluid condition. The pressures at the moment of homogenization is calculated to range from 100 to 1800 atm. The revivable boiling of the fluids is manifested at the top of the porphyry body by an intimate coexistence of gaseous and polyphase inclusions.

The fluid in the inclusions belongs to the NaCl-KCl ($CaCl_2$, $MgCl_2$)-$CaSO_4$-H_2O type. As indicated by our analyses the thermal fluids of mineralization were rich in halogens and alkali metals, but poor in base metals, sulphur, phosphorus, etc., with very high temperature (600°C) during the initial stage. Such thermal fluids could easily have extracted the metals out from the country rocks around the tunnel through which they rose. When they rose up and gathered into the top of the porphyry intrusive and its neighboring wall-rocks, both alkali and hydrogen metasomatism would take place inevitably with the ensued decrease in temperature, thus giving rise to the deposition of metal sulphides. (Authors' abstract)

LI, Zhaolin, SUN, Fengyu and LI, Mao, 1981, Study on microinclusions in minerals and microtextures of the meteorites: Scientia Sinica, v. 24, no. 7, p. 995-981 (in English). First author at Dept. Geol., Nanjing Univ., P.R.C.

Different samples of meteorites (unheated and artificially heated) have been observed and studied by means of TEM (transmission electron microscope). As a result, primary and secondary microinclusions of less than 1 μmhave been found in the meteorites. At the same time, in the meteorites of Jilin, Dongtai and Lishui and in their fused crusts, microtextures reflecting the agglomeration, melting, rotation (of the nebular disk; sic) and condensation of meteorites and collision among heavenly bodies during falling have been observed. Observation of the meteorite samples heated under different temperatures has been made so as to ascertain the melted texture and temperature of the falling meteorites. It shows that at different temperatures the melt textures are obviously different. The Jilin meteorites are melted obviously at 900-1050°C. (Authors' abstract)

LIKHOYDOV et al. - See Appendix

LIN, Ruifen, WEI, Keqin and WANG, Zhixiang, 1981, Determination of deuterium in natural water and deuterium contents in some natural water samples and liquid inclusions from some mineral deposits in China: Geochimica, no. 4, p. 392-397.

A method for preparing hydrogen gas for the determination of stable isotope composition of hydrogen in natural water using metallic uranium as a reducing agent is described. The isotope fractionation during the experimental process is discussed in detail. The data on δD from some mineral deposits in China are presented as well. (Authors' abstract)

LINDBLOM, Sten, 1981, The environment of formation at the Laisvall lead-zinc ore from fluid inclusion studies (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated).

Laisvall is a lead-zinc deposit where the mineralization occupies the interstices in an Eocambrian sandstone sequence. 1.5 m. tons of the famous spotty disseminated galena ore is mined annually. On close inspection spots of similarly occurring sphalerite were found to consist of zoned crystals. Evidence of open space growth was strengthened by discoveries of still open pores with the appearance of microvugs containing crystals of sphalerite, calcite, quartz and galena.

Fluid inclusion temperatures (from sphalerite and calcite) indicate a pulsating ore solution with a temperature around 155-165°C and a total equivalent NaCl content around 24%.

A later non-mineralizing fluid phase is indicated by fluid inclusions in calcite giving a temperature of formation around 180°C with composition varying between 14 and 19% equivalent NaCl. (Author's abstract)

LITVINOVSKIY and IZUPOVA, 1981 - See Appendix

LITVINOVSKIY, B.A. and KAPERSKAYA, Yu.N., 1981, Geochemical evidences of activity of mantle substance in granitoid magma formation: Akad. Nauk SSSR Doklady, v. 259, no. 5, p. 1198-1201 (in Russian). Authors at Geol. Inst. of Buryatian Division of Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

The paper bears some Th of melt inclusions in granitoid, charnockite and basaltoid minerals, all from literature. (A.K.)

LLOYD, J.M., 1981, Vapor deposits on olivine in vugs in a basalt: an SEM application: Am. Min., v. 66, p. 980-984. Author at Dept. Geophy. Sci., The Univ. Chicago, Chicago, IL 60637.

Vugs in basalt from Hat Creek Valley, California, are lined with subhedral to euhedral crystals of plagioclase, pyroxene, olivine and magnetite. The olivines reveal two surface features: rows of platelets (hematite?) and thin films coating the entire olivine crystal surfaces. The presumed hematite platelets are perpendicular to the direction of the rows and are parallel to the (100) plane to the underlying olivine. The rows lie in the (001) plane. It is probable that both the platelets and the thin films are the result of vapor condensation. There may be a structural control between the olivine crystals and the hematite platelets that cause their arrangement parallel to the (100) plane of the olivines and the arrangement of the rows in the (001) plane. Structural control could also explain the absence of these features (except occasionally on plagioclase) on other vug minerals. (Author's abstract)

LOFGREN, G.E. and NORRIS, P.N., 1981, Experimental duplication of plagioclase sieve and overgrowth textures (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 498.

LOUBET, Michel, 1981, Residual nature of peridotitic nodules: geochemical evidence: Bull. Minéral., v. 104, p. 642-654 (in French; English abstract). Author at Inst. de Phys. du Globe, Lab. de Géochim. et Cosmo., Univ. Paris VI, 4, place Jussieu, 75230 Paris Cedex 05, France.

Considering elements presenting intermediate to high partition coefficients, i.e. less susceptible to have been introduced through contamination by the surrounding magma, it is shown that the composition of a set of peridotitic nodules from alkali-basalts and kimberlite pipes plot in continuity to the one of orogenic lherzolites, defining a same evolution kind.

Through the analysis of the evolution of a set of trace element contents it is shown that this trend should be residual. All these peridotites are interpreted as residual from a lherzolitic upper mantle originally rather homogeneous. The enrichment of most of these nodules in incompatible elements should result from a contamination by a magma rich in these elements (alkali basalt to kimberlitic) during a further process. (Author's abstract)

LU, H.-Z., 1981, Geologic, fluid inclusion studies of the different types of tungsten ore deposits in south China (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 550. Author at Dept. Geol., Univ. Pennsylvania, Philadelphia, PA 19104.

There are 10 types of tungsten ore deposit in south China, including granite, porphyry, volcanic rock, pegmatite, skarns, greisen, wolframite-microcline-quartz vein and wolframite-quartz vein, strata-bound, ferberite-quartz vein and placer. Most of them are related to the Yanshan age granites (isotopic age: 160-180 and 70-100 m.y.) in space and in origin. The trace elements W, Sn, Mo, Be, Nb, Ta, and Li have been concentrated in these granites. Five principal alterations were studied.

Four types fluid inclusion were found in these ore deposits: liquid-rich, gas-rich, bearing liquid CO_2, and fluid inclusion with daughter minerals. Most common are the liquid-rich fluid inclusions; the daughter mineral type is only found in porphyry and skarns, others are found in wolframite-quartz veins, mostly in the upper part.

Salinity of fluid inclusions in wolframite-quartz veins is 5-10 % equiv. NaCl. Pressure of formation in this type is 450-750 bar. The forming temperatures of different types of tungsten ore deposits are: porphyry: 386°C; greisen: 244°-301°C; granite: 220°C skarns: 415°C and 232°C; strata-bound: 219°C; and ferberite-quartz vein: 142°C.

It is concluded that these tungsten ore deposits formed from a dilute solution at moderate to high temperatures and at moderate pressure. (Author's abstract)

LU, H.-Z., WANG, Z.-F., XU, S.-J. and GUO, Y.-Q., 1981, The geological features and fluid inclusion studies of Gejiu tin skarn ore deposit, Yunnan province, China: Symp. of the National Meeting of Experimental and Fluid Inclusion Studies of China, Scientific Publishing House, p. 15-25, (in Chinese).

Gejiu tin skarn deposit is one of the largest tin skarn ore deposits in China. It is located between a 66-115 m.y. biotite granite, and Triassic limestone, dolomite, marl and marble. The mineralization associated with the granite includes Sn, W, Cu, Be, Bi, Pb and Zn ores. Several types of tin ore were found such as greisen, skarns, bedded sulfide, tourmaline-cassiterite veinlets and cassiterite-bearing dolomite. From the granite to the outside, there is a typical mineralization zonation, i.e., W, Be -- Cu, Bi, W -- Cu, Sn -- Sn, Cu -- Sn, Pb to Pb, Zn. Detailed fluid inclusion studies indicated that there are three types of inclusions: liquid-rich (type I), gas-rich (type II), and daughter-mineral-bearing fluid inclusions (type III). The type I is by far the most common in all ores and granite. Th of cassiterite-sulfide skarns range from 325 to 351°C with salinity of 6-30 wt. % NaCl equiv.; that for greisen type ranges from 347 to 360°C; that for vein types ranges from 300 to 358°C. It is concluded that the hydrothermal fluids came from the granite and interacted with carbonate rocks and deposited the tin and other types of ore deposit. (Abstract courtesy Dr. Huan-Zhang Lu)

LUCIDO, Giuseppe, 1981, Silicate liquid immiscibility in alkaline rocks of western Sicily: Chem. Geol., v. 31, p. 335-346. Author at Istituto di Mineralogia, Petrografia e Geochimica, Univ. di Palermo, 90123 Palermo, Italy.

Felsic ocelli discovered in western Sicily have a highly contrasting composition compared with the basaltic host-rock. These ocelli are clearly richer in Si, Al, Na and K and are poorer in Ca, Fe, Mg, Mn, Ti and P than the basaltic rocks. They have irregular shapes, but fundamentally they are subspheroidal or ellipsoidal in appearance and range from some decimeters to a few centimeters in size. The Sicilian ocelli show structures different from the more commonly described ocelli the world over. Chemical evidence and textural features strongly suggest that they are formed by liquid immiscibility. (Author's abstract)

LUCKSCHEITER, B. and MORTEANI, G., 1981, The H contents of quartz from Alpine veins from the Penninic rocks of the central and western Tauern Window (Austria/Italy): TMPM Tschermaks Min. Petr. Mitt., v. 28, p. 223-228.

The hydrogen content of 29 quartz crystals originating from the Penninic series of the central and western Tauern Window (Tyrol, Austria) was determined by IR spectroscopy. The hydrogen contents are between 7 and 66 H/10^6 Si-atoms. In one sample showing a mimetic lamellar structure H-contents up to 140 H/10^6 Si-atoms could be found. In most cases no difference exists between the hydrogen contents of margins and cores of the crystals. No clear relationships between the hydrogen content of the quartz lattice and the metamorphic temperatures ranging from about 600°C to about 450°C can be found. (Authors' abstract)

LUDVIGSON, G.A. and GARVIN, P.L., 1981, Evidences for a vertical plumbing system in the Upper Mississippi Valley zinc-lead district (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 286-287. First author at Iowa Geol. Survey, Iowa City, IA 52242. (Continued)

On the northern, updip fringe of the Upper Mississippi Valley District, epigenetic zinc, lead, copper, and iron sulfide mineralization is exposed in Lower Ordovician and Upper Cambrian host rocks. The structural controls of these deposits vary significantly from those known in the Middle Ordovician host rocks in the main district. These structural controls include north-south-trending vertical veins, northwest trending gash veins, east-west-tending disseminated breccias, and sub-St. Peter Sandstone karst depressions. These structures may be related to previously documented Early Ordovician tectonism in the Upper Mississippi Valley.

The paragenetic sequence of the epigenetic sulfide mineralization in the lower deposits closely parallels that in the main district deposits. Wall-rock alteration in the Cambro-Ordovician host rocks differs from that in the main district; specifically, silicification is much more abundant in Cambro-Ordovician hosts. The similar sequences of mineralization in the Cambro-Ordovician and main district rocks suggests a systematic vertical plumbing system within the entire district. Structural and petrologic evidence suggests that mineralization in the main district occurs at intersections of Early Ordovician structures and post-Ordovician structures. (Authors' abstract)

LUPTON, J.E. and CRAIG, Harmon, 1981, A major helium-3 source at 15°S on the East Pacific Rise: Science, v. 214, no. 4516, p. 13-18. First author at Marine Sci. Instit., Univ. California at Santa Barbara, CA 93106.

An extensive plume of water enriched with helium-3 has been discovered in the deep Pacific Ocean at latitude 15°S on the East Pacific Rise. In the core of the plume, at a depth of 2500 meters over the ridge crest, the helium-3/helium-4 ratio is 50 percent higher than the ratio in atmospheric helium, indicating a strong injection of mantle or primordial helium at the spreading center axis through local hydrothermal systems. The helium-3 plume is completely absent east of the rise, but it can be traced over 2000 kilometers to the west above a newly observed physical feature: a density discontinuity here called the "ridge-crest front." The injected plume provides a unique deep-sea tracer with an asymmetric distribution which shows that the deep circulation across the rise is from east to west. The striking intensity and lateral extent of this helium-3 anomaly, compared to observations at known oceanic hydrothermal sites, suggest that the largest hydrothermal fields in the ocean are yet to be discovered and that they will be found near 15°S on the East Pacific Rise. (Authors' abstract)

L'VOV, S.N., ZAREMBO, V.I. and GILYAROV, V.N., 1981, Precise studies of volumetric peculiarities of water solutions of sodium chloride at elevated parameters: Geokhimiya, no. 4, p. 505-516 (in Russian, English abst.). Authors at Leningrad Technological Inst., Leningrad, USSR.

The specific volumes of water solutions of sodium chloride were measured for concentrations 0.1-1.0 mole at T 293-573K and P 10-80 MPa. A new equation of state for water solutions was proposed. (A.K.)

LYKOV, 1981 - See Appendix

MACDONALD, A.J. and SPOONER, E.T.C., 1981a, Hydrothermal fluid flow and molybdenite transport in the Boss Mountain breccia pipe and sheeted vein deposit, B.C. (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-36.

The fracture system which contains molybdenum mineralization at Boss Mountain, B.C., consists of subvertical, irregular breccia pipes, the largest of which is 150m by 50m in cross section and 360m deep, and an incomplete annulus of shallow dipping, sheeted veins related symmetrically to the apex of a quartz monzonite stock. Average vein width is 10 cm, while spacing varies between 50 cm and 5 m. A small amount of additional mineralization is hosted within late, steeply dipping, quartz veins. The transport medium for the ore, as shown by fluid inclusions studies, consisted of a low to moderately saline aqueous fluid and a carbon dioxide dominated gaseous phase. The coexistence of both water- and carbon dioxide-rich fluid inclusions in quartz associated with molybdenite indicates that ore deposition in both the breccia pipes and veins was accompanied by carbon dioxide effervescence. Therefore, measured filling temperatures (370 to 250°C) are equal to formation temperatures since the fluid was trapped on the solvus in the CO_2-H_2O-NaCl system. The depression of carbon dioxide clathrate melting points indicates that the aqueous fluid contained 4-8 equivalent weight percent NaCl. Thermodynmaic properties of molybdenum reveal that (i) molybdenite is very soluble at 350°C (several thousand ppm) in an ore forming solution, and (ii) the solubility decreases by $\sim 10^6$ as the temperature drops to 300°C. This calculated temperature range for the solubility decrease (300°-350°C) corresponds closely to the depositional temperature range (250°-370°C) inferred for the Boss Mountain deposit. (Authors' abstract)

MACDONALD, A.J. and SPOONER, E.T.C., 1981b, Calibration of a Linkam Th 600 programmable heating-cooling stage for microthermometric examination of fluid inclusions: Econ. Geol., v. 76, p. 1248-1258. Authors at Dept. Geol., Univ. Toronto, Toronto, Ontario M5S 1A1, Canada.

A discussion of the results obtained using a series of calibration standards covering the range -95°C to +593°C, along with recommendations of 19 selected as most suitable for the calibration procedures used here. Also includes a discussion of the thermal gradients in the Linkam stage. (E.R.)

MacGEEHAN, P.J., 1981, Mineralogy, geochemistry and lateral zonation within a 1.5 km long gold-bearing fissure vein system in the Campbell Red Lake and Dickenson mines, Red Lake district, Ontario, Canada (abst.): Geol. Soc. Australia, Abstracts, no. 3, p. 69. Author at Dept. Geol. Sci., Queens Univ., Kingsto, Ontario, Canada.

The F-A (Campbell) - South C (Dickenson) vein system is composed of a sequence of metamorphogenic gold-bearing quartz-carbonate fissure veins, localized within a linear-deformed zone over 1.5 km in length and only 3 m in width, which transects a thick packet of Archaean mafic volcanic rocks bordering a sedimentary (dominantly exhalative) repository. Over most of its length, the vein system is comprised of from one up to eight sequentially emplaced cross-cutting en echelon unit veins, each composed of bilaterally symmetric outer rims of inward-growing comb-textured fibrous banded carbonate, and a central core of massive carbonate and/or fine-grained polygonal quartz after chert. At the east end, bordering the metasediments, the vein system frays-out into a "horse-tail" of myriad hair-line fracture-bound fissure veins.

A strong lateral change in mineralogy and geochemistry is present in the vein system, from rich gold-bearing banded dolomite-ferrodolomite-quartz (recrystallized chert) veins, flanked by magnetite-rich alteration selvages in the east, through lower-grade quartz-poor dolomite-ferrodolomite with successive zones of Hg (cinnabar) and W (scheelite) enrichment, to lower grade to uneconomic quartz-barren massive banded ferrodolomite-siderite veins flanked by chlorite-rich alteration selvages in the west.

Genesis of the vein system is consistent with derivation of gold-bearing hydrothermal fluid during dewatering of the adjacent sedimentary pile, and with formation of the present vein-filling mineral assemblages by the recrystallization of an earlier fissure-filling mud or gel. (Author's abstract)

MACHIELS, A.J., YAGNIK, S.K., OLANDE, D.R. and KOHLI, R., 1981, The mechanism of intergranular migration of brine inclusions in salt (abst.): Transactions of the Am. Nuclear Soc., v. 38, p. 169-170.

MCLIMANS, R.K., 1981, Applications of fluid inclusion studies to reservoir diagenesis and petroleum migration: Smackover Formation, U.S. Gulf Coast, and Fateh Field, Dubai (abst.): Association Round Table, p. 957. Author at Conoco, Inc., Ponca City, OK.

The Smackover trend of the United States Gulf Coast is a prolific producer of oil and gas. The distribution of porosity is partly controlled by precipitation of late, void-filling calcite. The timing of the formation of these cements is interpreted from fluid inclusion geothermometry. In general, the fluid inclusion filling temperatures closely approximate those of the formation of the calcite and indicate that cementation occurred near the maximum depth of burial. The trapped fluid is a dense calcium-rich brine, consistent with modern formation fluids. The geochemistry of the fluid inclusions reflects the environment of diagenesis; for example, H_2S-rich inclusions occur in cements from deep, dolomitic, reservoirs.

The Fateh field, offshore Dubai, has estimated petroleum reserves of 2.3 billion bbl of oil. Production is principally from the Mishrif Formation, an Upper Cretaceous rudist reef complex. Late, coarse-grained, calcite cements partly occlude porosity. These cements contain both aqueous and oil-bearing fluid inclusions. Fluid inclusion geothermometry indicates temperatures consistent with the geothermal gradient indicating a Miocene age for cement deposition. Since oil was trapped during growth of the calcite cement, petroleum generation and migration are also Miocene in age. Preliminary analyses of the oil trapped in inclusions show it to be different than the oil in the reservoir. The oil trapped in the inclusions may be an early generated, less mature, oil. (Author's abstract)

McMURTRY, G.M., YEH, E.-W. and MALAHOFF, A., 1981, Chemical and isotopic composition of hydrothermal deposits from Loihi Seamount, southwest Hawaiian arch (abst.): EOS, v. 62, p. 1084.

McNAUGHTON, N.J., BORTHWICK, J., FALLICK, A.E. and PILLINGER, C.T., 1981, Deuterium/hydrogen ratios in unequilibrated ordinary chondrites: Nature, v. 294, no. 5842, p. 639-641.

MAGARA, Kinji, 1981, Possible primary migration of oil globules: J. Petr. Geol., v. 3, no. 3, p. 325-331. Author at Bureau Econ. Geol., The Univ. Texas at Austin, Austin, TX 78712, USA.

Difficulty of migrating a large amount of oil in either molecular or micellar solution may lead to an assumption that a continuous oil phase or a relatively high (20-30%) concentration of oil in pores of shales is necessary for primary migration to overcome the capillary restrictions against the oil. Movement of small oil globules in shales is believed by many workers to be an extremely difficult process. However, the above assumption is not necessarily valid in shales which contain a large quantity of structured and semi-solid water. Such oil globules may deform by the effect of compacting grains (solid material) and the semi-solid water, thus reducing the capillary restrictions significantly. This suggests that the small oil globules which are separated from each other can move in the direction of lower stress in the shales: a continuous oil phase or relatively high oil concentration is not a necessary requirement for primary oil migration. (Author's abstract)

MAKHNACH, et al. - See Appendix

MAKO, D.A. and SHANKS, W.C., III, 1981, The geology and genesis of the stratiform zinc-lead-barite mineralization of the Vulcan property Selwyn Basin, Northwest Territories (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 502. First author at Getty Oil Co., P.O. Box 15668, Salt Lake City, UT 84115.

The Vulcan deposit occurs as sedimentary exhalative shale-hosted sulfides (pyrite, sphalerite, galena) and massive barite-fluorite-galena mineralization in Upper Silurian-Lower Devonian shales of the Road River Formation along the eastern flank of the Selwyn Basin, Northwest Territories. Active growth faulting during deposition of the Road River Formation resulted from tensional tectonism along the Selwyn Basin-Mackenzie Platform transition. These growth faults permitted metal-rich basinal brine to vent on the seafloor.

Cooling of the brine during venting into oxidizing bottom waters caused initial rapid precipitation of fine-grained barite, resulting in a baritic build-up above vent areas. Continued percolation of the brine through the baritic mound caused recrystallization of the barite and allowed deposition of interstitial fluorite and galena. Afer venting, the dense ore fluid collected in topographic depressions, or brine pools, in which stratiform sulfide minerals accumulated under anoxic conditions. Location of hydrothermal vents, paleotopography, and intensity of hydrothermal activity were the main controls on the thickness, distribution, and grade of Vulcan mineralization.

Sulfur isotope studies indicate that both sulfate and sulfide were derived from the venting metalliferous brine. Sulfur-isotopic data also suggest that reduction of sulfate in the brine occurred as a result of organic decomposition, possibly during thermal maturation of hydrocarbons at temperatures greater than 80°C. Fluid inclusion observations suggest that the salinity of the fluid was greater than 4 M NaCl. (Authors' abstract)

MALAHOFF, A., 1981, Contemporary volcanic and hydrothermal activity on Loihi Seamount (abst.): EOS, v. 62, p. 1082.

MALYSHEV, A.G., 1981, On the role of granite magmatism and metamorphism during the formation of quartz veins and pegmatites in the Baikal-Patom elevation: Akad. Nauk SSSR Doklady, v. 259, p. 179-182 (in Russian).

MAMADZHANOV, F.I., BEGZHANOV, R.B. and AKKERMANTSEV, S.M., 1981, A study of Na, K, Ga and Br contents in quartz crystals by a neutron activation method: Akad. Nauk SSSR Izv. Seriya Geologicheskaya, no. 12, p. 99-106 (in Russian).

MARAKUSHEV, A.A., 1981, Contribution to problem of fluid regime of formation of diamond-bearing rocks: Geol. Rudn. Mest., v. 23, no. 4, p. 3-17 (in Russian). Author at Moscow State Univ., Moscow, USSR.

Pertinent to composition of fluid inclusions. (A.K.)

MARAKUSHEV, A.A., IVANOV, I.P. and RIMKEVICH, V.S., 1981, Experimental reconstruction of rhythmic magmatic stratification: Akad. Nauk SSSR Doklady, v. 258, no. 1, p. 183-186 (in Russian). Authors at Inst. Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka near Moscow, USSR.

The experiments were made in the "systems" trachyte - K_2SiF_6 and liparite - K_2SiF_6 at temperatures 1300°C and 950°C, and produced immiscible melts. Pertinent to immiscibility in melt inclusions. (A.K.)

MARSHALL, Brian and TAYLOR, B.E., 1981, Origin of hydrothermal fluids responsible for gold deposition, Alleghany district, Sierra County, California, in Proceedings of the Symp. on Mineral Deposits of the Pacific Northwest, Silberman, M.L., Field, C.W. and Berry, A.L., eds., U.S. Geol. Survey Open-File Rept. 81-355, p. 281-294. First author at Dept. Earth and Space Sci., Univ. California, Los Angeles, CA 90024.

Fluid inclusions in quartz, some containing liquid CO_2(?), were released by vacuum crushing and analyzed for δD. These values ranged from -47 to -78‰. The first, coarse crushing yielded isotopically lighter water than the second, more complete crushing (which also yielded more CO_2). The differences are assumed to stem from easier crushing of planes of secondary inclusions, or some isotopic fractionation. (E.R.)

MARSHALL, W.L. and FRANCK, E.U., 1981, Ion product of water substance, 0-1000°C, 1-10,000 bars. New international formulation and its background: J. Phys. Chem. Ref. Data, v. 10, no. 2, p. 295-304. First author at Chem. Div., Oak Ridge Natl. Lab., Oak Ridge, TN 37830.

This paper is the background for a new international formulation for the ion product of water substance (May 1980) issued by the International Association for the Properties of Steam. The ion product of water (K_w) is represented by an equation, based on density and two quadratic functions of reciprocal absolute temperature, for use from 0 to 1000°C and 1 to 10,000 bars pressure. The equation is believed to describe within ±0.01 units of log K_w^* (where K_w^* equals $K_w/(\text{mol kg}^{-1})^2$) many of the measurements at saturated vapor pressure up to 200°C, and to within ±0.02 units up to the critical temperature (374°C). It also describes within the experimental uncertainty the several sets of measurements of high pressures and should provide values within ±0.05 and 0.30 units at low and high temperatures, respectively. (Authors' abstract)

MARSHALL, W.L., HALL, C.E. and MESMER, R.E., 1981, The system dipotassium hydrogen phosphate-water at high temperatures (100-400°C); liquid-liquid immiscibility and concentrated solutions: J. Inorg. Nucl. Chem., v. 43, p. 449-455. Authors at Chem. Div., Oak Ridge Nat'l. Lab., Oak Ridge, TN 37830, USA.

Phase equilibrium behavior in the condensed system K_2HPO_4-H_2O was determined at temperatures from 100 to 400°C. Solutions saturated with a solid, which is believed to be (nearly) anhydrous K_2HPO_4, increase in K_2HPO_4 content from 72 wt% at 100°C to 78 wt% at 400°C. A region of liquid-liquid immiscibility at compositions between 3 and 58 wt% was discovered, with a minimum temperature of 360°C. Separate experiments with saturating solids K_3PO_4, K_2HPO_4, and KH_2PO_4 at 350°C indicated that each of these solids are in stable equilibrium with the solution phase, thus with no conversion to polyphosphate species. (Authors' abstract)

MATHEZ, E.A. and DELANEY, J.R., 1981, The nature and distribution of carbon in submarine basalts and peridotite nodules: Earth and Planet. Sci. Letters, v. 56, p. 217-232. First author at Dept. Geol. Sci., Univ. Washington, Seattle, WA 98195, USA.

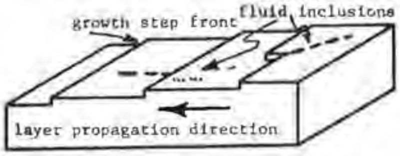
Primary carbonaceous material has been identified in submarine basaltic glasses and mantle-derived peridotite nodules from alkali basalts using electron microprobe techniques. In the submarine rocks carbon occurs (1) in quench-produced microcracks in glasses and phenocrysts, (2) in vesicles, where it is preferentially concentrated on the sulfide spherules attached to vesicle walls, and (3) in microcracks and CO_2-rich bubbles in inclusions of glass completely enclosed by phenocrysts. In peridotite nodules carbon exists in intergrain cracks, along grain boundaries, and on the walls of fluid inclusions disposed in two dimensional arrays. The carbonaceous material is believed to consist of a mixture of graphite, other forms of elemental carbon, and possibly small amounts of organic matter.

It is suggested that carbon precipitates by disproportionation of CO according to the reaction $2\ CO \rightarrow C + CO_2$ and that this reaction is catalyzed by sulfide-oxide surfaces in vesicles. Once deposition has begun, the reaction continues on carbon surfaces as well. Based on the large amounts of condensed carbon observed in some vapor inclusions and the apparent lack of oxidation features associated with them, it is proposed that carbon condensed from a magmatic vapor in which CO was a significant constituent. This implies that oxygen fugacities of undegassed basaltic melts under confining pressures of the shallow crust are typically lower than those of the QFM buffer at equivalent temperatures. This is in agreement with some intrinsic oxygen fugacity measurements on similar undegassed materials.

Regardless of the mechanism of its formation, the presence of carbon in CO_2-rich vesicles and inclusions in basaltic glasses and mantle nodules adds uncertainty to estimates of minimum pressures of entrapment based on measurements of fluid densities. Condensed carbon also accounts for some of the carbon isotopic characteristics of these rocks. (Authors' abstract)

MAZE, W.B., BERGMAN, S.C. and SISSON, V.B., 1981, Direct observations of the formation of primary fluid inclusions (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 506. Authors at Dept. Geol. Sci., Princeton Univ., Princeton, NJ 08544.

The processes involved in the growth of KH_2PO_4 (KDP) and K_2SO_4 (KS) crystals from cooling supersaturated aqueous solutions can be observed with an optical microscope. Growth occurs by propagation of approximately linear growth steps forming layers across crystal faces at rates of 1-50 µm/sec. When the pile up of molecular layers exceeds a critical thickness (<1-5 µm) these growth steps can be observed due to light interference at the step front. The growth step front can be linear, curved or jagged and the direction of propagation is generally constant but can be highly variable, depending on the growth rate. Disruption of the growth steps by surface impurities or imperfections can cause primary cracks or gaps in the crystal structure. Entrapment of the aqueous growth solution (sometimes two phase:L+V) occurs either within the initial growth step or as successive layers cover previously formed gaps. These gaps are typically created at right angle kinks in the growth step layers; a single irregularity can initiate a complex surface or train of inclusions. These superimposed trains of inclusions can produce a group of inclusions which appear to lie along a surface. Forms similar to necked down inclusions have also been observed. We have observed virtually all forms and occurrences of inclusions commonly seen in hydrothermal quartz and other minerals. Many of the fluid inclusions in KDP and KS crystals have features commonly interpreted as secondary or pseudosecondary. Thus, we have direct evidence for the primary formation of pseudosecondary inclusions. (Authors' abstract)



MELENEVSKIY, V.N. and NIKITINA, Ye.I., 1981, Studies of processes of gas release from natural quartz: Izv. AN SSSR, Ser. Geol., no. 9, p. 81-91 (in Russian). Authors at Siberian Sci. Research Inst. of Geol., Geoph. and Mineral Raw Materials, Novosibirsk, USSR.

Samples (5-50 mg) of quartz were placed in quartz vessel for decrepitation and released gases were analyzed by mass spectrometer. Water released from quartz sample at T <600°C may appear from 1) surface adsorption, 2) G/L inclusions, 3) OH groups in quartz, 4) structural channels in quartz. The kinetic theory of resistivity is applied to description of the decrepitation phenomena. Loss of volatiles from G/L inclusions due to diffusion in the quartz structure during geological time may be omitted for T <100°C. (A.K.)

MEL'NIKOV et al., 1979, 1981 - See Appendix

MEL'NIKOV, F.M. and YUDIN, I.M., 1979, The decrepitophonic method in prospecting for gold mineralization: Geol. i Razvedka, 1979, no. 5, p. 120-125 (in Russian; translated in Int'l. Geol. Rev., v. 23, no. 5, p. 607-608, 1981). Authors at Lomonosov Univ., Moscow, USSR.

Decrepitophonic aureoles have been found around gold deposits that can be used to delineate areas of gold mineralization. The decrepitation activity in the aureole is 10 or more times that of the background. (E.R.)

MELIKHOV, I.V., PROKOFIEV, M.A., SYCHEV, Yu.N. and SIDOROV, V.N., 1981, Study on liquid inclusions in microcrystals: J. Crys. Growth, v. 51, p. 292-298. Authors at Faculty of Radiochem., Chem. Dept., Moscow State Univ., Leninskiye Gory, Moscow 117234, USSR.

It has been established by electron and optical microscopy and EPR (using a paramagnetic probe) that the occluded mother liquor creates three-dimensional inclusions in the crystal bulk. The removal of water from these inclusions in stepwise isothermic heating has been studied on spring balances. It was established that the removal takes place according to a dislocation mechanism. A method has been suggested allowing one to estimate the inclusion size distribution (ISD) function from the data on decreasing the mass of crystals upon stepwise heating. The applicability of the method was checked by comparing ISD in crystals A found by two techniques: transmission electron microscopy and the one suggested in this paper. (Authors' abstract)

MELTON, C.E. and GIARDINI, A.A., 1981, The nature and significance of occluded fluids in three Indian diamonds: Am. Min., v. 66, p. 746-750. First author at Dept. Chem., Univ. Georgia, Athens, GA 30602.

Fluids extracted from two Type I and one Type II diamonds from the Panna mine of India have been analyzed by mass spectrometry. Two extraction methods were used. In the first, each crystal was crushed at 200°C in the high vacuum inlet of a high-sensitivity mass spectrometer. In the second, gases were released by graphitizing selected crushed fragments with a rhenium heater operated at about 3000°C under high vacuum. Gas compositions varied between the three crystals and the two methods, but they are qualitatively consistent. The compositions are also qualitatively consistent with those reported earlier for diamonds from other global locations. The range in volume percent for major constituents released by crushing are H_2 (58.5-65.3), H_2O (10.8-26), CO (tr-2.7), CO_2 (9.9-18.3), CH_4 (5.4-10), N_2 (tr-1.2), and by graphitization, H_2 (41.1-45.3), H_2O (20.9-28.5), CO (5.5-6), CO_2 (12.1-16.4), CH_4 (4.4-12.7), N_2 (2.7-3.7). Average H, O, C, and N atomic percents from crushing and graphitization are, respectively, 73.6, 17.4, 8.4, 0.6; and 64.5, 17.5, 16.0 and 2.0. Hydrogen was the most abundant compound found by both methods of extraction, and it was more abundant in the Type II diamond than in the Type I diamonds. A positive qualitative correlation was found between N_2 and CO contents and anomalous birefringence. Variations in entrapped fluid composition with diamond crystal form and source locations are discussed in terms of diamond crystallization depth in the upper mantle, the redox state, and the age of diamond crystallization. The H_2:H_2O ratio found in the occluded fluid of Indian diamonds can be interpreted as supporting a molten iron-silicate equilibrium in the mantle at the time of the Earth's core formation. (Authors' abstract)

MENYAYLOV, I.A., VETSHTEYN, V.Ye., NIKITINA, L.P. and ARTEMCHUK, V.G., 1981, D/H and $^{18}O/^{16}O$ in magmatic waters and gases of the Great Fissure Eruption of Tolbachik Volcano, Kamchatka: Akad. Nauk SSSR Doklady, v. 258, no. 2, p. 469-472 (in Russian). First author at Inst. of Volcanology of the Far East Sci. Center of Acad. Sci. USSR, Petropavlovsk-Kamchatskiy, USSR.

Pertinent to isotope studies of inclusion fluids. (A.K.)

MIKHAILOV, M.Yu., 1981, Transformation of gas-liquid inclusions in beryls: Geol. i. Geofiz., v. 22, no. 9, p. 127-132 (in Russian; translated in Soviet Geol. & Geophys., v. 22 no. 9, p. 111-115).

Beryls are described, from quartz-topaz-beryl veins, that contain unique gas-liquid inclusions surrounded by fringes of mineral host. Possible mechanisms for the formation of such fringes are discussed. It is shown that their formation is caused by the redeposition of material of the mineral host in the process of the inclusion's acquiring an even shape under conditions of significant anisotropy of the surface energy. (Author's abstract) See Appendix for A.K. abstract.

MITCHELL, P.A., SILBERMAN, M.L. and O'NEIL, J.R., 1981, Genesis of gold vein mineralization in an Upper Cretaceous turbidite sequence, Hope-Sunrise district, southern Alaska: U.S. Geol. Survey Open-File Rept. 81-355, p. 33-42 (see also U.S. Geol. Survey Open-File Rept. 81-103, 18 pp.).

Preliminary fluid inclusion filling temperatures suggest that the mineralized quartz veins were deposited at significantly lower temperatures than evident from the metamorphic mineral assemblage of the country rocks. Th L-V(L) of inclusions in quartz and calcite ranged from 100 to 219°C, and pressure corrections are assumed to be very low. The δD values of H_2O for three quartz veins averaged -106 ±6 per mil, very close to meteoric water in the area. (E.R.)

MIYANO, Takashi, 1981, Examination of thermodynamic properties and stability relations of aqueous iron species at 25°C: Sci. Rep., Inst. Geosci., Univ. Tsukuba, Sec. B, v. 2, p. 61-75.

MIYANO, Takashi and EINAGA, Hisahiko, 1981, Prediction of thermodynamic properties of aqueous ionic species at zero ionic strength and 25°C: Sci. Rep., Inst. Geosci., Univ. Tasukuba, Sec. B, v. 2, p. 45-60.

MOISEENKO, V.G., ed., 1980, Thermobarogeochemistry in ore genesis (Materials of the Sixth All-Union Conference on Thermobarogeochemistry): Akad. Nauk, Vladivostok, 236 pp. (in Russian).

This volume contains selected papers from the Vladivostok conference (in 1978), most of which have been given in abstracts in earlier volumes of Fluid Inclusion Research--Proceedings of COFFI. (E.R.)

MONTGOMERY, G.E., 1981, Obsidian; a versatile gem material: Jewelry Making Gems & Minerals, May 1981, no. 523, p. 14-15, 92 illus.

Indexed under fluid inclusions. (E.R.)

MOORE, C.H. and DRUCKMAN, Yehezkeel, 1981, Burial diagenesis and porosity evolution, upper Jurassic Smackover, Arkansas and Louisiana: Am. Assoc. Petrol. Geol. Bull., v. 65, no. 4, p. 597-628. Authors at Dept. Geol., Louisiana State Univ., Baton Rouge, LA 70803.

The Jurassic Upper Smackover ooid-lime-grainstone of the central Gulf Coast has been a major hydrocarbon exploration target for nearly half a century. Study of the geologic and sedimentologic framework, petrography, two-phase fluid inclusions, and trace element and stable isotope chemistry was used to establish a detailed diagenetic history. (From the authors' abstract)

A very extensive study of the diagenetic changes in this formation including a discussion of the problems in the use of fluid inclusions in calcite cements (p. 614). Tm ice values of -20 to -24.4°C and Th 85 to 112°C are reported. These data agree with other paleothermometric techniques, such as O and C isotopes, and other geological, geochemical, and petrographic data. Some inclusions contain hydrocarbons. (E.R.)

MOORE, J.G. and CLAGUE, D.A., 1981, Loihi Seamount lavas: volatile contents (abst.): EOS, v. 62, p. 1083. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

The wide range in composition of basaltic lavas from Loihi Seamount permits a comparison of composition with apparent volatile content. In general, the more alkalic lavas are more vesicular; 20 volume percent vesicles at 1,500 m depth is not uncommon. Both the least and most highly differentiated alkalic lavas are commonly the highest in vesicle content. However, some lavas from the summit plateau are particularly low in vesicle content and appear to have lost volatiles during shallow-level storage.

Water (H_2O+) content of glass, ranging from 0.3-0.7 weight percent, shows a positive correlation with K_2O content, such that $H_2O+ = 0.9K_2O$. There is no evidence that water is lost upon vesiculation in these samples.

Sulfur content of the glasses, ranging as high as 2,900±200 ppm, shows a positive correlation with FeO, K_2O and H_2O+. However, sulfur is distinctly lost upon vesiculation and decreases systematically as the vesicle content increases above 10 volume percent. The most vesicular samples have lost about 70% of their sulfur during this degassing.

Dense CO_2 inclusions, similar to those in xenolithic olivine from Hualalai Volcano, are common in xenolithic and xenocrystic olivine and suggest entrapment pressures equivalent to 10-15-km depth.

The vesicularity of more than 50% of some alkalic lavas suggests that mild explosive activity or, at least, gas streaming may occur at Loihi vents. The high gas content of early alkalic lavas provides a mechanism for initiation of volcanism on the deep-sea floor and for transport of magma through a thick relatively cool lithospheric plate. Similarly, expanding gases in the rising magma may provide the lift necessary to carry ultramafic inclusions to the surface. (Authors' abstract)

MORROW, C., LOCKNER, D., MOORE, D. and BYERLEE, J., 1981, Permeability of granite in a temperature gradient: J. Geophy. Res., v. 86, no. P4, p. 3002-3008. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

Changes in permeability of granite were measured as water flowed through samples in a temperature gradient. The experimental conditions simulated those around the "very deep hole concept" nuclear waste repository. Temperature was maintained beween 200° and 310°C, in a borehole of a cylindrical sample. Confining pressures of 30 and 60 MPa, with corresponding pore pressures of 10 and 20 MPa, simulated depths of burial of approximately 1.2 and 2.4 km, respectively. A small pore pressure gradient enabled distilled water to flow from the borehole (high temperature) to the outside of the sample (low temperature). Tests were run for intact samples with initial permeabilities of several hundred nanodarcies and for samples containing throughgoing fractures, with initial permeabilities of about 1 millidarcy. In all cases, permeability decreased between 1 and 2 orders of magnitude at a rate that increased with higher temperatures. At 200°C, permeability dropped by an order of magnitude over a 1-month period, whereas at 310°C, permeability dropped sharply within a few days to 5% of the initial value. The dissolution of quartz and feldspar and redeposition of these minerals within cracks at lower temperature was found to be the major cause of reduction of permeability. If similar processes occurred near a deep hole nuclear waste repository site in granite, then migration of radionuclides away from the site might be suppressed, even if the rock surrounding the waste contained fractures. (Authors' abstract)

MOSKOVSKIY, V.A. and SIROTIN, K.M., 1981, Utilization of results from a study of inclusions in salt minerals for an explanation of sedimentation conditions and separation of sections; areas of El'ton, Baskunchak and the northwestern part of the border zone of the Caspian Depression, in The Structure and Formation Conditions of Salt-Bearing Horizons: A.L. Yanshin and M.A. Zharkov, eds.: Izd. Nauka, Sibirsk. Otdel., Novosibirsk, USSR, p. 44-52 (in Russian). See Translations.

MOTORINA, I.V. and YASHCHENKO, N.J., 1981, Physicochemical conditions of the formation of quartz basaltoids and quartz liparite-dacites from the

Baian-Aul region (Central Kazakhstan): Akad. Nauk SSSR Doklady, v. 261, p. 961-965 (in Russian).

Includes four analyses of melt inclusions in pyroxene and quartz (Table 3). (E.R.) See Appendix for A.K. abstract.

MUNASINGHE, Tissa and DISSANAYAKE, C.B., 1981, The origin of gemstones of Sri Lanka: Econ. Geol., v. 76, p. 1216-1225. Authors at Dept. Geol., Univ. Peradeniya, Peradeniya, Sri Lanka.

Most such gemstones come from contact metamorphic zones and pegmatites in metamorphic rocks. Previous work suggests temperatures of 700-840°C and pressures of 3-7 kb. (E.R.)

MUNOZ, J.L. and SWENSON, Alan, 1981, Chloride-hydroxyl exchange in biotite and estimation of relative HCl/HF activities in hydrothermal fluids: Econ. Geol., v. 76, p. 2212-2221. First author at Dept. Geol. Sci., Univ. Colorado, Boulder, CO 80309.

A combination of laboratory studies using synthetic annite, thermodynamic modeling, and analysis of compositions of natural biotites suggests that the equilibrium constant for the exchange reaction Bi-OH + HCl = Bi-Cl + H_2O can be expressed as $\log K(OH\text{-}Cl) = 5151/T(K) - 5.01 - 1.93\ X_{Mg}$, using for standard states the pure ideal gas H_2O and HCl at 1 bar and T, pure hydroxyl-biotite, and (hypothetical) chlorbiotite at P and T and X_{Mg} as the mole fraction of octahedral Mg in biotite. The exchange reaction was directly measured in the Mg-free system at 1 kb and 445° to 575°C using a synthetic biotite of nominal annite composition. The assemblage muscovite-quartz-K-feldspar-H_2O-HCl (2.0 m total Cl) buffered the fugacity ratio HCl/H_2O in the fluid phase. Analogous experiments using phlogopites were unsuccessful because of the small amount of Cl accepted (less than 0.1%), as compared with annite (up to 1.4%). Accordingly, the quantitative effect of Mg $\rightleftarrows$ Fe substitution on Cl $\rightleftarrows$ OH exchange was evaluated using chemical data from a suite of biotites from the porphyry copper deposit at Santa Rita, New Mexico (Jacobs, 1976). When combined with analogous data for F $\rightleftarrows$ OH exchange, the equilibrium constant of the halogen exchange reaction Bi-Cl + HF = Bi-F + HCl is: $\log K(F\text{-}Cl) = 3051/T - 5.34 + 3.13\ X_{Mg}$ (see note). This equation is used to compare the Santa Rita biotites with biotites from the porphyry molybdenum deposit at Henderson, Colorado (Gunow, 1978). These two biotite suites are strongly separated on a long (X_F/X_{Cl}) - X_{Mg} plot and suggest a difference in fugacity ratio of HF to HCl in their respective hydrothermal fluids of more than an order of magnitude, with the Henderson fluids being the more fluorine rich. (Authors' abstract)

MYENCHINSKAYA, T.I., 1981, Turquoise: Moscow, "Nedra" Publishing House, p. 120-122 (in Russian); pp. 159, price 85 kopeck, 23,000 copies printed.

Turquoise and paragenetic quartz from the Middle Asian deposits Ayakaschi I, Kal'makyr and Biryuzakan were studied for fluid inclusions. Inclusions in quartz homogenized in G (Th 420-350°C), with critical phenomena (Th 385-310°C) and in L (Th 420-90°C); LCO_2 is commonly present in inclusions. Quartz with Th 190-80°C was formed contemporaneously with turquoise. In turquoise inclusions of colloidal origin occur with the habit of double-spherical and rosette-like spongy individuals sometimes with syneresis figures, as well as tiny G/L inclusions (0.0006-0.0012 μm)* with filling degree 0.97-0.88; Th of the latter 135, 154, 186, 195, 120-90°C. Quartz and turquoise were also characterized by the decrepitation method (Td 80-160°C for turquoise). IR absorption spectra of quartz sometimes bear absorption bands attributable to CO_2 in inclusions. Early mineral-forming solutions were of type F-SO_4-K-Ca-Ba-Na-CO_2, next changing to higher Ba, HCO_3 and CO_2 concentrations. (Abstract by A.K.) * sic

MYSEN, B.O., 1981, Rare earth element partitioning between minerals and (CO_2 + H_2O) vapor as a function of pressure, temperature, and vapor composition: Carne~gie Inst. Washington Yearbook 80, (1981), p. 347-349.

The vapor-crystal partition coefficients (K) increase rapidly with both increasing pressure (as already noted by Mysen, 1979, for hydrous fluid) and increasing $H_2O/(H_2O + CO_2)$. In contrast to major elements, where the solubility in CO_2 fluids is negligible, that of REE, as exemplified by the coefficient for Sm between vapor and diopside, is so high that the vapor-crystal partition coefficients are much greater than unity under pressure and temperature conditions corresponding to those of the upper mantle. It is possible, therefore, as also observed by Wendlandt and Harrison (1979), that CO_2-rich fluid may act as metasomatizing agents in the upper mantle. (From the paper)

NAMBU, Masateru and SATO, Toshio, 1981, The analysis of fluid inclusions in the microgram range with an ion microanalyzer: Bull. Minéral., v. 104, p. 827-833. First author at Faculty of Engrg., Tohoku Univ. Aramaki, Sendai, 980, Japan.

This paper deals with the development of a method of microanalysis of inclusions by means of the ion microanalyzer (i.e., ion microprobe). In this method, the ion beam works not only to analyze the inclusion fluid, but also to sputter the host mineral which encloses an inclusion. The fluid inclusions are kept frozen to avoid rapid evaporation into vacuum. The ionization properties of aqueous solution in the frozen state were investigated, since such a study had never been done before. Semi-quantitative analysis is possible, using the relative ion intensities and the molarity of inclusion. Results are reported on samples from hydrothermal deposits in Japan. It was found that the compositions of the mineralizing fluid varied with time, especially in Mg and Al, even in the same minerals from the same deposit. As an example of application to prospecting, a new copper deposit was found based on the analysis fo fluid inclusions under the so called barren zone of Pb-Zn vein type deposit. (Authors' abstract)

NAPOLES, E.M., 1981, Fluid inclusion study of core samples from the Malitbog thermal area, Tongonan geothermal field, Philippines: Unpublished, Univ. Auckland Geothermal Inst. Report No. 81.13, Nov. 1981. Author at P.N.O.C., Manila, Philippines.

Fluid inclusion studies of cores from Wells MB1 to 5, 208A and MN1 demonstrate strong meteoric water dilution as the geothermal fluid coming from beneath the Mahiao sector migrates to the southeast towards Sambaloran, Malitog and Mamban. Extensive silicification in the area, probably induced by percolating ground water to the east of Malitbog, must have caused the present hot fluid boundary to migrate deeper, sloping quite steeply towards Mamban.

Reports on the hydrothermal alteration minerals of the andesites in the area suggest the existence of a "fossil system" with relict epidote, grossular, biotite, and amphibole at relatively low temperatures (Wood, 1978) but latter vein minerals (epidote, adularia, anhydrite) reflect the present fluid characteristics. Fluid inclusion Th measurements give strikingly similar temperature results with chemical fluid geothermometers of discharges and show parallel trends with the boiling-point-with-depth profiles that are extrapolated to the water level for each well. Salinity measurements on fluid inclusions by freezing point depression (F.P.D.) method reveal a complex pattern of meteoric water dilution. In some samples, however, contamination with highly saline fluid seem to have occurred. Present day fluids contain ~1.0 wt.% NaCl at near neutral pH, with ~0.1 molal CO_2 and 0.005 molal H_2S dissolved in total discharge. However, F.P.D. measurements indicate 1.-8. wt.% NaCl equiv. in fluid inclusions, suggesting that present day discharges are less saline than the fluid at the time of inclusion formation. (Author's abstract, modified by J.W. Hedenquist)

NASH, J.T., 1981, Geology and genesis of major world hardrock uranium deposits -- an overview: U.S. Geol. Survey Open-File Report 81-166, 123 pp.

Where available, fluid inclusion data from the literature are discussed for each deposit considered. (E.R.)

NAUMKO, I.M. and KALYUZHNYI, V.A., 1981, Genetic characteristics of topaz from zones of leaching and recrystallization of zanorsh pegmatites of Volynia: Mineralog. Zhur., 1981, no. 3, p. 52-62 (in Russian).

Genetic peculiarities of topaz crystallization in the leaching and recrystallization zone of the Volyn zanorsh (chamber) pegmatites, are characterized on the basis of data obtained from studies in multiphase fluid inclusions by methods of mineralogical thermobarometry. It is shown that the mineral was formed during the post-inversion (below 573°C) stage of the pegmatite process from acid metasomatic solutions enriched in F and CO_2. The results of the investigations make it possible to go into details of albitization and topazization processes while chamber pegmatites were formed and to estimate the amount and quality of developed topaz mineralization for requirements of jewelry industry. (Authors' abstract)

NAUMOV, V.B. and IVANOVA, 1980, Association between rare-metal mineralization and acid magmatism based on a study of mineral inclusions: Geologiya Rudnykh Mestorozhdeniy, 1980, no. 3, p. 95-103 (in Russian; translated in Int'l. Geol. Rev., v. 23, no. 5, p. 591-598, 1981).

Abstracted in Fluid Inclusion Research--Proc. of COFFI, v. 13, p. 171, 1980. (E.R.)

NAUMOV, V.B. and KOVALENKO, V.I., 1981, Water concentration and pressure in acid magmas according to the results of study of inclusions in minerals: Akad. Nauk SSSR Doklady, v. 261, p. 1417-1420(in Russian).

NAUMOV, V.B., KOVALENKO, V.I., GOREGLIAD, A.V. and IARMOLIUK, V.V., 1981, Conditions of the crystallization of alkali granites and comendites of the South-Gobi belt of the MPR according to the data of melt inclusion study: Dokl. Akad. Nauk SSSR, v. 255, no. 5, p. 1244-1247 (in Russian).

Ranges of Th values are given for 11 samples (total range 700-1000°C). (E.R.)

NAUMOV, V.B. and NAUMOV, G.B., 1980, Mineral-forming fluids and physical-chemical principles of their evolution: Geokhimiya, no. 10, p. 1450-1460 (in Russian; translated in Geochem. Int'l., v. 17, no. 5, p. 104-113, 1981).

Abstracted in Fluid Inclusion Research--Proc. of COFFI, v. 13, p. 171, 1980. (E.R.)

NAUMOV, V.B. and SOKOLOV, A.L., 1981, Genetic relations between granites and tin ore veins of the deposit Industryal'noe on the basis of fluid inclusion studies in minerals: Geol. Rudn. Mest., v. 23, no. 4, p. 74-80 (in Russian). First author at GEOKHI Acad. Sci. USSR, Moscow, USSR.

The deposit Industryal'noe occurs in the leucocratic granites of the massif Levo-Omsukchan that formed by several magma injections. Ores occur in metasomatic quartz-sericite-chlorite zones and veinlets. Melt inclusions were studied in quartz of granite of the first injection stage; the inclusions consist of anisotropic silicates (including muscovite) + G + LH_2O, Th of 250 inclusions 760-1020°C, mostly 850-950°C, water concentration in melt 1.7-7.0 wt.%, fluid P 0.3-3.6 kbar. Th as follows: quartz in granites 340-920°C (density 0.24-1.7 g/cm^3, total salt concentration NaCl equiv. wt.% 13-74, P 0.4-3.1 kbar); quartz-tourmaline (-fluorite) metasomatites 355-710°C (density 0.88-1.8 g/cm^3, total salts 35-70 wt.%, P 0.36-2.5 kbar); quartz-cassiterite veins 275-465°C (density 1.00-1.63 g/cm^3, total salts 35.6-60 wt.%, P 0.12-1.1 kbar); fluorite in veins 300-420°C (density 0.7-1.73 g/cm^3, total salts 4.0-65 wt.%). Main dms are halite and sylvite. Fluid inclusion studies indicate genetic connections between fluids of magmatic and early post-magmatic stage and ore-forming solutions. (Abstract by A.K.)

NEDACHI, Munetomo and UENO, Hirotomo, 1981, Chlorine and fluorine in apatites from the Orikabe granitic rocks, Kitakami Mountains, Japan: Mining Geol. (Japan) Special Issue 10, p. 219-225 (in Japanese; English abstract). First author at Dept. Geol., College of Liberal Arts, Kagoshima Univ., Kagoshima 890, Japan.

Chlorine and fluorine contents were determined on apatites from the Orikabe granitic rocks intruded to the Kesennuma Cretaceous gold-silver mineralized district of southern Kitakami Mountains. The Orikabe granitic body consists of three rock types: dioritic rocks of Tokusenjo type, monzodioritic rocks of Orikabe type, and granodioritic rocks of Sasamori type (Ishijima and Kato, 1971). The rock which is genetically related to the mineralization is of the Sasamori type.

In the Tokusenjo type, chlorine contents of apatite increased remarkably through the crystallization, but fluorine content decreased gradually after a slight increase at the early stage of crystallization.

On the other hand, in the Orikabe and Sasamori types, the decrease of chlorine contents and the increase of fluorine contents through the crystallization can be observed.

The Cl/OH ratio of apatite from the Orikabe type decrease, but that from the Sasamori type is almost constant through the crystallization. It is suggested that the constancy of Cl/OH ratio during the crystallization would be one of the essential characters of the granitic rocks which genetically related to the mineralization. (Authors' abstract)

NEWBERRY, R.J. and EINAUDI, M.T., 1981, Tectonic and geochemical setting of tungsten skarn mineralization in the Cordillera, in Relations of tectonics to ore deposits in the southern Cordillera, W.R. Dickinson and W.D. Payne, eds.: Arizona Geol. Soc. Digest, v. 14, p. 99-111. First author at Dept. Applied Earth Sci., Stanford Univ., Stanford, CA 94305. (Continued)

Tungsten skarns occur throughout the western Cordillera from the Yukon-Northwest Territories in Canada to Sonora, Mexico, in carbonate host rocks of Cambrian to Jurassic ages, and associated with calc-alkalic intrusive rocks of Late Triassic to Late Cretaceous ages. Throughout this range in time and space, consistencies in the geology, tectonic setting, and mineralogy of tungsten skarns and associated rocks suggest a common environment of formation rather than a specialized host or intrusive rock particularly enriched in tungsten. This common environment is the mesabyssal levels of the crust: stratigraphic reconstructions and mineralogical data indicate a depth of formation of 5 to 15 km below the surface. Specific features of the tungsten skarn environment which additionally suggest high temperature/moderate pressure include: typically large, high temperature metamorphic aureoles; locally migmatic intrusive contacts; association with coarse-grained intrusive rocks; abundant associated pegmatite dikes and sills; a lack of intrusive or hydrothermal breccias; and the general scarcity of low temperature alteration effects in intrusives and skarns. In addition, scant fluid inclusion data suggest temperatures of prograde skarn formation in excess of 500°C, in contrast with temperatures of copper skarn formation of 350-500°C. Tungsten skarns are notably associated with the more deeply eroded Mesozoic intrusives of the Idaho, Sierra Nevada and Aconchi batholiths and outliers, rather than with the shallowly eroded Tertiary stocks of Arizona, New Mexico, Utah, Washington, and eastern Nevada. (Authors' abstract)

NGUENE, F.R. and NORMAN, D.I., 1981, Mayo-Darle Sn deposit, west central Cameroon (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 519. Authors at Dept. Geosci., New Mexico Inst. Mining and Tech., Socorro, NM 87801.

Tin mineralization occurs as porphyry-type stock-works and high-grade veins in biotite granite plus alluvial and residual ores. Primary deposits occur as sub-millimeter to meter-wide quartz-cassiterite veins with minor topaz, which for the most part are centered around highly silicified breccia pipes. The breccia pipes are barren themselves of cassiterite. Alteration minerals are hematite and chlorite. Zones of kaolinization up to 100's of meters in diameter occur nearby, but not centered on, primary Sn mineralization. In alluvial deposits the gravels are derived from volcanic rocks implying that Sn mineralization extended from the granite well into overlying volcanic rocks.

Fluid inclusion studies indicate mineralization by 500 ± 20°C boiling fluids with a salinity of ~55 eq.wt.% NaCl. Secondary inclusions have homogenization temperatures of 170 to 270°C and salinity ~20 eq.wt.% NaCl.

Tin-bearing granites are part of a caldera complex which occurs along the Cameroon line (a strike-slip shear zone) and intrudes Pan-African orogenic-belt meta-sediments and meta-volcanics. The complex consists of alkaline granite, granite porphyry, rhyolite, quartz syenite, syenite, and trachyandesite. Whole rock Rb-Sr studies indicate the following age and $(^{87}Sr/^{86}Sr)_0$: Syenite, 73 ± 6 my, 0.7025 ± 36, Trachyandesite, 67 ± 8 my, 0.7075 ± 22, Granite, 54 ± 1 my, 0.7117 ± 28, Belt rocks, 616 ± 13 my, 0.7056 ± 05.

Trace element and isotopic studies suggest a multistage process for the genesis of the igneous complex and that the granite cannot be derived solely from partial melting of the belt metamorphics. (Authors' abstract)

NIELSEN, C.H. and SIGURDSSON, Haraldur, 1981, Quantitative methods for electron microprobe analysis of sodium in natural and synthetic glasses: Am. Min., v. 66, p. 547-552. First author at JEOL (USA) Inc., 11 Dearborn Road, Peabody, MA 01960.

Two methods have been developed for the microprobe analysis of sodium in natural and synthetic glasses that exhibit time-dependent element migration during electron bombardment. A cryogenic method is based on the cooling of the sample to -90°C at which temperature sodium diffusion rate from the excitation volume is reduced to zero. An empirical correction method determines the shape of the sodium decay curve as a function of time during electron bombardment, which under normal operating conditions, gives initial sodium concentration by extrapolation. (Authors' abstract)

NIKISHOV, K.H. and SAFRONOV, A.F., 1981, Some problems of genesis of chromite and magnesian garnet from inclusions in diamonds and from kimberlite rocks: Akad. Nauk SSSR Doklady, v. 256, no. 5, p. 1215-1217 (in Russian). Authors at Geol. Inst. of Yakutian Division of Siberian Branch of Acad. Sci. USSR, Yakutsk, USSR.

Solid inclusions in diamonds. (A.K.)

NIKOLSKII, N.S., 1981, Principles of simulation of the polycomponent fluid phase equilibrium compositions (exemplified by the H-O-C system) and their role in magmatism. Akad. Nauk SSSR Doklady, v. 257, p. 983-988 (in Russian).

NIKOL'SKIY, N.S., 1981a Metastable crystallization of natural diamonds from the fluid phase: Dokl. Akad. Nauk SSSR, v. 256, no. 4, p. 954-958 (in Russian).

NIKOL'SKIY, N.S., 1981b The parameters of equilibrium in fluid systems: Izvestiya Akad. Nauk SSSR, Ser. Geol. 1981, no. 2, p. 21-34 (in Russian).

See Appendix

NORMAN, D.I., 1981, Gases in the mica minerals: a possible exploration tool for hydrothermal ore deposits (abst.): Geol. Soc. Am. Abstracts with Programs, v. 13, p. 520. Author at Geosci. Dept., New Mexico Instit. Mining and Tech., Socorro, NM 87801.

Chlorite, muscovite and biotite from igneous rocks, metamorphic rocks, and resulting from hydrothermal alteration have been step heated in a vacuum extraction line. Water is separated from the volatiles released and measured. The gases are analyzed with a quadropole mass spectrometer. In greatest abundance are CO_2, H_2S and NH_3. Other gases measured are H_2, N_2, Ar, and CH_4. Concentrations of the major gases vary considerably and range up to 500 ppm for CO_2, 350 ppm for H_2S, 1300 ppm for SO_2, and 30 ppm for NH_3.

Step heating indicates most of the major gases are in water sites. CO_2, and H_2S are evolved in greater abundance upon dehydration of the talc layer and NH_3 and SO_2 are in greater abundance when the brucite layer in chlorite is dehydrated. H_2 and CH_4 abundances closely parallel the evolution of water and CO_2 and probably are the result of oxidation-reductions reactions during heating-dehydration. This observation raises the question as to whether H_2S-SO_2 ratios measured reflect those in the mineral.

Highest concentrations of sulfur gases (amounting up to 1000 ppm S in the minerals) are in alteration samples from sulfide ore deposits.

These high concentations of sulfur have been confirmed by chemical analysis. A preliminary conclusion is that sulfur gases in hydrous alteration minerals may be a valuable guide in the exploration of hydrothermal sulfide deposits.

Significant amounts of sulfur gases occur in all micas measured, especially chlorite. This suggests that the mica minerals may be an important source of sulfur for some sulfide ore deposits. (Author's abstract)

NORMAN, D.I. and TRANGCOTCHASAN, Y., 1981, Fluid inclusion study of the Yod Nam tin mine, southern Thailand (abst.): J. Geol. Soc. (London), v. 138, no. 2, p. 214.

The Yod Nam deposit consists of cassiterite-quartz fracture fillings in a Cretaceous or Tertiary biotite granite stock. Fluid inclusion studies indicate depositing fluids of erratically varying salinity: 0-8 eq. wt% NaCl, CO_2 content ranging from low during cassiterite mineralization to >10% during quartz deposition, temperatures falling through the paragenesis from 490 to 220°C, and a pressure of about 1 kb. The fluids may have been meteoric/connate, or distillates from boiling saline magmatic solutions. The fCO_2 of hydrothermal fluids may exert a control on the deposition or transport of Sn. (Authors' abstract)

NORRIS, J.R., 1981, Fracturing, alteration, and mineralization in oxide pit, Silver Bell mine, Pima County, Arizona: Master's thesis, Univ. Arizona, Tucson, AZ, 72 p.

Indexed under fluid inclusions. (E.R.)

OBERHEUSER, G., KNOBEL, R., REIL, R. and FREUND, F., 1981, Metal transport by the intermediary of a gas phase; CO_2 and hydrocarbon isolation from olivine inclusions in the Eifel (abst.): Fortschritte der Mineralogie, Beiheft, v. 59, no. 1, p. 257.

OBOLENSKIY, A.A., 1981, Kuznetsk-Altay mercury belt: Geol. Rudn. Mest., v. 23, no. 3, p. 55-66 (in Russian). Author at Inst. Geol. Geoph. of Siberian Branch of Acad. Sci. of the USSR, Novosibirsk.

Ore mineralization (cinnabar, Hg-tetrahedrite and Hg-sphalerite) in the deposits: Chaganuzun, Krasnogorskoe, Aktash, Sukhon'koe, Kuray, Tadzhilin, Beloosipovskoe, Tyutyo, Orlinogorskoe, Koksair, Otsalar, Dzhylkydal, Kokuri, Akkain, Sarasin, formed at T (from Th) 250-70°C and P $101.3 \times 10^3 - 202.6 \times 10^2$ kPa. Parent solutions were of Na-S-Cl-HCO_3 plus CO_2+N_2+acid gases composition. (Abstract by A.K.)

OBOLKIN et al. - See Appendix

OCHIAI, Takeshi, 1981, An investigation of electrum from the Manzai No. 3 vein, Nebazawa mine, Gunma Prefecture, central Japan: Mining Geol. (Japan) Special Issue 10, p. 107-117 (in Japanese; English abstract). Author at Dept. Earth Sci., College of Humanities & Sci., Nihon Univ., 3-25-40 Sakurajosui, Setagayaku, Tokyo 156, Japan.

The Nebazawa gold-silver ore deposit consists of eight veins of epithermal fissure-filling type. The veins occur in the hydrothermally altered welded tuff (the Katashinagawa rhyolitic rocks) of Palaeogene age. Multiple cymoid loops and horsetail structures are predominant in the Manzai veins and the Honpi vein.

In this study, modes of occurrence and chemical composition of electrum in the high grade ore from four localities of the Manzai No. 3 vein have been investigated by means of microscope and EPMA. And the filling temperatures of fluid inclusions in quartz have been measured.

The results of this work are as follows:

(1) The vein minerals are quartz, adularia, sericite, chalcopyrite, pyrite, sphalerite, galena, electrum, argentite, pyrargyrite, argentian tetrahedrite and stephanite.

(2) Four stages of mineralization recognized are, from early to later, (I) sulfide stage, (II) electrum stage, (III) sulfosalt stage, and (IV) last barren quartz stage.

(3) Three modes of occurrence of electrum recognized are, A-type: irregular grains filling cavities of intergranular quartz; B-type: globular grains occurring in void spaces; C-type: amoebic or dotted grains in sulfosalts.

(4) In globular grain, the marginal part is 10-40 wt.% higher in silver than that of the core.

(5) The filling temperature of fluid inclusions in quartz ranges from 215°C to 265°C.

(6) The value of sulfur fugacity estimated by means of electrum-tarnish method ranges from $10^{-10.3}$ to $10^{-11.3}$ atm. (Author's abstract)

O'DONOGHUE, Michael, 1981, Characterization of crystals with gem application: Prog. Crys. Growth Charact., v. 3, p. 193-209.

Includes some drawings of inclusions in such materials. (E.R.)

OLSEN, Edward, 1981, Vugs in ordinary chondrites: Meteoritics, v. 16, no. 1, p. 45-59. Author at Dept. Geol., Field Museum of Natural History, Chicago, IL 60605.

Large vugs occur in the ordinary chondrite, Farmington. They contain the same phases present in the body of the meteorite, either as vug wall lining or as crystals attached to linings. The morphologies of these phases indicate a history of melting and vapor deposition. These vugs are compared with vugs in the ordinary chondrites, Orvinio and Tadjera, and with published reports of vugs in Rose City and Shaw. It is concluded that although shock events may not cause heating above the liquidus for the body of the meteorite, local pockets of melting and vapor formation do occur due to inhomogeneities in the shock wave pattern. Vugs represent such pockets. Vug formation, as a consequence of shock processing, is widespread among ordinary chondrites and shows no correlation with the average temperature of shock heating, subsequent average cooling rate (as indicated by metallurgical criteria), or blackening of body color. (Author's abstract)

ORR, F.M., Jr., YU, A.D. and LIEN, C.L., 1981, Phase behavior of CO_2 and crude oil in low-temperature reservoirs: Soc. Petr. Engrs. J., v. 21, no. 4, p. 480-492.

Phase behavior of CO_2/crude-oil mixtures which exhibit liquid/liquid (L/L) and liquid/liquid/vapor (L/L/V) equilibria is examined. Results of single-contact phase behavior experiments for CO_2/separator-oil mixtures are reported. Experimental results are interpreted using pseudoternary phase diagrams based on a review of phase behavior data for binary and ternary mixtures of CO_2 with alkanes. Implications for the displacement process of L/L/V phase behavior are examined using a one-dimensional finite difference simulator. Results of the analysis suggest that L/L and L/L/V equilibria will occur for CO_2/crude-oil mixtures at temperatures below about 120°F (49°C) and that development of miscibility occurs by extraction of hydrocarbons from the oil into a CO_2-rich liquid phase in such systems. (Authors' abstract)

OTKHMEZURI, Z.V. and DOLIDZE, I.D., 1981, Chemical composition of fluid inclusions in the ore-forming minerals of antimony-mercury-arsenic deposits: Bull. Minéral., v. 104, p. 361-366. Authors at Geol. Inst., Acad. Sci. of the Georgian SSR, Zoia Roukhadze str. 1, b9, 380093 Tbilisi, USSR.

Chemical composition of ore-forming minerals in antimony, mercury, mercury-arsenic and arsenic (realgar orpiment) deposits on the southern slope of the Great Caucasus has been investigated. These deposits represent medium and low-temperature formations, developing stage-by stage in quartz-antimonite, quartz-dickite-carbonate-cinnabar and realgar-orpiment stages of mineralization. Chemical composition of fluid inclusions, investigated by the method of triple water extractions shows the evolution of ore-forming solutions from chlorine-sodium at initial (quartz-antimonite) stage to hydrocarbonate-magnesium-calcium composition in the final (realgar-orpiment) stage of mineralization. (Authors' abstract)

OUDIN, E., FOUILLAC, C. and Le BEL, L., 1981, Mineralogical studies and geochemistry of submarine sulfide deposits of the East-Pacific Rise (21°N): Documents du BRGM, no. 25, 241 pp.

An extensive study of samples from the hydrothermally active zone, collected with the Alvin submersible. A detailed examination of one vent allowed an evaluation of its thermal evolution from a combination of chemical arguments and measurements in excellent larger inclusions in anhydrite and wurtzite-sphalerite. Th ranged from 180 to 348°C (mostly 270-320°) and Tm ice was -1.8 to -2.7°C. The range of Th values arises from entry of +2°C seawater into the porous chimney and mixing with the rising hydrothermal fluid (at 350°C). (E.R.)

PAMPURA, V.D., KARPOV, I.K. and KAZ'MIN, L.A., 1981, Physico-chemical model of equilibrium composition of the system CO_2-NaCl-H_2O in the region 49-1000 bar and 25-300°C: Akad. Nauk SSSR Doklady, v. 258, no. 4, p. 989-992 (in Russian). Authors at Inst. Geochem. of Acad. Sci. of USSR, Irkutsk, USSR.

Pertinent to the inclusion fluid studies. (A.K.)

PANINA et al., 1981 - See Appendix

PANNO, S.V., HARBOTTLE, Garman, SAYRE, E.V. and HOOD, W.C., 1981, Genetic implications of halogen host rock aureoles surrounding a Mississippi Valley-type ore deposit (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 525. First author at Dept. Chem., Brookhaven Nat'l. Lab., Upton, NY 11973.

Analysis of host dolomite adjacent to the Mississippi Valley-type lead-zinc deposits of the Viburnum Trend, Southeast Missouri by instrumental neutron activation (INAA) and X-ray fluorescence (XRF) has revealed broad and distinct aureoles of bromine and chlorine respectively. Metallic aureoles were also found adjacent to the deposits and show close spatial and morphological relationships to the halogen aureoles. The presence of bromine and chlorine as host rock aureoles and their relationship to the metallic aureoles are strong additional evidence that the ore-forming solutions responsible for these deposits were metalliferous Na-Cl brines. Moreover the bromine to chlorine ratios of the samples, when plotted against distance from ore, also display an aureole-like configuration. These ratios range from 0.0095 to 0.0080 for dolomite samples within and adjacent to the deposits and from 0.0035 to 0.0030 for samples over 230 meters from the deposits. The relatively high bromine to chlorine ratios probably reflect those of the ore forming solutions while the lower ratios, which are close to that of normal seawater, reflect that of the solution present during the formation of the dolomite. This suggests that the ore solutions responsible for the deposits of the Viburnum Trend were enriched in bromine relative to seawater and thus, in their embryonic stage of development, were hypersaline brines formed within an evaporate sequence. (Authors' abstract)

PARMENTIER, E.M. and SCHEDL, A., 1981, Thermal aureoles of igneous intrusions; some possible indications of hydrothermal convective cooling: The J. Geol., v. 89, no. 1, p. 1-22. First author at Dept. Geol. Sci., Brown Univ., Providence, RI 02912.

The size and shape of metamorphic aureoles is investigated as a possible indicator of hydrothermal convective cooling of epizonal igneous intrusions. A simple family of numerical models illustrates the effect of convective cooling on maximum temperatures attained in the country rock surrounding an intrusion. Boundary layer approximations have also been applied to describe convection of vaporizing groundwater near the contact of an intrusion early in its cooling history. Maximum temperature isotherms are taken to reflect the width and shape of thermal aureoles defined by preserved mineral assemblages as appears to be reasonable based on several well-studied conductively cooled intrusions. The thermal aureoles of intrusions for which oxygen and hydrogen isotope data indicate convective groundwater circulation have been examined on the basis of the simple numerical and boundary layer models. The shape of the low temperature alteration aureole of the well-mapped El Salvador porphyry copper deposit suggests convective cooling of a permeable intrusion. The width of the low temperature (greenschist) aureole of the Mull intrusive complex can be explained by convective cooling of permeable intrusive rock. The narrow high temperature (amphibolite) aureole of the Cuillin gabbro on Skye can be explained by strong convective cooling; but the low temperature (greenschist) aureole is wide enough to be consistent with conductive cooling, thus suggesting decreasing permeabilities during the cooling history. This is consistent with oxygen isotope sampling and other geologic observations. (Authors' abstract

PARTSEVSKIY and BEBIK - See Appendix

PASTERIS, J.D., 1981a, Occurrence of graphite in serpentinized olivines in kimberlite: Geology, v. 9, p. 356-359. Author at Dept. Earth. and Planet. Sci. and McDonnell Center for the Space Sci., Washington Univ., Box 1169, St. Louis, MO 63130.

Abundant (6 to 9 wt %) graphite has been found in the serpentinized regions of olivine grains from several kimberlites. If the graphite originally was dissolved as atomic carbon in high-pressure olivine, this factor must affect petrologic models of mantle melting in the presence of CO_2. On the other hand, if the carbon originally existed as CO_2-filled fluid inclusions in olivine grains or was introduced during serpentinization, the development of graphite provides fO_2 constraints on kimberlite serpentinization. There is evidence for all three mechanisms of graphite formation. However, it appears most likely that graphite developed during reduction of serpentinizing fluids (probably methane-bearing). (Author's abstract)

PASTERIS, J.D., 1981b Significance of sulfide textures and mineralogy in mantle xenoliths (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 526.

PASTERIS, J.D., 1981c, Kimberlites: strange bodies?: EOS, v. 62, no. 43, p. 713-716.

A review (38 refs.) of "the kimberlite problem," with particular attention to the evidence of metasomatic changes and the possible fluids responsible. (E.R.)

PATIL, R.R., PANCHAPAKESAN, V. and SAHU, K.C., 1981 Fluid inclusion studies on amygdaloidal and vein calcite in Deccan traps: in Geol. Soc. India Memoir 3, Deccan Volcanism, K.V. Subbarao and R.N. Sukheswala, eds., Bangalore, 1981, p. 422-427. Authors at Indian Inst. Tech., Powai, Bombay-400 007, India.

Fluid inclusion studies were carried out on calcites from three locations of North Bombay. The results indicate very little effect of post-crystallization mechanical forces on the inclusions. Vein calcites show a higher Th of the biphase fluid inclusions than the amygdaloidal calcites. (Authors' abstract)

PATTERSON, D.J., OHMOTO, H. and SOLOMON, M., 1981, Geologic setting and genesis of cassiterite-sulfide mineralization at Renison Bell, western Tasmania: Econ. Geol., v. 76, p. 393-438. First author at Res. and Dev. Div., Mount Isa Mines Ltd., Mount Isa, Queensland 4825, Australia.

Cassiterite mineralization at Renison Bell is spatially and temporally related to the Upper Devonian Pine Hill Granite and occurs in dolomites and associated clastic sediments of probable Cambrian age. The sedimentary succession consists of an older siliceous clastic and carbonate sequence (the Success Creek Group) overlain by, and in faulted contact with, a predominantly volcaniclastic sequence (the Crimson Creek Formation). The Success Creek Group includes thinly bedded quartzites, siltstones, shales, and dolostones of probable shallow marine origin, and the Crimson Creek Formation consists of siltstones and volcaniclastic graywackes of basaltic composition. The Success Creek and Crimson Creek rocks are separated by the Red Rock sequence, consisting of polymict conglomerates, tuffs, cherts, and carbonate rocks. Mafic intrusives in the Crimson Creek Formation are chemically similar to the enclosing sediments. Carbonate beds in the Success Creek Group and Red Rock sequence consist principally of highly ordered ferroan dolomite, and their textural, mineralogical, and stable isotopic features suggest they are diagenetically dolomitized marine limestones.

The Pine Hill Granite is a porphyritic biotite granite which has been locally altered to greisen and muscovitic assemblages carrying minor cassiterite. Adjacent rocks have been thermally metamorphosed to hornblende-hornfels facies assemblages.

Cassiterite mineralization occurs in stratabound replacement bodies in dolomite beds in the Success Creek Group and Red Rock sequence, in veins with variable wall-rock replacement in major fault zones and to a minor extent in recrystallized sandstone. The generalized paragenetic sequence in the Renison mine is:

stage 1: cassiterite + silicates - tentatively inferred as an early stage of replacement ore formation;

stage 2: cassiterite + pyrrhotite + arsenopyrite + silicates + minor sulfides and iron oxides, etc. - the main stage of mineralization, associated with sideritic alteration of dolomites and tourmalinization of clastic sediments;

stage 3: cassiterite + pyrrhotite + arsenopyrite + silicates + minor sulfides - forming veins in major fault zones;

stage 4: minor veining by sphalerite + galena + silicates + carbonates ± fluorite; and

stage 5: vug-filling sequence of carbonates, quartz, fluorite, and sulfides.

Temperatures of about 350° and 300°C are inferred for stages 1 to 3 and stage 4, respectively, from fluid inclusion, mineralogical, and stable isotope data. Temperatures during stage 5 mineralization were probably in the range 200° to 150°C and were probably lower during stage 6 mineralization.

Bulk fluid inclusion analyses indicate that fluids during stages 1 to 4 were Na-K-Cl brines with a total salt concentration of about 2 molal and an Na/K ratio of about 7. Variable Ca and Mg concentrations may be partly due to contamination during sample leaching. Fluids were gas poor with average gas/water molal ratios of about $2x10^{-2}$ and CO_2/CH_4 ratios near 1. Nitrogen and argon were detected only in some samples. Stage 5 fluids were more saline, with average salt concentrations of about 5 molal and Na/K ratios of about 20. (Authors' abstract)

PATTERSON, M.A. and TAYLOR, B.E., 1981, Multiple stages of serpentinization in the Sierra Nevada foothills metamorphic belt (abst.): EOS, v. 62, p. 1059. Authors at Dept. Geol., Univ. California, Davis, CA 95616.

Textural and light stable isotopic evidence indicates two distinct periods of serpentinization of ultramafic rocks found in the foothills metamorphic belt in the western Sierra Nevada. Serpentinization occurred in the presence of water of different origins, and products of both serpentinization processes may be distinguished in the same hand sample.

Antigorite is the common pervasive replacement of the ultramafic rocks, and formed at temperatures >250°C. Oxygen isotope compositions are in the range of +5.85 to +8.09‰, and -41.6 to -63.3‰ for δD. Admixture of lizardite-chrysotile increases the $\delta^{18}O$ and decreases the δD values in composite samples. Lizardite-chrysotile is often found as an amorphous-appearing, waxy, apple green fracture filling, or as coarse, asbestiform serpentine fibers (+ magnetite) oriented perpendicular to the walls of tensional fractures. This vein serpentine is characterized by $\delta^{18}O$ of +9.23 to +10.98‰ and δD of -86.1 to -113.7‰. Oxygen isotope fractionation between lizardite-chrysotile and magnetite indicates low formation temperatures, 100°C.

Antigorite serpentine formed from water isotopically similar to ocean water. This serpentinization most likely resulted from ocean floor hydrothermal metamorphism, while the formation of lizardite-chrysotile represents a later event, one involving meteoric water in addition to metamorphic pore fluid. Both serpentinizing fluids may be distinguished from fluids responsible for quartz veining in the Mother Lode gold belt. (Authors' abstract)

PAVLOV, N.V. and GRIGOR'YEVA, I.I., 1981, Intensivity of serpentinization of ultrabasites of main ore field of the Kempirsay massif and its change with the depth: Geol. Rudn. Mest., v. 23, no. 4, p. 18-29 (in Russian). Authors at IGEM, Moscow, USSR.

Gas-liquid inclusions were found in chrome spinels from chromite ores with intergranular serpentine. Inclusions bear H_2, N_2 CO_2 and Ar (total

30 cm^3/kg, H_2 occupies 63%). Beginning of decrepitation was between 500 and 700°C. (Abstract by A.K.)

PAVLUN', 1981 - See Appendix

PECHER, Arnaud, 1981, Experimental decrepitation and re-equilibration of fluid inclusions in synthetic quartz: in G.S. Lister, et al, eds., The effect of deformation on rocks: Tectonophysics, v. 78, p. 567-583. Author at I.R.I.G.M., Univ. de Grenoble I, B.P. 53X, 38041 Grenoble, France.

Strong discrepancies between densities of the fluids trapped in fluid inclusions (F.I.) and P-Tp couples deduced from other geological considerations are common. So, it was decided to test experimentally the possible F.I. re-equilibrations when bringing the host crystal in P-Tp conditions, different from trapping conditions. Runs were conducted on synthetic quartz in a gas apparatus and in a Griggs solid medium apparatus. The following modifications of the F.I. were observed: (1) drastic shape changes of the primary F.I., and appearance of clusters or trails of small secondary inclusions sometimes related to a crack; and (2) lowering of the fluid densities. Such a re-equilibration is a decrepitation phenomenon: first, hydraulic fracturing, then sealing of the cracks with appearance of secondary inclusions. When using the gas apparatus, the new measured densities are in very good accordance with the nominal P-Tp conditions. When using the solid-medium apparatus, the new densities are surprisingly low relative to the nominal P-Tp conditions, probably due to a strongly anisotropic stress state in the apparatus. (Author's abstract)

PECHER, Arnaud, 1981, Some aspects of experimental high pressure - high temperature fluid inclusions reequilibration (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Ecole des Mines, Parc de Saurupt, 54000 Nancy, France.

When using fluid inclusions (F.I.) as pressure markers, discrepancies between measured densities and P-Tp couples inferred from other geological markers are common. Such discrepancies reflect late reequilibration. They seem to be mainly due to decrepitation, i.e., brittle failure of the inclusions, sometimes clearly evidenced by its microstructural aspects.

To test such reequilibration processes, experiments have been conducted in a gas apparatus (confining pressure Pc: 200 MPa, Tp: 500°C, duration: 600 h) and in a solid medium apparatus (nominal Pc: 500 and 800 MPa, Tp: 500°C, duration: 1 h, 20 h and 255 h).

Fast and drastic modifications of the F.I. (shape and filling) have been evidenced: (i) Even in the 1 h run, important shape modifications of the primary F.I. take place (they can be entirely destroyed) and numerous secondary F.I. appear, sometimes connected to microcracks issued from primary F.I. (ii) The new fluid densities are lower than the initial ones.

The reequilibration mechanism appears to be fundamentally a decrepitation mechanism: hydraulic fracturing when Pi (in the F.I.)>Pc + T_0, then healing of the cracks and formation of trails or clusters of new F.I. filled with a lower density fluid. The new density roughly corresponds to the condition Pi = Pc.

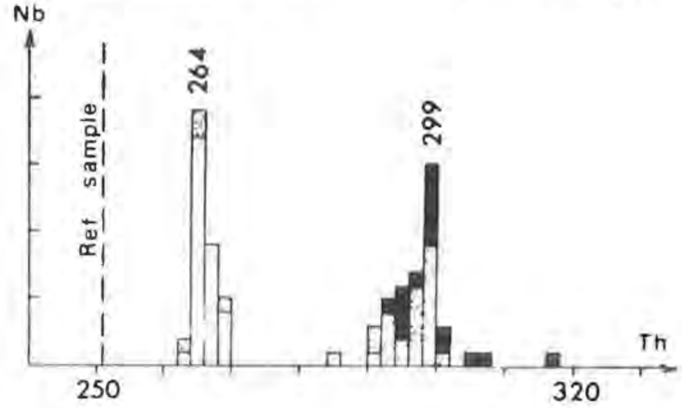
Actually, the sample heated in the gas apparatus (500°C, 140 MPa internal overpressure) displays a two-maxima Th (i.e., densities) histogram (fig.):

- Densities of some of the new F.I. are in quite good accordance with densities expected in the case of decrepitation reequilibration (0.71 instead of 0.70).

- Densities of the other ones are intermediate between the initial (0.80) and the expected densities.

So, (i) the pressure conditions were probably very close to the decrepitation conditions, and (ii) some of the primary inclusions have not suffered brittle failure, but have been partly reequilibrated following another process (volume increase due to plastic deformation or by fluid leaking by diffusion?).

For the runs conducted in the solid medium apparatus, decrepitation evidences are numerous in spite of the high nominal Pc. Low reequilibration pressures can be inferred from new densities. They probably mainly point out to the strongly anisotropic stress state in the apparatus. (Author's abstract)



PERCHUK, L.L., 1981, Correction of biotite-garnet thermometer for the case of the isomorphism Mn ⇄ Mg + Fe in garnet: Akad. Nauk SSSR Doklady, v. 256, no. 2, p. 441-442 (in Russian). Author at Moscow State Univ., Moscow, USSR.

PERSIKOV, 1981 - See Appendix

PESHECK, P.S., SCRIVEN, L.E. and DAVIS, H.T., 1981, Cold stage scanning electron microscopy of crude oil and brine in rock: Scanning Electron Microscopy, 1981, I, p. 515-524. First author at Pillsbury Co., 311 Second Ave., S.E., Minneapolis, MN 55414.

To determine the distribution and morphology of liquid phases in porous rock by scanning electron microscopy requires rapid cooling of the sample, suitable fracturing, and maintenance of sufficiently low temperature throughout preparation and examination to avoid sublimation of the frozen liquids. A cold stage system developed to meet these and additional requirements was tested with specimens of brine and crude oil in 3 mm diameter plugs of Berea sandstone. Keys to the system design were use of high conductivity silver, copper, and aluminum, a minimum number of contact junctions, lowering of thermal resistance across them by compression, and shielding from heat and contamination by a cryopanel. Preparation and mounting of specimens, and effects of sublimation and beam heating during examination were studied.

According to thermocouple measurements the first prototype cold stage maintained the sample holder at 133 K (-140°C), at which the crude oil did not sublime appreciably but 2 wt% sodium chloride solution in water did. The second prototype, with reduced thermal resistances, maintained the sample holder at 94 K (-179°C), and there was no evidence of sublimation. Moreover, beam heating effects at the sample fracture face were seen, but rarely, and calculations support the observation.

Micrographs showing a crude oil-in-brine emulsion, and crude oil and brine phases in the Berea sandstone demonstrate that good results can be obtained with simple but carefully designed equipment and that the method has exciting promise for the study of reservoir-fluid interactions. (Authors' abstract)

PETERSEN, E.U., VALLEY, J.W. and ESSENE, E.J., 1981, Fluorphlogopite and fluortremolite in Adirondack marbles: phase equilibria and C-O-H-F-S fluid compositions (abst.): EOS, v. 62, p. 422. First author at Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109.

The new minerals fluorphlogopite ($XF=0.96$) and fluortremolite ($XF = 0.82$) have been found in Grenville marbles near Balmat, NY. Buffered assemblages containing these minerals permit the calculation of nine metamorphic fluid components and tightly restrict the value of the free energy of fluortremolite. The sustitution of F for OH extends the stability fields of fluorine-bearing micas and amphiboles relative to any hydrous and/or fluorine-free phase and is partly responsible for stabilizing these minerals in the granulite facies marbles of the Adirondacks. Application of volatilization equilibria without consideration of possible fluorine substitution can lead to large errors in estimated pressures, temperatures, and fluid compositions.

The fugacities of eight C-O-H-F fluid components are restricted by the assemblage fluorphlogopite+calcite+quartz+graphite. At 650°C, 6kb, the estimated range in these values is: log $fH_2O=2.47$ to 3.37, log $fCO_2=4.52$ to 4.22, log $fCH_4=2.25$ to 2.35, log $fCO=2.07$ to 1.92, log $fH_2=0.34$ to 1.39, log $fO_2=-18.01$ to -18.31, log $fHF=-1.27$ to -0.37, log $fF_2=-34.19$ to -33.43. Calculation of oxidation-fluoridation equilibria from common calc-silicate minerals confirm the fF_2 and fO_2 values. The assemblage pyrite+pyrrhotitte fixes fS_2 at $10^{-2.06}$.

The mineral assemblage fluortremolite+fluorphlogopite+diopside+calcite +quartz+graphite and fluortremolite+calcite+graphite+norbergite restricts ΔG_{923} (fluortremolite) to $-10{,}337.6 \pm 11.2$ kjoules relative to the free energy for norbergite from Duffy and Greenwood (1979) and for the other minerals from Robie et al. (1979). Fluortremolite in graphitic marbles restricts fO_2 to values at or just below QFM. (Authors' abstract)

PETERSHAGEN, J.H. and NORDLIE, B.E., 1981, Experimental bubble nucleation and growth in a granitic melt (abst.): Geol. Soc. Am. Abstracts with Programs, v. 13, p. 313. Authors at Dept. Earth Sci., Iowa State Univ., Ames, IA 50011.

The primary goal of this study was to examine the nucleation and growth of water vapor bubbles in a melt of granitic composition. Water saturated melt compositions of 30.0% $KAlSi_3O_8$ - 30.5% $NaAlSi_3O_8$ - 39.5% SiO_2 (500 Kg/cm^2 minimum melt) were used at 800°C over a range of pressures. The method used required accurate determinations of water solubilities and water-saturated, bubble-free glass densities.

Water solubilities in the melt were determined at 800°C from 250 to 1500 bars; example values in wt. percent are 1.53 at 250 bars, 4.04 at 1000 bars, 4.72 at 1500 bars. The data are in good agreement with previous work on similar systems.

Glass densities determined on the quenched bubble-free solubility run products ranged linearly from 2.233 g/cm^3 at 4.72 wt % H_2O to 2.295 g/cm^2 at 1.53 wt % H_2O and 2.334 g/cm^3 at 0.00 wt % H_2O.

Bubbles were nucleated and grown at 800°C by saturating melts with water at 1000 bars and subsequently reducing the pressure instantaneously to 900, 700 or 500 bars. Bubble growth rates were determined by holding samples at the reduced pressure for varying time periods before instantaneous quenching under pressure. Total bubble volumes were indicated by sample densities; volumes increased with time to reach a maximum value when equilibrium was achieved between melt and vapor.

Bubble nucleation was nearly instantaneous. A detailed study of bubbles grown at 700 bars included counting and measuring individual bubbles. Bubble sizes follow a normal frequency distribution. This distribution is maintained as means and total bubble volumes increase with time, although there is an increase in size range as growth progresses. (Authors' abstract)

PETROV, P.P. and MARCHEV, P., 1981, Glass inclusions in quartz phenocrysts from acid volcanites (Borovitsa volcanic region): Comptes rendus de l'Academie bulgare des Sci., v. 24, no. 10, p. 1425-1427 (in English).

Primary glass inclusions contain a bubble (15-20 vol. %), sometimes plus small opaque phases. Secondary gas/liquid inclusions had Th 320-180°C and these hdyrothermal fluids have devitrified some glass inclusions to an opaque mass. Glass-vapor inclusions had Th 1210-1190°C, with glass melting starting at 1050-1100°C.Th determined after maintaining T near Th for 6-15 hours. Even so, large inclusions required even longer to achieve equilibrium. These high results cannot be from low volatile contents, as the host rhyolites also contain phenocrysts of biotite and amphibole.(E.R.)

PETROSYAN, 1981 - See Appendix

PETROSYAN and BUNTIKOVA, 1981 - See Appendix

PETROV, P., MICHAEL, K.G., 1979, Mineral-thermometric studies of the copper-molybdenum deposit Studenets: Annuaire de l'Universite de Sofia "Kliment Ohridski," Faculte de Geologie et Geographie, Part 1 - Geologie, v. 73, p. 175-182 (in Russian; English abstract).

The Studenets deposit is located in the Western part of Srednogorian metallogenic zone. The rocks in the area are part of the Plana pluton and are predominantly granodiorites, granites, quartzmonites (sic), diorite porphyrites, aplites and pegmatites. The ore bodies are represented by the copper-molybdenum porphyritic type and later polymetallic vein mineralization. The results of the mineral-forming temperatures have been obtained by studies of fluid inclusions in quartz, following the mineral parageneses. The data 190-170°C for the porphyritic and 250-240°C for the polymetallic mineralization display a low ore-forming temperature. Comparing the ore-forming temperature of Studenets with other porphyritic copper and copper-molybdenum deposits shows that the productive mineralization in Studenets is formed by the most low temperature. An additional indication are the low-temperature metasomatic rocks with small thickness and the low salt concentration of the mineral-forming fluids. (Authors' abstract)

PETROVA and ROYZENMAN, 1981 - See Appendix

PFEIFER, H.-R., 1981, A model for fluids in metamorphosed ultramafic rocks III. Mass transfer under amphibolite facies conditions in olivine-enstatite rocks of the Central Alps, Switzerland: Bull. Minéral., v. 104, p. 834-847. Author at Univ. de Lausanne, Sec. Sci. de la Terre, Centre d'Analyse Min., Route de Blévallaire, CH-1015 Lausanne, Switzerland.

The high grade metamorphic part of the Penninic zone of the Central Alps is characterized by 1 to 100 meters large ultramafic lenses of originally hazburgitic composition. A usually concentric zonation of these lenses indicates a syntectonic hydrothermal alteration related to the regional metamorphism. Five different zones can be distinguished: 1) original rock (mainly olivine-enstatite-chlorite-Cr-Fe-spinel), 2) hydrated zone (olivine-talc-chlorite-Cr-Fe-spinel ± amphibole), 3) hydrated and carbonatized zone (talc-magnesite-chlorite-amphibole-Fe-spinel), 4) zone strongly enriched in Ca, Al and Si (amphibole-chlorite-Fe-spinel ± magnesite, pentlandite), 5) complex marginal zonation (mono-and bimineralic zones of biotite, amphibole and plagioclase). The spectacular zone boundaries allow reconstruction of fluid-rock reactions in detail. Using temperature and pressure estimations of 580-650°C and 5 kbar, the fluid composition in the various zones can be estimated: CO_2, O_2 and S_2 increase towards the margins of the lenses, XCO_2 showing values between 0 and 0.9. Aqueous species concentrations like SiO_2, Ca, Al and Mg also increase towards the margins. The pH is predicted to vary between 5 and 7. Direction and extent of mass fluxes are estimated on the basis of field observations and various assumptions concerning mass and volume of the zones. Whereas Mg and Fe appear to be internally redistributed, large amounts of Si, Al and Ca are predicted to move in from felsic and mafic country rocks, leading to a volume increase of up to 30%. The only slightly affected country rocks and stable isotope data exclude a local origin of these elements and suggest a more distant source of the fluid phase. The dominant mass transport mechanism for aqueous species is assumed to be infiltration in a fluid pressure gradient. Locally at zone boundaries, composition-distance plots for Fe indicate a combination of diffusion and infiltration. (Author's abstract)

PHILLIPS, G.N. and WALL, V.J., 1981, Evaluation of prograde regional metamorphic conditions: their implications for the heat source and water activity during metamorphism in the Willyama Complex, Broken Hill, Australia: Bull. Minéral., v. 104, p. 801-810. First author at Dept. Geol., Univ. Western Australia, Nedlands, 6009, W.A., Australia.

The Willyama Complex around Broken Hill shows a NW to SE increase in metamorphic grade from andalusite-muscovite to sillimanite-muscovite, sillimanite-K feldspar and two pyroxene grade. Mineral assemblages in the dominant pelitic and lesser mafic gneisses (andalusite → sillimanite, cummingtonite-plagioclase, cordierite) indicate a low-intermediate pressure metamorphic path; and by using solid-solid, silicate-based barometers (cordierite-garnet, orthopyroxene-garnet-plagioclase, garnet-plagioclase-sillimanite) pressures of 5-6 kbar are inferred for a large part of the two pyroxene zone including Broken Hill itself. The overall increase in pressure to the SE is accompanied by a small rise in temperature (T from 650 to 800°C) and a gradual decrease in water activity (from 1.0 to ~0.5) above the second sillimanite isograd. A gradual transition from amphibolite to granulite facies conditions is indicated.

The decrease in water activity appears to be related to the onset of partial melting; i.e., as in situ partial melting proceeds in response to temperature rise, water activity declines. The latter is compatible with increased dilution of an aqueous fluid by another component, perhaps carbon dioxide, or with fluid-absent conditions.

The low-intermediate pressure prograde P-T path and nearly constant pressure retrograde path cannot be explained by a heat source related to tectonic thickening alone and instead an external heat source (perhaps a deep crustal mafic magma) may be required. Such a heat source may have wider applicability to other low-intermediate pressure terrains. (Authors' abstract)

PHILPOTTS, A.R., 1981a, Liquid immiscibility in silicate melt inclusions in plagioclase phenocrysts: Bull. Mineral., v. 104, p. 317-324. Author at Dept. Geol. and Geophys., and Instit. Material Sci., Univ. Connecticut, Storrs, CT 06268, USA.

Immiscible silicate liquids, preserved as globules of one glass in another, occur, not only in the mesostasis of many tholeiitic basalts and some andesites, but as melt inclusions in the plagioclase phenocrysts of these rocks. In the mesostasis, iron-rich globules are surrounded by a more abundant silica-rich host, but in the melt inclusions the reverse is more common. In both cases alumina and alkalis partition strongly into the silica-rich melt, whereas the high field-strength cations enter the iron-rich melt. The iron-rich liquids in the melt inclusions differ from those of the mesostasis in having high magnesium and low phosphorus contents, reflecting their early stage of entrapment in the phenocrysts. Those in the mesostasis form from fractionated liquids which are strongly depleted in magnesium and enriched in phosphorus.

While experiments indicate that unmixing takes place stably in the mesostasis, immiscibility in the melt inclusions is thought to form metastably. The inclusions are invariably glassy, and contact no crystalline phases other than the surrounding plagioclase. Furthermore, the iron-rich globules have compositions equivalent to mixtures of pyroxene and plagioclase of the compositions found in the surrounding rock. Failure of these minerals to crystallize results in the trapped liquid intersecting the metastable immiscibility field at temperatures that are high enough to allow for some coalescence of droplets. This metastable immiscibility field extends to compositions approaching those of primary basalts. (Author's abstract)

PHILPOTTS, A.R., 1981b, A model for the generation of massif-type anorthosites: Canadian Mineralogist, v. 19, p. 233-253. Author at Dept. Geol. and Geophys. and Inst. Materials Sci., Univ. Connecticut, Storrs, CT 06268, U.S.A.

The relative constancy of plagioclase compositions within large anorthosite massifs is difficult to explain by simple magmatic crystallization; it can, however, be accounted for if the plagioclase was buffered by coexisting immiscible magmas that changed their proportions during the crystallization of plagioclase. Immiscible liquids in many basalts and andesites coexist with plagioclase of the composition found in anorthosites. Moreover, these liquids are compositionally similar to jotunite and quartz mangerite, two of the rock types commonly associated with anorthosites. Experiments done on a mixture of jotunite and quartz mangerite at approximately one atmosphere total pressure and under oxygen fugacities controlled by the Ni-NiO buffer reveal extensive immiscibility between liquids compositionally similar to these rocks. Plagioclase (An_{32}) first crystallizes at 1050°C from a homogeneous liquid prepared from a mixture of these rocks; then, at ten degrees lower, after only a few percent crystallization, the remaining liquid splits into iron- and silica-rich fractions. Partial melting experiments on quartz mangerite alone also result in the formation of immiscible liquids; certain textures commonly exhibited by this rock type can be interpreted as resulting from immiscibility. The following genetic model is proposed for massif-type anorthosites; they form by accumulation of plagioclase from a magma, possibly originally basaltic to andesitic in composition, that splits into immiscible fractions during the crystallization of this mineral. The separation by flotation of a light, silica- and alkali-rich, immiscible liquid from the original magma buffers the accumulating plagioclase at a relatively constant composition and enriches the upper part of the magma chamber in those components that eventually form quartz mangerite. Continued separation of plagioclase crystals and globules of immiscible silica-rich liquid from the original magma causes it to become increasingly more mafic, and eventually to crystallize as jotunite, which typically occurs between anorthosites and quartz mangerites in the field. (Author's abstract)

PICHAVANT, Michel, 1981, An experimental study of the effect of boron on a water saturated haplogranite at 1 Kbar vapor pressure: Contrib. Mineral. Petrol., v. 76, p. 430-439. Author at Centre de Recherches Pétrographiques et Géochemimiques, C.O. no. 1, F-54500 Vandoeuvre-les-Nancy, France.

An experimental study of the effect of boron in the water saturated Q-Or-Ab-B_2O_3-H_2O system has been performed at P = 1 Kbar to provide experimental data and explain the role of boron in some late magmatic and early hydrothermal events. Experiments were conducted between 500°C and 800° starting from a gel, or a previously crystallized gel, and variable amounts of boron (0 to 18% B_2O_3) added to water. The phases obtained were: quartz, sanidine, albite, silicate liquid quenched to glass, and aqueous vapor phase. Boric acids, borates and isotropic low index materials were found in the quenched vapor phase. An aluminium silicate-like mineral, not yet fully identified, is also present.

The solidus temperature of the Q-Or-Ab composition is lowered by 60°C when 5 wt. % B_2O_3 is added and by more than 130°C when 17 wt. % B_2O_3 is added. Compositions of equilibrated silicate melts and vapors were obtained between 780°C and 750°C for various B_2O_3 concentrations. The vapor phase is B and Si rich. It is also enriched in Na with respect to K, and in alkalis with respect to Al. Its silicate solute content is higher than in experiments with pure water. The solubility of water is increased by the addition of boron in Q-Or-Ab melts. Microprobe data show that the melts equilibrated with vapor phases become hyperaluminous and more potassic than sodic. The partition coefficient of boron is in favor of the vapor (K_D = B_2O_3% in melt/B_2O_3% in vapor = 0.33 ± 0.02). The effect of the interaction between the silicate phases and the vapor is discussed. Comparison is made between the behavior of boron and that of chlorine and fluorine. Geological applications are also provided, which concern the influence of boron on minimum melting, on muscovite stability and on the hypersolvus-subsolvus transition. (Author's abstract)

PICHAVANT, M., SCHNAPPER, D. and WEISBROD, A., 1981, The system albite-quartz-NaCl-H_2O; result at P=2 kbar, T=780°C (abst.): Terra Cognita, 1981 Spring, Special Issue, p. 41-42. Authors at CRPG-CNRS, C.O. no. 1, 54500 Vandoeuvre, France.

In order to study the mechanisms of interaction between a crystallizing granitic magma and a chloride-bearing solution, an isothermal isobaric (P = 2 kbar; T = 780°C) section was determined in the system Ab-Q-NaCl-H_2O. Ab and Q are taken in the eutectic proportions and are considered as a single "granitic" component.

The vapor invariant point of the three phase triangle liquid + crystals + vapor was located at about 45% NaCl. The silicate solute content was not determined but is very low. The low amount of Cl dissolved in the Ab-Q melt (0,12%) is consistent with the data obtained for comparable compositions and PT conditions. The solubility of H_2O in the melt is also in agreement with the published results. The acid values of the quench-pH of the saline solutions show that Cl and Na are strongly partitioned between the melt and the vapor. These data can be applied to the generation of early brines in porphyry coppers. They also demonstrate the small influence of Cl upon the physical properties of aluminosilicate melts, compared to boron or fluorine. (Authors' abstract)

PIKE, J.D., POPP, R.K. and TIEH, T.T., 1981, Feldspar diagenesis in the Yowlumne sandstones-II. Geochemical considerations (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 529.

PINEAU, Françoise, JAVOY, Marc, BEHAR, Françoise and TOURET, Jacques, 1981, The isotopic geochemistry of the Bamble granulite facies (Norway) and the origin of the deep crust carbonic fluids: Bull. Mineral, v. 104, p. 630-641 (in French; English abstract). First author at Lab. de Geochimie des Isotopes Stables, Dept. des Sci. de la Tere, Univ. Paris VII, 2, Place Jussieu, 75005 Paris, France.

Various carbonaceous species found in granulite facies rocks from the Bamble area (Norway) have been separated and isotopically analyzed in order to specify mantle or crustal origin. Quartz crystals in the acidic rocks contain CO_2 fluid inclusions with isotopically light carbon (-24.2 to -14.1‰ relative to PDB), which can be related to mixtures of organic carbon common in the Scandinavian basement with minor amounts of CO_2 from decarbonatation of carbonates. These inclusions are supposed to represent the memory of prograde metamorphism. Acidic rocks as well as intrusive amphibolitized mafic rocks (hyperites) contain abundant late synmetamorphic carbonate, which after their ^{18}O composition were precipitated or reequilibrated down to 400°C. Their $\delta^{13}C$ (-8.2 ± 1‰ relative to PDB) points to growing up mantle influence just after the metamorphic paroxysm. The hyperites contain also large amounts of noncarbonate carbon (400 to 1700 ppm representing 60 to 90% of the total carbon), released only upon fusion of the sample. This carbon is considered to represent carbon dissolved in the melt at the time of emplacement and trapped in the silicate network (interstitial defects or scapolite) during crystallization. Its concentration and isotopic composition (-13.9 ± 2.5‰ relative to PDB) is explained in terms of equilibrium with heavy carbonic fluid and partial outgassing under a few kbars. (Authors' abstract)

PIPEROV, N.B., PENCHEV, N.P. and ZIDAROVA, B.P., 1981, New data from studies on fluid inclusions in hydrothermal fluorites (Mikhalkovo, Bulgaria) with respect to mineral genesis: Chem. Geol., v. 32, p. 87-94. First author at Instit. Gen. and Inorganic Chem., Bulgarian Acad. Sci., 1040 Sofia, Bulgaria.

The volatiles (CO_2 and H_2O) from the inclusions in fluorite crystals from seven sites of the Mikhalkovo ore deposit were determined. Vacuum heating up to the decrepitation temperature (400°C) was used to extract the volatiles and they were later analyzed mass-spectrometrically. The salinity of the mineral-forming solutions ($\leq$1%) was evaluated using freezing temperature data. On the basis of the analytical results and some geological data, and assuming an equilibrium state between hydrothermal solutions and carbonate, the pH-values of the fluorite-forming media were calculated. In the acidity of the solution vs. temperature plot, the points from the seven ore sites delineate the crystallization field of the Mikhalkovo fluorites. The different crystal habits pertain to different regions of this field. (Authors' abstract)

PISUTHA-ARNOND, V., ELDRIDGE, C.S. and OHMOTO, H., 1981, Thermal history of the ore-forming fluids responsible for the Kuroko massive sulfide deposits in Japan (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 529. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Using the doubly-polished thin section technique, the paragenesis of minerals and the filling and freezing temperatures of fluid inclusions were determined on over 50 samples of stockwork siliceous ores from 5 Kuroko mines in the Hokuroku district of Japan. Period I mineralization is characterized by the formation of minor amounts of quartz and fine-grained, framboidal or colloform pyrite at relatively low temperatures (150°-250°C). In Period II the major mineralization of coarse-grained, euhedral to subhedral sphalerite, pyrite and galena occurred at somewhat higher temperatures of 220°-300°C. The majority of chalcopyrite and quartz formed in Period III when the temperatures were the highest at 275°-350°C. Minor sphalerite mineralization also took place in Period IV at 200°-280°C. Despite the variation in temperature, the salinity of fluids remained essentially constant at ~3 to ~6 wt.%eq. NaCl. These data confirm the suggestions made from the paragenetic study of the overlying massive ores by Eldridge and Ohmoto (GSA Abst., 1980) that the metal zoning (i.e., Cu-rich ores at the bottom and Pb-Zn-rich ores at the top) is a reverse of the paragenesis, and that the Kuroko ores were formed in an intensifying hydrothermal system in which major sulfide mineralization took place during the waxing phase of its thermal history. Such a mineralogical, thermal and saline history is expected in a seawater convective hydrothermal system that received its heat progressively and regressively from cooling igneous bodies, and obtained its metal and some of its sulfur from fractured country rocks. (Authors' abstract)

PITZER, K.S., 1981, Characteristics of very concentrated aqueous solutions, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 249-272. Author at Dept. Chem. and Lawrence Berkeley Lab., Univ. California, Berkeley, CA 94720, USA.

The electrical conductance and thermodynamic properties (activities) are described for the few aqueous electrolytes which have been investigated over the full range from fused salt to pure water. The activities are quite well represented by a simple equation originally proposed by van Laar for non-electrolytes. Comments are made concerning the properties of various strong electrolytes up to saturation concentration and their dependence on temperature up to 300°C. These properties are accurately represented by virial-coefficient equations. Such equations have been used by Harvie and Weare to calculate all of the solubility relationships in the sea-water-related system Na-K-Mg-Ca-Cl-SO_4-H_2O; the agreement with experiment is excellent. (Author's abstract)

PIZNYUR, A.V., 1981, Practical aspects of thermobarogeochemistry: Mineralog. Sbornik, v. 35, no. 1, p. 97-100 (in Russian, English abstract). Author at the L'vov Univ., L'vov, Ukrainian SSR.

A notice of the all-union school "Thermobarogeochemical methods of studies of mineral raw material" that was organized in Alma-Ata, Kazakhstan in 10-14 Dec., 1979. (A.K.)

POMÂRLEANU, Vasile, PELTZ, Sergiu and BALLA, Zoltan, 1981, The study of fluid inclusions in the hydrothermal mineralization area associated with the Zebrac-Mermezeu eruptive structure (Stinceni, Calimani Mountains): St. Cerc. Geol., Geofiz., Geogr., Geologie, v. 26, no. 2, p. 233-240 (in Romainian; English abstract).

The study of the fluid inclusions of some minerals of the gold-silver, polymetallic mineralization associated with the complex Zebrac-Mermezeu eruptive structure south of the Calimani Mountains, points to the fact that the thermic conditions of the mineralized solutions varied between 386°C and 170°C.

The possibility of a correlation between the filling degree (gas/liquid ratio) of fluid inclusions of vein minerals and the minerals of surrounding volcanites is noted. This correlation allows the delimitation of the dispersion halo of the solutions preserved as secondary fluid inclusions in the volcanite minerals. This halo is an important criterion in exploring the gold and the polymetallic mineralizations in this region. (Authors' abstract)

POMÂRLEANU, V. and POMÂRLEANU, Eleonora, 1981, Carbon dioxide in fluid inclusions of pegmatite minerals: Rev. Roum. Géol. Géophys. et Géogr., Géologie, v. 25, p. 101-108 (in English; German abstract).

A review of the amounts of CO_2 and H_2O in various minerals from various pegmatites. The CO_2/H_2O molar ratio varies from 0.05 to 0.737, and ranges widely even in the same mineral; it correlates with Th to some degree. (E.R.)

POPIVNYAK, I.V., NAMOLOV, Ye.A., OKHRIMENKO, V.G., MITROFANOV, G.L. and EKHIVANOV, V.A., 1981, Discrete character of the gold-ore-formation process (on the example of an ore region in Western Transbaikalia): Mineralog. Sbornik, v. 35, no. 1, p. 51-62 (in Russian, English abstract). Authors at the L'vov Univ., L'vov, Ukrainian SSR.

The region under study is the part of the Baikal-Muy structural-metallogenic zone; it consists of Archean gneisses, amphibolites, calciphyres and rocks of Proterozoic-Mesozoic age. The ore bodies are quartz and quartz-sulfide veins. From early to late inclusion solutions the following features are apparent: slight increase of Na, K and Li contents, high Mg and Ca contents in the initial and final stage solutions, HCO_3 and $HSiO_3$ contents increase in the late solutions but simultaneously SO_4 decreases sharply. Cl varies slightly and F contents are low or below detection. No regularities were found in the distribution of Mo, Ba, total Fe and Mn in inclusion fluids. CO_2 ranges from 3 vol.% in early quartz to 74 vol.% in late quartz, CH_4 from 1 to 20 vol.%, N_2 is most abundant in early quartz, C_nH_{2n+2} were found only in late quartz. Th values as follows: dark quartz stage 460-350°C, tourmaline-quartz stage 500-350°C, pyrite-quartz stage 460-310°C; commerical gold-sphalerite-galena stage 330-170°C, quartz-carbonate stage 160-100°C. Pressure, determined by syngenetic H_2O-CO_2 inclusions, halite-rich inclusions and heterogeneous H_2O inclusions, was from 1.1×10^5 Pa to 0.7×10^4 Pa. (Abstract by A.K.)

POPIVNYAK, I.V. and SIMKIV, Zh.A., 1981, Soluble components in mantle mineral-forming media: Akad. Nauk SSSR Doklady, v. 256, no. 4, p. 966-969 (in Russian). Authors at the L'vov State Univ., L'vov, Ukrainian SSR.

Multiple water leachates were made from pyropes extracted from kimberlite of the pipe "Sytykanskaya." The studied garnets were considered to be upper mantle relics. Garnets bear melt inclusions consisting of glass, fine-crystalline aggregates and opaque dms, Th 1290-920°C, depending on phase composition; no G/L inclusions were found in the 74 preparations studied. The specimen for water leachate was a 33-gram sample of grain size 0.5-1.0 mm, handpicked under binocular microscope. The results of determinations were as follows (in mg/250 ml of leachate): Li 0.005, Na 2.11, K 1.12, Ca 0.35, Mg 4.80, Sr 0.026, Ba 0.34, Fe 0.07, total cations 8.821, HCO_3 21.68, Cl 0.58, SO_4 0.21, $HSiO_3$ 2.14, total anions 24.61, i.e. Mg and HCO_3 prevail very strongly. Authors combine the results with the presence of soluble components in melt inclusions. (Abstract by A.K.)

POPOV, V.D., 1981, Geological structure and temperature of formation of the Egitinsk fluorite ore bodies (western Transbaikalia): Geol. i Geofiz., 1981, no. 4, p. 132-134 (in Russian).

See Appendix

POREDA, R., CRAIG, H. and MOTYKA, R., 1981, Helium isotope variations along the Alaskan-Aleutian Arc (abst.): EOS, v. 62, p. 1092. First author at Isotope Lab., Scripps Instit. Oceanog., UCSD, La Jolla, CA 92093.

Fumaroles and hot springs of the Alaskan-Aleutian Arc have been sampled for gas chemistry and helium isotope ratios. The areas studied include fumarole systems on the flanks of seven of the chain's active volcanoes from Mt. Augustine in the east to Great Sitkin in the west. The highest $^3He/^4He$ values, 7.6 ± .1 times the atmospheric ratio, occur at Mt. Augustine, Mt. Griggs, and at Okmok Volcano on Umnak Island in the eastern Aleutians, and are similar to those in vapor-dominated systems at Lassen Park [7.8-8.1 x R(atm)]. These $^3He/^4He$ ratios for volcanic arc fumaroles overlap the low end of the range of fresh mid-ocean ridge basalt glass [~7.5-9.0 x R(atm)] indicating that the dominant source of He in this volcanic arc terrain is mantle-derived. Since the highest ratios are observed in the continental part of the arc (Mt. Augustine and Mt. Griggs), the presence of continental crust and the influx of large amounts of terrigeneous sediments into the trench do not lower the $^3He/^4He$ ratio of the fumaroles or, presumably, of the magma, through addition of radiogenic ^4He. In fact, the $^3He/^4He$ ratios are consistently lower in the oceanic part of the arc. The lower ratios, relative to the continental arc, may be attributed to mantle heterogeneity or, more probably, to an increased contribution of radiogenic helium from the subducting oceanic slab which is older for the oceanic part of the arc. (Authors' abstract)

PRICE, L.C., 1981a, Primary petroleum migration by molecular solution: consideration of new data: J. Petr. Geol., v. 4, no. 1, p. 89-101. Author at U.S. Geol. Survey, Box 25046, Denver, CO 80225, USA.

Previous criticisms of primary petroleum migration by molecular solution have been: (1) the large compositional and molecular weight differences between hydrocarbons most readily dissolved in water and those found in crude oils, and (2) previously-measured aqueous petroleum solubilities were not high enough to account for petroleum deposits using reasonable geologic assumptions. New crude oil aqueous solubility data remove both of these criticisms. Above 275°C, with both increasing gas content and temperature, the solute hydrocarbons become compositionally more and more similar to, and eventually exactly match, the starting material. Mass balance calculations, using experimentally-measured crude oil solubilities, show that between 275° and 375°C, under realistic geologic assumptions, crude oil aqueous solubility is high enough to account for petroleum deposits. These new data also show that molecular solution is not a viable agent of primary petroleum migration below 275°C.

Although the new data remove these two criticisms, three others are immediately raised: (1) there is inadequate water in sediments at temperatures between 275° to 375°C for migration by molecular solution, (2) sediment hydrocarbons will be thermally destroyed by these temperatures, and (3) these high temperatures are not present in most petroleum basins. Consideration of existing data suggests these criticisms can be satisfactorily answered. It is therefore concluded that a deep-hot origin of petroleum and its migration by solution could fall within the restraints of the natural system.

It is possible much or most of the world's oil has undergone primary migation by molecular solution; however two other mechanisms may also be viable: gaseous solution, and in the case of extremely rich source rocks, some form of bulk phase migration. (Author's abstract)

PRICE, L.C., 1981b, Aqueous solubility of crude oil to 400°C and 2000 bars pressure in the presence of gas: J. Petr. Geol., v. 4, no. 2, p. 195-223. Author at U.S. Geol. Survey, Denver Fed. Center, Denver, CO 80225, USA.

This study reports aqueous solubilities of crude oil distillation fractions over the carbon number range C_1-C_{34} as a function of: temperature (100° to 400°C), pressure (100 to 2000 bars), NaCl concentration, and gas in solution (N_2, CO_2, CH_4). Experimental parameters were designed so that conditions within a petroleum basin would be duplicated. Increases in temperature increased crude oil solubility, and the higher molecular weight species were affected more positively than lower molecular weight species. Increases in pressure or salinity decreased solubility. The presence of gas in solution increased the solubility of high molecular weight hydrocarbons ($>C_{24}$) over all temperatures, and increased the solubility of lower molecular weight hydrocarbons at high temperatures (>180-260°C). Gas decreased the solubility of low molecular weight hydrocarbons at low temperatures.

Hydrocarbon solute compositional changes were also examined as a function of the above parameters. At high temperatures, both increasing gas concentration and increasing temperature caused hydrocarbon solutes to become compositionally more similar and eventually identical to the original distillation fraction. The high molecular weight hydrocarbons and saturated hydrocarbons, especially the n-paraffins, were taken into solution in progressively greater concentrations over the aromatic and low molecular weight hydrocarbons. Thus, the strong preferential uptake of low molecular weight and aromatic hydrocarbons into solution at lower temperatures was reversed. (Author's abstract)

PRICE, L.C., CLAYTON, J.L. and RUMEN, L.L., 1981, Organic geochemistry of the 9.6 km Bertha Rogers No. 1 well, Oklahoma: Organic Geochem, v. 3, p. 59-77. Authors at U.S. Geol. Survey, Box 25046, Denver Fed. Center, Denver, CO 80225, USA.

Organic geochemical analyses of fine-grained rocks from the 9.590 km Bertha Rogers No. 1 well have been carried out: total organic carbon, Soxhlet extraction and silica gel chromatography, C_{15}-saturated and aromatic hydrocarbon gas chromatography and mass spectrometry, pyrolysis, kerogen analysis, X-ray diffraction and visual kerogen analysis.

Rocks ranged in age from Permian to Ordovician; the well has an estimated bottom hole temperature of 252°C. Some data from this study are inconsistent with conventional theories concerning the generation and thermal destruction of hydrocarbons. For example, appreciable amounts of C_{15}-gas-condensate-like hydrocarbons are present in very old rocks currently at temperatures where current theory predicts that only methane and graphite should remain. Also, substantial amounts of pyrolyzable C_{15}-hydrocarbons remain on the kerogen in these deeply buried Paleozoic rocks. This suggests, at least in some cases, that temperatures much higher than those predicted by current theory are required for generation and thermal destruction of hydrocarbons. The data from this well also suggest that original composition of organic matter and environment of deposition may have a much stronger influence on the organic geochemical characteristics of fine-grained sediments than has previously been ascribed to them. The results from this well, from other deep hot wells in which temperatures exceed 200°C, and from laboratory experiments, suggest that some of the basic concepts of the generation and maturation of petroleum hydrocarbons may be in error and perhaps should be reexamined. (Authors' abstract)

PRONE, André, 1981, Use of quartz bipyramids and their inclusions as paleogeographic markers (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated).

Frequently the study of the morphology and fluid inclusions in abundant bipyramidal quartz gives some data on their original environment. They also reveal their history after liberation from rocks according to their exoscopic characteristics. These investigations need light and scanning electron microscopes. Study of the numerous quartz types in sedimentary rocks is aimed at determination of the provenance for each main basin. Utilization of heavy minerals is misleading due to the great homogeneity of stocks from Permian to Oligocene. The results obtained show the usefulness of bipyramidal quartz and its fluid inclusions as paleogeographic indicators. (Author's abstract, revised by E.R.)

PUSANOV, L.S., see PUZANOV, L.S.

PUTNAM, B.R., III and NORMAN, D.I., 1981, Genesis of the Hansonburg Mississippi Valley-type mineralization in New Mexico, based upon fluid inclusion and structural interpretations (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 534. First author at AMAX Exploration, Inc., Salem, MO 65560.

The Hansonburg Mississippi Valley-type deposits, located on the eastern-most margin of the Tertiary-aged Rio Grande rift in New Mexico are hosted in Pennsylvanian-aged reef-facies limestones. The deposits occupy karst solution-ways developed in allochthonous, fragmental layers of the host, and are characterized by nearly sequential open-space filling of galena, fluorite, barite and quartz. Fluid inclusion homogenization temperatures (200-140°C) and salinities (18-12 eq.wt.% NaCl) decrease through the paragenesis. Temperatures are higher near SE-trending faults which pre-date the main rifting event. Analysis of inclusion fluids indicate that they are hypersaline brines similar in composition to present day oil-field brines and to analyses from other Mississippi Valley-type deposits. Pb of 300 and F of 900 ppm were measured in the fluids with 1.0 wt.% CO_2. Depth estimates based upon fCO_2 and minimum fH_2O yield pressures of 70 bars during mineralization. Calculations based on the analyses and mineral equilibria predict both the mineralization and paragenesis observed, and indicated pH of 4.5, log fO_2 of -38 and log fS_2 of -15 near 200°C, with fO_2 increasing with dropping temperature (to 140°C). The results suggest that mineralization resulted primarily from a drop in temperature of nearly saturated solutions. The allochthonous-host localized atop a high caused by differential uplift across the Capitan lineament during Pennsylvanian time. Subaerial uplift with karsification of the host-unit created laminated cavities (bedding-plane anastomoses) developing in the fragmental layers. Early rifting tectonics created differential lateral displacement along the lineament's intersection with the rift, causing the SE-trending high-angle faults. Basin-brines, by utilizing these faults invaded and occupied the pre-existing open space in the host. While mixing with near-surface waters is not apparent, it cannot be ruled out. (Authors' abstract)

PUZANOV, L.S., 1981a Fluid inclusions show their origin: Piroda, 1981, no. 10, p. 23-31 (in Russian).
A review of the use of fluid inclusions. (E.R.)
PUZANOV, 1981b- See Appendix
PUZANOV, L.S. and PARTSEVSKIY, A.I., 1978, Genesis of the Seligdar apatite deposit, central Aldan: Akad. Nauk SSSR Dokl., v. 243, no. 1, p. 179-182 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., v. 243, p. 36-39, 1981).
Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 11, p. 173 (1978). (E.R.)

PUZANOV, L.S., PARTSEVSKIY, A.I. and KASHINTSEVA, Ye.N., 1978, Two high-temperature anhydrite varieties in the Seligdar apatite deposit: Doklady Akad. Nauk SSSR, 1978, v. 242, no. 5, p. 1170-1172 (in Russian; translated in Dokl. Acad. Sci., USSR, v. 242, p. 156-158). (Incorrectly given there as "Pusanov.")
Abstracted in Fluid Inclusion Research--Proc. of COFFI, v. 11, 1978, p. 174. (E.R.)

RABENAU, A., 1981, Methods for the study of hydrothermal crystallization, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 361-374. Author at Max-Planck-Inst. für Festkörperforschung, 7000 Stuttgart, FRG.

RADTKE, A.S., 1981, Geology of the Carlin gold deposit, Nevada: U.S. Geol. Survey Open-File Report 81-97, 1981, 221 pp.
Th and salinity measurements were made on quartz, calcite, realgar, barite, and sphalerite. Most salinities were either low (<4 wt.%, down to 0.0%), or high (10-17%). Th averages ranged between 70°C (0.0 salinity) and 330°C (mostly 200-300°C). Boiling was common. H, O, C, and S isotopic studies were made on various minerals. Gold was deposited by earlier, weakly acidic, 2-4 wt.% NaCl fluids at 175-200°C. Temperatures then increased to 250-300°C and boiling occurred, with loss of CO_2 and H_2S. Oxidation of evolved H_2S yielded acid solutions at 17 wt.% NaCl. (E.R.)

RAFAL'SKIY, R.P. and MASALOVICH, A.P., 1981, Determination of the instability constants of lead chloride complexes at elevated temperatures: Geokhimiya, 1981, no. 12, p. 1868-1885 (in Russian).

RAI, C.S., MUENOW, D.W. and SHARMA, S.K., 1981, Measurements of CO_2 solubility in high-pressure quenched glasses of diopside and soda-melilite compositions using high-temperature mass spectrometry and Raman spectroscopy (abst.): EOS, v. 62, p. 427. First author at Hawaii Inst. Geophys., Univ. Hawaii, Honolulu, HI 96822.

Carbon dioxide solubilities in CO_2-saturated high-pressure quenched glasses of diopside and soda-melilite compositions have been investigated using a combination of thermogravimetric/mass spectrometry and Raman spectroscopy. Glasses were prepared by quenching CO_2-saturated melts under high pressures (to 2.5 GPa) in a piston cylinder apparatus over a temperature range of 1500 to 1725°C for diopside, and 1275 to 1550°C for sodium-melilite.

Mass pyrogram of a typical diopside glass showed a bimodal release of CO_2 as well as trace amounts of methane and H_2O. The two CO_2 release-peaks are separated in temperature by approximately 100° (700° and 800°C) suggesting the presence of two carbon-containing species. In view of the Raman spectoscopic data on the same glasses, the bimodal release pattern indicates that the CO_3^{2}-ions occupy at least two distinct sites. The possible origins of trace amounts of methane and H_2O in these glasses are discussed.

The absolute concentrations of volatile species in these glasses, determined by thermogravimetric/mass spectrometry, are compared with previously published data on CO_2 solubility using β-track radio-autography[1] and Raman spectroscopy.[2] (Authors' abstract)

1. Am. Min. 65, 885, (1980).
2. Carn. Inst. Yearbook 78, 532, (1979).

RAMBOZ, C., 1981a A fluid inclusion study of an intragranitic wolframite-scheelite showing from Ardeche, France (abst.): J. Geol. Soc. (London), v. 138, no. 2, p. 215.

In the southern border of the Saint-Cierge granite, wolframite, scheelite and apatite are concentrated in strongly muscovitized facies containing 10% quartz. Fluid phases in the quartz have been studied. In rare, hyaline, idiomorphic quartz crystals, complex steam inclusions of CO_2-CH_4-NaCl-H_2O were trapped at temperatures above 360°C. In xenomorphic secondary quartz, strictly aqueous liquids were trapped at temperatures above 300°C. Phyllic alteration, silica dissolution and tungsten transport are related to the circulation of the carbonic steam. Dilution of the carbonic fluids by aqueous liquids may have caused tungsten deposition. (Author's abstract)

RAMBOZ, Claire, 1980b, Geochemistry and fluid phase study of Sn-W deposits and showings from the southern Massif Central (France): Thesis, Doc. de Spec. (3e Cycle), Inst. Nat. Polytech, de Lorraine (in French).

The thesis documents the information summarized in earlier abstracts (Ramboz, 1980a,b,c; COFFI, v. 13, 1980, p. 201-202). Part I, based on microthermometric and Raman microprobe analyses of fluid inclusions in quartz, examines the relation of Sn-W mineralization to the physical chemistry of the system CO_2-CH_4-NaCl-H_2O (see Ramboz, 1980c). Parts II-III present the petrographic, geochemical and fluid inclusion studies of three showings and three economic deposits of Sn-W mineralization from the southern Massif Central. Two principal types of two-phase are described (see Ramboz, 1980a,b): Gas-rich inclusions represent a CO_2-rich vapor phase trapped at 400-550°C and 500-750 bars; the vapor phase contained dissolved SiO_2, Sn, W, B and P. Liquid-rich inclusions represent an H_2O-rich liquid phase, containing variable amounts of CO_2 and salts, that homogenizes between 160° and 360°C. Ramboz interprets the geochemical and fluid phase relations to indicate that phyllic alteration, silica dissolution and Sn-W transport are related to hydrothermal circulation of CO_2-rich vapor phase; the evidence is consistent with Sn-W and silica deposition due to dilution of the CO_2-rich fluids by aqueous fluids. (English summary by Mark J. Lugsdon)

RAMBOZ, Claire, PICHAVANT, Michel and WEISBROD, Alain, 1981, Constraints for identifying unmixing processes from the study of fluid inclusions (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). First author at C.R.P.G., Case Officielle no. 1-54500 Vandoeuvre, France.

Unmixing processes are often invoked to account for the occurrence in crystals of two chemically and/or physically constrasted fluids. The P-T-X phase relations in the H_2O-CO_2, H_2O-NaCl, and H_2O-CO_2-NaCl systems define constraints on such interpretations.

1) Unmixing within a P-T range reproducible under the microscope. At the temperature of the unmixing, a phase equilibrium must be observed in the same T range in the two populations of inclusions interpreted as cogenetic. This equilibrium is necessarily an equilibrium in the fluid state ($L + V \rightleftharpoons F_V$ and $L + V \rightleftharpoons F_L$), exclusive of any equilibrium involving a solid and a fluid in this T range.

2) Unmixing beyond the P-T range reproducible under the microscope. As a necessary condition, the two generations of inclusions interpreted as cogenetic must remain unhomogenized at the highest P and/or T to be reached by microthermometry. The reason is that, in the considered binary and ternary systems, no isochore can intercept an immiscibility surface) (or hypersurface) twice not intercept two (or more) immiscibility surfaces (or hypersurfaces)(sic).

3) Intersection of isochores for determining P-T conditions of unmixing. Because immiscibility surfaces expand continuously toward low pressure and temperature in systems comparable to the H_2O-NaCl-CO_2 system, a homogeneous fluid of given composition cannot unmix in the course of an isochoric evolution at increasing P and T. As a consequence, the P-T point at which the isochores of two fluids of contrasted composition intersect can never represent thermobarometric conditions of coexistence along a miscibility loop. The two fluids are homogeneous fluids along an isochoric P-T path. If they are proved to be cogenetic and at thermal equilibrium then they were formed in the P-T conditions of the intersection point; they were miscible in these conditions: inclusions of intermediate features are interpreted as resulting of a mixing of the two parental contrasted fluids. (Authors' abstract)

RAMENSKAYA, M.Ye., 1981, The van der Waals' relations between calcite and saturated hydrocarbons: Akad. Nauk SSSR Doklady, v. 257, no. 3, p. 614-618 (in Russian). Author at the Moscow State Univ., USSR.

Pertinent to formation of the hydrocarbon inclusions in minerals.(A.K.)

RASHIDOVA, G.Sh. and AKRAMOV Sh.A., 1981, Studies of gas-liquid inclusions in quartz of the deposit Kyzylalmasay: Zapiski Uzbek. Otd. Vses. Mineral. Obshch., v. 34, p. 13-15 (in Russian).

For prospecting purposes Td and thermoluminescence properties of quartz from the deposit Kyzylalmasay (ore type or metal in ore not specified) was studied. The inclusions found were one-phase L H_2O or two-phase G/L, rarely polyphase. Four varieties of quartz of various decrepitation characteristics occur in the deposit: I - one peak at the decrepitation curve at T interval 250°C (beginning) - 350°C (end); II - split peak with maxima at 280-320°C and 340-380°C; III - three peaks at 280-300°C, 320-360°C and 360-400°C, the first peak is the highest one, each following is lower than previous; IV - complicated curve with two main peaks: 240-260°C and 520-600°C (metasomatic quartz). (Abstract by A.K.)

REED, J.E., 1981, A fluid inclusion study of the Tintic district, Utah: Master's thesis, Univ. Missouri, Rolla, MO, 83 pp.
Indexed under fluid inclusions. (E.R.)

REYF and BAZHEEV, 1981 - See appendix

RICE, J.M., 1981, Phase equilibria governing the metamorphism of rodingite in the system $CaO-MgO-Al_2O_3-SiO_2-CO_2-H_2O$ (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 538.

RICHARDSON, C.K. and PINCKNEY, D.M., 1981, Temperature and salinity variations during ore deposition at the Deardorff mine, Cave-in-Rock district, Illinois (abst.): Geol. Soc. Am. Abstracts with Program, v. 13, p. 538. First author at Dept. Earth Sci., Iowa State Univ., Ames, IA 50011.

Homogenization temperatures and fluid salinities were measured in inclusions from a distinctive purple band that occurs in fluorite crystals from 41 sample locations throughout the Deardorff Mine, Cave-in-Rock District, Illinois. This band acts as a paragenetic marker, recording one stage in fluorite deposition. Temperatures and salinities vary across the mine, delineating individual fluid upwelling areas within a series of coalescing pod-like "mini-orebodies." These areas show concentric temperature patterns with temperatures dropping as much as 5° to 6°C over 25 to 50 feet. The total temperature range is 140-153°C. Salinities for these same samples show very little change over these "mini-orebodies" (19.6-20.5 NaCl equiv. wt. %). Quartz samples from the Deardorff Mine show zoning of clear and milky bands. Homogenization temperatures on inclusions from the clear inner and outer parts of the quartz crystals yield low temperatures around 115-145°C whereas inclusions in the milky bands yield temperatures of 175-185°C. The salinities of the inclusions in the milky quartz are 20-20.5 NaCl equiv. wt. %. Studies on inclusions in sphalerite have yielded temperatures and salinities equal to those in fluorite. Temperature appears to be a significant factor in the deposition of the ore at the Deardorff Mine. (Authors' abstract)

RICKARD, D., 1981, Comments on precipitation and mixing mechanisms in Laisvall-type sandstone lead-zinc deposits: Org 81; Annual Report of the Ore Research Group, D. Rickard, ed., Stockholm Univ., p. 178-198.

Laisvall-type sandstone lead-zinc deposits are formed through the interaction of two solutions, a hotter, metalliferous brine and a cooler, less saline, sulfidic solution of local origin. Mixing of these two solutions occurs initially by salt finger convection and molecular diffusion and subsequently by convective processes as the densities of the fluids equalize. Resultant ore geometries are typically stratigraphically high level layers of low grade mineralization (representing the initial mixing stage) extending into an irregular, cross-cutting mass of high grade mineralization reflecting the convection cell in size and form.

The greater diffusivity of heat causes calcite to be precipitated first before minerals, such as sphalerite and galena, which depend on mixing for precipitation. As the temperature decreases on mixing the initial calcite redissolves, causing corrosive textures. Penetration of further brine pulses, with concomitant re-heating produces more calcite precipitation, and sulfide mineral dissolution. The combination of several brine pulses with effects due to double diffusion leads to the observed complex paragenesis of a few simple minerals. (Author's abstract)

RINGROSE, C.R., HARMON, R.S., JACKSON, S.E. and RICE, C.M., 1981, Stable isotopic composition of fluid inclusions in a porphyry-style hydrothermal system near Silverton, San Juan Mountains, Colorado (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 538. First author at Dept. Geol. and Min., Univ. Aberdeen, Aberdeen, Scotland, UK.

A porphyritic monzonite intrusion (25.1my), outcropping along the northern side of the Sultan Mountain monzonite stock (25.9my), occurs within an area of strong sericitic to argillic alteration (25.0my) which is superimposed upon the regional meteoric propylitization and which is characterized by country rock enrichment in both D and ^{18}O.

D/H ratios for fluid inclusions (dominantly halite-bearing and vapor-rich types) in quartz + MoS_2 veinlets from the central zone of mixed sericitic to argillic alteration range from -109 to -73‰ with quartz $^{18}O/^{16}O$ ratios of +7.6 to +9.5‰. By contrast, fluid inclusions (liquid-rich types) in quartz from barren and base-metal veins from within the peripheral propylitized rock have D/H ratios of -137 to -83‰ and quartz $^{18}O/^{16}O$ ratios of -2.8 to +9.7‰. Limited homogenization data indicate fluid temperatures of 200-420°C in the central zone and 210-310°C in the peripheral zone. At these temperatures, the calculated $^{18}O/^{16}O$ ratios of the fluids in the central and peripheral zones are -4.6 to +5.3‰ and -14.4 to +2.7‰ respectively.

These data suggest: 1) magmatic fluid, released from a partially-consolidated stock, caused molybdenum mineralization as well as sericitic alteration and D and ^{18}O enrichment of the local country rock, 2) this fluid mixed with an active meteoric hydrothermal convection cell which had been established adjacent to the stock - the initial mixing region being marked by Pb-Zn-Py mineralization, and 3) hydrothermal circulation collapsed inwards as the stock cooled, adding a meteoric D/H overprint to portions of the system. (Authors' abstract)

RISON, W. and CRAIG, H., 1981, Loihi Seamount: mantle volatiles in the basalts (abst.): EOS, v. 62, p. 1083. Authors at Isotope Lab., Scripps Inst. of Oceanogr., UCSD, La Jolla, CA.

Loihi Seamount is erupting tholeiites (TH) and vesicular alkali basalts (AB) at the site of the Hawaiian hot spot. A study of rare gases, C, and H_2O is in progress: tholeiitic Ne (<.3 ncc/g) and Ar (<30 ncc/g) are so low that isotopes are not yet measured, but other data on glasses include:

SAMPLE	He (μcc/g)	He^3 R/R_A	C (ppm)	δC^{13} (PDB)	H_2O (%)	δD (SMOW)
TH:29-10	0.56	27.2	128	-24.0	0.39	-77
AB:15-04	0.040	5.4	150	-20.0	0.77	-73
AB:21-02	0.023	5.4	163	-15.0	0.95	-71
AB:20-04	0.36	24.6	-	-	-	-

where R/R_A is $He^3/H3^4$ relative to air He. In agreement with Kurz et al.

(1981) we find 3/4 ratios up to 27x atmospheric, ~twice our value (15 x R_A) for Kilauea gases, and 3 times greater than mean MORB He. Maui 3/4 ratios are even higher, up to 31.6 x R_A. Alkali basalts have high 3/4 ratios in vesicles (AB:20-04 in table, He extracted by crushing; all others = total He by melting). For AB:15-04, vesicle He has R = 20.8 x R_A, and 89% of the He is in the glass with R = 3.5 x R_A. A Kilauea East Rift Zone dredged glass similarly has R = 13 x R_A in vesicles and 9 x R_A for total He, with 71% of the He in the glass. For normal U+Th, these data correspond to apparent ages of 10^5 years since eruption and vesiculation, about 10x actual ages. Although these effects are not yet understood, the He isotope data show clearly that vertical transport of plume material from a deep mantle source is required at the Hawaiian hot spot.

C and H_2O increase linearly from Th:29-10, with similar C-13 and D/H trends. The tholeiitic D/H value is identical with mean MORB (-77 per mil), a strong argument that normal MORB H is unaffected by subduction water. Carbon in TH:29-10 is isotopically similar to Hawaiian basalt C; in AB:21-02 it is similar to mean C (CO_2+C) in MAR "Popping Rocks." (Authors' abstract)

ROBERT, F., MERLIVAT, L. and JAVOY, M., 1981, Hydrogen isotopic composition of fluid inclusions in the St-Severin meteorite (abst.): Terra Cognita, Spec. Issue, Spring 1981, p. 47-48. First author at Lab. de Geochimie des Isotopes Stables, Dept. des Sci. de la Terre, Uni. Paris VII, 2, place Jussieu 75251 Paris Cedex 05, France.

Hydrogen isotopic compositions have been measured for fluid inclusions recently discovered in felspar and apatite from the St-Severin and Peetsz meteorites which consist of essentially pure water. Our hydrogen extraction technique allows us to trace the release pattern of hydrogen compounds and their isotopic compositions as a function of the extraction temperature. Samples are outgassed in an helium flow and hydrogen is selectively introduced into the source of the mass spectrometer through a palladium thimble. The minimum amount of gas we need for an isotopic analysis is $2x10^{-3}$ μ moles. The calibration of the experimental apparatus was made using terrestrial micas,+an equilibrated ordinary chondrite (Guarena H6) previously analyzed with the techniques of classical pyrolysis. A feldspar separate from the Estacado meteorite was analyzed in order to observe the release pattern of inclusion-free mineral that was separated with chemical techniques that are similar to those used for St-Severin. The release pattern of hydrogen isotopic composition from the St-Severin feldspar, clearly shows a low deuterium compound (<-300‰) at 600°C. Although a further investigation is needed, we attribute this unique isotopic pattern to the decrepitation of fluid inclusions. Mass balance calculation taking into account both the experimental background and the mineralogical estimation of total hydrogen expected from inclusions, indicates isotopic compositions as low as -800‰ for this component which is close to the present estimates of primordial D/H in the solar system. (Authors' abstract)

ROBINSON, R.W. and NORMAN, D.I., 1981, Ore mineralogy and fluid inclusion study of the southern Amethyst vein system, Creede, Colorado (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 539. Authors at Geosci. Dept., New Mexico Inst. Mining and Tech., Socorro, NM 87801.

One of the most productive areas in the Creede mining district was the southern portion of the Amethyst vein. This area has received limited attention in the numerous studies on the district of recent years.

Mineralization is fine grained and occurs in veins and is disseminated in zones of high fracture density and/or brecciation. Sericitic cap rock which occurs over most of the Amethyst vein and is attributed to fluid boiling doesn't occur in the southern portion of the vein. However, isolated occurrence of intense sericitic alteration and minor amounts of fluid inclusions rich in CO_2 and/or CH_4 are evidence that a limited amount of boiling may have occurred during mineralization.

The paragenesis is divided into two stages with economic quantities of silver and base metals occurring in the second stage. Stage one mineralogy is rhodochrosite, quartz, barite, calcite and base metal sulfide; stage two mineralogy is quartz, barite, base metal sulfides, sulfosalts, and native Ag.

Fluid inclusion analysis indicated mineralizing fluids of 130 to 260°C and salinity 2-13 eq.wt.% NaCl. Homogenization temperature and salinity show a regular decrease with mine elevation (a distance of 365 m). Enthalpy-salinity and enthalpy-elevation plots of the fluid inclusion data are linear.

Mixing of hot mineralizing solutions and cooler, low salinity, shallow waters is proposed to explain the data. Precipitation of metals from solution is proposed to have been caused by the rapid cooling and dilution of the ore fluids resulting from mixing. (Authors' abstract)

ROEDDER, Edwin, 1981a Significance of Ca-Al-rich silicate melt inclusions in olivine crystals from the Murchison type II carbonaceous chondrite: Bull. Minéral, v. 104, p. 330-353.

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 13, 1980, p. 209-210 (title slightly different). (E.R.)

ROEDDER, Edwin, 1981b Natural occurrence and significance of fluids indicating high pressure and temperature, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds; Physics and Chem. of the Earth, v. 13/14, p. 9-40. Author at U.S. Geol. Survey, Reston, VA 22092, USA.

Most natural minerals have formed from a fluid phase such as a silicate melt or a saline aqueous solution. Fluid inclusions are tiny volumes of such fluids that were trapped within the growing crystals. These inclusions can provide valuable but sometimes ambiguous data on the temperature, pressure, and composition of these fluids, many of which are not available from any other source. They also provide "visual autoclaves" in which it is possible to watch, through the microscope, the actual phase changes take place as the inclusions are heated.

This paper reviews the methods of study and the results obtained, mainly on inclusions formed from highly concentrated solutions, at temperatures ≥500°C. Many such fluids have formed as a result of immiscibility with silicate melt in igneous or high-temperature metamorphic rocks. These include fluids consisting of CO_2, H_2O, or hydrosaline melts that were <50% H_2O. From the fluid inclusion evidence it is clear that a boiling, very hot, very saline fluid was present during the formation of most of the porphyry copper deposits in the world. Similarly, from the inclusion evidence it is clear that early (common) pegmatites formed from essentially silicate melts and that the late, rare-element-bearing and chamber-type pegmatites formed from a hydrosaline melt or a more dilute water solution. The evidence on whether this change in composition from early to late solutions was generally continuous or involved immiscibility is not as clear. (Author's abstract)

ROEDDER, E., 1981c Origin of fluid inclusions and changes that occur after trapping, Chapter 5, pp. 101-137, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 5 Contents

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ROEDDER, Edwin, 1981d Use of lunar materials in space construction: Space Solar Power Rev., v. 2, p. 249-258. Author at U.S. Geol. Survey, National Center, Stop 959, Reston, VA 22092.

Of pertinence here only insofar as the high-K granitic glass found in the lunar basalts, and frequently trapped as melt inclusions since it was present as an immiscible silicate fluid, has considerable potential use in space construction. (E.R.)

ROEDDER, Edwin, 1981e Are the 3,800-Myr-old Isua objects microfossils, limonite-stained fluid inclusions, or neither?: Nature, v. 293, p. 459-462. Author at U.S. Geol. Survey, 959, Reston, VA 22092, USA.

Bridgwater et al. issued a 'cautionary note' concerning several reports published by Pflug and co-workers describing objects called yeast-like microfossils (Isuasphaera isua Pflug) from a metamorphosed quartzite of the 3,800-Myr-old Isua supracrustal belt of south-west Greenland; Bridgwater et al. believe that the objects described by Pflug et al. are 'indistinguishable from limonite-stained fluid inclusions' and hence are non-biogenic. I show here that the objects are neither limonite-stained fluid inclusions nor microfossils, but are limonite-stained cavities from the otherwise complete dissolution by weathering of ferruginous dolomite grains in these rocks. Several supporting arguments presented by both sides are believed to be invalid, and others are ambiguous. In view of the extensive research on the earliest life forms, and their significance to evolution, to early geochemical cycles and to the origin of the atmosphere and some ore deposits, the exact nature of the Isua objects, and particularly the validity of the evidence either for or against a biological origin, are of considerable importance. A careful evaluation of the evidence from Isua is particularly pertinent, as bona fide Precambrian fossils are also found in chemically similar (but much younger) silica-rich environments. (Author's abstract)

ROEDDER, Edwin, 1981f Problems in the use of fluid inclusions to investigate fluid-rock interactions in igneous and metamorphic processes: Fortschr. Miner., v. 59, no. 2, p. 267-302. Author at U.S. Geol. Survey, National Center, Stop 959, Reston, VA 22092, USA.

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 13, 1980, p. 208-209 (with different title - see "Roedder, 1980a"). (E.R.)

ROEDDER, Edwin, 1981g CO_2-, sulfide-melt-, and silicate-melt inclusions in olivine nodules from Loihi Seamount, Hawaii (abst.): EOS, v. 62, p. 1083. Author at 959 U.S. Geol. Survey, Reston, VA 22092.

Abundant fluid inclusions in olivine of dunite nodules (~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 the olivine crystals. Some olivine xenocrysts, possibly from disaggregation of nodules, contain similar inclusions.

Most of the inclusions (2-10μm) are on planes (secondary), trapped during rehealing of fractures some time after the original crystal growth. Some such planes end abruptly *within* single crystals and hence are pseudosecondary, formed *during* the growth of the host olivine crystals. The "vapor" bubble in a few large (20-60μm), 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, aggregate d = ~0.6-0.8 g·cm^{-3}, and represent trapped globules of dense supercritical CO_2 (i.e., incipient "vesiculation" at depth). Some spinel crystals enclosed within olivine also 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, proving that an immiscible sulfide melt was also present.

Assuming olivine growth at 1,200°C, extrapolations of CO_2 P-V-T data indicate that these inclusions were trapped at 300-550mP (3,000-5,000b*), or 10-18 km depth in basalt magma of d = 3.0 g·cm^{-3}. Because the temperature is relatively constant, the range of CO_2 densities reveal the change in pressure from original olivine growth through later deformation and rise to eruption on the sea floor. (Author's abstract)

*Incorrectly given as kb in original.

ROEDDER, E. and BASSETT, R.L., 1981, Problems in determination of the water content of rock-salt samples and its significance in nuclear-waste storage siting: Geology, v. 9, p. 525-530. First author at U.S. Geol.

Survey, 959 National Center, Reston, VA 22092.

The in situ water content of rock salt in beds or domes and the exact nature of its occurrence are of considerable importance for the safe design and operation of nuclear-waste storage facilities in salt deposits. Most published determinations of the "water content" of salt are not comparable. Many determinations contain serious, and in part systematic, errors. The multiplicity of water sources in salt samples, the methods of sample selection and preparation, and the analytical methods used are such that some of these results may be low by as much as an order of magnitude. There is no panacea, but most of the sources of error can be minimized. (Authors' abstract)

ROEDDER, Edwin and BELKIN, H.E., 1981, Petrographic study of fluid inclusions in salt core samples from Asse mine, Federal Republic of Germany: U.S. Geol. Survey Open File Rept. 81-1128, 33 pp. Authors at U.S. Geol. Survey, Reston, VA.

A series of 12 core samples from the Asse salt mine in F.R.G. were studied to determine the amount and nature of fluid present as fluid inclusions. The samples as received were badly fractured due to the coring procedure used, and hence were completely unsuited for quantitative analysis of the water present, but some qualitative petrographic studies could be made. The salt was found to be relatively impure, as these samples contained an average of 9% by weight of insoluble residues, mainly anhydrite.

These samples contain water in at least three forms: intracrystalline (in part primary) fluid inclusions, intercrystalline (grain boundary) fluid inclusions, and hydrous minerals. Quantitative estimates are not possible due to the nature of the samples, but intracrystalline water may be larger than intercrystalline water. Practically all intercrystalline water and much of the intracrystalline water has been lost through cracks probably introduced during coring. Most of the grain boundaries are now hairline cracks from which fluid can be seen to ooze out over a period of a few days, and most hydrous accessory mineral grains lie along such grain boundaries. Some features of the very erratic distribution of the intracrystalline inclusions raise interesting and at present unanswered questions concerning their genesis and the geological history of these salt deposits.

The fluid in these fluid inclusions is not simply a saturated NaCl brine, but a bittern that must contain very significant amounts of $CaCl_2$, plus gases of undetermined composition under relatively high pressure. The gas-rich inclusions could contribute to decrepitation of the walls during heating tests, and expansion of this gas might also help to push intergranular liquid to regions of lower pressure.

If valid data on the water content of the salt beds at the specific nuclear waste test site at Asse are to be obtained to use in calculations of the potential flow to be anticipated during the test, and to use as the source term in various mathematical models of brine migration after the test, more appropriate samples are required. (Authors' abstract)

ROSSOVSKIY, L.N., 1980, Rare-metal pegmatites with precious stones and conditions of their formation (Hindu Kush): Vses. Mineralog. Obshch. Zapiski, 1980, v. 109, no. 3, p. 301-311 (in Russian; translated in Int'l. Geol. Rev., v. 23, no. 11, p. 1312-1320, 1981).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 13, p. 213, 1980. (E.R.)

ROVETTA, M.R., 1981, Melt and vapor migration in the upper mantle: ultramafic nodule permeability estimated from fluid/melt inclusions (abst.): EOS, v. 62, p. 1062. Author at Dept. Oceanogr. WB-10, Univ. Washington, Seattle, WA 98195.

Measurement of CO_2 fluid/melt inclusion (1) abundance, (2) diameter, (3) array length, and (4) diameter to spacing ratio provides data to estimate in situ microfracture (1) width, (2) length, (3) hydraulic radius, and (4) porosity under the assumption that coplanar arrays of inclusions preserve the length and volume of pre-existing cracks.

Microfracture porosity arose due to nonhydrostatic loading in the mantle and grain scale stress inhomogeneities. Fracture and creep operate simultaneously in mantle peridotite when the pore pressure due to melt and vapor reduces the effective pressure around stress concentrations. Fluids are preserved in healed microfractures as inclusions of the lowest melting temperature assemblage in the nodule: glass, sulfide, spinel, and CO_2 fluid. Independent paleo-piezometers, based on recrystallized grain size and crack length, indicate an identical stress of 10 to 20 MPa for cracking and creep.

Bulk porosity is low, 0.003, but unrecrystallized porphyroblasts preserve a relict porosity as high as 0.03. Application of Poiselkuille's law provides permeability estimates of 10^{-18} and 10^{-15} cm^2 respectively; values far too low to allow the host basalt entry into the nodule during ascent, but large enough to provide a significant mass transport path in situ over long time periods. Transport throught observed microfractures would be 10^3 times more rapid than the most rapid grain boundary diffusion ($D = 10^{-8}$ cm^2/s).

Rewetting of dry grain boundaries is unnecessary for a subsequent melt or metasomatic fluid to permeate a refractory region of the mantle if a sufficient nonhydrostatic stress exists. Porosity and permeability will increase spontaneously when melt and vapor reduce effective pressure around stress inhomogeneities and induce microfracturing. (Author's abstract)

ROWLINSON, J.S., 1981, The thermodynamic properties of fluid mixtures, _in_ Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds,; Physics and Chem. of the Earth, v. 13/14, p. 41-64. Author at Physical Chem. Lab., South Parks Road, Oxford OX1 3QZ, UK.

ROZINOV, M.I. and KOLESNIKOV, D.I., 1981, Mineralogical-geochemical signs of ore capacity of liparites of the Okhotsk-Chukotka belt: Zapiski Vses. Mineral. Obshch., v. 110, no. 1, p. 35-47 (in Russian). Authors at All-Union Sci.-Res. Geol. Inst. (VSEGEI), Leningrad, USSR.

The paper bears some literature Th for gold-silver mineralization. (A.K.)

RUIZ, Joaquin and KESLER, S.E., 1981, Strontium isotopic geochemistry of fluorite mineralization in northern Mexico (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 542.

RUMBLE, D., FERRY, J.M., HOERING, T.C. and BOUCOT, A.J., 1981, Fluid flow during metamorphism at the Beaver Brook fossil locality, New Hampshire (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 542-543. First author at Geophys. Lab., 2801 Upton Street, NW, Washington, DC 20008.

Rocks at the Beaver Brook fossil locality were regionally metamorphosed at 3.5 kb and 600°C. Metamorphic fluids were water rich, $XH_2O>0.80$ (mole fraction), and contained variable amounts of CO_2 and CH_4 as controlled by the buffer capacity of different mineral assemblages in individual sedimentary beds. The minimum amount of fluid that flowed through the beds during metamorphism has been estimated using mineralogic and oxygen isotopic evidence. The mineralogic evidence is the extent to which decarbonation reactions have gone to completion as measured by petrographic modal analysis. The isotopic evidence is the inferred metamorphic change in the oxygen isotopic composition of fossil brachiopods. Fluid-rich ratios of 1.5-4.0 (minimum estimate, by volume) are obtained from the mineralogic evidence and ratios of 4.0-6.0 from the isotopic evidence. The large amounts of fluid flow observed at Beaver Brook are believed to be a consequence of metamorphic decarbonation reactions. These reactions, not in themselves capable of producing the computed amounts of fluid, nevertheless, are responsible for enhancing permeability sufficiently so that fluid flow could occur. (Authors' abstract)

RUMYANTSEV, V.N., 1981, Problems of information obtained by thermobarogeochemical methods and genesis of filling of quartz veins: Zapiski Vses. Mineral. Obshch., v. 110, no. 3, p. 257-265 (in Russian).

Information possibilities and limits of thermobarogeochemical methods are discussed. Together with experimental data, thermobarogeochemistry is an important source of information about physico-chemical parameters of quartz vein mineral formation. The existing hypotheses on formation of the filling of quartz veins are analyzed, many of which either do not explain all geological facts or they are not supported sufficiently by physico-chemical data. Most satisfactory explanation of essential geological peculiarities of quartz vein mineralization is possible if one accepts the injection from a magmatic chamber of a viscous, highly concentrated (with respect to SiO_2) gel-like mass (similar to "ore magma") with following crystallization of vein-filling material. This process is preceeded by formation of remnant fluids at final stages of origin of granitoids. The remnant fluids have composition $H_2O-SiO_2-Na_2O-K_2O$. Segregation of highly concentrated SiO_2 solutions is atypical feature of such fluids. This SiO_2-rich solution is under high P and hence fills fractures in one stage. The author supposes that fluorite, barite, and carbonate veins genetically connected with granitoids, may be formed this way. (Author's abstract, translated by A.K.)

RUSSELL, N., SEAWARD, M., RIVERA, J.A., McCURDY, K., KESLER, S.E. and CLOKE, P.L., 1981, Geology and geochemistry of the Pueblo Viejo gold-silver oxide ore deposit, Dominican Republic: Trans. Instn. Min. and Met., Section B, v. 90, p. B153-B162. First author at Rosario Dominicana, S.A., Santo Domingo, Dominican Republic.

Fluid inclusion studies and mineral stabilities indicate that solutions in the hydrothermal system ranged from about 300°C to less than 115°C, that they were dilute and that they boiled. These observations, as well as the funnel-like configuration of the alteration zone, suggest that the deposit was formed by a hot spring similar to those at Wairakei and Broadlands in New Zealand. (From the text)

RYABCHIKOV, I.D., 1981, Mobilization of ore metals by supercritical fluids from crystallizing magmas, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 529-536. Author at Inst. Geol. of Ore Deposits, USSR Acad. Sci., Moscow, USSR.

The available experimental data and thermodynamic calculations permit an estimate of the concentrations of volatile components and ore metals in fluids coexisting with crystallizing granitic magmas. The amounts of metals mobilized by aqueous fluid after the solidification of a granitic batholith (1000 km^3) are comparable with or even exceed the resources of large mineral deposits.

The heated exogenetic chloride solutions may be efficient agents of metals mobilization from basic magmatic rocks or metasedimentary formations.

Fluids arising in the mantle may play an indirect role in the concentration of ore metals, but it is not very likely that the large masses of such fluids reach higher levels of the earth's crust by themselves. However, volatile components dissolved in the mantle-derived magmas, may play a certain role in the hydrothermal transportation of ore material. (Author's abstract)

RYABCHIKOV, I.D., SOLOVOVA, I.P. and BABANSKIY, A.D., 1981, Studies of melt inclusions in artificial crystals: Geokhimiya, no. 12, p. 1891-1893 (in Russian). Authors at Inst. Geol. of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow, USSR.

The authors write that if during crystal growth the trapped melt is undersaturated with respect to a fluid phase, the difference between T of trapping and Th of inclusion generally may be significant; if the trapped melt coexisted with fluid, the difference is much smaller. However, Th of fluid-saturated melt inclusions may differ from T of trapping due to the fact that P in magma in time of trapping may be different than P in inclusion during homogenization, but appropriate corrections are difficult to evaluate. Experiments were made with crystals grown from water-saturated silicate melts under known P. First run was made with andesite melt at 1200±7°C, Ni-NiO buffer, P 1 atm without water, time 8 days, Pt ampules. Glass with 500 µm plagioclase phenocrysts were obtained. Plagioclase bears ~15 µm long P G + glass inclusions, Th 1195 to 1205±10°C. The second run was made in the system jadeite-diopside-water at 1000°C, 1 kbar and diopside crystals with numerous inclusions were obtained. The inclusions were mostly of G/L type, but also G + glass type. Grains of diopside were immersed in glass of composition: diopside:Na_2SiO_3 = 1:1, at T 1200°C. Th of melt inclusions in diopside crystals were 990 to 1000°C ± 10°C. Thus, Th is a sufficiently exact measure of the T of mineral growth. (Abst. by A.K.)

RYABCHIKOV, I.D., GREEN, D.H., WALL, W.J. and BREY, G.P., 1981, The oxidation state of carbon in the reduced-velocity zone: Geokhimiya, 1981, no. 2, p. 221-232 (in Russian).

RYABCHIKOV, I.D. and NOVGORODOVA, M.I., 1981, Reducing fluids in hydrothermal ore formation: Akad. Nauk SSSR Doklady, v. 258, no. 6, p. 1453-1456 (in Russian). Authors at Inst. Geol. of Ore Deposits, Petrogr. Mineralogy, Geochem. of Acad. Sci. of the USSR, Moscow.

Gases extracted from intergrowths of native aluminum with native lead and other metals (by melting of metals at T = 1000°C) were analyzed by mass spectrometry and yielded dominantly oxidized gases (CO_2, H_2O, SO_2) over the reduced ones (CH_4, CO or N_2, H_2S) in the ratio 10:1. (Continued)

Authors suppose that those gases are not primary but "reacted" gas mixture trapped in native metals. Appropriate calculations are presented. (A.K.)

An attempt to explain the widely reported occurrences of native metals (Al, Zn, Fe, Cr, etc.) in hydrothermal deposits on the basis of thermodynamic calculations assuming a hydrocarbon component (from great depths) in the ore fluids. (E.R.)

RYABCHIKOV, I.D., REKHARSKIY, V.I. and KUDRIN, A.V., 1981, Mobilization of molybdenum by fluids during the crystallization of granite melts: Geokhimiya, 1981, no. 8, p. 1243-1246 (in Russian).

RYZHENKO, 1981 - See Appendix

RYZHENKO, B.N., MEL'NIKOVA, G.L. and SHVAROV, Yu.V., 1981, Computer simulation of chemical composition of natural solutions in the system water-rock: Geokhimiya, no. 4, p. 481-495 (in Russian, English abst.). Authors at the Moscow State Univ., Moscow, USSR.

Calculations were made for the "systems:" alumosilicate rocks-water solution-CO_2, alumosilicate rocks-water solution bearing Cl-CO_2 at T 25-300°C; pertinent to fluid inclusion studies. (A.K.)

SABOURAUD, Christiane, 1981, Experimental decrepitation of fluid inclusions under pressure. Application to the case of primary inclusions in fluorite: C.R. Acad. Sci. Paris, v. 292, p. 729-732 (in French).

Primary fluid inclusions in fluorite, Th ≤50°C, were subjected to 3 experimental conditions:

	1	2	3
Internal pressure (bar)	2200	3200	3600
Confining pressure (bar)	400	1000	400
Inclusions not decrepitated (%)	82	70	53

The decrepitated inclusions had new Th values and densities near to those of the autoclave. (E.R.)

SABOURAUD, C., MACQUAR, S.-C. and ROUVIER, H., 1981, Response to the observations of J.-C. Touray and A. Ziserman: Mineral. Deposita, v. 16, p. 181-183.

A response to the criticism of Touray and Ziserman (1981; see abstract this volume) of an earlier paper. Sabouraud et al. believe their calculations are correct. (E.R.)

SAKHAROVA, M.S., BATRAKOVA, Yu.A. and RYAKHOVSKAYA, S.K., 1981, The effects of pH on the deposition of gold and silver from aqueous solution: Geokhimiya, 1981, no. 3, p. 371-378 (in Russian).

SAMAMA, J.-C. and THOUVENOT, Claude, 1981, The foreign elements of authigenic overgrowths of minerals: primary solid inclusions of secondary contamination?: C.R. Acad. Sc. Paris, v. 292, Ser. II, p. 333-336 (in French).

The discrimination between primary and secondary solid inclusions occurring in authigenic quartz overgrowths of clastic rocks cannot result from textural analysis only. Point analysis of specific elements can show some zonal distribution which proves the development of secondary contamination and calls in question again the usual textural criteria of identification of primary solid inclusions. (Authors' abstract)

SAMSON, Iain, 1981, Fluid inclusion studies on minerals from the feeder zones to the exhalative Zn + Pb deposit: Silvermines, Ireland (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Univ. Strathclyde, Scotland.

The Silvermines Zn+Pb(+Ba) deposit in Ireland is an example of a "non-volcanogenic" exhalative base metal deposit. It is syngenetic with Waulsortian mudbank limestones and dolomites of Tournaisian age. It is one of the few deposits of this type to have a substantial epigenetic feeder system below it, which at Silvermines is undeformed.

The study of fluid inclusions in quartz, sphalerite, barite, calcite and dolomite from the epigenetic mineralization has revealed that the mineralizing fluids had salinities of between 10 and 27 equiv. wt.% NaCl and temperatures of between 95 and 265°C.

The presence of vapor-rich inclusions indicates that the fluids were boiling. This causes a decrease in temperature and an increase in pH, both of which can result in mineral precipitation. Boiling may be the reason for the epigenetic mineralization at Silvermines. The fact that the solutions were boiling allows an estimate for the depth of seawater at Silvermines ($\leq$200m).

Leachate analyses indicate K/Na ratios of between 0.05 to 0.39 (average 0.2). K/Ca ratios are very variable ranging from 0.17 to 6.8. Mg contents are low, K/Mg ratios ranging from 1.7 to 32.7.

It is not possible for this deposit to have formed as a result of the explulsion of basinal brines as temperatures are too high. Also, Mississippi Valley type deposits have typically low K/Na ratios (0.01 to 0.05), which is again not the case at Silvermines.

Preliminary oxygen and hydrogen isotope analysis of the inclusion fluids and of quartz suggest a non-magmatic origin for the fluids. The fluids were probably in equilibrium with metamorphic rocks at some time and it is therefore probable the Lower Paleozoic metasedimentary pile underlying the deposit was the source for the ore metals in the deposit. (Author's abstract)

SANTIVÁÑEZ, Reynaldo, HEIN, Ulrich and SCHNEIDER, H.-J., 1981, Studies of fluid inclusions in vein quartz of the Sn-W deposit Chojlla/Bolivia: Zbl. Geol. Palaontol. Teil I, v. 3/4, p. 478-493 (in German; English abstract).

The Chojlla deposit, Cordillera Real/Bolivia, represents the common type of wolframite-cassiterite-quartz vein systems predominating in the North Bolivian metallogenetic province, which is connected with granitic intrusions of Mesozoic age in time and space. Within the Ordovician sedimentary host rock series of low grade metamorphism some granitic apophyses are explored on the lowermost level of the mine. This granite was considered to be the source of the mineralization formed by a sole hydrothermal phase.

The extraordinary vertical extension of the mineralization however (for Chojlla mine alone 550 m) necessitates a new genetical concept presuming a polyphase ascended remobilization. Determinations of the H/F coefficient of wolframites as well as trace element fractionation in fluorites and cassiterites point to a distinct geochemical recurrence which is indicated in between the mining levels 4 and 5.

Three types of fluid inclusions are to be detected in the vein quartzes: Type A contains only aqueous solution, type B aqueous solution and CO_2, and type C pure CO_2 solely. Especially the appearance of CO_2 within the inclusions underlines the recurrence mentioned above.

Homogenization temperatures of primary inclusions range from 190°C to 377°C in the Chojlla mine and from 216°C to 331°C in the Enramada mine.

Freezing temperatures indicate a salinity of at least 10-15% equiv. NaCl for the quartz forming solutions. Genetical conclusions are discussed. (Authors' abstract)

SATO, Juichi, ENJOJI, Mamoru, OKEYA, Mitsuo and ONO, Shuji, 1981, Black-colored ore of the Pifue-Honpi vein, the Chitose mine, Hokkaido, Japan: Mining Geol. (Japan) Special Issue 10, p. 127-142 (in English). First author at Dept. Min. Resources Dev. Engrg., Faculty of Engrg., Hokkaido Univ., Sapporo 060, Japan.

The features of ore mineralogy and inclusion of black-colored ore are described in this paper in comparison with those of other kinds of ore from the Pifue-Honpi vein of the Chitose mine and from other veins of this type.

The Pifue-Honpi deposit of the Chitose mine is of an epithermal fissure-filling gold- and silver-bearing quartz vein type, closely related to the igneous activity of Late Miocene age. It is situated at the northern end of the Fukujinzawa vein swarm. The vein shows a banded structure composed of the following four kinds of ores, in the sequence of their formation: brecciated ore; banded ore; black-colored ore; and, white quartz ore. The black-colored ore is found only in the Pifue-Honpi vein, and generally occurs in the form of a vein and as a lense in some parts. The ore is composed of a large amount of quartz, a small amount of pyrite and black matter, and a minor amount of adularia, chalcopyrite and marcasite.

The feature and origin of the minute black matter, which is a major source of the color of the ore, is of special interest. By a high frequency induction furnace method it was assumed that the carbon content of the black-colored ore was about 2.2 wt.% as a bulk sample. By the X-ray microprobe analysis, the carbon content of the black matter was found to reach to about 20 wt.%. Microscopic observation, scanning electron microscopic observation, and X-ray diffraction analysis suggested that the black matter is amorphous. Microscopic and thermal examinations, and stoichiometric relation between CaO and carbon contents show that the black matter is not a carbonate.

Another feature of interest is glass inclusions found in quartz grains which constitute the black-colored ore. Quartz grains are composed of two parts: a core and a marginal rim, showing an overgrowth structure. Quartz of the core part includes various kinds of glass inclusions, and is obviously of the high-temperature type.

Quartz of the marginal rim includes primary fluid inclusions composed of liquid and vapor. Homogenization temperatures of the fluid inclusions were within the range of 230°-250°C, and the salinity inferred from the melting temperature of frozen inclusion was 0.1-2.0 wt.% NaCl equivalent. (Authors' abstract)

SAVEL'YEVA, N.I. and NAUMOV, G.B., 1979, Methods of analyzing salt composition for fluid inclusions in minerals: Geokhimiya, 1979, no. 5, p. 730-736 (in Russian; translated in Geochem. Int'l., v. 16, no. 3, p. 65-70, 1980).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 12, 1979, p. 168. (E.R.)

SAWKINS, F.J. and SCHERKENBACH, D.A., 1981, High copper content of fluid inclusions in quartz from northern Sonora: implications for ore-genesis theory: Geol., v. 9, p. 37-40. Authors at Dept. Geol. and Geophys., Univ. Minnesota, Minneapolis, MN 55455.

Fluid inclusions in quartz associated with copper- and molybdenum-bearing breccia pipes in northern Sonora, Mexico, contain from 4,000 to 16,000 ppm copper and similar amounts of iron. These values suggest that the base-metal transporting capability of some postmagmatic fluids is considerable.

Metal-bearing hydrous fluids of magmatic origin may undergo sufficient dilution by nonmagmatic waters to lose their magmatic identity and still represent major metal-transporting agents. Thus, stable-isotope data that indicate the predominance of nonmagmatic water during the formation of an ore deposit may be misleading in terms of the true origin of the metals involved. (Authors' abstract)

SCHÄFER, Harald, 1981, Chemical transport reactions in gases and some remarks concerning melts and fluid phases, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 409-418. Author at Inst. Inorganic Chem., Univ. Münster, FRG.

SCHEFFEN-LAUENROTH, Th., KLAPPER, H. and BECKER, R.A., 1981, Growth and perfection of organic crystals from undercooled melt: J. Crys. Growth, v. 55, p. 557-570. Authors at Instit. fur Kristallogr. der Techn. Hochschule, D-5100 Aachen, Federal Republic of Germany.

Crystals of benzil $(C_6H_5CO)_2$, space group $P3_12$, melting point T_m = 369 K, were grown from undercooled melts and examined by X-ray topography. Their defects are compared with those of solution-grown crystals. The crystals grow on habit faces with the same morphology as from solution. At low undercooling of 0.2 K (growth rate ≈0.3 mm/h), the structural perfection is high and comparable with that of solution growth. At higher undercooling (>0.5 K), hopper growth occurs on the rhombohedral faces, giving rise to numerous bubbles in the corresponding growth sectors. The bubbles are the source of grown-in dislocations and of glide-dislocation half-loops. Channels due to gas bubbles sticking to the growth faces were observed, too. The grown-in defects in general show the same arrangement as in solution-grown crystals. This is due to growth on the same habit faces in both methods. Most of the dislocations have Burgers vectors ⟨100⟩ and, in a few case, [001]. They are mainly straight and have prefered directions, which agree with those in solution-grown benzil. Growth bands and faulted growth-sector boundaries were also observed. The growth bands, however, are not so clearly visible as in solution-grown benzil. Glide dislocations occur only in melt-grown crystals, because benzil is plastic at temperatures near the melting point and brittle at the temperatures (310-320 K), at which solution growth is performed. (Authors' abstract)

SCHEIDEGGER, K.F., FEDERMAN, A.N., TALLMAN, A. and LILLIE, J., 1981, Temporal variations in the glass chemistry, mineralogy and grain size distribution of tephra from the 18 May 1980 eruption of Mt. St. Helens (abst.): EOS, v. 62, p. 1088.

SCHREYER, Werner, 1981, Metamorphism and fluid inclusions in the basement of the Vredefort structure (abst.): in South African Geodynamics Project, Geocongress '81 Abstracts, 6-10 July, 1981, Univ. Pretoria, South Africa, p. 189-192.

See next item and extensive abstract in Fluid Inclusion Research--

Proc. of COFFI, v. 10, 1977, p. 247-249. (E.R.)

SCHREYER, W. and MEDENBACH, O., 1981, CO_2-rich fluid inclusions along planar elements of quartz in basement rocks of the Vredefort Dome, South Africa: Contrib. Mineral. Petrol., v. 77, p. 93-100. Authors at Inst. für Min. der Ruhr-Univ., Postfach 102148, D-4630 Bochum 1, Fed. Republic of Germany.

Along a NW-SE profile through the basement core, starting below the sedimentary unconformity and ending in the center of the nearly circular structure, the constituent quartz grains and their fluid inclusions exhibit the following characteristics:

In the NW, fluid inclusions composed of CO_2 and occasionally up to 50 vol.% H_2O occur along shock-induced planar elements following predominently $\{0001\}$ of coarse, largely unrecrystallized quartz grains. The planar elements are partly still open microcracks, partly they are healed, the fluid inclusions decorating the former sites of the cracks. Along these planar elements recrystallization into fine grained new quartz fabrics starts, this process increasing decidedly towards the southeast; nevertheless fluid inclusions are still retained. - Near and within the center of the dome the formerly coarse quartz grains are completely recrystallized to medium grained annealing fabrics, in which - surprisingly - the fluid inclusions have often retained their original positions relative to the old grains, so that their planar alignment now traverses the new grain boundaries. Here the enclosed fluid is pure CO_2 as far as can be determined.

On the basis of the homogenzation temperatures of the fluid inclusions measured, and of independent petrologic geothermometry of the basement rocks near the center, the fluids trapped after the shock even had exhibited partial pressures of CO_2 as high as 3 kbars at temperatures around 850°C. The derivation of these CO_2-rich, post-shock fluids is either through release of older fluid inclusions from the lower crustal granulites affected by the catastrophic shattering event, or it is from a direct mantle source that might be genetically connected with the Vredefort event itself. (Authors' abstract) (See previous item).

SCHUBERT, Gerald and STRAUS, J.M., 1981, Thermodynamic properties for the convection of steam-water-CO_2 mixtures: Am. J. Sci., v. 281, p. 318-334. First author at Dept. Earth & Space Sci., Univ. California, Los Angeles, CA 90024.

Geothermal fluids often contain considerable quantities of gases such as CO_2, H_2S, CH_4, N_2 and H_2. If these gases are present in sufficiently large concentrations, they can influence profoundly the physical state of the geothermal system. Such is the case at the Broadlands geothermal field, New Zealand, for example, where the fluid contains about 4 wt percent CO_2. This paper presents calculations of the thermal expansivity, isothermal compressibility, specific heat at constraint pressure, and adiabatic temperature gradient for steam-water-CO_2 mixtures as functions of temperature for pressures of 1, 50, 100, and 200 bars and CO_2 mass fractions of 0.02, 0.04, and 0.06. The thermal expansivity of the mixture can be as large as 100 times that of liquid water and is typically 10 times as large. The mixture is also substantially more compressible (by a factor of $10\text{-}10^5$) than is liquid water and has a specific heat typically 10 times that of water. It also has an adiabatic temperature gradient larger than that of liquid water. Depth profiles of these properties are calculated for the measured temperatures and pressures in the Broadlands geothermal field prior to exploitation. (Authors' abstract)

SCHULZE, D.J., 1981, Mantle-derived calcite and phlogopite in discrete nodules from a Kentucky kimberlite: evidence for primary kimberlitic liquids (abst.): EOS, v. 62, p. 414. Author at Geosci. Program, UT/ Dallas, Richardson, TX.

Discrete garnet (gt) and diopside (di) nodules from kimberlite in Elliot Co., KY, contain inclusions with abundant calcite (cc) and Ti-phlog (~5.5 wt% TiO_2). Inclusions in di (~2 wt% Al_2O_3) also contain serpentine+clays (after olivine). It is inferred that the inclusions in gt were once the same as those in di but through subsolidus reaction aluminous cpx (~8 wt% Al_2O_3) and spinel has formed at the expense of the original gt host and included ol. Prior to serpentinization or reaction with gt, the included ol probably had the composition Fo 89.5, which is that of ol in associated dunite nodules (also members of the discrete nodule suite). From the absence of the common discrete suite minerals (e.g., gt, di, ilm) in the polyphase inclusions, it is suggested that the assemblage phlog+cc+ol represents included liquid while monomineralic inclusions of discrete suite minerals were included as solids.

Least squares mixing of calculated model liquids (phlog+cc+ol) and various kimberlites (including autoliths) yields solutions all of which have excess K_2O (except Nigerdlikasik), high Mg/Fe and >50 wt% ol in the model liquids. The best fit model liquid (20/16/64 wt% phlog/cc/ol, MgO 32.5, Al_2O_3 2.5, SiO_2 31.8, K_2O 1.8, CaO 14.7, TiO_2 1.1, FeO 7.8, H_2O 0.8, CO_2 7.0) is with the Nigerdlikasik kimberlite in Greenland. Discrepancies between model liquids and kimberlites imply that 1) most kimberlite analyses represent igneous kimberlite plus extensive mantle and crustal contamination or 2) the high-K model liquids may themselves be "kimberlite" contaminants. Observation of similar inclusions in discrete nodules from Montana, Wyoming and Colorado kimberlites indicates that these important inclusions may be common in discrete nodules but have been previously overlooked. (Author's abstract)

SCRATCH, R.B., 1981, Geologic, structural, fluid inclusion and oxygen isotope study of the Lake George antimony deposit, southern New Brunswick: Doctoral dissertation, Univ. Western Ontario, London, Ont., Canada (avail. Nat'l. Library of Canada, Ottawa, Ont.).

SELVERSTONE, J.E., 1981, Petrologic and fluid inclusion study of granulite xenoliths, Pali-Aike volcanic field, Chile: Master's thesis, Univ. of Colorado, Boulder, CO, 151 pp.

Similar to Selverstone and Stern, 1980; see Fluid Inclusion Research--Proc. of COFFI, v. 13, p. 223-224. (E.R.)

SEN, Gautam and PRESNALL, D.C., 1981, Petrogenesis of the pyroxenite suite xenoliths on the Koolau shield, Oahu, Hawaii (abst.): EOS, v. 62, p. 1068.

SERDIUCHENKO, D.P., 1981, On the volatiles in the structure of pyroxenes: Akad. Nauk SSSR Doklady, v. 259, p. 462-466 (in Russian).

SEWARD, T.M., 1981, Metal complex formation in aqueous solutions at elevated temperatures and pressures, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 113-132.

Author at Chem. Div., Dept. Sci. and Ind. Research, Private Bag, Petone. New Zealand.

SEWARD, T.M. and FRANCK, E.U., 1981, The system hydrogen-water up to 440°C and 2500 bar pressure: Ber. Bunsenges. Phys. Chemn., v. 85, p. 2-7. First author at Chem. Div., Dept. Sci. and Ind. Res., Private Bag, Petone, New Zealand.

The system H_2-H_2O has been studied isochorically from 0.5 to 90 mol% H_2 and up to 440°C and 2500 bar pressure using an autoclave containing two sapphire windows through which phase transitions could be observed at elevated temperatures and pressures. The system was found to exhibit so-called "gas-gas" immiscibility with a critical curve proceeding to higher temperatures and pressures from the critical point of pure water. Within the range of these experiments, the critical temperature of H_2-H_2O mixtures does not change greatly from that of pure water (e.g., $T_c = 381.3°C$ at $p_c = 2520$ bar for 38 mol% H_2). pVT measurements have been made in the homogeneous region and excess volumes have been calculated at 400°C and at different pressures. At 300 bar, the excess volumes are relatively large and positive (e.g. $V^E = 58.0$ cm^3 mol^{-1} at 40 mol% H_2) whereas at 2500 bar, excess volumes of H_2-H_2O mixtures indicate only small positive or negative departures from ideality. (Authors' abstract)

SHAN, Lin and ZHANG, Wenzhi, 1981a, The characteristics of the melt inclusions and the method for measuring temperature: Scientia Geologica Sinica 1981, no. 2, p. 164-170 (in Chinese; English abstract). First author at Fuzhou Geol. College, Jiangxi Province.

The melt inclusions were formed as minerals trapped silicate magma in the process of crystallization. The melt inclusions differ from gas-aqueous inclusions in form, characteristic of gas bubbles and solid products, and the change in the heating and cooling process. The quenching method, using quartz-glass tubes, was used to determine the formation temperature of granite, monzonite and rhyolite. The results of these determinations agree well with those published in earlier literature: granite, 850-900°C; monzonite, 1050-1100°C; rhyolite, 1200-1250°C. (Authors' abstract)

SHAN, Lin and ZHANG, Wenzhi, 1981b, A preliminary study of inclusions in several salt minerals and their vaporizing feature: Geological Rev., v. 27, no. 3, p. 213-216 (in Chinese; English abstract). First author at Fuzhou Geological College., P.R.C.

Most halogen minerals deposit generally from surface water at normal temperature and pressure. Involved in their crystallization, are usually some inclusions which have been commonly used as criteria to decipher their physical and chemical conditions of formation.

The inclusions in most halogen minerals usually occur as a pure liquid phase, but in a few others they appear as combinations of both gaseous and liquid phases. The inclusions in such minerals are also classified into primary and secondary ones. Several primary inclusions in halogen minerals were examined and a preliminary study was made with rising temperature. It was found that the inclusion of pure liquid phase will give rise to "vaporized" bubbles when heated to a certain temperature. These bubbles will enlarge with increase in temperature until the explosion of the inclusions. If heating was stopped when pure liquid phase inclusions form "vaporized" bubbles, the latter will remain and yield combined gas and liquid inclusions. Such inclusions appear to be very similar to those in hypothermal minerals, but their genesis is apparently different. These two different kinds of inclusions must be separately treated when the measurement of temperature is made with the homogenization method, otherwise the results will be unreliable. The "vaporization" in the inclusions is therefore of significance in the correct study of inclusions and their temperature measurement. (Authors' abstract)

(The authors end their text with the following: "The cause of inclusion vaporization in halogen minerals has not been completely solved in this paper; it needs to be studied further. The authors welcome readers to figure out the errors in the paper and to correct them.")

SHAPENKO, V.V. and RATKIN, V.V., 1981, Conditions of formation of volcanite of acid composition (according to the data of study of the inclusions in quartz): Dokl. Akad. Nauk SSSR, v. 255, no. 5, p. 1247-1251 (in Russian).

Ranges of Th are given for 21 samples. Total range 820-1150°C.(E.R.)

SHAPENKO, V.V. and SHCHEPETKIN, Yu.V., 1978, Paleotemperatures of petroliferous rocks in the southeastern part of the West Siberian block: Dokl. Akad. Nauk SSSR, v. 242, no. 2, p. 402-404 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 242, p. 69-70, 1981).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 11, 1978, p. 191. (E.R.)

SHATAGIN, N.N., 1981, Rapid method of evaluation of amount of inclusions in minerals: Zapiski Vses. Mineral. Obshch., v. 110, no. 1, p. 112-118 (in Russian). Author at Moscow State Univ., Moscow, USSR. See Translations.

SHCHERBAKOV, Yu.G., ROSLYAKOVA, N.V., AGEENKO, N.F., PORTYANNIKOV, D.I., RADOSTEVA, N.E. and BORTNIKOVA, S.B., 1981, Genetic relationship of polymetallic and gold mineralization in the Salair ore field: Geologiya i Geofizika, v. 22, no. 5, p. 68-73 (in Russian; translated in Soviet Geol. and Geophysics, v. 22, p. 61-64, 1981).

Regional and local structural, mineralogic, and geochemical features are considered for the appearance and combination in a single ore field of pyrite-barite-polymetallic and gold-quartz mineralization of different ages and belonging to different ore formations. The appearance of indices characteristic of each type of mineralization ought to contribute to the evaluation of their potential and to the execution of prospecting and survey work. (Authors' abstract) See Appendix for A.K. abstract

Th values are given for a number of samples of quartz, barite, sphalerite and calcite (their Table 2), and range from 65 to 550°C, but only one of the values is mentioned in the text. (E.R.)

SHELTON, K.L., 1981, Carbon and oxygen isotopes as an exploration tool and ore guide for skarn-type ore deposits: an example from the Gaspé Peninsula, Quebec (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 552. Author at Dept. Geol. and Geophys., Yale Univ., P.O. Box 6666, New Haven, CT 06511.

Skarn-type mineralization at Mines Gaspé, Murdochville, Quebec occurs in a sequence of hydrothermally metamorphosed limestones and calcareous shales and siltstones. The carbon and oxygen isotopic compositions of the carbonates in these units reflect isotopic exchange with an isotopically light ore fluid. With increasing fluid:rock ratios during metamorphism and mineralization, the carbonates show isotopic depletion from original compositions of $\delta^{13}C$ = 0.0 and $\delta^{18}O$ = 23.0 to $\delta^{13}C$ = -9.0 and $\delta^{18}O$ = 8.0‰.

The depletion of the $\delta^{13}C$ and $\delta^{18}O$ values of the carbonates is directly proportional to the copper ore grade. Unmineralized skarn-type ore has carbonates with isotopic compositions of $\delta^{13}C$ = -5.7 to -7.5 and $\delta^{18}O$ = 14.5 to 10.0‰. Economically mineralized skarn-type ore has carbonates with isotopic compositions of $\delta^{13}C$ = -7.6 to -9.1 and $\delta^{18}O$ = 9.9 to 7.4‰. Using this relationship as an ore guide, the stratigraphic units which acted as ore-fluid aquifers have been determined. It has been possible to isotopically map these ore-fluid pathways and to delineate the extent of the known ore horizons.

The $\delta^{13}C$ and $\delta^{18}O$ values of the carbonates also show a systematic decrease toward the lens-shaped ore bodies at Mines Gaspé. Depletion of $\delta^{13}C$ and $\delta^{18}O$ values of 4 and 6‰, respectively, occur over a few meters. This technique of isotopic mapping may therefore be applicable as an exploration tool for ore bodies in known skarn ore terrains. (Author's abstract)

SHELTON, K.L. and RYE, D.M., 1981, Sulfate-sulfide disequilibrium in ore-forming fluids at Mines Gaspé, Murdochville, Quebec (abst.): EOS, v. 62, p. 411. Authors at Dept. Geol. Geophys., Yale Univ., New Haven, CT 06511.

Sulfur isotopic compositions of co-precipitated anhydrite, pyrite and chalcopyrite from the late stage porphyry-type mineralization of Mines Gaspé Murdochville, Quebec suggest a kinetic isotopic disequilibrium between sulfate and sulfide in the ore-forming fluid. Δ^{34}Ssulfate-sulfide ranges between 7 and 12‰, suggesting equilibrium depositional temperatures between 750 and 500°C. However, microthermometric measurements of fluid inclusions indicate temperatures between 425 and 250°C. Δ^{34}Spy-cp ranges also suggest unrealistically high depositional temperatures.

Δ^{34}Spy-cp increases with increasing Δ^{34}Ssulfate-sulfide. A mechanism is suggested in which the sulfur isotopic composition of the py and cp is controlled by the relative amounts of sulfate and sulfide removed from solution during their formation. The controlling reactions suggested:

$$4Fe^{2+} + 7H_2S + SO_4^{2-} = 4py + 4H_2O + 6H^+$$

and

$$8Cu^{+} + 8Fe^{2+} = 15H_2S + SO_4^{2-} = 8cp + 4H_2O + 22H^+$$

require $H_2S:SO_4^{2-}$ ratios of 7:1 and 15:1 for the formation of py and cp, respectively. Inferring the disequilibrium isotopic compositions of SO_4^{2-} and H_2S in solution, the resultant isotopic compositions of py and cp deposited from that ore-forming fluid were calculated. The predicted isotopic behavior of py and cp are in agreement with the measured values.

This consistent sulfate-sulfide disequilibrium behavior places constraints on the evolution of the ore-forming fluid at Mines Gaspé and has important implications for: redox disequilibrium in solution, mixing of sulfate- and sulfide-rich fluids, and solution, transport, and redeposition of early stage sulfides. (Authors' abstract)

SHEPHERD, T.J., 1981, Temperature-programmable, heating-freezing stage for microthermometric analysis of fluid inclusions: Econ. Geol., v. 76,

p. 1244-1247. Author at Inst. Geol. Sci., 64 Gray's Inn Road, London WC1 8NG, England.

A description of the Linkam TH600 heating/freezing stage (-180°C to +600°C). The stage uses a small sapphire sample support disk in a silver block that contains both the heating and cooling devices. Temperature change is by means of a programmable temperature controller. (See Macdonald and Spooner, this issue, for calibration). (E.R.)

SHEPHERD, T.J. and DARBYSHIRE, D.P.F., 1981, Fluid inclusion Rb-Sr isochrons for dating mineral deposits: Nature, v. 290, p. 578-579. Authors at Isotope Geol. Unit, Geochem. and Petrol. Div., Instit. Geol. Sci., 64 Gray's Inn Road, London WC1X 8NG, UK.

Samples of fluid inclusions in quartz from the tungsten deposits at Carrock Fell, Cumbria, U.K., were analyzed for Rb and Sr, and the $^{87}Rb/^{86}Sr$ and $^{87}Sr/^{86}Sr$ ratios. The sample preparation and analytical techniques "will be described elsewhere." The Rb/Sr age was 392 ± 5 Myr, in good agreement with published K/Ar ages on vein muscovites. (E.R.)

SHEPPARD, S.M.F., 1981, Stable isotope geochemistry of fluids, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 419-446. Author at Centre de Recherches Pétrogr. et Géochim., Case Officielle No. 1, Vandoeuvre-lès-Nancy 54500, France.

The principles of the stable isotope geochemistry of the elements H, C, O, and S are summarized as they relate to systems containing gaseous mixtures, silicate melts, and hydrothermal fluids. The following selected topics are considered, using theoretical considerations and/or laboratory experimental and geological investigations, to illustrate the wide variety of applications in both geochemistry and related aspects of chemistry: equilibrium fractionations among gaseous molecules, equilibrium versus disequilibrium in CO_2-CH_4 gases from geothermal systems, magma-mineral fractionations and fractional crystallization, magma-CO_2 fractionations and the nature of the dissolved carbon species in the melt, diffusion of oxygen in silicate melts, sources of magmas and their chemical modification by assimilation of wall-rocks (also incorporating Sr, Nd and Pb stable isotope data), isotopic characterization of natural waters, isotopic activity ratios versus concentration ratios in hydrothermal fluids, the structure of aqueous solutions, and the rate of sulphur isotope exchange during sulphate-sulphide reactions in solutions. A number of areas of uncertainty are highlighted for future research activity including the importance of conducting well-designed experimental studies to determine the kinetics and mechanisms of exchange during rections. (Author's abstract)

SHEVEL'KOVA et al., 1981 - See Appendix

SHIKINA, N.D., ZOTOV, A.V. and KHODAKOVSKII, I.L., 1981, An experimental investigation of equilibria in the α-HgS-H_2S-H_2O system at 90 and 150°C: Geokhimiya, 1981, no. 4, p. 496-503 (in Russian).

SHIMIZU, M. and SHIMAZAKI, H., 1981, Application of the sphalerite geobarometer to some skarn-type ore deposits: Mineral Deposita, v. 16, p. 45-50.

SHISHAKOV, V.B. and YUDIN, I.M., 1981, Ore-metasomatic zoning and certain geochemical peculiarities of ores in the deposit Borly, northern Pribalkhash'ye: Akad. Nauk SSSR Doklady, v. 257, no. 3, p. 701-704 (in Russian). Authors at the Central Sci.-Research Geol.-Prosp. Inst. of Color and Precious Metals, Moscow, USSR.

The copper-porphyry deposit Borly with widely developed metasomatism bears minerals which yielded the following Td values: quartz+pyrite 285-240°C, molybdenite 280-260°C, pyrite+chalcopyrite 280-245°C, polymetallic 270-240°C, gypsum-anhydrite 260-215°C. (A.K.)

SHKODZINSKIY, V.S., 1981, Evolution of phase composition and genesis of granitic magma: Geokhimiya, no. 1, p. 45-62 (in Russian, English abst.). Author at Inst. Geol. of Yakutian Division of Sib. Branch of Acad. Sci. of USSR, Moscow (sic., maybe "Moscow" is misprint for Yakutsk, A.K.).

Theoretical calculations pertinent to melt inclusion studies. (A.K.)

SHU, Gu, FAN, Qinxuan, WU, Jiaquan and KEI, Kerun, 1981, The extraction and the determination of micro-amounts of sulfate ions in the liquid phase of fluid inclusions: Jour. Central-South Inst. of Mining and Metallurgy, v. 27, no. 1, p. 17-21 (in Chinese; English abstract).

High temperature extraction in an enclosed system after decrepitation and the improvement of the indirect barium iodate method for determination of sulfate are reported in this paper. It was proved experimentally that the composition extracted is equal to that of the liquid phase of the inclusion and that the amount extracted is basically complete. The sensitivity is 0.25 ppm. Determination error of the method is about ±15%. (Authors' abstract)

SHUKOLYUKOV, Yu.A., VERKHOVSKIY, A.B., DRUBETSKOY, Ye.R., OLEYNIKOV, B.V., OKRUGIN, A.V., BIBIKOVA, Ye.V., MAKAROV, V.A., KIRNOZOVA, T.I., PRASOLOV, E.M., MESHIK, A.P., SUBBOTIN, Ye.P. and ZUYEV, B.K., 1981, Isotope indicators of a mantle origin for native metals in trap rocks: Geokhimiya, 1981, no. 10, p. 1442-1452 (in Russian).

SHURUPOV and KALININ, 1981 - See Appendix

SIDOROV et al., 1981 - See Appendix

SIGVALDASON, G.E., 1981, Fluids in volcanic and geothermal systems, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 179-196. Author at Nordic Volcanol. Inst., Reykjavik, Iceland.

Mineral buffers control the composition of most volatile components of magmas and dissolved species in geothermal fluids. The only element which occurs in significant quantities in volcanic and geothermal fluids and is not controlled by mineral buffers is chlorine. It is argued that in absence of marine influence, geothermal fluids reflect the chlorine content of associated magmatic fluids.

The model predicts that all volcanic fluids, with the exception of those which are associated with the most primitive olivine tholeiites, are partly or wholly recycled through all stages of hydrothermal and metamorphic reactions. In that sense associated volcanic and geothermal systems are a part of the same chemical fractionation column.

It is concluded that the chemistry of fluids in volcanic and geothermal systems can be viewed in the perspective of predictable crustal fractionation processes before any conclusion need be drawn concerning more deep seated causes for chemical anomalies. (From the author's abstract)

SILBERMAN, M.L., MITCHELL, P.A. and O'NEIL, J.R., 1981, Isotopic data bearing on the origin and age of the epithermal lode gold deposits in the

Hope-Sunrise mining district, northern Kenai Peninsula, Alaska, in The United States Geological Survey in Alaska; accomplishments during 1979, Albert, N.R. et al., eds., Geol Survey Circular No. 0823-B, p. 81-84.

Preliminary stable isotope and K-Ar age data on the gold-bearing veins in the Hope-Sunrise mining district help establish their origin and age of emplacement. The average δD value of fluid-inclusion waters of the three mineralized quartz veins is -106 ± 6, which is about the same as that of modern meteoric water (-110) in this area. Literature data on fluid inclusions indicate that the ore fluid was dominantly meteoric water. (E.R.)

SILVA, L.C., Le BAS, M.J. and ROBERTSON, A.H.F., 1981, An oceanic carbonatite volcano on Santiago, Cape Verde Islands: Nature, v. 294, p. 644-645. First author at Junta de Investigacoes Cientifica do Ultramar, Lab. de Estudos Petrol. e Paleon., Lisbon 1000, Portugal.

Carbonatite volcanoes are rare, the only active one being at Oldoinyo Lengai in northern Tanzania although a few dead volcanic centers with recognizable carbonatitic extrusive materials are known elsewhere in Africa and one in Germany. During an expedition in 1980 to the Cape Verde Island, in the Central Atlantic Ocean 500 km west of Senegal, the eroded remains of a carbonatite volcano were discoverd on the island of Santiago just north of Tarrafal at Arruela (Fig. 1). This, the first example of an oceanic carbonatitic volcanic pyroclastic structure, shows typical carbonatite mineralogy and geochemistry, and demonstrates that carbonatite magmas can be generated in the oceanic lithosphere as well as in the continents. (Authors' abstract)

SIMKIV, Zh.A., 1981, Contribution to the geochemistry of hydrothermal solutions, trapped in sphalerite and quartz of the Arkhon deposit (Northern Caucasus): Mineralog. Sbornik, v. 35, no. 2, p. 63-65 (in Russian, English abstract). Author at L'vov Univ., L'vov, Ukrainian SSR.

Arkhon Pb-Zn deposit belongs to the Sadon group. It formed by quartz-pyrite, quartz-sphalerite-galena and quartz-carbonate stages. Early ore quartz yielded Th ~340°C, sphalerite 310-245°C. Main ions in water leachates from inclusions are Cl, $HSiO_3$, Na, Ca and Mg, subordinate - HCO_3, SO_4, K and ΣFe. Variations of ion content in solutions of various stages are presented. (Abstract by A.K.)

SIMKIV, Zh.A. and POPIVNYAK, I.V., 1981, Spatial variability of chemical composition of mineral-forming solutions in one of the gold-ore deposits in Northern Buryata: Mineralog. Sbornik, v. 35, no. 1, p. 63-70 (in Russian, English abstract). Authors at L'vov Univ., L'vov, Ukrainian SSR.

The deposit occurs in the ranges of the Archean Southern-Muy shield. Ore bodies (veins) formed under strong structural control. Five stages of mineral formation were distinguished: 1 - quartz (460-350°C); 2 - tourmaline-quartz (500-350°C, 1.1×10^6-1.0×10^6 h/Pa); 3 - pyrite-quartz (460-310°C, 7.1×10^5-6.1×10^5 h/Pa); 4 - gold-sphalerite-galena (330-170°C, 2.0×10^6-8.3×10^5 h/Pa); 5 - quartz-carbonate (160-100°C; all are Th and P from fluid inclusions). Gold ores belong to low-sulfide formation, pyritic type. Ore-forming fluids were rich in CO_2 since fluid inclusions bear LCO_2 (15-25 to 60-70 vol.%). By triple water leachates the contents of the following ions in fluid inclusions were determined: Cl, HCO_3, $HSiO_3$, F, SO_4, Na, K, Ca, Mg, Li, Sr, Ba, Mo, ΣFe; pH of water leachates varies from 6.62 to 5.90. Ions of Cl, $HSiO_3$ and Na are the main components. Na and Cl contents decrease from the lower to the upper levels, similar but weaker tendency was found for $HSiO_3$. Relatively rapid changes of the ion contents are associated with heterogenization (i.e. boiling) of ore forming solutions and precipitation of the richest ores. (Abstract by A.K.)

SIMON, Ralph, 1981, Enhanced oil recovery: definitions, fundamentals, applications, and research frontiers, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 447-460. Author at Chevron Oil Field Research Co., P.O. Box 446, La Habra, CA 90631, USA.

Pertinent to the organic content of aqueous and CO_2 inclusions. (E.R.)

SIMONOV, V.A., 1981a Conditions of mineral formation in nongranitic pegmatites: Izd. Nauka, Novosibirsk, 168 pp. (in Russian).

An extensive study, involving fluid inclusion data in many places (67 photomicrographs, mainly of inclusions). (E.R.) See Appendix

SIMONOV, 1981b - See Appendix

SIMONOV, V.A., 1981c Inclusions in minerals of the pit No. 298 in the Il'menskiy Reserve: in Mineralogical studies in the Il'menskiy Reserve, Ural Sci. Center of Acad. Sci. of USSR Pub. House, Sverdlovsk, p. 81-83 (in Russian). Book price 95 kopeck; 700 copies printed.

In the newly opened pit No. 298, a vein of corundum-bearing syenite-pegmatite crops out. Feldspar and large platy corundum crystals (up to 20 cm dia.) are the main minerals. Corundum crystals are zonal, gray in center and bright blue transparent or cloudy blue in the outer core. Columbite and monazite also occur with corundum. Fluid inclusions were found in corundum and monazite. Blue corundum bears S and PS inclusions. PS inclusions are filled by solids (up to 60%), G (up to 50%) and L (up to 25%). Optical features of the largest solids indicate that they may be diaspore. Other solids melt at 150-200°C, thus may be salts. Most inclusions homogenize at 502-520°C, but some of them don't even homogenize at 1100°C. From the triple point of -56.6°C, CO_2 was determined in inclusions; its Th is 22.4-28.7°C, specific volume 1.37 and 1.62 cm^3/g, hence P 1880 and 1440 bars. G in blue corundum consists of 78-98 vol.% of CO_2, 2-22 vol.% of N_2+rare G, hydrocarbons, O_2, CO, H_2 not found. Inclusions in gray corundum are similar, Th 510-530°C, P 1450 bars, CO_2 99-99.5 vol.%, N_2+rare G 0.5-1 vol.%. Monazite bears P tubular inclusions parallel to (100), filled by ~50% of silicates, G and L. PS inclusions bear mostly salts, S inclusions - G/L. Th of P inclusions were 800-850°C, PS 530-540°C, S 380°C G consists of CO_2+"acid gases" 44.5-73.5 vol.% N_2+rare G 26.5-55.5 vol.%, hydrocarbons, O_2, CO and H_2 not found. P was 1450-1880 bars PS inclusions have Th 530-540°C. (Abstract by A.K.)

SINCLAIR, A.J. and TESSARI, O.J., 1981, Vein geochemistry, an exploration tool in Keno Hill Camp, Yukon Territory, Canada: J. Geochem. Explor., v. 14, p. 1-24. First author at Dept. Geol. Sci., Univ. British Columbia, Vancouver V6T 2B4, Canada.

Seventy-two samples, taken across the width of the Keno No. 18 vein at an average interval of 3 m and encompassing several Ag ore shoots and barren zones, were analyzed for twenty-three elements. These samples were rearranged in order of decreasing silver values as a means of evaluating metal zonation patterns relative to an ideal ore shoot. This idealized zonation model is compared with four independent sets of data and found to apply throughout the deposit for ore shoots from 6 to 90 m in diameter.

These results indicate that routine mine-sampling procedures, with samples analyzed for Pb, Zn, Ag, Ca, Hg and Co provide an adequate basis for use of the ideal ore shoot concept as an exploration tool. The approach appears useful in: (1) re-evaluating ends of existing underground workings and their possible proximity to undiscovered ore shoots; and (2) monitoring new workings. The methodology simply entails construction of profiles for Ag, Pb, Zn, Ca, Hg, Co, Zn/Ag and Co/Ag and comparison of these with patterns expected according to the ideal model. Most advantages of the procedure can be obtained in practice by supplementing normal assaying for Ag, Pb and Zn with Ca analyses. (Authors' abstract)

(Is it possible that some of these elements, e.g., Ca, were present in fluid inclusions? E.R.)

SISSON, V.B., CRAWFORD, M.L. and THOMPSON, P.H., 1981, CO_2-brine immiscibility at high temperatures, evidence from calcareous metasedimentary rocks: Contrib. Mineral. Petrol., v. 78, p. 371-378. First author at Dept. Geol. and Geophy. Sci., Princeton Univ., Princeton, NJ 08544, USA.

Study of fluid inclusions in quartz segregations and in the rock matrix of a calcareous psammite and a carbonate schist suggests that brines containing 23-24 weight percent salt (NaCl equivalent) are immiscible with CO_2 at the metamorphic conditions of approximately 600° and 6.5 Kb. The presence of a high temperature solvus between saline brine and CO_2 is supported by other fluid inclusion studies as well as experimental measurements from the literature. As saline brines are common in metamorphic and hydrothermal systems, CO_2-brine immiscibility should play an important role in petrogenesis. The fluid inclusions preserved in the quartz segregations probably represent the fluids generated by prograde metamorphic reactions, whereas the compositions of the fluids trapped in the rock matrix quartz suggest they have reequilibrated with the matrix minerals during incipient retrograde reactions. The isochores from the densest inclusions observed in this study pass close to the inferred peak metamorphic conditions; other isochores suggest an episode of deformation and recrystallization at 275°C and 1.4 Kb. Using the density information preserved in all the inclusions, a convex-downward uplift path on a P-T diagram is inferred for these rocks. (Authors' abstract)

SKINNER, B.J., ed., 1981, Economic Geology Seventy-Fifth Anniversary Volume 1905-1980: Econ. Geol. Pub. Co., 964 pp.

An excellent collection of 30 review articles by many authors, including many using published fluid inclusion data. Includes chapters on uranium, gold and uranium in conglomerates, sediment-hosted stratiform Cu, Pb, and Zn, sandstone Pb, porphyry copper, Climax-type Mo, skarn, geothermal systems, etc. (E.R.)

SKLAREW, D.S. and NAGY, Bartholomew, 1981, Pyrolysis of Transvaal kerogens. I. Diagenesis of kerogen in a stromatolite near Zeerust, South Africa: one possible chemical evolution process: Precambrian Res., v. 15, p. 97-111. First author at Battelle Pacific Northwest Labs., Bldg. 329, P.O. Box 999, Richland, WA 99352, USA. (Continued)

This study represents an attempt to understand some of the many post-lithification chemical processes which affect the evolution of kerogen. Kerogens separated from four carbonate stromatolites, collected over a horizontal distance of ~350 km from the Malmani Dolomite of the Olifants River Group in the Transvaal Supergroup, were characterized by combined vacuum pyrolysis-gas chromatography-mass spectrometry. The relative profiles of the gas chromatographic peak distributions and intensities ('finger print patterns') of three of the kerogen pyrolyzates were closely similar. The Zeerust stromatolite kerogen yielded a different pattern, showing a greater abundance of higher molecular weight aliphatic and alkyl aromatic hydrocarbon moieties than the other three samples. Many of the stromatolites near the Zeerust area contain epigenetic fluorite introduced by aqueous solutions. Fluid inclusion homogenization analysis showed that the emplacement temperature of fluorite in the sample studied was 100-200°C. Fluoride ion initiated base catalyzed condensations may have been a feasible cause for the production of higher molecular weight aliphatic and (indirectly) some alkyl aromatic moieties in this stromatolite, as compared to those in the other three samples. Acid-catalyzed condensations may also achieve similar results in aqueous diagenetic environments. (Authors' abstract)

SKRYABIN, V.Yu., 1978, Composition of crystallized inclusions of granite melt: Dokl. Akad. Nauk SSSR, 1978, v. 242, no. 2, p. 416-418 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 242, p. 144-147, 1981).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 11, 1978, p. 200. (E.R.)

ŚLÓSARZ, J. and KARWOWSKI, Ł., 1981, Physico-chemical conditions of polymetallic mineralization in Paleozoic rocks in the Myszków region (NE margin of the Upper Silesian Coal Basin): Post-magmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, p. 14-15, Wydawnictwa Geologiozne, Warsaw (in Polish). First author at Upper Silesian Division of Geol. Inst., Sosnowiec, Poland.

Polymetallic mineralization in this area occurs in Lower Paleozoic metapelites and metagraywackes and in Variscan magmatic rocks cutting them: rhyolites, rhyodacites and microgranites. Ore mineralization is post-metamorphic, post-magmatic and post-tectonic. On the basis of mineralogical and fluid inclusion studies, the main parageneses were distinguished: quartz-feldspar, quartz-molybdenite, quartz-magnetite with bornite, feldspar with molybdenite, polymetallic with molybdenite, barite-carbonate with fluorite and carbonate with galena and sphalerite. Mineral-forming fluids were hydrotherms with T beginning from 400°C to <100°C, the calculated P were in ranges 80-60 MPa. Variscan magmatism was probably the source of those hydrotherms. (Authors' abstract, translated by A.K.)

SMITH, J.V., DELANEY, J.S., HERVIG, R.L. and DAWSON, J.B., 1981, Storage of F and Cl in the upper mantle: geochemical implications: Lithos, v. 14, p. 133-147. First author at Dept. Geophys. Sci., The Univ. Chicago, Chicago, IL 60637, USA.

Electron microprobe analyses yielded mean values of F 0.43 and Cl 0.08 wt.% for primary-textured phlogopites in coarse, depleted garnet-lherzolite xenoliths from kimberlites. Most secondary-textured phlogopites have too low Cl (0.01-0.08 wt.%) to be metamorphic precursors of primary-textured phlogopites. MARID-suite phlogopites and many megacrysts in kimberlites have low Cl (~0.02 wt.%), and some but not necessarily all secondary micas may result from infiltration of kimberlite into peridotite xenoliths. A good correlation between P and F in some oceanic basalts and gabbros might suggest that these elements are derived mainly from F-rich apatite in the mantle, and that whitlockite is not present in the source region. Mantle-derived mica and amphibole have such low Cl that it is necessary to attribute Cl in oceanic basalts and gabbros either to substantial Cl in the source apatite, or to Cl from invading solutions, or both: three apatites from the mantle contain 0.8-1.0 wt.% Cl, and others contain lower amounts. The halogen contents of kimberlitic magmas can be explained by incorporation of Cl-bearing mica and F-rich apatite during melting of peridotites, but compositional constraints are weak. (Authors' abstract)

SMITH, R.W. and NORMAN, D.I., 1981, Gas analyses of fluid inclusions from Questa, NM molybdenite deposit (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 557. Authors at Dept. Geosci., New Mexico Inst. Mining and Tech., Socorro, NM 87801.

Molybdenite mineralization at Questa occurs as early qtz-bio-Kspar-mo veins with fluid inclusion temperatures of up to 500°C and high salinities, and as qtz-py-mo veins with lower temperatures (350° to 400°C) and lower salinities. Fluid inclusions from samples of vein quartz from both types of ore were analyzed using a quadrupole mass spectrometer. The fluids analyzed were predominately water with about 3 wt. % CO_2 and up to 1 wt. % H_2S. Fluids from the "clotty moly" (qtz-bio-Kspar-mo) zone had H_2S molalities of 0.02 m and mole fractions of H_2 of 0.0006. The qtz-py-mo veins were 0.5 m in H_2S and had H_2 mole fractions of 0.001. In addition, all samples had small amounts of N_2, SO_2 and light hydrocarbons.

Log oxygen and sulfur fugacities calculated from the gas analyses were -26 to -23 and -9 to -6 respectively for the "clotty moly" and -30 to -26 and -8 to -3 respectively for the qtz-py-mo veins. The gas fugacities calculated from the gas analyses are in good agreement with fugacities calculated from the observed mineral assemblages.

The results suggest that latter hydrothermal fluids were highly enriched in H_2S relative to earlier fluids. This enrichment may have been the result of boiling of earlier magmatic fluids. The results also indicate that mineralization occurred from solutions that were in equilibrium with vein mineral assemblages. Sulfide complexes may have been important in the transport of molybdenum in the latter, H_2S rich solutions, while fluoride complexes transported molybdenum in the earlier high temperature fluids. (Authors' abstract)

SMITH, S.P., KENNEDY, B.M. and REYNOLDS, J.H., 1981, Solubility of noble gases in fresh water and NaCl brines (abst.): EOS, v. 62, p. 1066. First author at Dept. Physics, Univ. California, Berkeley, CA 94720.

Using a mass-spectrometric method, we have measured the solubilities of the five stable noble gases in fresh water and laboratory-prepared NaCl brines from 0°-65°C and over the complete range of dissolved salt concentrations (0-26 wt% NaCl). Noble gases can be used as conservative tracers to constrain possible histories of terrestrial fluids such as geothermal water and steam, ore-forming solutions, meteoric ground waters, etc. The presence of dissolved electrolytes in water can greatly modify the solubilities of the gases in solution (the "salt effect"). Previously available solubility data for noble gases do not cover the possible range of NaCl concentration and temperature adquately to allow reliable comparisons with the gas content of natural brines. The effect of salt on the solubilities of the gases is parameterized using an empirical relation due to Setschenow:

$$(1/C)\log[So(T)/S(T)] = K(T)$$

[C is the concentration of NaCl, So(T) and S(T) are the noble gas solubilities in fresh water and salt solution, respectively, at temperature T, K(T) is the empirical salt coefficient; all concentrations are per liter of solution.]

Significant results of this study include: (1) Up to 65°C, the salting coefficient K(T) is independent of the concentration of NaCl, even for saturated NaCl solutions; (2) Differences in the salting coefficient for two noble gases [e.g. K(argon) - K(helium)] are linear with temperature; (3) In the range 0°-65°C, the absolute solubility of He (unlike the other noble gases) in NaCl brines varies little with temperature. (Authors' abstract)

SOBOLEV et al, 1981 - See Appendix

SOBOLEV, R.N. and MELAMED, V.G., 1981, Determination of temperature of magmatic melts during their intrusion: Geol. Rudn. Mest., v. 23, no. 5, p. 106-109 (in Russian). Authors at Moscow State ULniv., Moscow, USSR.

Pertinent to melt inclusion studies. (A.K.)

SOBOLEV V.S., 1981, Problem of magma mixing during formation of igneous rocks: Zapiski Vses. Mineral. Obshch., v. 110, no. 6, p. 641-645 (in Russian)

Mixing of magmas may be considered the opposite process of magma immiscibility. During mixing an intermediate zone may coexist between the two melts (glasses) for some time Melt inclusions of various composition may coexist in phenocrysts formed in various magmas and during crystallization of mixing magma inclusions should give a series of intermediate compositions. During immiscibility the same solid phases should be in equilibrium with two various liquids. During mixing phenocrysts may react with melts. Melt inclusions trapped by phenocrysts during immiscibility may contain globules of liquids of two different compositions in direct contact. In melt inclusions of mixing magmas the partial melting of host mineral may occur, sometimes followed by opening of inclusions. Two glasses in one inclusion may coexist only in exceptional cases of trapping in zones of turbulent mixing and during heating irreversible homogenization should be observed. The described phenomena are illustrated by nine microprobe analyses of melt inclusions in pyroxene, garnet, sphene, sodalite and quartz. (Abstract by A.K.)

SOEDA, Akira and WATANABE, Makoto, 1981, Electrum-silver telluride ores of the Takeno mine, Hyogo Prefecture, SW Japan, and their genetic significance: Mining Geol. (Japan) Special Issue 10, p. 43-52 (in English). Authors at Inst. Geol. & Min., Faculty of Sci., Hiroshima Univ., Hiroshima 730, Japan.

In the "Takeno Au-Ag-Te province" of the northen part of Hyogo Prefecture are developed several epithermal gold-silver-tellurium-adularia quartz veins in altered Miocene volcanogenic rocks of intermediate to acid composition and in their basement granitic rocks of the Sanin-type. The ores are characterized by the presence of gold-rich electrum, hessite, and a trace amount of petzite with an abundance of slightly disordered adularia and the very rare occurrence of argentite. Petzite is intimately associated with electrum and hessite included in chalcopyrite, apparently suggesting a reaction rim between gold and hessite, which was produced during ore deposition. Fluid inclusion data (210° to 270°C), iron contents of sphalerite coexisting with pyrite and/or electrum (0.8 to 1.4 mol.% FeS), zinc contents of tetrahedrite-tennantite series mineral (7.10 to 7.73 wt.% Zn), and composition of electrum (N_{Ag}=0.31 to 0.41) all indicate that comparatively high fO_2 and fS_2 condition and somewhat alkaline environment may have prevailed during the mineralization. K-Ar isotope data for adularia indicate that the Au-Ag-Te mineralization took place in early Middle Miocene (17.9 to 18.2 Ma). (Authors' abstract)

SOKOLOV and MEL'NIKOV, 1981 - See Appendix

SOKOLOV, S.V., 1981a, Evolution of temperature in the process of formation of rocks of alkaline-ultrabasic massifs bearing carbonatites: Geokhimiya, no. 2, p. 249-256 (in Russian, English abst.).

The paper discusses Th and other inclusion data obtained from minerals of the alkaline-ultrabasic rocks from E. Africa; Kola Peninsula: Kovdor, Afrikanda, Vuorijarvi, Turiy; Polar Siberia: Guli, Odikhincha, Yessey, Magan; and E. Sayan: Beloziminskiy. The data are taken essentially from earlier published papers. Th (1480-680°C) were measured in olivine, pyroxene, melitite, nepheline and apatite. The review shows that for platform rocks Th is very similar for the same minerals of various rock types. Also, e.g., nephelinization of pyroxenites is suggested on the basis of Th ranges. (Abst. by A.K.)

SOKOLOV, S.V., 1981b, Shortite from massif Kovdor: Akad. Nauk SSSR Doklady, v. 259, no. 2, p. 466-469 (in Russian). Author at All-Union Sci.-Research Inst. of Mineral Raw Materials, Moscow, USSR.

Shortite $Na_2Ca_2(CO_3)_3$ from Kovdor massif, occurring in apatite-magnetite ore body, yielded Td 210-460°C and in other sample 270-520°C. By microscope methods the following inclusions were found: secondary two-phase with Th 90-150°C and polyphase secondary and uncertain primary with 1-4 anisotropic dms occupying 10-40 vol.%. Homogenization was not achieved because at 340-390°C polyphase inclusions always decrepitated. (Abstract by A.K.)

SONDEREGGER, J.L. and DONOVAN, J.J., 1981, Problems of trace element ratios and geothermometry in a gravel geothermal aquifer system, in Geothermal Direct Heat Program; Glenwood Springs technical conference proceedings; Volume 1, Papers presented; State Coupled Geothermal Resource Assessment Program, Ruscetta, C.A. et al., eds., p. 50-62, Rep. No. DOE/ID/12079-39 Rep. No. ESL-59.

SONYUSHKIN - See Appendix

SORAPURE, R., 1981, The solubility of water in albite melt determined from nucleation of vesicles following isothermal decompression: Progress in Experimental Petrology (Fifth), C.E. Ford, ed., The Natural Environment Research Council (U.K.) Pubs. Series D, No. 18, p. 7-9.

SOROKIN, V.I., SOBOLEV, V.P. and KORZHINSKIY, D.S., 1981, Talc solubility in aqueous solution of 0.1 M HCl and certain problems of the acid post-magmatic leaching: Akad. Nauk SSSR Doklady, v. 258, no. 1, p. 197-201 (in Russian). Authors at Inst. Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka near Moscow, USSR.

Pertinent to composition of inclusion fluids. (A.K.)

SOTNIKOV, V.I., KASTRYKIN, Yu.P. and NIKITINA, Ye.I., 1981, Distributions of chlorine and fluorine in the minerals of intrusive and postmagmatic rock bodies of molybdenum shows in the Stanovoy: Geokhimiya, 1981, no. 3, p. 361-370 (in Russian).

SPEAR, F.S., 1981, $\mu(H_2O)$-$\mu(CO_2)$-X(Fe-Mg) relations in amphibolite assemblages (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 559.

SPERA, F.J., 1981, Carbon dioxide in igneous petrogenesis: II. Fluid dynamics of mantle metasomatism: Contrib. Mineral. Petrol., v. 77, p. 56-65. Author at Dept. Geol. and Geophy. Sci., Princeton Univ., Princeton, NJ 08544, USA.

Petrographic, fluid inclusion, geochemical and isotopic evidence from xenoliths in alkali basalts suggests that low-viscosity fluids rich in O-H-C, dissolved silicates and especially the incompatible elements may ascend, decompress and precipitate crystalline phases and/or induce partial fusion in the upper mantle. Such mantle metasomatic fluids (MMF) may be important in generating isotopic heterogeneity and in transporting and focusing mantle heat. In order to model the movement of MMF, the ordinary differential equations governing the variation of P, T, ascent velocity and fluid density of a compressible, viscous, single-phase (H_2O or CO_2) non-reacting fluid ascending through a vertical crack of constant width have been solved. A large number of numerical simulations were carried out in which the significant factors affecting flow behavior (thermodynamic and transport fluid properties, roughness and width of cracks, geothermal gradient, initial conditions, etc.) were systematically varied. The calculations show that: (1) MMF tends to move at uniform rates following a short period of rapid initial acceleration, (2) MMF ascends nearly isothermally, (3) MMF acts as an efficient heat transfer agent; numerical experiments show that transport of heat into regions undergoing metasomatism can lead to partial fusion. The heat transported by movement of MMF averaged over the age of the Earth is sufficient to generate about 0.1 km^3 of basaltic magma per year, which is approximately equal to the production rate of alkaline magma. If an intense period of mantle degassing occurred early in the history of the Earth, the transport of heat and mass (K, U, Rb, LREE) by migrating fluids might have been important. (Author's abstract)

SPERA, F.J. and BERGMAN, S.C., 1980, Carbon dioxide in igneous petrogenesis: I: Contrib. Mineral. Petrol., v. 74, p. 55-66. Authors at Dept. Geol. & Geoph. Sci., Princeton Univ., Princeton, NJ 08544, USA.

A thermodynamic treatment of published P-T-wt% CO_2 data for a number of mineral and natural melts. (E.R.)

SPOONER, E.T.C., 1981, Fluid inclusion studies of hydrothermal ore deposits, Chapter 9, pp. 209-240, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 9 Contents

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References

STALDER, H.A., 1981, Hydrothermal alteration of the Aare granite in the Gotthard-roadtunnel (Switzerland) (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated).

The hydrothermal alteration around alpine mineral fissures is very obvious. The decrease of the volumetric weight comes to 22-44%. The mineralogical alteration consists in the dissolution of biotite, quartz and sometimes white mica. In a minor extension a cementation of new quartz, biotite, chlorite, epidote, titanite, white mica and calcite can be observed. Chemically a strong decrease of SiO_2 is noticeable. Also the values for Fe_2O_3 (incl. FeO), MgO, MnO and CaO decrease systematically whereas the values for TiO_2, P_2O_5, Al_2O_3, Na_2O and K_2O show little deviation; but important exceptions exist.

In fissure quartz there are found only 2-phase fluid inclusions: an aqueous solution with 5-10 equiv. wt% NaCl and a gas bubble. The CO_2-content should be about 1-3 wt%. Th is 195-224°C; they need a relatively large pressure correction to obtain Tf. The average m_{KCl}/m_{NaCl} ratio of 0.17 from the included solution corresponds to Tf of approximately 430°C.

Normally the feldspars from the altered rock are themselves scarcely altered by the fissure solutions. Only a precipitation of adularia in a relatively late phase of crystallization is noticeable. This fact can be explained with the curve of Lagache and Weisbrod (1977) which defines the buffering of the K/Na-ratio in a solution in equilibrium with the K and Na feldspars: the slow decrease of the temperature in a fissure led to a potassium excess which was balanced again by the precipitation of adularia.

The formation of chessboard-albite in one case can be explained by a lack of potassium in the fissure solution, and a complete dissolution of all albite in another case must be related to a lack of sodium. (Author's abstract)

STAROSTIN, V.I., LYCHAKOV, V.A. and SERGEEVA, Nat.Ye., 1981, Metamorphogenic redistribution of chemical elements of sulfide-polymetallic ores: Geol. Rudn. Mest., v. 23, no. 4, p. 30-43 (in Russian). Authors at Moscow

State Univ., Moscow, USSR.

Sulfide-polymetallic ores in the Irtysh zone of the Rudnyi Altai of primary volcanic-sedimentary origin were selectively melted at 560-920°C and 3-6x10^2 MPa (fluid inclusion data). Homogeneous melt was very low in H_2O and saturated with CO_2, and relatively rich in HCO_3, Cl and F. Total content of volatiles in inclusions was up to 235 g/kg*. (Abstract by A.K.)
*This is not explained in the text. (A.K.)

STEPANOV, 1981 - See Appendix

STERNFELD, J.N., 1981, The hydrothermal petrology and stable isotope geochemistry of two wells in the Geysers geothermal field, Sonoma County, California: Master's thesis, Univ. California Riverside, CA, 202 pp.

This report is a comprehensive study of the drill cuttings from two wells in The Geysers geothermal field, Sonoma County, California. The Geysers geothermal field is a large vapor-dominated geothermal field with reservoir temperatures of up to 240°C. It currently supplies steam to the largest geothermal electric installation in the world, with an installed capacity in excess of 1,000 MWe. Geysers 1, a production well, penetrated 1646 m of strata and encountered two major and five minor steam entries. Geysers 2, a non-producing well, penetrated 2835 m of strata and encountered a single uneconomic steam entry.

The strata penetrated by these wells are a melange of imbricated Franciscan Formation fault blocks consisting of interbedded greywacke and argillite, greenstone, and minor serpentinite that were subjected to low grade regional metamorphism during emplacement. The reservoir rock is a stack of juxtaposed greywacke slabs that vary in textural grade. The strata are crosscut pervasively by a highly communicative, interconnected network of fractures. Mineralogical, textural and stable isotope data indicate that semi-permeable brecciated zones, 50 to 100 m wide, are situated adjacent to the thrust-fault contacts and act as the primary conduits for convective fluid flow in the reservoir.

Based on mineralogical and stable isotope characteristics in both wells, two generations of hydrothermal activity can be recognized, which are here designated the Franciscan Event and Big Geysers Reservoir Events. The Franciscan Event is associated with the Late Cretaceous-Early Tertiary regional metamorphism. The later Big Geysers Events are related to Pliocene to Recent volcanism of the Clear Lake volcanic group and to the present steam field.

The Franciscan Event mineralization consists of quartz, calcite, chlorite, ankerite and ferrierite. The Big Geysers mineralization is subdivided into two successive assemblages. The earlier mineral assemblage was deposited during a water-dominated phase of the geothermal system: it consists of quartz, calcite, adularia, sphene, epidote, andradite, celadonite, micaceous illite, tremolite, diopside, pyrite, marcasite, sphalerite, chalcopyrite, galena, rutile, hematite and bornite. The later mineral assemblage, associated with the transition to the present steam-dominated conditions, consists of calcite, quartz, adularia, pyrrhotite, marcasite, sphalerite, chalcopyrite, galena, fahlore and gersdorffite. The mineral assemblages are distributed in prograde metamorphic mineral zones that progress from greenschist to hornfels facies. The maximum temperature during mineralization was approximately 350°C based on fluid inclusion temperatures and co-existing mineral phases. Salinity measurements for both quartz and calcite fluid inclusions ranged from .5 to 2.2 wt % NaCl equivalent with an averaged value of about 1%.

The transition from a water-dominated to a vapor-dominated reservoir occurred in three stages. The first was the Meteoric Stage, which is characterized by low $\delta^{18}O$ values indicative of abundant meteoric water at the inception of the geothermal system. The second stage was the Sealed Circulation Stage, which is characterized by high $\delta^{18}O$ values, indicative of a low water to rock ratio and a more limited influx of meteoric waters. This was presumably due to a reduction in permeability due to self-sealing by mineral precipitation. During this stage the hydrothermal fluids were superheated and geopressured with respect to hydrostatic boiling, as evidenced by fluid inclusion temperature data.

The third stage was the Stepped Boiling Stage, which is characterized by the occurrence of pyrrhotite as the principal iron sulfide phase, calcite fluid inclusion temperatures corresponding to vapor-static boiling, and calcite $\delta^{13}C$ values which indicate that the water present was steam condensate. A steam-water interface descended through the reservoir in steps, affecting each successive thrust fault block individually. Decompression of the geopressured fluids caused boiling, which in turn formed mineralized barriers in the high permeability zones. Residual waters trapped above each of these barriers or incrustation seals were subject to steam-static vaporization and the fluids below the seals maintained their high temperatures and pressures. The factors which promoted the pressure drop which caused vaporization of the reservoir were increased permeabililty in the discharge system due to hydraulic fracturing caused by geopressuring and tectonic activity, and insufficient permeability in the recharge system due to sealing of fractures. (Author's abstract)

STEVEN, T.A., CUNNINGHAM, C.G. and MACHETTE, M.N., 1981, Integrated uranium systems in the Marysvale volcanic field, west-central Utah, in Goodell, P.C. and Waters, A.C., eds., Uranium in volcanic and volcaniclastic rocks: Am. Assoc. Petro. Geologists Studies in Geol., no. 13, p. 111-122. Authors at U.S. Geol. Survey, Denver, CO.

Uranium in the Marysvale volcanic field is known to occur in several geologic environments and is thought to occur in others. These known and hypothetical occurrences are of various kinds, ranging in derivation from rhyolite magma, through porphyry-type deposits, hydrothermal vein deposits, dispersed hydrothermal deposits, and, after secondary transport in ground and surface water, roll-front or sedimentary-trap deposits in basin-fill sediments. To date, only the hydrothermal vein environment has been productive, but billions of pounds of uranium were available in all other environments, and if proper conditions existed, significant concentrations probably formed by other processes. The intracaldera fill of the Mount Belknap caldera and sediment-filled basins adjoining the Tushar Mountains are especially favorable exploration targets for the undiscovered uranium believed to exist. (Authors' abstract)

Fluid inclusion studies indicated that alunite veins formed from a highly acid, wet-steam geothermal system. The hydrothermal uranium veins were formed by dilute brines at temperatures of about 150°C. Mineral assemblage and paragenesis indicate that the solutions were rich in fluorine, contained some H_2S, and were acidic and reducing. Uranium, probably carried in uranous fluoride complexes, was deposited as the acidic solutions rose along the fractures, cooled, and became progressively neutralized by reaction with wall rocks. Uranium combined with oxygen and silica to form uraninite and coffinite, and fluorine combined with calcium to form fluorite. H_2S combined with iron to form pyrite, which is widely but sparsely distributed. The generally low pyrite content is believed to indicate relatively low concentrations of sulfur in the hydrothermal system. (From the authors' text)

STOGNIY, G.A. and SHUGUROVA, N.A., 1981, Physico-chemical conditions of formation of corundum in corundum-bearing veins of the Urals: in Mineralogical studies in the Il'menskiy Reserve, Ural Sci. Center of Acad. Sci. of USSR Pub. House, Sverdlovsk, p. 84-85 (in Russian). Book price 95 kopeck, 700 copies printed.

Specimens were taken from Il'menskiy Reserve, pits Nos. 210, 299, 300, corundum deposit Borzovskoe, asbestos deposit Sysert and ruby-bearing rocks of the massif Ray-Iz. Over 90 inclusion groups were studied, including: S one-phase inclusions, freezing temperature(sic) 15-18°C; S LCO_2 two-phase, Th 27-30°C, Te -56.6°C; PS three-phase with dm which on heating is redeposited as corundum on inclusion walls, Th 500-550°C or 570-640°C, plus G or LCO_2 and LH_2O with freezing temperature +7°C(sic). G consists of CO_2 (75-98 vol.%), N_2+rare G (5-25 vol.%) and NH_3+acid G (12-18 vol.%). Td of 12 samples of corundum were in ranges (series of peaks at indicated T ranges on each decrepitogram) 320-420, 540-570 and 700-800°C. (Abstract by A.K.)

STRASHIMIROV, S., 1981, Cryometric studies of inclusions in quartz from the Medet deposit: God. Vissh Min.-Geol. Inst., Sofia, v. 27, 1980-1981, no. 2, 1981, p. 73-80 (in Bulgarian; summary in Russian and English).

Two-phase (gas-liquid) and three-phase (gas-liquid-solid) inclusions in the main quartz generations are studied. Most of them show chloride or chloride-carbonate composition (freezing point at -21°C), and some inclusions contain also carbonic acid. Part of the inclusions from the first magnetite-hematite and pyrite-molybdenite-chalcopyrite parageneses have salinity equal to about 12% NaCl concentration, others have intermediate salinity between 8 and 5%, and the inclusions from the quartz-molybdenite paragenesis have salintiy of about 4%. Both salinity and temperature of the hydrothermal fluids are comparatively lower than those of other known porphyry-copper deposits, which correlates with the relatively smaller mass of ore matter and the lower grade of ore. This is attributed to the greater distance of the deposit from the magma hearth. (Author's abstract)

STYRT, M.M., BRACKMANN, A.J., HOLLAND, H.D., CLARK, B.C., PISUTHA-ARNOND, V., ELDRIDGE, C.S. and OHMOTO, H., 1981, The mineralogy and the isotopic composition of sulfur in hydrothermal sulfide/sulfate deposits on the East Pacific Rise, 21°N latitude: Earth & Planet. Sci. Letters, v. 53, p. 382-380. First author at Dept. Earth & Planet. Sci., Massachusetts Inst. Tech., Cambridge, MA 02139, USA.

The mineralogy of five groups of hydrothermal chimneys from the East Pacific Rise has been examined. Three of the chimneys, where the exit temperature of the hydrothermal fluids was close to 350°C, are rich in copper sulfides. Exit temperatures from the other two chimneys were less than 300°C; in these, the chimney walls are rich in zinc sulfide. The major sulfides in the chimneys as a whole were found to be wurtzite, chalcopyrite, pyrite, and cubanite. Anhydrite is always the dominant sulfate, and is present in all the deposits. Silicates are also present but in relatively minor amounts. There are considerable differences in the mineralogy of sulfides, sulfates, and silicates between the active and inactive vent deposits.

The isotopic composition of sulfur in anhydrites from active vents is close to that of seawater; the $\delta^{34}S$ values of the sulfides range from +1.3 to 4.1‰. The isotopic composition of sulfur in the anhydrites is consistent with a derivation predominantly from seawater sulfate. The sulfur in the sulfides must have a complex origin including contributions from both sulfur in basalts and sulfide produced by reduction of sulfate in seawater. Mixing of H_2S-dominated hydrothermal fluids with cold seawater near the seafloor resulted in the precipitation of non-equilibrium assemblages of sulfides and sulfates. (Authors' abstract)

Examination by E.R. of a series of doubly polished plates of wurtzite crystals from these vents showed no usable fluid inclusions. (E.R.)

SULKOWSKA, E., 1981, Mineralogy and geochemistry of quartz from pegmatites and quartz veins in the Sowie Mts.: M.Sc. thesis, Inst. Geochem., Mineral. and Petrogr. of the Warsaw Univ., unpublished (in Polish).

Quartz samples were taken from three outcrops in the Sowie Mts., Sudetes, SW Poland: pegmatite with rose quartz in amphibolites, Nowa Bielawa; pegmatite in gneiss, Kietlice near Owiesno; and pegmatite in gneiss, Pitawa Gorna. Th of inclusions in quartz from those metamorphic pegmatites (50 measurements, since inclusions good enough for the determinations were rare) are in ranges 330-440°C; from lithostatic load (4-5 km rock of about 1-1.5 kbar the P correction for Th obtained was ~120°C, i.e. probable T of quartz formation was 450-560°C. All inclusions homogenized in L phase, their fillings were of LH_2O+G or $LH_2O+LCO_2+GCO_2$ types. (Abstract by A.K.)

SUNAGAWA, Ichiro and SATO, Koji, 1981, Nucleation density and morphology of quenched crystals in a pillow lava from Awa-Kamogawa, Boso Peninsula, Japan: J. Japan. Assoc. Min. Petr. Econ. Geol., v. 76, p. 111-121. First author at Inst. Min., Pet. and Eco. Geol., Tohoku Univ., Aoba, Sendai, Japan.

Densities of nucleation sites of clinopyroxene, plagioclase and spherulite were measured and their morphologies were observed from the core to the outer parts of a pillow lava of tholeiitic basalt collected at Awa-Kamogawa, Boso Peninsula. Systematic changes of nucleation densities and morphologies were observed, which were interpreted in terms of the sample's cooling history. It was concluded that the lava had solidified within an hour, and that changes in nucleation densities and morphology represented the events of this short period. (Authors' abstract)

SUKHODUB, L.F., BERKIN, B.I., SHEL'KOVSKIY, V.S. and YANSON, I.K., 1981, Mass-spectrometry studies of thermodynamic characteristics of autoassociates of water: Akad. Nauk SSSR Doklady, v. 258, no. 6, p. 1414-1417 (in Russian). Authors at Physico-Technical Inst. of Low Temp., Khar'kov, Ukrainian SSR.

Dimer, trimer, tetramer and pentamer of H_2O molecules are characterized; pertinent to fluids in inclusions. (A.K.)

SUSHCHEVSKAYA, T.M., GRIGORYAN, S.S., KNYAZEVA, S.N. and KOZERENKO, S.V., 1981, Gaseous components of ore-forming solutions of a gold ore deposit: Izv. Akad. Nauk Arm. SSR, Nauki Zemle 1981, v. 34, no. 3, p. 45-53 (in Russian).

Based on gas chromatog. study of the gases from inclusions in quartz, the concn. of CO_2, the predominant gas in the ore-forming solns., increased significantly during the productive stage of mineralization at the Zod Au deposit. CO, CH_4, N_2, and H_2 occurred in the solns. in small amt. The CO_2/CH_4 ratio of the solns. from the inclusions in quartz was 2.6-25.08, 33.3-447.4, and 3.2-41.8 for the pre-ore, ore, and post-ore stages, resp. (C.A., 95: 190238r)

SUZUKI, Teruo, 1981, Cathodoluminescence of vein quartz from gold-silver ore deposits: Mining Geol. (Japan) Special Issue 10, p. 235-245 (in Japanese; English abstract). Author at Dept. Mining & Min. Engrg., Faculty of Engrg., Tohoku Univ., Sendai 980, Japan.

Quartz crystals show cathodoluminescence produced by electron bombardment. Samples from the various gold-silver ore deposits, i.e., three vein type deposits and one massive siliceous deposit, were studied for cathodoluminescence.

Broadly speaking, there are two types of quartz crystals; nonluminescent and luminescent. The former is found in hypothermal veins, and the latter found in the vein and massive siliceous ore, related to volcanism. The color of luminescent quartz has a characteristic wavelength through the monochromatic filter, B-47, of which hue is greenish. The intensity variation of luminescence corresponds strictly with a zonal structure within a crystal, but in most cases it is uneven in each crystal or in each part within a crystal.

It appears that such various appearances of quartz for cathodoluminescence may be intimately related to the vein textures and then to the origin of the deposits. (Author's abstract)

Pertinent to studies of the origin and interrelations of inclusions in quartz. (E.R.)

SVERJENSKY, D.A.a 1981, The origin of a Mississippi Valley-type deposit in the Viburnum Trend, southeast Missouri: Econ. Geol., v. 76, p. 1848-1872. Author at Dept. Earth and Space Sci., State Univ. of New York at Stony Brook, Stony Brook, NY 11794.

Petrologic and isotopic studies of the base metal sulfide mineralization in the Buick mine have established the following paragenesis: an early stage of fine-grained pyrite and marcasite replaced the dolostone host rock; the iron disulfides and dolostone were replaced by sphalerite during the main stage of sphalerite precipitation ($\delta^{34}S^{sp}$ 16.5 to 19.0‰). Following the sphalerite, two main stages of galena were precipitated - a cuboctahedral stage ($\delta^{34}S^{gn}$ 21.3 to 10.0‰), during which galena replaced dolostone and sphalerite and grew in vugs in the dolostone and in the sphalerite, and a cubic stage ($\delta^{34}S^{gn}$ 10.5 to 0.9‰). The two stages of galena precipitation were separated by a period during which the main stage of sphalerite and the cuboctahedral galena were partially dissolved and bladed marcasite ($\delta^{34}S^{mc}$ 2.3 to 4.1‰) was precipitated, and followed by a period of mild etching of the cubic galena. Minor amounts of pale sphalerite ($\delta^{34}S^{sp}$ 14.0 to 16.5‰) were then precipitated. White and colorless rhombs of dolomite were precipitated at the same time as some of the main stage of sphalerite, the cubic galena, and the pale sphalerite. After the pale sphalerite was precipitated, chalocpyrite, quartz, and siegenite were precipitated, followed by calcite and finally kaolinite. The paragenetic and textural data for both galena and sphalerite in the Buick mine strongly suggest that these minerals were precipitated and dissolved repetitively during ore formation. Similar textural evidence for galena reported by other workers for different mines in the Viburnum Trend imples that repetitive precipitation and dissolution of galena was probably an important process during the formation of the entire Viburnum Trend.

Fluid inclusions in late quartz crystals coprecipitated with chalcopyrite have filling and freezing temperatures within the ranges reported for sphalerite from other parts of the Viburnum Trend, demonstrating that the ore-forming solutions in the Viburnum Trend were probably at temperatures in the range 105° to 141°C (assuming a maximum pressure correction of about 11°C) and were extremely saline, containing about 4.0 to 5.0 molal chloride. Consideration of typical chemical analyses of fluid inclusions from other Mississippi Valley-type deposits suggests that the maximum likely concentration of dissolved CO_2 in the ore-forming solutions was about 0.05 molal. At these concentrations, the ore-forming solutions that travelled to the site of deposition could have had pH's about two units less than neutral and still have been in equilibrium with dolomite or calcite.

The ranges of sulfur and lead isotopic compositions of galena from the Buick mine are very similar to those established by earlier studies of the Old Lead Belt and adjacent subdistricts. However, the correlation of isotopically lighter sulfur with more radiogenic lead is much stronger for the Viburnum Trend, suggesting that galena was precipitated from many solutions, each of which carried lead and sulfur together and had different lead and overall sulfur isotopic compositions.

The textural, paragenetic, and isotopic data for the Buick mine cannot be easily explained either by a sulfate reduction model in which sulfate was reduced by organic matter or methane, or mixing models in which base metals and reduced sulfur were transported separately to the site of deposition. Instead, the data strongly support a reduced sulfur model for ore formation according to which the base metals were transported together with reduced sulfur (as H_2S), in the same solutions, to the sites of deposition. The reduced sulfur model is also supported by a theoretical calculation of the solubilities of galena and sphalerite, which demonstrate that low, but economically significant, concentrations of lead or zinc could have been transported as chloride complexes, together with equivalent concentrations of reduced sulfur, at temperatures of 100° to 150°C and pH's of one to two units less than neutral, and could have been precipitated by pH increases, cooling, or dilution at the sites of deposition. (Author's abstract)

SVERJENSKY, D.A., 1981b Isotopic alteration of carbonate host rocks as a function of water to rock ratio - an example from the Upper Mississippi Valley zinc-lead district: Econ. Geol., v. 76, p. 154-157. Author at Dept. Geol. & Geoph., Yale Univ., New Haven, CT 06520.

Isotopic alteration of carbonate host rocks in the Upper Mississippi Valley district can be modeled as a function of variable water to rock ratio. The large decreases of $\delta^{13}C$ and $\delta^{18}O$ toward a particular orebody can be attributed to recrystallization under conditions of progressively higher water to rock ratios near the orebody, and the extremely low carbon and oxygen isotopic compositions of the gangue calcite crystals from vugs in the orebodies may result from crystallization under conditions of an extremeley high water to rock ratio, as well as dilution by meteoric water. According to this model, limestone and dolostone with $\delta^{13}C$ values as high as 0 per mil and $\delta^{18}O$ values as high as 28 per mil were altered during recrystallization by hydrothermal solutions with initial isotopic compositions in the ranges of $\delta^{13}C$ -12 to -80 per mil and $\delta^{18}O$ 2 to 3 per mil. (Author's conclusions)

SVIRIDENKO, A.F., BALAKIREV, V.G. and KOVALENKO, I.V., 1979, "Icy" quartz from the Itmurunda deposit (northern Balkhash area): AN SSSR Izvestiya ser. geol., 1979, no. 11, p. 98-100 (in Russian; translated in Int'l. Geol. Rev., v. 23, no. 4, p. 477-494, 1981). Authors at All Union Sci. Res. Inst. of the Synthesis of Raw Materials, Aleksandrov.

"Icy" quartz from the Itmurunda jadeite deposit, visually resembling pieces of bluish-gray ice, forms lens-like bodies in fault zones among serpentinites. Monomineral quartz individuals are contoured by zones of amphibole-quartz-albite and albite-amphibole rocks. Study of these formations by optic and electronmicroscopy has established the presence of phenomena of metasomatic replacement and recrystallization of quartz with the liberation of mechanical impurities and gas-liquid inclusions from the latter. It is concluded that "icy" quartz is formed as a result of metasomatic replacement of amphibole-albite and quartz-amphibole-albite rocks which are widespread in the region of the deposit. (Authors' abstract)

Considerable attention is given to the nature of fluid inclusion cavities along grain boundaries. (E.R.)

TAGUCHI, Sachihiro and HIROWATARI, Fumitoshi, 1981, Chemical composition of sphalerite associated with gold mineralization at the Fuke mine, Kagoshima Prefecture: Mining Geol. (Japan) Special Issue 10, p. 35-42 (in Japanese; English abstract). First author at Res. Inst. of Ind. Sci., Kyushu Univ., Fukuoka 812, Japan.

Chemical composition and Fe distribution of sphalerite of the "Tozikin" gold ore from the Fuke mine, which shows a characteristic zonal arrangement of electrum and sulfides, have been investigated in order to clarify the gold mineralization.

It reveals that the FeS content of sphalerite which precipitated before electrum gradually decreases in a grain during its deposition ranging from about 2 to 1 mole%. Moreover, electrum usually occurs at the time of the FeS mole% of sphalerite being about 1%. It may be concluded from the above data that an increase of fS_2 caused by the oxidation of ore forming fluid is more important than the decrease of temperature. (Authors' abstract)

Th of quartz from "Tozikin" gold ore range from 215-280°C. (E.R.)

TAGUCHI, Sachihiro, MATSUMOTO, Yukio, HAYASHI, Masao, FUJINO, Toshio and YAMASAKI, Tatsuo, 1981, Geothermal structure of Kirishima Volcano in southern Kyushu (abst.): Abstracts 1981 IAVCEI Symp. on Arc Volcanism, p. 363-364. First author at Res. Inst. Industrial Sci., Kyushu Univ. 86, Fukuoka 812, Japan.

Maximum inclusion Th values for well samples occur hundreds of meters above equivalent temperatures in the well itself, indicating that temperatures were higher in the past than they are now. (E.R.)

TAGUCHI, Sachihiro, OKAGUCHI, Masako and YAMASAKI, Tatsuo, 1980, Reduction of the length of fission tracks by geothermal heating and its application to thermal history: Reports Research Inst. Indust. Sci., Kyushu Univ., v. 72, p. 21-26 (in Japanese; English abstract).

A fission track age of zircon from altered welded tuff from a well in the Kirishima geothermal field has been obtained. Spontaneous fission tracks reduce to 0.82 in length as compared with induced tracks by geothermal heat(sic). This reduction ratio may indicate that past underground temperatures were higher than the present maximum one observed around its depth. Moreover, the annealing time attains at least 4000 years if we can assume the annealing temperature to be 260°C, an average fluid inclusion temperature. (Authors' abstract)

TAKENOUCHI, Sukune, 1981, Fluid inclusion studies of Tertiary gold deposits: Mining Geol. (Japan) Special Issue 10, p. 247-258 (in Japanese; English abstract). Author at Dept. Min. Dev. Engrg., the Univ. of Tokyo, Tokyo 113, Japan.

Papers on the fluid inclusions of Tertiary gold deposits are briefly reviewed. Available data on filling temperature, salinity, stable isotopic composition, sulfur and oxygen fugacities, etc., of the Yatani (Japan), Antamok-Acupan (Philippines), Maratoto (New Zealand), Carlin (Nevada, U.S.A.), Sunnyside (Colorado, U.S.A.), and Finlandia (Peru) deposits, are summarized and compared. General tendency of ore-forming fluids of Tertiary gold deposits can be inferred from these data as follows; formation temperature is generally in a range of 200°-300°C except some deposits such as the Carlin, salinity is low, and the origin of water is meteoric. Papers on the transportation mechanism of gold are also reviewed briefly in relation to the character of hydrothermal solutions. (Author's abstract)

TALANTSEV, A.S., 1979, Combinational geological thermobarometer, derived from data on gas-liquid inclusions and maximum isomorphic substitution in calcite: Dokl. Akad. Nauk SSSR, v. 244, no. 4, p. 978-982 (in Russian; translated in Dokl. Acad. Sci. USSR, v. 244, p. 158-161, 1981).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 12, 1979, p. 185. (E.R.)

TALANTSEV, 1981a, 1981b - See Appendix

TALANTSEV, A.S., 1981c On the reliability of the determination of temperatures of hydrothermal mineral formation by the method of homogenization of primary inclusions: Zapiski Vses. Mineral. Obshch., v. 110, no. 3, p. 266-277 (in Russian). Author at Inst. of Geol. and Geochem. of the Ural Sci. Center of Acad. Sci. of USSR, Sverdlovsk, USSR.

The data obtained on the basis of various methods of joint determination of temperatures and pressures during development of natural hydrothermal processes, in significant part changes the previous opinions on hydrothermal mineral formation. Pressure in those processes may vary over very wide ranges even within one stage of mineral formation and not rarely it reaches 1-2 kbar. The unambiguous conclusion may be made from the above data that results of studies of temperature regime of mineral- and ore-formation, obtained by homogenization of P inclusions have too high level of probable error and in many cases they may lead to incorrect conclusions both on T regime and on peculiarities of development of the studied hydrothermal processes. This conclusion is illustrated by a number of examples described in the paper.

It is evident that very spectacular opinions about P inclusions in natural minerals as "self-registering" geological thermometers made in the early stages of the development of thermobarogeochemistry and put in the basis of the homogenization method appears too simple. That was evidenced over 20 years ago by P.V. Klevtsov and G.G. Lemmlein, but at that time their conclusions were not commonly accepted due to the prevalent widespread opinion about low P during hydrothermal processes. Subsequent data did not support this opinion.

Hence, one of the most urgent problems of thermobarogeochemistry is the finding of ways of determination of P corrections for Th of the studied P inclusions. One of the prospective ways of its solution is the use of multiple geothermobarometers, in which the determination of P and T during mineral origin is made not only on the basis of results of inclusion studies, but also on the peculiarities of host mineral in which they are trapped. Extensive application of microanalyzers makes possible the further development of appropriate studies. (Author's conclusions, translated by A.K.)

TANAKA, Hidehiko, UEMURA, Yoichiro and INOMATA, Yoshizo, 1981, Observations of holes around dislocation core in SiC crystal: J. Crys. Growth, v. 53, p. 630-632. Authors at Natl. Inst. Res. in Inorganic Materials, Namiki 1-1, Sakura-mura, Niihari-gun, Ibaraki-ken 305, Japan.

The growth spiral and the hole around the dislocation core in SiC crystal were observed. The measurements of the step height of the spiral and the length of circumference of the hole suggest that the distortion of the (0001) plane about the c-axis by about 1.3° changes the bonding energy by about 0.2%, i.e. by about 270 cal/mole. (Authors' abstract)

TARAN, Yu.A., NOVAK, F.I., ANTOSHCHUK, I.A. and BASHKIROV, A.N., 1981, Catalytic properties of volcanic rocks in synthesis of hydrocarbons from carbon (mon)oxide and hydrogen: Akad. Nauk SSSR Doklady, v. 257, no. 5, p. 1158-1161 (in Russian). First author at Inst. of Oil-Chemical Sythesis of Acad. Sci. of USSR, Moscow.

Samples of dacite and basalts displayed catalytic activity in the process of synthesis of hydrocarbons (gaseous and liquid) from a 1:1 mixture of H_2 and CO at T 350-450°C and P = 50 atm; up to 80% of CO and up to 60% of H_2 is used under those conditions. Pertinent to gas presence in fluid inclusions. (A.K.)

TAYLOR, B.E., 1981, Hydrothermal fluids in the Mother Lode gold deposits of California (abst.): EOS, v. 62, p. 1059. Author at Dept. Geol., Univ. California, Davis, CA 95616.

Gold-bearing quartz veins fill faults and fractures in metamorphic sedimentary and volcanic wall rocks of the Mother Lode gold belt which bear evidence of CO_2 metasomatism.

Locally, $\delta^{18}O$ values of vein quartz typically vary less than 3.0‰. Regionally, $\delta^{18}O$ values are in the range of +15 to +22‰, reflecting the dominant wall rock lithology due to low water/rock ratios away from the veins. Oxygen isotope fractionations between quartz, muscovite (mariposite), magnetite, (some) serpentine, calcite, and Fe-carbonate suggest formation temperatures of 300 to 350°C. The oxygen isotope composition of the vein-forming fluids was approximately +11 to +15‰.

Hydrogen isotope analyses of minerals and fluids inclusions indicate a range in δD of -45 to -80‰ for the vein fluid. Meteoric water may have been present in very minor amounts locally, but was not characteristic of the Mother Lode deposits as a whole.

Fe-carbonate ($\delta^{13}C$ = -4.9 to -6.9‰) in wall rocks was in carbon isotope equilibrium with CO_2 ($\delta^{13}C$ = -1.92 to -5.16‰) from fluid inclusions in quartz at about 300°C. Graphite in quartz veins ($\delta^{13}C$ = -20 to -25‰) is isotopically indistinguishable from wall rock graphite of organic origin, would be in isotopic equilibrium with the carbonate at ≈350°C.

Pyrite, arsenopyrite, galena, and sphalerite associated with free gold have $\delta^{34}S$ values of 0 to +5.0% , compatible with derivation of sulfur from the metavolcanic rocks.

Ore-forming solutions were essentially metamorphic in nature, and contained CO_2 of possible magmatic and metamorphic origin. Although gold was leached from the volcanic-sedimentary rocks during metamorphism, a particular source rock is not unequivocally indicated. (Author's abstract)

TAYLOR, R.P., 1981, Isotope geology of the Bakircay porphyry copper prospect, northern Turkey: Mineral. Deposita, v. 16, p. 375-390. Author at Dept. Geol., Memorial Univ. of Newfoundland, St. John's, Newfoundland, Canada.

Isotopic data for the Bakircay granodiorite porphyry (K-Ar ages and initial $^{87}Sr/^{86}Sr$ ratios) for unaltered, potassic altered, and potassic-propylitic altered rock give a Late Eocene age for the development of the porphyry copper system. They suggest a close temporal and genetic relationship between igneous and hydrothermal activity, and indicate that magmatic-hydrothermal fluids produced potassic alteration and that meteoric fluids enriched in radiogenic ^{87}Sr were responsible for propylitic alteration. The granodiorite porphyry is petrologically similar to porphyry copper-related intrusions from island arc and continental margin settings, which form a group with initial $^{87}Sr/^{86}Sr$ ratios of less than 0.7043, representing magmas produced in tectonic environments lacking any important component of old (i.e., Precambrian) continental material. (From the author's abstract)

TAYLOR, R.P., STRONG, D.F. and FRYER, B.J., 1981, Volatile control of contrasting trace element distributions in peralkaline granitic and volcanic rocks: Contrib. Mineral. Petrol., v. 77, p. 267-271. Authors at Dept. Geol., Memorial Univ. of Newfoundland, St. John's, Newfoundland, Canada A1B 3X5.

Anomalous enrichments of Zr (>500 ppm), Zn (>100 ppm), Nb (>25 ppm), Y (>60 ppm), Th (>20 pm), U (>5 ppm), LREE (>230 ppm) and HREE (>35 ppm), and high Rb/Sr (>5) characterize peralkaline granites, in contrast to their peraluminous and calc-alkaline equivalents. Within the peralkaline suite, comenditic and pantelleritic volcanics exhibit two- to five-fold increases in the concentrations of these trace elements over comagmatic granites. These cannot be explained by crystal-liquid fractionation processes, and require the evolution of a sodium-enriched fluid. Corresponding trace element increases in the granites in areas of alkali metasomatism support this argument, and reflect the partial confinement of this volatile phase within the high-level magma chambers. REE studies in particular might eventually allow an evaluation of the role of Cl^- versus F^- and CO_3-complexing in the evolution of the volatile fluid. (Authors' abstract)

THOMPSON, A.B., 1981, The pressure-temperature (P, T) plane viewed by geophysicists and petrologists: Terra Cognita, v. 1., no. 1, p. 11-20.

It is often difficult to explain to many colleagues who are not immediately involved in a particular research effort just why it is necessary to call a temporary halt to active research to take a step back and to ask "Why we are doing what we are doing?" and more specifically "Are we doing things the right way?" In our opinion the stance of critical observer is a badly needed one within the realms of the petrological endeavors in geothermometry and geobarometry and the geophysical endeavors in thermal evolution associated with tectonic processes. To place our symposium* in context, it is at least useful to consider some prevalent practices and spare no embarassment to question both their correctness and usefulness. (Author's abstract)

*Symposium on some current aims of geothermometry and geobarometry held at the First Meeting of the European Union of Geosciences in Strasbourg, April 1981.

THOMPSON, C.A. and KOSTER VAN GROOS, A.F., 1981, Experimental determination of phase relations in the system Fe_3O_4 - $Ca_5(PO_4)_3F$ (abst.): Geol. Soc. Am. Abstracts with Programs, v. 13, p. 319. Authors at Dept. Geol. Sci., Univ. Illinois, Box 4348, Chicago, IL 60680.

Phase relations along the composition join magnetite (Fe_3O_4) - apatite ($Ca_5(PO_4)_3F$ have been determined at 1 atm pressure and temperatures between 1200-1700°C. Oxygen fugacity was maintained at values appropriate for the magnetite stability field. An extensive two-liquid field is found at temperatures above 1450°C. Almost pure (5% Fe_3O_4) apatite liquids are separated from iron-rich liquids containing up to 12% apatite. The temperature of the solidus is difficult to determine, but it must lie below 1360°C. The maximum apatite content of a magnetite rich liquid is determined as a function of temperature. This study will shed some light on the conditions of formation of iron oxide-apatite rocks, especially those that are magmatic in origin (e.g., El Laco, Chile). (Authors' abstract)

THOMPSON, Michael, 1981, Prospects for the use of the inductively coupled plasma (ICP) in fluid inclusion analysis (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Applied Geochem. Res. Group, Dept. Geol., Imperial College, London SW7 2BP, England.

The ICP is a recently developed excitation source for atomic emission spectrometry with uniquely powerful analytical characteristics. Material introduced into the plasma is atomized with high efficiency by the high temperature (9000-10,000 K), and provides an optically thin low background emission. A wide range of elements can be simultaneously determined, with low detection limits, low interference effects, and linear calibrations. Samples are normally introduced by nebulization of aqueous solutions in argon carrier gas, but any technique which produces an aerosol of fine (<5 μm) particles can be used as an alternative. Most metallic elements have detection limits of 0.01 μg/ml or less, and the non-metals B, C, S and P can also be determined with ease. Only the halogens F, Cl and Br cannot be determined at all.

The Crushing-Leaching Technique. In fluid inclusion analysis an important feature of the ICP nebulization technique is the small (0.5 ml) volume of solution required for a multielement analysis. Thus the conventional crushing and leaching method of opening inclusions can be conducted with a minimal dilution of the inclusion contents. This fact, in combination with the inherently low detection limits of the ICP, allows the determination of most metals that are more concentrated than 5 μg/ml in the inclusion fluid, and some (e.g., Be, Mn, Ba, Sr) which are considerably less.

Crushing of 0.5 g of material with 2 ml of liquid is carried out in a sealed 10-ml ball mill. The leach liquid must be acidified to minimize loss of trace ions such as Cu^{2+} and Sn^{4+} by hydrolysis or adsorption on the large surface created by the crushing. The resultant liquid is centrifuged to remove suspended host mineral, and analyzed directly on the ICP. Contamination by the material of the ball mill or by foreign mineral grains is a problem in this technique.

The Decrepitation Technique. Many minerals which contain fluid inclusions are ruptured by the internal pressure produced when the crystals are rapidly heated. The consequent explosive release of pressure results in a fine spray from the fluid phase of the inclusions, from which the water rapidly evaporates leaving an aerosol of very fine solid particles, ideal for transport into the plasma. Small fragments of host mineral simultaneously released do not usually cause spurious analytical signals.

This is a more efficient way than nebulization of injecting inclusion material into the plasma. Thus lower concentrations, and hence a wider range of elements, can be detected. There is also less scope for sample contamination or loss of analytes. However the results are more difficult to interpret because it is not certain whether all of the inclusion contents (for example daughter minerals) are carried into the plasma. In addition some trace elements (such as Pb, Cu and Zn) can volatilize from samples at moderate temperatures, and this fraction may also be injected into the plasma. Despite these problems it seems that decrepitation-ICP can provide a rapid semi-quantitative method for identifying the former presence of metal-bearing fluids in a rock. (Author's abstract)

TINGLE, T.N., 1981, An experimental study of liquid immiscibility in the Davie County orbicular rock, central North Carolina Piedmont (abst.): EOS, v. 62, p. 1063.

TITLEY, S.R. and BEANE R.E., 1981 Porphyry copper deposits. Part I. Geologic settings, petrology, and tectogenesis; Part II. Hydrothermal alteration and mineralization Econ. Geol., 75th Anniv. Vol., 1981, p. 214-269. First author at AMAX Exploration, 130 S. Scott Ave., Tucson, AZ 85701.

Knowledge about many aspects of porphyry copper deposits has broadened immensely over the past several decades and especially since the mid-1960s. This review focuses on the deposits in two ways, by discussing their broad geologic setting and tectogenesis and their alteration and mineralization; however, the review is largely limited to the Mesozoic and Cenozoic deposits of the Pacific basin rim.

Radiometric age data show that porphyry deposits formed in three, clearly separated, broad intervals of time - the pre-Laramide, the Laramide, and the interval since ~40 m.y. ago. The deposits, regardless of age, occur within terranes having comparable distinctive geologic characteristics. On the eastern side of the Pacific basin, they are generally situated between older batholitic complexes and uplifted or exposed older cratons and are in moderately to strongly deformed mobile belts containing large numbers of parallel faults and folds. This environment is present in both accreted continental margins, such as the Canadian Cordillera, and in rigid margins, such as coastal Peru and Chile. Although the environment of deposits in the island regions of the western Pacific, most of which are of post-Laramide age, are more varied, most deposits occur along island or archipelago axes and in regions characterized by known or inferred parallel fault systems.

Petrologic data on rocks of the basin rim indicate two basic kinds of intrusions; the first, in the island regions, is characterized by low

K_2O/CaO ratios, the other, in continental settings, has relatively higher ratios. Differences in Na_2O and K_2O content also exist between the two settings. A distinctive alkaline suite occurs with certain deposits of the Canadian Cordillera. Most suites, where studied, are grossly of calc-alkaline nature, but differentiation trends are different in different settings, and there does not seem to be any specific kind of rock composition that is uniquely related to porphyry copper plutons. Initial Sr ratios for rock types of New Guinea and the American southwest are closely similar for both barren and productive plutons and for coeval volcanic rocks within regions, but the ratios differ considerably from one region to another.

A review of plate tectonic phenomena as they may relate to porphyry copper evolution suggests that episodes of intrusion in the Pacific basin rim correspond to times of higher convergent rates, to times when the convergence style changed and, most fundamentally, to destructive plate margins. Different convergence styles, such as oblique convergence, may prepare the crust to permit rapid access of magmas to shallow levels. Copper metallogeny has been related by some to subducted ocean crust; others interpret some metals as inherited from crust or mantle. Nevertheless, consideration of events of plate history in the context of intrusion episodes reveals, almost unequivocally, that a close cause and effect exists between the geotectonics of plate interactions and porphyry copper formation.

Intrusions related to porphyry copper-type mineralization differ from nonproductive plutons by having persistent and pervasive hydrothermal effects that extend into the surrounding wall rocks. Characteristic assemblages of alteration minerals exhibit systematic spatial and temporal relationships with respect to one another, but the patterns and compositions differ in quartz monzonitic and dioritic intrusions. Quartz monzonitic rocks have a central potassic or K-silicate zone containing hydrothermal K-feldspar and biotite, an intermediate zone of quartz + sericite, and a peripheral propylitic halo containing epidote, chlorite, and albite similar to greenschist facies metamorphism. Hypogene mineralization consisting of low ($\sim$1 vol %) total sulfides but high chalcopyrite/pyrite ratios occurs in the outer portion of the potassic zone surrounding a barren core; the surrounding quartz + sericite zone has considerably higher sulfide content, consisting almost entirely of pyrite. In dioritic rocks, central potassic alteration is predominanted by biotite, and quartz + sericite alteration is largely lacking. Consequently, these deposits characteristically have lower sulfide contents than the quartz monzonite analogue, although hypogene copper may be higher in the diorite type. Alteration in silicate wall rocks commonly continues outward from that of the central intrusion. In carbonate wall rocks, on the other hand, calc-silicate phases are developed, consisting chiefly of garnet and diopsidic pyroxene, which are bordered outward from the intrusion by marble. This anhydrous skarn is commonly crosscut by chlorite, epidote, talc, calcite, quartz, and/or clay minerals. Hypogene mineralization consisting of chalcopyrite and sphalerite takes place at the same time as the formation of anhydrous skarn, or at least prior to formation of the later hydrous assemblage. The upper portions of intrusions or preore lithocap contain chiefly argillic or solfataric alteration comprising clay minerals, fine-grained silica, and alunite accompanied, apparently, by chalcopyrite, enargite, pyrite, and hematite. It has been tentatively suggested that such mineralization is in part derived by leaching and remobilization of intrusion-related mineralization at depth.

Mineral stability diagrams provide a useful link for interpreting diverse alteration mineral assemblages in a variety of geologic environments. Most important is the suggestion that propylitic (chlorite ± epidote) alteration is a high Mg-Ca analogue to the quartz + sericite assemblage and may occur in dioritic environments. Additionally, stability of chalcopyrite requires a relatively restricted range of interrelated environmental factors, including temperature, activities of sulfur and oxygen, and the iron/hydrogen ratio in the hydrothermal fluid. Examination of mineral stability diagrams in view of the spatial and temporal relationships among hydrothermal minerals in the porphyry copper deposits indicates that with time, fluids within these systems produce alteration compatible with decreasing temperatures or lower cation/hydrogen activity ratios. Both changes can be called upon as explanations for certain observed zoning and paragenetic features.

Oxygen isotope studies indicate that early potassic alteration in intrusions was generated by fluids derived by magmatic processes, and that later quartz + sericite was produced from fluids of meteoric origin. Fluid inclusion studies suggest that magmatic fluids had high salinities (on the order to 30 to 60 wt % NaCl equiv.), whereas the meteoric variety were far more dilute (<15 wt %). Evidence for boiling (or condensation) of both fluid types is seen at various deposits, but the occurrence of such is neither systematic nor universal. Computed fluid-flow models predict that at various positions in the porphyry copper system, these two fluids would appear at different times and in different relative and absolute abundances. Such fluid flow patterns around and through a cooling pluton are greatly influenced by the distribution of rock permeabilities, which are directly related to the abundance and nature of fractures. With time, abundance of fractures appears to be increasingly confined to the intrusion-wall rock contact, with late hydrothermal effects generally concentrated in this space. No clear-cut evidence exists to relate fluids of either predominantly magmatic or meteoric origin to hypogene mineralization. (Authors' abstract)

TOURAY, J.C. and ZISERMAN, A., 1981, Comments on: "Fluid inclusions as indicators and false indicators of deposition conditions. Some examples of Pb, Zn, Ba and F of southern French Massif Central" by C. Sabouraud, J.C. Macquar and H. Rouvier, Mineralium Deposita, 211-230 (1980): Mineral. Deposita, v. 16, p. 177-179.

The discussed paper was abstracted in Fluid Inclusion Research--Proceedings of COFFI, v. 13, p. 216-217, 1980. (See also Sabouraud et al., 1981, this volume.) The following abstract was provided by Dr. Touray:

The best argument for claiming natural stretching of inclusions in fluorite at Saint Laurent les Bains is the occurrence of *rare* two-phase inclusions amongst one-phase primary liquid inclusions. Such two-phase inclusions homogenize around 120°C, with limited scatter, which is a very perverse phenomenon. One may ask if it is general; in other cases, notable scattering is known after overheating. Overheating may be early, indicating thermal oscillations in hydrothermal systems, or late (e.g., related to burial). The geological significance of these two is very different.

At "Le Burc," overheating was early, the stretched fluorite being intercalated between "fluorine bleue ou bleu et blanc" and "fluorine miel" homogenizing at temperatures higher than 100°C. At Saint Laurent les Bains, the authors favor a late overheating. Apparently some of their data require some additional explanations: in fig. 21, the modal homogenization temperature is 160°C and in fig. 22, stretched inclusions indicate 120°C only (as secondary ones do). We think that no late overheating affected the Ba-F deposits from Marche, as we did not observe one-phase liquid inclusions, except in limited late recrystallization zones; if further examination would indicate that "preserved" primary low temperature inclusions are present, the conclusion would be thermal oscillations during deposit and not late overheating for the following reasons:

a) The Chaillac deposit being partly stratiform was dated using classical stratigraphical concepts as post Hettangian and pre Binemurian (i.e. about 180 m.y. old).

b) Fluorite vein deposits in other parts of the Marche district (Le Peurault, Le Chatenet) contain adularia whose K-Ar ages are 195 ± 10 m.y.

c) Adularia is well known to be highly sensitive to thermal rejuvenation (argon loss). Accordingly, if any overheating occurred in Marche, it was at the time of ore deposition at Chaillac. (Authors' abstract)

TOURET, Jacques, 1981a, Binary systems and microthermometry with particular reference to the N_2-CO_2 system (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Inst. voor Aardwetenschappen, Vrije Univ., 1007 MC, Amsterdam, The Netherlands.

Fluid inclusions are isochoric systems, which can only be interpreted in terms of P and T if the system is pure. In most cases, the purity of a fluid is estimated from the coincidence between final melting temperature and triple point of a pure component. For mixtures of CO_2 and permanent gases, notably CH_4 and N_2, the depression of the melting point of the mixture is nearly constant and relatively small (a few °C) for a large compositional range, while homogenization temperatures show a much greater range of variation. This is illustrated by isobaric T-X sections of the P-T-X space. In fluid inclusions from Tunisian metamorphic dolomites, microthermometric data have been measured and chemical composition has been estimated by Raman analysis (N. Guilhaumou, thesis, Orleand University, 1981, 145 p.). From these data, a tentative T-X section of the N_2-CO_2 system is proposed. It supposes a similar behavior of N_2-CO_2 and CH_4-CO_2 systems (total immiscibility of the solid, miscibility of the liquid phases, continuous 1st order critical curve) and it agrees with most features observed by N. Guilhaumou: (CO_2 milting around -60°C for $0.15 < XN_2 < 0.57$, CO_2 sublimation <u>below</u> this temperature for $XN_2 > 0.57$). (Author's abstract)

TOURET, J., 1981b, Fluid inclusions in high grade metamorphic rocks, Chapter 8, pp. 182-208, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 8 Contents

Microthermometry: Melting and Homogenization Temperature Histograms
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References

TRUFANOV, V.N., GRANOVSKIY, A.G., GRANOVSKAYA, N.V., KURSHEV, S.A. and PROKOPOV, N.S., 1981, Mineralogical criteria for evaluating rare metal and polymetallic mineralization in the Northern Caucasus: Mineral. Zhurnal, v. 3, no. 1, p. 29-37 (in Russian; English summary). First author at Rostov. Gos. Univ., Rostov-na-Donu, USSR.

The paper deals with the results of complex mineralogical and thermobarogeochemical studies performed for mercury, polymetallic and rare-metal deposits of the Northern Caucasus. Four decrepigrams are shown, as examples of mineralogical criteria applicable for determining the prospects of insufficiently explored ore manifestations within the limits of the Caucasian metallogenic province. (From the authors' abstract)

TRUFANOVA, L.G., 1981, Experimental studies of formation conditions of lithium minerals in the system granite-H_2O-LiCl: Akad. Nauk SSSR Doklady, v. 260, no. 2, p. 476-480 (in Russian).

Pertinent to reconstructions of conditions of origin of petalite- and spodumene-bearing pegmatites by fluid inclusion studies. (A.K.)

TSUSUE, A., NEDACHI, M. and HASHIMOTO, K., 1981, Geochemistry of apatites in the granitic rocks of the Molybdenum, Tungsten, and Barren provinces of southwest Japan: In A.W. Rose and H. Gundlach, eds., Geochemical Exploration 1980: J. Geochem. Explor., v. 15, p. 285-294.

Recognition of the importance of chlorine complexing in enhancing the solubility of metal sulfides in aqueous solutions has led to the view that the chlorine content of intrusive rock could govern the ability of a magma to separate a metal-rich hydrothermal phase. This article presents the chlorine and fluorine contents of apatites in the granitic rocks of the Barren, Tungsten, and Molybdenum provinces of southwest Japan.

The abundance of Cl in apatites correlates negatively with rock D.I. (differentiation indices), and the abundance of F in apatites correlates positively with rock D.I. The abundance of Cl in apatites of the Molybdenum province is generally higher than that of the Tungsten and Barren provinces, and the abundance of F in apatites in the Molybdenum province is generally lower than that of F in apatites of the Tungsten and Barren provinces.

Apatites in the granitic rocks associated with tungsten and fluorite mineralization and granite pegmatite formation, and from the Barren province are mostly F-OH apatites. (Authors' abstract)

TSUSUE, Akio, NEDACHI, Munetomo and MIZUTA, Toshio, 1981, On the granitic rocks of the Tsumo mining district, especially on the halogen contents of rock-forming minerals: Mining Geol. (Japan) Special Issue, v. 9, p. 15-22 (in Japanese; English abstract). First author at Dept. Geol., Faculty of Sci., Kumamoto Univ., Kumamoto 860, Japan.

Two series of granitic rocks, namely the ilmenite series and the magnetite series, are found in the Tsumo mining district. The K-Ar ages of the former belong to 60-100 m.y. range, whereas those of the latter belong to 30-50 m.y. range. From the distribution of base metal ore deposits and granitic rocks, base metal mineralization in the Tsumo district appears to be associated with the granitic rocks of late Cretaceous age.

Chloride almost certainly plays an important role in extracting base metals from granitic magmas. To find an intrusive mass associated with the base metal mineralization in the Tsumo district, the halogen contents of apatite in the granitic and dioritic masses have been determined by microprobe methods. From the zoning of ores, size of intrusive masses, and width of contact aureoles, it has been suggested that the Masago mass of adamellitic composition is a probable candidate for the direct source of the mineralization. From the chlorine content of apatite, however, the Miyakodani mass of granodioritic composition appears to be a more probable candidate in this respect. (Authors' abstract)

TUGANOVA and EGOROV, 1981 - See Appendix

TURPIN, L., RAMBOZ, C. and SHEPPARD, S.M.F., 1981, Chemical and isotopic evolution of the fluids in the Sn-W deposit, Panasqueira, Portugal (abst.): Terra Cognita, 1981 Spring, Special Issue, p. 42. Authors at Centre de Recherches Petrog. et Geochim., C.O. no. 1, 54500 Vandoeuvre-les-Nancy, France.

Fluid inclusion analyses, $^{18}O/^{16}O$ ratios of quartz, muscovite, cassiterite, whole rock and D/H ratios of both muscovite and fluid inclusions in quartz, cassiterite, arsenopyrite have been determined for two different paragenesis, in the schists ($\delta^{18}O$~+12‰), at Panasqueira. Fluids associated with the most usual geodic paragenesis (qtz-musc-apat-cass-arspy.) are liquid dominant (~7 wt-equiv.NaCl), two-phase fluids containing minor CO_2 and/or hydrocarbons, N_2, etc., which homogenize at 310±10°C and have δD~-50 to -60‰ (calcul. and/or meas.), $\delta^{18}O$~+8‰(calcul.). The CO_2/H_2O ratio decreased whilst the N_2, CH_4, C_2H_6 contents increased with time. The other is a sheared and brecciated qtz-musc-cass-tourm-wolfr-topaz-rutile vein. Fluid inclusions in cassiterite are complex and include saline liquids (~14% wt-equiv.NaCl) with homogenization temperatures of 270±10°C, low density CO_2 and/or hydrocarbons inclusions and indirect evidence for boiling. Inclusions in quartz are heterogeneous and contain high density CO_2 and hydrocarbons. For quartz and muscovite, δD fluid ~-45‰, but for cassiterite δD fluid = -5‰. The following results contrast with those of Kelly and Rye (1979): - Evidence for boiling during precipitation of some cassiterite; - At least for some cassiterite, same δD fluid as that for associated quartz, miscovite, arsenopyrite. The interpretation of δD fluid = -5‰ at Panasqueira is not certain although Permo-Triassic meteoric waters at some other Hercynian deposits had such values. (Authors' abstract)

TVALCHRELIDZE, A.G., 1981, Geochemistry of hydrothermal-sedimentary sulfide mineral formation: Geol. Rudn. Mest., v. 23, no. 2, p. 3-16 (in Russian). Author at Caucasian Inst. of Mineral Raw Materials, Tbilisi, Georgian SSR.

Pertinent to composition of inclusion fluids. (A.K.)

VAKHRUSHEV, V.A., 1981, Halite-magnetite ores from the Siberian platform: Geol. Rudn. Mest., v. 23, no. 6, p. 100-105 (in Russian). Author at the Homel State Univ., Homel, Ukrainian SSR.

The paper presents magnetite-halite ores formed by replacement of halite evaporite layers. Pertinent to NaCl-rich mineral-forming fluids in inclusions. (A.K.)

VAR'YASH, L.N. and REKHARSKIY, V.I., 1981, Behavior of Cu(I) in chloride solutions: Geokhimiya, 1981, no. 7, p. 1003-1008 (in Russian).

VASIL'YEV, B.D. and VASILENKO, V.N., 1981, Mineralogic criteria for ore-bearing capacity and features of the formation of gold as a result of experimental studies, in: Mineralogic criteria for analyzing ore composition, Rundkvist, D.V. et al., eds.: Leningrad, Izd. Nauka, p. 167-175 (in Russian).

VDOVYKIN, G.P., VISHNEVSKIY, S.A., ZHUYKOVA, T.L. and ZYKOVA, P.D., 1981, Gas-liquid inclusions, gas composition and carbon content in deep-seated trap sills of the Western part of the Tunguska syncline and Nep-Botuoba anticline, Siberian platform: Akad. Nauk SSSR Doklady, v. 256, no. 2, p. 452-456 (in Russian). Authors at All-Union Sci.-Research Inst. of Natural Gases, Vidnoe, Moscow Region, USSR.

Dolerites found in boreholes bear gases with a composition similar to gases of the sedimentary wall-rocks. Inclusions occur in pyroxenes, olivines, and more rarely in plagioclases. Melt inclusions contain silicate glass + G + magnetite dm, secondary G inclusions sometime also bear carbonate(?) dm. G was released from ground samples at 200°, 600° and 900°C and analyzed by G chromatography. On heating of dolerites up to 200°C, N_2 (5.6-23.5 cm^3/kg) and CO_2 (19-128 cm^3/kg) were detected, and up to 600 and 900°C - H_2, N_2, CO_2 and hydrocarbons, mainly CH_4; CO_2 is the prevailing component. The reference samples of basalt and kimberlite yielded moreover CO and kimberlite - H_2S. The detected gases are total of inclusion components, absorbed gases and products of pyrolysis. (Abstract by A.K.)

VERKHOVSKIY, A.B., KHOREV, A.N. and LEVSKIY, L.K., 1981, Cosmochemical and geochemical consequences of sorption of argon and xenon by minerals: Geokhimiya, 1981, no. 11, p. 1627-1636 (in Russian).

VETSHTEIN, V.E. and SHCHERBAK, D.N., 1981, Distribution pattern of hydrogen isotopes of gas-liquid inclusions in sodium metasomatites: Dopov. Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim. Biol. Nauki 1981, no. 1, p. 3-6 (in Ukrainian).

The distribution of H isotopes of gas-liq. inclusions in Na metasomatites gives information about the genesis of the aq. solns. responsible for metasomatism. The water of meteoric and metamorphic compn. formed during the development of Na metasomatities. The high ionic activity of meteoric water is probably responsible for the occurrence of U in the analyzed samples. (C.A., 94: 195346p)

VIDALE, Rosemary, 1981, Potential for geochemical experiments in large scale tests (including ranges of stresses, pore fluid pressures and compositions, and temperatures): Geophys. Res. Letters, v. 8, no. 7, p. 657-658. Author at Los Almos Natl. Lab., Los Alamos, NM 87545.

Geochemical problems that would benefit from large scale experiments include: 1) the determination of the physical properties of the many common rocks that are chemically homogeneous on the scale of 5-100 cm but not on a scale of 1-5 cm, 2) the study of the influence of rock textures and compositions and of the chemistry of the pore solution on stress corrosion cracking, and 3) the study of chemical transport within gradients in temperature, chemical potentials and stress. The ultimate goal of a few well-chosen large scale studies should be the development of predictive models. (Author's abstract)

VIKRE, P.G., 1981, Silver mineralization in the Rochester district, Pershing County, Nevada: Econ. Geol., v. 76, p. 580-609. Author at ASARCO Inc., Southwestern Explor. Div., Box 5747, Tucson, AZ 85703.

The Rochester district encompasses a number of precious metal vein deposits which produced $7 million in silver and gold from 1912 to 1928. The largest deposits were mined on Nenzel Hill where over 100 million tons of low-grade silver-gold mineralization have recently been defined. The veins and low-grade mineralization occur in rhyolites of the Permian-Triassic Koipato Group. The Koipato Group includes mafic to siliceous volcanic and intrusive rocks scattered throughout north central Nevada. Overlying Mesozoic sedimentary rocks, once more than 11,000 ft thick in the vicinity of Rochester, have been severely eroded since the inception of Tertiary basin and range tectonism. Koipato rhyolites were hydrothermally altered on a regional scale to quartz-sericite-pyrite as a result of both the emplacement of comagmatic Koipato intrusives and Late Cretaceous stocks. Precious metal mineralization at Rochester probably accompanied the Late Cretaceous event.

The major veins of Nenzel Hill comprise two mineral assemblages which fill and replace faults and strongly fractured rhyolite. Stage 1 veins consist of quartz, K-feldspar, and base and precious metal sulfides. They occur as open space filling and are confined to deeper portions of the Nenzel Hill mineralized zone. Stage 2 veins consist of a similar assemblage but cut stage 1 veins and display strong vertical zoning. With increasing elevation, stage 2 silver minerals are more abundant, Ag/Au increases, and sericite becomes prevalent. In stage 2 veins the FeS content of sphalerite varies from >11 to <1 mole percent over 800 vertical feet, with iron-poor sphalerites occurring nearer to the present surface. The stage 2 assemblage of quartz, sericite, sulfides, and sulfosalts is most common on intermediate and near-surface levels in Nenzel Hill. Low-grade mineralization consists largely of oxidized (80%) and unoxidized (15%) stage 2 assemblages which fill thin, randomly oriented, closely spaced fractures between major veins. Some precious metal grade (5%) is derived from wall-rock pyrite. The low-grade deposit is best developed within several hundred feet of the present surface but appears not to be significantly enriched.

Fluid inclusions, oxygen isotopes, mineral compositions, and stabilities and stratigraphic reconstruction indicate that Nenzel Hill mineralization formed at about 300°C and 1 kb. The major components of ore fluid were water, carbon dioxide, and solute approximated by $(Na_{0.843}Ca_{0.075}K_{0.006}Mg_{2.2\times10^{-4}})Cl$. Vein sulfides, silicate alteration phases, and sphalerite compositions indicate that fS_2 and fO_2 of ore fluid in major conduits progressively increased with elevation. The marked correlation of these changes in fluid composition with silver grade suggests that precious metal distribution was governed by hypogene processes. Buffering of the ore solution by a K-feldspar + sericite + quartz wall-rock assemblage permitted dispersion of metal values for great distances from main channel ways, forming a large tonnage of low-grade mineralization. (Author's abstract)

VINCENT, Denis, CLOCCHIATTI, Robert and LANGEVIN, Yves, 1981, First dating of pyroclastic formation by fission tracks in glass inclusions in quartz phenocrysts: C.R. Acad. Sc. Paris, v. 293, p. 229-234 (in French).

The fission track method has been used for dating melt inclusions in volcanic quartz. This work, carried out on weathered pyroclastic rocks in S. Pietro island (SW of Sardinia), has given an age of 14.0 ± 1.8 M.Y., in good agreement with previous dating. (Authors' abstract)

VINOGRADOV, V.I., KULESHOV, V.N. and LITSAREV, M.A., 1981, Possible causes of the change in carbon and oxygen isotopic composition of Archean carbonates of the Aldan shield: Akad. Nauk SSSR Doklady, v. 258, no. 5, p. 1195-1200 (in Russian).

VISHNEVSKII, S.A., FELDMAN, V.I. and SHUGUROVA, N.A., 1981, Gases in inclusions from impact glasses of the astrobleme El'gygytgyn: Akad. Nauk SSSR Doklady, v. 261, p. 1220-1223(in Russian). See Appendix

VISSER, Wiekert, 1981, Fluid inclusion data on the diagenesis of the La Luna oil source rock, Maracaibo basin, Venezuela (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Koninklijke/Shell Exploratie en Productie Laboratorium.

The maximum temperature to which the La Luna petroleum source rock, cored in an oil well in Venezuela, has been exposed was determined by fluid inclusion geothermometry. The value of 145-160°C is in good agreement with the formation temperature deduced from well logs, i.e., 157°C.

The results further indicate that quartz vein fillings were formed about 4 million years ago at T=125-130°C at the onset of liquid hydrocarbon expulsion from the source rocks. (Author's abstract)

VLYNAR, O.N., NAUMKO, I.M. and SUPRUNENKO, N.S., 1981, On forming conditions of accessory mineralization in rare-metal pegmatites of the Korostyshev granitic massif: Dopovidi Akad. Nauk Ukr. RSR Ser. B. Geol., Khim., Biol., 1981, no. 2, p. 7-10 (in Ukrainian).

The paper presents results of thermobarometrical and geochemical investigations of fluid inclusions in accessory apatite, tourmaline, garnet and beryl from rare-metal pegmatites of Korostyshev granitic massif. (Authors' abstract)

Includes 13 analyses of gases for CO_2, N_2, CH_4, C_2H_6 and C_3H_8. (E.R.)

VOEVODINA et al., 1981 - See Appendix

VOGEL, T.A., WILBAND, J.T., MATTISON, S.R. and TAYLOR, T.R., 1981, Immiscibility in non-volcanic rocks (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 574.

VOLKOV, A.V., 1981, Gold-silver ore mineralization in terrigenous beds: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razv., no. 8, p. 50-56 (in Russian). Author at Moscow Geol.-Prosp. Inst., Moscow, USSR.

The deposit (name not given) occurs in Carnician clastic sediments cut by andesite-basalt dikes. Ore bodies are quartz, quartz-antimonite and quartz-polymetal veins with Au-Ag mineralization. Pre-ore barren quartz yields Th 350-250°C, ore pyrite-arsenopyrite association 300-250°C, gold-pyrargyrite-tetrahedrite and polymetal associations 250-200°C, final antimonite-pyrite association 220-130°C. (Abstract by A.K.)

VOLLBRECHT, A., 1981, Tectogenesis of the Münchberg Gneiss Massif (quartz-fabric investigations and microthermometry on fluid-inclusions): Göttinger Arb. Geol. Paläont., v. 24, 122 pp., 60 figs., 1 Tab.; Göttingen. (in German; English abstract and summary). Author at Geol. Inst. Univ., Universitätsstr. 150, D-4630 Bochum, W. Germany.

Lattice preferred orientations of quartz in tectonites reveal that during the ascent of the Münchberg Gneiss Massif (diaphthoresis) internal deformations took place at various structural levels. Fluid-inclusion studies indicate an early phase of degassing, followed by an influx of high-salinity solutions, which are likely to be derived from very-low-grade sediments overthrust by the Münchberg Massif. During a late stage of uplift low-salinity solutions were trapped as secondary inclusions along micro-cracks. The development of quartz-c-axes fabrics and fluid phases can be well correlated with a nappe-model for the Saxothuringian zone. (Author's abstract)

Inclusion details, from the author's summary: According to the fluid-inclusion studies the development of the M.M. can be divided into 3 phases (See Fig. 60 and pp. 64-87):

- The quartz in gneisses of both lithostratigraphic units (Liegend- und Hangendserie) is almost free of primary inclusions. Only a few CO_2-, CH_4-inclusions with extremely varying densities were observed. This may be explained by an early phase of degassing due to intense internal deformations during the ascent of the gneiss-block.

- The second phase is characterized by an influx of high-salinity solutions (L1), which were trapped as primary inclusions (L1a) in cogenetic quartz (albite-pegmatites, joints). It is assumed that L1 migrated from very low-grade sediments into the overthrusting gneiss-nappe. This influx was restricted to the southeastern part of the M.M. Probably on the northwestern part an influx of L1 was hindered by another nappe-unit (? greenschists), which separated the gneisses from the underlying "wet" sediments.

The presence of H_2O was of considerable effect on the deformation mechanisms at the base of the gneiss-nappe (platy mylonites). First, further grain-growth of the recrystallized feldspars was inhibited by crystallization of white mica flakes along grain-boundaries. Thus the fine-grained microstructure favoring a super-plastic behavior remained stable. Second, plastic deformation of quartz was facilitated by hydrolytic weakening, to be concluded from overprinted (pseudosecondary) inclusions of L1 (L1b) in the platy mylonites.

For the isolated albite-pegmatites a tectonic-hydrothermal model involving alkali-supply by L1 is discussed. This results from primary L1a-inclusions within the pegmatite-quartzes and the fact that both L1a-inclusions and albite-pegmatites are restricted to the southeastern part of the M.M.

- The last phase of the structural development (see above) was accompanied by an influx of low-salinity solutions (L2), which affected the whole gneiss-body. These solutions were exclusively trapped as secondary inclusions along healing micro-cracks. The temperatures of formation lie between 230 and 260°C as estimated by intersecting the L2c-isochore with suitable geothermal gradients (60 and 50°C/km). It seems likely that for the mobilization of L2 heat was supplied by late Variscan granite intrusions of the near-by "Fichtelgebirge."

The influx of L1 and L2 must have been separated by a distinct break, because there is no evidence for any primary mixing of both fluids.

VOLOSOV, A.G., BORISOV, M.V., SUSHCHEVSKAYA, T.M. and KNYAZYEVA, S.N., 1981, Precipitation of cassiterite during formation of hydrothermal tin ore deposits, results of physicochemical modelling: Geokhimiya, no. 1, p. 71-81 (in Russian, English abst.). First author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Calculation of equilibria were made for solutions containing solid phases in the system H-O-K-Na-Ca-Mg-Fe-Al-Si-C-Cl-S-F at 300°C, under P of saturated vapor. Fluid inclusion data were used as the basis of calculations. Pertinent to fluid inclusion studies. (A.K.)

VOLZHIN and KOROLEV, 1981 - See Appendix

VOROB'YEV, Ye.I. and MATONIN, V.N., 1978, Conditions of formation of lazurite from Pribaykal'ye: data from fluid inclusion studies, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 171 (in Russian). Authors at Inst. Geochem. of Siberian Branch of Acad. Sci. of USSR, Irkutsk, USSR.

Metasomatic calcite syngenetic with lazurite bears two major types of fluid inclusions: P and S. S inclusions are rare, tubular and G/L. P inclusions are numerous, 10 µm in dia., and bear a grain of anhydrite (seemingly trapped mineral, A.K.), native sulfur (~60 vol. %), L and G. Sulfur melts at 120-150°C. At T ~650°C inclusions become homogeneous black (sic., A.K.). Optimum T of calcite-lazurite paragenesis was estimated to be 650°C. (From the authors' abstract translated by A.K.)

VOROB'YEV, Ye.I. and MATONIN, V.N., 1980, New data on geology and genesis of lazurite deposits in Pribaykal'ye, p. 149-157 <u>in</u>: Iron- and magnesium metasomatism and ore formation, "Nauka" Publ. House, Moscow, 196 pp., 800 copies printed, price 2 rbls. 30 kopecks (in Russian).

Calcite from the Malobystrinskoe deposit (syngenetic with lazurite) bears P inclusions of anhydrite and small (≤10 µm) P polyphase fluid inclusions (dms or trapped minerals mostly anhydrite, dm-also native sulfur); on heating such inclusions become yellow, brown, and black at 640-650°C; no further changes up to 800°C, and the changes are reversible on cooling. S inclusions are two-phase G/L, tubular, up to 100 µm long. (Abstract by A.K.)

VOVK, I.F., 1981, Radiolytic model of formation of brine composition in crystalline basement of the shields: Geokhimiya, no. 4, p. 467-480 (in Russian, English abst.). Author at Inst. Geol. Sci. of Acad. Sci. of Ukr. SSR, Kiev, Ukrainian SSR.

The author presents the evidences (including brine inclusions) of occurrence of brines in basements of crystalline shields and suggests that radiolysis of water is the only known process which may cause simultaneous enrichment of mineralized waters in light isotopes of oxygen and hydrogen and increase in salt concentration. (A.K.)

VOZNYAK, D.K., KVASNITSA, V.N. and KROCHUK, V.M., 1981, Inclusions of solidified melts in baddeleyite from carbonatites of Priazov'ye: Akad. Nauk SSSR Doklady, v. 259, no. 4, p. 952-955 (in Russian). Authors at Inst. Geochem. and Physics of Minerals of Acad. Sci. of Ukrainian SSR, Kiev, Ukraine.

Baddeleyite from calcite carbonatites of the Chenikhov massif in Priazov'ye is 0.1-1 mm long and bears P inclusions 0.00n-0.0n mm filled by mineral-forming medium and solids (trapped minerals). Often ~90% by vol. is occupied by calcite (identification by refractive indices and "boiling" in hydrofluoric acid), plus gas phase. Also inclusions were found filled by carbonate, possible silicate melt and gas. On heating, at 750-850°C carbonate decomposes with formation of fractures. Silicate component does not change up to 1210°C. Hence, calcite carbonatites crystallized from carbonate magma; trapping of carbonate melt inclusions by baddeleyite was at T>>860°C. Probably two immiscible melts: carbonate and silicate - existed during rock formation. (Abstract by A.K.)

WAFF, H.S. and HOLDREN, G.R., Jr., 1981, The nature of grain boundaries in dunite and lherzolite xenoliths: implications of magma transport in refractory upper mantle material: J. Geophys. Res., v. 86, no. B5, p. 3677-3683. First author at Dept. Geol., Univ. Oregon, Eugene, OR 97403.

Using X-ray photoelectron spectroscopy (XPS), we have determined that the composition of intergranular regions on olivine crystals of unaltered dunite and lherzolite xenoliths from flows in Hawaii, Australia, and Arizona are markedly different from the compositions of both the olivine and the host transporting lavas. The boundaries are without low-melting components, such as alkalis, but are rich in aluminum, silicon, magnesium, and iron. While XPS spectra offer only semiquantitative analyses, the compositions of the intergranular regions appear to be such that they would remain unmelted at temperatures existing in the xenolith source regions. We infer that within their source regions, refractory dunite bodies, of which the Hawaiian dunites are samples, have solid mechanical contacts along the olivine grain boundaries. Furthermore, we feel that the compositions of surface films are established so as to minimize the surface free energy along intergranular faces as melt is gradually removed. This is consistent with the observed inability of the host lavas to penetrate these xenoliths during their ascent to the surface. As such, the parent refractory material within the mantle appears to be effectively nonporous to the magma, and hence magma transport within the upper mantle would have to proceed by some mechanism other than the migration of melt along channels developed along wetted intergranular surfaces. (Authors' abstract)

WAGNER, G.A., 1981, Thermoluminescence of the Jilin meteorite (abst.): Max-Planck-Inst. für Kernphysik, Jahresbericht, 1981, p. 176-177.

The measurements on the meteorite sample Jilin 1-2 indicate that it was not heated--except the ablation surface--above 300°C during the last 30,000 years. (Author's abstract)

Pertinent to the possibility of finding aqueous inclusions in this meteorite; see Ashwal et al. (1981) this volume. (E.R.)

WALSHE, J.L. and SOLOMON, M., 1981, An investigation into the environment of formation of the volcanic-hosted Mt. Lyell copper deposits using geology, mineralogy, stable isotopes, and a six-component chlorite solid solution model: Econ. Geol., v. 76, p. 246-284. Authors at Dept. Geol., Univ. Tasmania, G.P.O. Box 252C, Hobart, Tasmania 7001, Australia.

The Mt. Lyell copper deposits occur within 10 km^3 of hydrothermally altered, calc-alkaline felsic pyroclastics and lavas that form the overturned, steeply west-dipping limb of a north-south-trending anticline within the Mt. Read Volcanics.

Exhalative pyritic massive sulfide deposits (e.g., The Blow) and siliceous barite-bornite-chalcopyrite mineralization (e.g., North Lyell) occur at or near the top of the volcanic sequence. The bulk of the mineralization occurs as disseminated pyrite-chalcopyrite lenses within the volcanics (e.g., Prince Lyell). The entire sequence was metamorphosed to lower greenschist grade during the Devonian.

Determination of the physicochemical conditions of formation of the disseminated pyrite-chalcopyrite mineralization has been attempted using the composition of chlorite coexisting with quartz, pyrite, and chalcopyrite, by means of a six-thermodynamic-component solid solution model for chlorite, and assuming ideal mixing for cations on energetically equivalent sites. The model is calibrated on the composition of the chlorite from the OH vein, Creede, Colorado, and estimates of the oxidation state and temperature during vein formation. Log $\Sigma SO_4/\Sigma H_2S$ versus pH and log $\Sigma SO_4/\Sigma H_2S$ versus T diagrams have been constructed to illustrate the variation in chlorite stoichiometry as a function of temperature and solution conditions.

The temperatures of 260° to 290°C calculated from chlorite compositions at Prince Lyell, assuming quartz-iron oxide-chlorite equilibrium and the fO_2 conditions above the hematite-magnetite buffer, probably reflect metamorphic reequilibration. Assuming quartz-chlorite-pyrite equilibrium and that each chlorite is a closed system for four of the six components, it is possible to estimate ore deposition temperatures of 270° to 310°C, initial log fS_2 values of about -10 to -11.5, and initial ΣS values between 0.0005 and 0.003 -- the latter estimate involving additional assumptions about the concentration of the major components in the ore fluid and the pH which was taken as 1 unit below neutrality. At 300°C and a ΣS value of about 0.001, a pH of between 4 and 4.25 and a log $\Sigma SO_4/\Sigma H_2S$ value between 0 and -2 are required to maintain about 10 ppm Fe and 1 ppm Cu in a 1-molal chloride solution in equilibrium with pyrite and chalcopyrite.

Bornite-bearing cores in the North Lyell area may have formed from acid, oxidized ground waters that derived their copper from leaching of preexisting chalcopyrite.

The variation in $\delta^{34}S_{py}$ values from Prince Lyell (10 to 5.2‰) to Cape Horn (+6.4 to -0.4‰) to Crown Lyell-North Lyell (+0.8 to -5.3‰) is consistent with a progressive increase in the oxidation conditions at which these deposits formed. The $\Delta^{34}S_{py-ccp}$ values vary from +1.8 to -1.5 per mil and can be reproduced by mass transfer modeling of possible reaction paths in a feldspar-ore solution system at constant temperature and varying initial oxidation conditions. The calculations suggest an initial value of $\delta^{34}S_{\Sigma S}$ of 7 per mil for the ore fluid(s).

Th of five fluid inclusions in recrystallized fluorite from a quartz-chlorite-chalcopyrite vein ranged from 130° to 150°C. Applying a pressure correction for 1 kb gives a minimum temperature of 200° to 225°C. (From the authors' abstract, modified)

WANG, Qingduo, DING, Biying and LI, Shijin, 1981, Fluid inclusion studies of the Taolin Pb-Zn ore deposit, in Symposium, National Meeting [1978] on Experimental Studies of the Inclusions in Minerals and the Genesis of Rocks and Minerals: Sci. Pub. House, Beijing (in Chinese).

Taolin Pb-Zn ore deposit is located in Hunan province. The fluid inclusion study indicated that the main type of fluid inclusion is liquid-rich. Th ranges from 116 to 212°C. Th of sphalerite ranges from 165 to 201°C, that for quartz 164-212°C, that for fluorite 121-153°C, that for barite 116-163°C. Based on the geological setting, sulfur isotopes and fluid inclusion studies it suggested that the Taolin Pb-Zn ore deposit is a medium-low temperature hydrothermal ore deposit.

The decrepitation method was used for getting the flow direction of hydrothermal fluid. The sphalerite which formed in the same mineralization stage but at a different location was used for determining the decrepitation temperature. The temperature gradient shows that the flow direction of hydrothermal fluid may be from NWW to SEE. These results may be useful for further exploration of this model. (Abstract courtsey Dr. H.-Z. Lu)

Note: In the table of contents of the symposium volume (see entry under Acad. Sci. PRC, 1981), this paper is listed on p. 283 with a somewhat different title and with authorship as "Dept. Geology Central-South Mining and Metallurgical Institute." (E.R.)

WASSERBURG, G.J. and JACOBSEN, S.B., 1981, Isotopic facts and inferences about layering in the mantle and Earth evolution (abst.): EOS, v. 62, p. 1073. First author at Lunatic Asylum, Div. Geol. Sci., Calif. Inst. Tech., Pasadena, CA 91125.

A summary of the Nd, Sr, and Pb isotopic composition of igneous rocks of various ages from both oceanic and continental settings will be presented. The timescale required to generate the isotopic variations will be given and the contrast in initial isotopic composition will be interpreted in terms of models of mantle evolution involving (I) a layered mantle, (II) a mottled heterogeneous mantle, and (III) a homogeneous mantle with crustal interactions. The evidence of recycling of crustal materials in the oceanic mantle will be outlined. The possible relationships between continued outgassing of volatile juvenile isotopes (^{129}Xe, ^{3}He) and models and models of a layered mantle will be discussed. (Authors' abstract)

WATANABE, Makoto, SHIMADA, Nobutaka and YOSHIDA, Tetsuo, 1981, Fluid inclusion study on the granitic rocks and possibly related ore deposits in the Tsumo mining district, southwest Japan: Mining Geol. (Japan) Special Issue 9, p. 145-162 (in Japanese; English abstract). First author at Inst. Geol. & Min., Faculty of Sci., Hiroshima Univ., Hiroshima 730, Japan.

In the Tsumo mining district, the Inner Zone of southwest Japan, various granitic bodies of middle Cretaceous to early Tertiary age are found, with or without mineralization. Fluid inclusions are common in these granites. They are generally several microns in size and divided into three types: high saline (type I, e.g., Miyakodani granitic body), moderately saline (type II, e.g., Masago body) and gas-rich (CO_2-poor) (type III, e.g., acidic dikes). In addition to halite, solid phases present are possibly sylvite, anhydrite and hematite with some other unidentified transparent and opaque minerals. Examination of relative abundance of these fluid inclusions in the granitic bodies indicates that the Miyakodani body is most likely to be the direct source for skarns and ores in the district. This is in good accordance with an observation that the body is characterized by the extensive dissemination and veining of sulfides such as chalcopyrite and pyrrhotite. A few associated ore deposits are also known near the body. Acidic dikes (quartz porphyry or granitic porphyry) in and around the Maruyama deposit may also be a possible source rock of mineralization.

Microscopic observation and Th measurements were made on: (i) fluid inclusions in skarn minerals, (ii) those in quartz veins with or without scheelite; (iii) those in small-grained scheelite associated with strong hydrothermal alteration (Tsumo-Maruyama deposit); (iv) those in relatively large euhedral to subhedral scheelite and associated quartz coexisting mainly with magnetite, pyrrhotite, and chalcopyrite (Tsumo-Horai deposit), and (v) those in the Kiyomizu molybdenite-wolframite-quartz vein associated with the Masago granitic body. Since fluid inclusions in the ore constituents aforementioned are small in size, commonly less than ten microns long, the cooling stage method was not applicable to them. Polyphase inclusions are often observed except for (iii) and (iv). Solid phases present are largely halite and tiny opaque minerals. CO_2 concentration in fluid inclusions is generally very small.

Assuming that total pressure of about 0.5 kb (Shimizu and Shimazaki, 1979) and fluids with the salinity of approximately 30 wt.% NaCl prevailed during the skarnization and ore formation, the following results on the formation temperature were obtained: 400 to 500°C for (i); 300 to 450°C for (ii); 320 to 380°C for (iii); 320 to 430°C for Iiv); and 330 to 400°C for (v).

It may be concluded that the fluids responsible for the skarnization and mineralization were in a liquid state (hydrothermal solutions). Low concentration of CO_2 in the inclusions may indicate certain specific chemistry of the related felsic magmas mentioned above.

Ubiquitous occurrence of polyphase inclusions in scheelite in coexisting quartz strongly indicates that chloride-complexed tungsten was responsible for this phase of mineralization. (Authors' abstract)

WATANABE, Makoto and SOEDA, Akira, 1981, Some characteristics of the Neogene mineralization in the Sanin Green Tuff region, southwest Japan: Mining Geol., v. 31, no. 1, p. 1-11. First author at Inst. Geol. and Min., Faculty of Sci., Hiroshima Univ., Hiroshima 730, Japan.

Efforts are made to draw some characteristics of the Neogene (kuroko-type and hydrothermal vein-type) mineralization in the Sanin Green Tuff region compared with equivalent activity in the Inner Zone of northeast Japan. In the Sanin region, the Onnagawa Stage is likely to be the major mineralization epoch and some of the deposits seem to be related to the Funakawa Stage, whereas the mineralizations in northeast Japan are known to occur mainly in the Nishikurosawa and Onnagawa Stages. In general, the main stage of mineralization in the Sanin region is characterized by ore mineral assemblage chalcopyrite-pyrite with quartz-sericite-chlorite as gangue assemblage. While the base-metal deposits of both regions are much alike in several aspects including ore- and gangue-mineralogy and fluid inclusion systematics, absence of pyrrhotite and arsenopyrite in the Sanin ores makes them sharply contrasted with the ores from northeast Japan. It seems that the Sanin ores were formed in relatively limited depositional conditions defined by pyrite-bornite-chalcopyrite univariant assemblage and less than 3 mol.% FeS in sphalerite coexisting with pyrite, while much varying physicochemical environments existed in the Neogene mineralization field of northeast Japan. (Authors' abstract)

Th of fluid inclusions in quartz, sphalerite or barite from 12 localities ranged from ~200 to ~300°C (almost all new measurements). (E.R.)

WATKINSON, D.H. and MAINWARING, P.R., 1981, Sodic solid and fluid inclusions in chromite from stratiform and podiform chromites in Canada (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-60.

Chromium-bearing pargasitic amphiboles, sodic phyllosilicates, albite, and saline fluid inclusions (with olivine, pyroxene, and their alteration products) occur as inclusions in chromite from deposits at Bay of Islands, Thetford, Puddy-Chrome Lake, Big Trout Lake, Shebandowan, Bird River, Muskox, and other mafic-ultramafic rock complexes. Electron microprobe analyses show that the ferromagnesian silicates have high Mg: (Mg+Fe) with a few percent Cr_2O_3. Layer silicates have a very high Na: (Na+K). Compositions of olivine inclusions are about Fo_{96}. Textural evidence suggests that many of these are primary inclusions that have survived various post-emplacement alteration and metamorphic events due to the refractory nature of the host chromite. These data suggest to us that although disseminated chromite was a normal magmatic product, chromite inclusions and textures suggest supersaturation and concentration involved sodic fluids. Such fluids may be magmatic but magma may also have incorporated sea-water-rich volcanic or sedimentary rocks. Circulation of fluid in the magma concentrated chromium and other species near the roof where sodic solids were stable. Disturbances to the system, such as pressure release caused local supersaturation in chromium, breakdown of hydrous phases and rapid precipitation and accumulation of chromite with some entrapment of sodic fluids and solids. (Authors' abstract)

WATSON, E.B., 1981, Diffusion in magmas at depth in the Earth: the effects of pressure and dissolved H_2O: Earth and Planet. Sci. Letters, v. 52, p. 291-301. Author at Dept. Geol., Rensselaer Polytechnic Inst., Troy, NY 12181, USA.

Experimental data on cation diffusion in silicate melts and glasses at atmospheric pressure cannot be quantitatively applied to diffusion in magmas at depth because pressure and dissolved H_2O have significant effects. Diffusivities of Ca and Cs in soda-lime aluminosilicate melt are reduced by roughly an order of magnitude as pressure increases from 1 to 30 kbar at 1100°C (in the case of calcium, the pressure effect is smaller at higher temperatures). The influence of dissolved H_2O is opposite to and (for some ions) far more important than that of pressure: at 1700°C, Cs diffusion in granitic obsidian is enhanced by four orders of magnitude by the addition of 6 wt.% H_2O, and Ca diffusivity increases by 2.5 orders of magnitude. Sodium diffusion, on the other hand, is relatively immune to changes in H_2O content.

The retarding effect of pressure on diffusion in deep-seated magmas is largely compensated by higher magmatic temperatures, such that overall "depth" effects on diffusion are of secondary importance - diffusion rates in mantle melts are probably well approximated by 1-atm, near-liquidus values. Diffusion rates in crustal magmas, however, are extremely sensitive to H_2O content, so that models of rate-controlled processes in hydrous magmas may be grossly in error if 1-atm diffusivity values are used. (Author's abstract)

WATSON, P.H.W., 1981, Genesis and zoning of silver-gold veins in the Beaverdell area, south-central British Columbia: Master's thesis, Univ. British Columbia, Vancouver, B.C., Canada, 156 pp.

Indexed under Fluid Inclusions. (E.R.)

WEISBROD, A., 1981, Fluid inclusions in shallow intrusives, Chapter 10, pp. 241-271, in L.S. Hollister and M.L. Crawford, eds., Fluid Inclusions: Applications to Petrology; Mineralog. Assoc. Canada Short Course Notes Vol. 6 (see Hollister and Crawford, 1981, this volume).

Chapter 10 Contents

WENDLANDT, R.F., 1981a, Influence of CO_2 on melting of model granulite facies assemblges: a model for the genesis of charnockites: Am. Min., v. 66, p. 1164-1174. Author at Lunar and Planet. Instit., 3303 NASA Road 1, Houston, TX 77058.

Partial melting studies at crustal pressures in SiO_2-rich portions of the system $KAlSiO_4$-Mg_2SiO_2-H_2O-CO_2 can be used to model the anatectic origin of charnockites. The univariant reaction

phlogopite + sanidine + quartz + vapor = enstatite + liquid

produces a SiO_2-rich melt (granite analog) at 3 kbar; the vapor composition at the solidus is buffered to high H_2O-contents by the coexistence of phlogopite with its breakdown products. At higher pressures, 8 and 15 kbar, the fluid phase is buffered to higher CO_2-contents and the melt composition becomes enriched in K_2O and MgO (charnockite analog). Melting relations are controlled by the expansion of the quartz liquidus field relative to the enstatite and sanidine fields with increasing pressure. Partial melts generated at the base of the crust in the presence of a CO_2-rich fluid will be of an alkaline nature and will crystallize enstatite at lower pressures.

CO_2-saturated melting of similar SiO_2-rich bulk compositions (phlogopite-absent) by the reaction

enstatite + sanidine + quartz + CO_2 = liquid

occurs at temperatures in excess of 1000°C to about 15 kbar. Liquid compositions show analogous trends, however, with increasing pressure, to those observed in the 5-component system as a consequence of the expansion of the quartz liquidus surface relative to the enstatite surface.

This partial melting model for charnockite genesis satisfies the constraints of observed charnockite mineralogies, P and T estimations for charnockite assemblages (5-12 kbar and 750°-1000°C), and reports of high-temperature CO_2-rich fluid inclusions that are believed to approximate solidus vapor compositions (Ormaasen, 1977, Konnerup-Madsen, 1979). Also, observations of anatexis preceding granulite facies metamorphism are reconciled: Influx of CO_2 vapor (to a melt-crystal system) in sufficient amount to exhaust the vapor phase buffer will result in H_2O extraction from the melt and crystallization of the melt, although temperatures may continue to rise. (Author's abstract)

WENDLANDT, R.F., 1981b Sulfide saturation of silicate melts (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 578.

WENINGER, H., 1981, Microthermometrical investigations on mineral deposits of the eastern Alps: TMPM, Tschermaks Min. petr. Mitt., v. 29, p. 127-149 (in German; English abstract).

Fluid inclusions in quartz from Alpine mineral veins in the Tauern Window, in the "Niedere Tauern," in Variscian metamorphic complexes and from deposits in nonmetamorphic environments have been investigated. Inclusions carry aqueous solutions with varying NaCl-content, as well as CO_2 as vapor and liquid. Rarely, hydrocarbons and solid NaCl have been recorded. The ratios CO_2/H_2O and $H_2O/NaCl$, and homogenization temperatures of fluid and vapor phases facilitate the determination of P/T-conditions during crystal growth. (Author's abstract)

WESOLOWSKI, D. and OHMOTO, H., 1981, Remobilization of molybdenum from W-Mo skarns by late meteoric fluids at King Island, Tasmania (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 578. Authors at Dept. Geosci., The Pennsylvania State Univ., University Park, PA 16802.

Paragenetic and fluid inclusion studies of the W-Mo deposits at King Island conducted by ourselves and Tan (1979) indicate that scheelite + anhydrous calc-silicates in tabular skarns and cross-cutting veins formed at T=400-600°C, and that this early assemblage was replaced at T=200-350°C by quartz + amphibole + epidote + calcite ± molybdenite ± pyrite ± pyrrhotite ± chalcopyrite along fractures and open spaces. Cathodoluminescence studies reveal that where early Mo-rich scheelite crystals are in contact with the late alteration assemblage, thin irregular patches along fractures and crystal faces are leached and converted to Mo-poor scheelite. Mo mineralization extends well beyond the skarn bodies as disseminated molybdenite in altered aplitic dikes and as molybdenite ± quartz veinlets in metasiltstones.

Oxygen isotopic compositions of pyroxene, garnet and scheelite suggest that the high T skarn-forming fluid had $\delta^{18}O = 8 \pm 2‰$, a typical magmatic range. C, O and S isotopic measurements of quartz, calcite and sulfides indicate that the low T alteration fluid had $\delta^{18}H_2O = 2 \pm 2‰$, $\delta^{13}CCO_2 = -9 \pm 2‰$ and $\delta^{34}SH_2S = 10.5 \pm 1.5‰$. Primary sulfides in the metasedimentary host rocks have $\delta^{34}S = 6\text{-}12‰$. We suggest that this late fluid was dominantly meteoric, having acquired its isotopic characteristics by interaction with graphite and sulfide bearing metasediments, and that it leached Mo from the skarn scheelites to form a peripheral molybdenite ore zone. The formation of separate W and Mo zones from original W-Mo bearing scheelite skarns may be a common phenomenon, the extent of which is controlled by the hydrodynamic characterisitics of the meteoric water system and the chemistry, particularly carbon and sulfur contents, of the country rocks. Mo halos around W-Mo bearing skarn deposits may be useful in exploration elsehwere. (Authors' abstract)

WHALLEY, E., 1981, The compression of liquids, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 273-294. Author at Div. Chem., Natl. Research Council, Ottawa, Canada K1A 0R9.

WHELAN, J.F. and COBB, J.C., 1981, High Zn-coals of Illinois: coal-hosted Mississippi Valley-type mineralization? (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 579. First author at U.S. Geol. Survey, Box 25046, Denver Fed. Center, Denver, CO 80225.

Sphalerite occurs as fracture- and cleat-fillings and as nodules in associated clay dikes in Pennsylvanian coal in a four-county area of west-central Illinois. The sphalerite, which is part of a distinct kaol-py-sph-py-cal paragenesis, precipitated from 75-110°C Na-Ca-Cl fluids of 17-25 wt % salinity.

The $\delta^{34}S$ values of most nodular sphalerite are 0.4-5.4. In contrast, the values of fracture- and cleat-filling sphalerite range from -12.4 to 0, and display a general decrease up the ~100 m section suggesting the mixing of fluid sulfur with the ^{34}S-depleted coal sulfur.

δD and $\delta^{18}O$ values of sphalerite inclusion fluids range from -55 to -3 and -0.5 to 9.9, respectively. Present-day brines of Illinois Basin range from -50 to 0 and -8 to +4. The $\delta^{18}O$ difference between them may simply reflect equilibration with sedimentary carbonate at different temperatures.

The brine system that deposited sphalerite in the coals was similar in extent and chemistry to that of the adjacent, but stratigraphically lower Upper Mississippi Valley district. In fact, reconstruction of Illinois Basin geometry suggests that the coal-sphalerite fluid could have contributed to the Upper Mississippi Valley district; more importantly, the inferred magnitude of the brine system suggest that other formations in the immediate vicinity of the coal seams may also harbor significant mineralization. (Authors' abstract)

WHITE, D.E., 1981, Active geothermal systems and hydrothermal ore deposits: Econ. Geol., 75th Anniv. Volume, 1981, p. 392-423. Author at U.S. Geol. Survey, Menlo Park, CA 94205.

During the past 25 years our understanding of hydrothermal ore deposits has progressed remarkably because of combined approaches through detailed study of actual deposits, laboratory experimental study of ore and gangue minerals and fluid inclusions, and study of active geothermal systems. My review emphasizes the active systems, which have recently become a focus of interest in a worldwide search for alternative energy sources.

Sulphur Bank, California, and Ngawha, New Zealand, have provided several keys for understanding the generation of many mercury deposits. Major requirements probably are: deep source regions of fluids and Hg at temperatures >200°C; metamorphic environments above subduction zones on continental margins; a through-going (rather than local) vapor phase enriched in CO_2 or other gases, migrating along with liquid water; and instability of HgS at high temperatures, decomposing to Hg^0 and S^0, with the migrating vapor required for major transport of Hg at temperatures <200°C; a coexisting liquid phase is generally required to transport SiO_2 and other nonvolatile constituents. This two-phase mechanism best explains the general absence of other significant ore metals. Vapor-phase transport of the Hg associated with other metals at higher temperatures is probably not essential.

Epithermal precious metal ore deposits are probably the fossil equivalents of high-temperature geothermal systems like Broadlands, New Zealand, and Steamboat Springs, Nevada. The evidence suggests that the fossil and active systems are similar in their rare chemical elements, ranges in temperature, pressure, compositions of fluids, isotope relationships, and mineralogy of ore, gangue, and alteration minerals. Broadlands and Steamboat Springs show a depth zoning of the "epithermal" chemical elements, Au, As, Sb, Hg, Tl, B, and some Ag, that selectively concentrate near the surface. Much Ag, base metals, and probably Se, Te, and Bi precipitate at somewhat greater depths and higher temperatures.

Nolan (1933) divided the epithermal precious metal deposits into a gold-rich group (Au>Ag by weight) and a silver-rich group. The concepts of depth zoning in active geothermal systems, if applied to epithermal deposits, suggest that some gold-rich deposits (including the recently recognized Carlin-type) form at relatively shallow depths and low temperatures. These may grade down into deposits enriched in Ag and base metals, perhaps in places separated by a relatively barren zone resulting from changes in the dominant complexing agent, Cl vs. S. This possibility, even if remote, justifies close examination.

Active systems that might form base metal ore deposits were virtually unknown 25 year ago. Discovery of the Salton Sea, Red Sea, and Cheleken thermal chloride brines in the early 1960s focused on Cl as the probable critical agent, permitting transport of base metals as metal-chloride complexes. Also, some oil field waters were found to have Pb and Zn contents in the range of a few parts per million (ppm) to many tens of ppm. The low-temperature brines have no sulfide within detection limits; only at temperatures >200°C can small quantities of sulfide coexist with the base metals in solution. All of these metal-bearing brines are deficient in sulfide; most of their metals can precipitate as ore deposits only where supplemental sulfide can be provided by any one of several proposed mechanisms. Comparable brines in the past probably formed low-temperature epigenetic deposits like those of the Mississippi Valley, as well as many marine sediment-hosted syngenetic and early diagenetic ore deposits.

Ore fluids rich in both base metals and reduced sulfide species probably require very high salinity, high temperature, and rock-water reactions buffered at low pH (thus, with little free S^{-2} immediately available). Hostile environments of extreme temperature and salinity, such as those indicated in generating porphyry copper deposits, cannot be drilled by present methods, even if we knew where to drill. Visual observation of comparable environments seemed unlikely until early in 1979, when Cu and Zn sulfides were found to be precipitating from spring vents on the spreading axis of the East Pacific Rise at temperatures exceeding 350°C. Low-temperature discharges on the sea floor had been known for a few years, but the activity in this hydrothermal area, known as Twenty-One North, is the first that bears directly on the origin of volcanogenic massive sulfide deposits (and indirectly on other deposits formed at extreme temperatures and salinities).

Brines of many origins can form base metal deposits; origin of the water may be less important than the physical and chemical environments of the brines and source rocks. Ocean water alone, ocean and fresh waters plus evaporites, evolved connate waters of marine sedimentary rocks, and magmatic waters are all effective solvents of base metals in suitable environments. Precipitation of metals from these brines can occur by decreasing temperature, mixing with low-salinity water, access of supplemental sulfide, and neutralizing reactions with wall rocks, as well as various combinations of these.

Suggestions for exploration for concealed deposits of the major groups considered here are offered, resulting from improved understanding of various genetic models. (Author's abstract)

WHITE, W.H., BOOKSTROM, A.A., KAMILLI, R.J., GANSTER, M.W., SMITH, R.P., RANTA, D.E. and STEININGER, R.C., 1981, Character and origin of Climax-type molybdenum deposits: Econ. Geol., 75th Anniv. Volume, 1981, p. 270-316. Authors at Climax Molybdenum Co., A Div. of AMAX, Inc., Western Operations, 1707 Cole Blvd., Golden, CO 80401.

Porphyry molybdenum deposits are spatially, temporally, and genetically associated with porphyritic intrusions of quartz monzonite to high silica, alkali-rich granite composition. Most molybdenum is in quartz-molybdenite veinlets that are part of an intrusion-centered stockwork of veinlets. Associated minerals are pyrite and fluorite. Recoverable to geochemically anomalous tungsten, tin, copper, lead, and zinc commonly occur marginally and/or peripherally to the molybdenum ore. Stockwork deposits associated with intrusions of high silica, alkali-rich rhyolite, and granite porphyry are herein recognized as a distinct class, referred to as "Climax type."

Numerous textural features in Climax-type intrusions suggest that ore-forming fluids exsolved directly from crystallizing magmas. Rhythmic quartz layers in porphyry indicate high water pressure and episodic buildup and release of volatiles. Replacement of albite phenocrysts by nearly pure orthoclase in a groundmass containing albite suggests the presence of a separate hydrothermal fluid before formation of the groundmass. Zones of micrographic textures indicate areas of hydrothermal fluid accumulation prior to overpressure relief and release of the fluid. Aplitic groundmass textures suggest pressure quenching. Veins near igneous contacts commonly have both igneous and hydrothermal characteristics.

Fluid inclusions from the Henderson mine that contain as much as 65 wt percent NaCl suggest that molybdenite mineralization formed at temperatures above 500°C, probably between 500° and 650°C. Consideration of phase equilibria in fluid inclusions indicates overpressures 150 to 250 bars greater than lithostatic pressure during mineralization. These overpressures probably caused the stockwork fracturing.

Hydrothermal alteration is best recorded at Red Mountain. Five major pervasive rock alteration zones include the potassium feldspar zone, quartz-sericite-pyrite zone, upper and lower argillic zones, and the propylitic zone. Five additional zones of less areal extent include the vein silica zone, pervasive silica zone, magnetite-topaz zone, greisen zone, and garnet zone.

Strontium and lead isotope data and trace element concentrations in Climax-type systems suggest that Climax-type igneous rocks represent extreme differentiates of parent magmas which formed by fractional partial melting of mafic- to intermediate-composition materials in the lithospheric mantle and lower crust, and the upper crustal rocks were not significantly involved in the generation or evolution of Climax-type magmas and ore leads. Age determinations, structural observations, and plate tectonic reasoning suggest that the Climax-type magmas of Colorado formed during a relatively atectonic transition, after subduction-related calc-alkaline igneous activity but before extension-related normal faulting and without or before known local basaltic volcanism.

The high concentrations of silica, alkalis, and Rb in Climax-type rocks, coupled with the low concentrations of Ca, Sr, and Ba, suggest fractional crystallization of plagioclase and potassic feldspar. This, together with gravitational crystal-liquid separation, probably was the dominant differentiation mechanism in the deep crustal environment. The high inferred concentrations of water, F, Mo, W, Sr, U, Th, and Nb in Climax-type magmas suggest upward enrichment of these constituents by convection-driven thermogravitational diffusion (Hildreth, 1979), a process which probably became dominant as magma columns traversed steepening thermal gradients in progressively shallower environments.

At depths between 2,000 and 10,000 ft, particularly volatile and molybdenum-enriched magma cupolas forcefully expelled ore-forming fluids. This caused stockwork fracturing of host rocks and pressure quenching of aplitic cupolas. Fracture filling by quartz, molybdenite, pyrite, fluorite, topaz, and/or huebnerite formed the orebodies. (From the authors' abstract)

WICKS, F.J. and RAMIK, R.A., 1981, Thermal analysis and evolved gas analysis at the Royal Ontario Museum (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Abstracts, v. 6, p. A-61.

The thermal analysis laboratory at the R.O.M. employs a Mettler TA1 vacuum Thermoanalyzer to obtain simultaneous DTA-TG-DTG. The instrument is designed to run samples in various atmospheres (N_2, CO_2, O_2, H_2O), or under vacuum. Recent modifications carried out at our laboratory have increased the high vacuum capability to 10^{-8} torr, and made possible the installation of a quadrupole mass spectrometer (Inficon IQ200), for continuous analysis of evolved gases. The identification and measurement of partial pressures of evolved gases aids the user in recognizing the initiation of reactions and unravelling complex overlapping reactions.

The system has been used primarily for TG determinations of H_2O and CO_2 in minerals. In this regard, much of the work has dealt with phosphate, arsenate, carbonate and zeolite species. The system has also found use in the production of DTA curves, phase transition studies, oxidation and reduction analyses, fluid inclusion studies and rock analyses for volatiles. The spectrometer is presently being interfaced to a PET microcomputer to provide data storage and processing as well as computer control of the instrument. (Authors' abstract)

WILKINS, R.W.T., BIRD, J.R. and EWALD, A.H., 1981, Observations on deformation microstructures and fluid inclusions in proton-irradiated halite: N. Jb. Miner. Abh., v. 141, no. 3, p. 240-257.

Deformation microstructures in naturally deformed halite can be color-decorated by irradiation with 2.5 MeV protons at low beam currents while the material is held at 150-200°C. Modification of the existing microstructure during irradiation can be reduced by the use of a more intense proton radiation, which raises the specimen temperature into the optimum range without supplementary heating; however, results tend to be erratic. Decoration is not obtained by irradiation at low temperature and subsequent annealing. In halite from Detroit, Michigan, irradiation readily revealed existing glide bands, subgrain boundaries and healed fracture surfaces. Fluid inclusions heated beyond their homogenization temperature in the beam developed a colored halo or set of radiating glide bands from the corners of the cavity, accompanied by a permanent increase in the cavity volume. Migration of fluid inclusions along the temperature gradient induced by the proton beam can be traced by colored trails. For the general case of aqueous fluid trapped in a water soluble salt of low strength, fluid inclusion behavior can be explained in some detail by considering hypothetical relative volume changes, of cavity and enclosed liquid, with temperature. (Authors' abstract)

WILKINS, R.W. and McLAREN, A.C., 1981, The formation of syngenetic fluid inclusions from etch pits in crystals: N. Jb. Mineral. Mh., v. 5, p. 220-224.

Study of fluid inclusions in the seed plates of synthetic quartz crystals by X-ray topography shows that syngenetic fluid inclusions may form by the etching of growth dislocations during a period of undersaturation of the growth medium, followed by sealing-off of the etch tubes during a subsequent period of crystal growth. (Authors' abstract)

WILKINSON, W.H., Jr., 1981, The distribution of alteration and mineralization assemblages of the Mineral Park mine, Mohave County, Arizona: Doctoral dissertation, Univ. Arizona, Tucson, AZ, 144 pp.

The Mineral Park mine is a porphyry copper-molybdenum deposit developed within and adjacent to a Laramide quartz monzonite porphyry stock which intrudes Precambrian rocks in northwestern Arizona. The Pecambrian sequence consists of older, broadly folded metasedimentary and metavolcanic rocks which were intruded by a 1700-1800 m.y. old granite gneiss batholith. The contact between the two Pecambrian terranes is a major structural element in the district and appears to have been important in localizing the Laramide intrusions and mineralization.

Alteration is defined by early pervasive biotitization of hornblende in the Precambrian rocks and by recrystallization of rock biotite in the quartz monzonite porphyry. Pervasively biotitized rocks are crosscut first by biotite and then by K-feldspar veinlets. Fracture-controlled, economic sulfide mineralization then began with quartz-molybdenite-K-feldspar-anhydrite and was followed by quartz-chalcopyrite-K-feldspar-anhydrite. This potassic alteration and accompanying mineralization occur throughout the deposit and are crosscut by later quartz-pyrite-sericite veinlets. Orientations of mineralized fractures evolved through time from EW during molybdenum mineralization to NW during quartz-pyrite-sericite mineralization. Fracture densities during molybdenum mineralization averaged 0.05 cm^{-1} and increased to 0.14 cm^{-1} during quartz-pyrite-sericite mineralization. Sulfides were deposited from low salinity fluids (0.5 - 2.0 molal) in the temperature range 330°-360°C. High salinity fluids occured only with quartz that was earlier than sulfide deposition. No Th >440 was observed.

Molybdenum mineralization cuts all rock types and defines a vertical cylinder with a distinct low-grade core. Ore grade molybdenum mineralization is equally distributed between Laramide and Precambrian rocks, and overall grade decreases with depth. Hypogene copper mineralization has a greater lateral distribution than molybdenum mineralization, and surrounds a low grade core coincident with the low grade molybdenum core. The distribution of alteration and mineralization assemblages and the fact that both of these features crosscut all exposed rock types suggest that copper-molybdenum mineralization was not temporally related to the quartz monzonite porphyry exposed in the mine area. The narrow range of Th observed and the lack of high Th compared with the results of computer modelled systems indicate formation of mineralization 2 to 3 km above a source intrusion. Because no evidence for boiling was observed, only minimum pressures of formation can be determined. Minimum pressures during sulfide deposition varied from 180 to 80 bars. These pressures correspond to minimum depths of formation of 2 to 3 km which is in good agreement with an inferred depth of burial of approximately 3 km based on stratigraphy restored from the adjacent Colorado Plateau. (Author's abstract)

Earlier Th studies on this deposit by Drake (1972) indicating higher (estimated) Th values were found to be in error. Drake and Ypma (1969) reported boiling but did not present evidence, and none was found in the present study. Nash and Cunningham (1974) and Drake (1972) found and measured CO_2(liq) but none was found here. Early fluid salinities 31-35 wt.%, and Th 300-350°C. These fluids were followed by 1-13 wt.% fluids at 300-440°C. Dm(?) include anhydrite, hematite, and chalcopyrite (none of which dissolved at Th), and halite (which did, always at <Th). (E.R.)

WILSON, Lionel and HEAD, J.W., III, 1981, Ascent and eruption of basaltic magma on the Earth and Moon: J. Geophys. Research, v. 86, no. B4, p. 2971-3001.

WŁODYKA, R. and KARWOWSKI, Ł., 1981, Beryl-bearing pegmatite from Jakuszyce (Karkonosie Mts): Post-magmatic processes in plutonic and volcanic rocks-igne formata '81, Abstracts, p. 11-12, Wydawnictwa Geologiozne, Warsaw (in Polish). Authors at Silesian University, Sosnowiec, Poland.

The pegmatite forms a vein along a horizontal tension fracture 25 cm thick and 20m long in coarse-grained granite. The vein consists of alkali feldspars, quartz, biotite, muscovite, beryl, ilmenite, titanomagnetite, pyrite and tourmaline (schorl). Crystallization of pegmatite vein started at ~400°C from walls and continued toward the axial part, with a small T decrease. Coarsely-crystalline zones formed at 340-320°C from LH_2O solutions (Th of P inclusions in beryl and quartz). Fractures were healed in beryl down to 120°C and in tourmaline down to 70°C. (From the authors' abstract, translated by A.K.)

WOODS, T.L., BETHKE, P.M., BODNAR, R.J. and WERRE, R.W., Jr., 1981, Supplementary components and operation of the U.S. Geological Survey gas-flow heating/freezing stage: U.S. Geological Survey Open File No. 81-954, 18 pp.

The supplementary components and operating procedures for the U.S. Geological Survey gas-flow heating/freezing stage have been developed to enhance the rapid, accurate measurement of fluid inclusions homogenizing between -150°C and 500°C. Doubly polished mineral slabs as thick as 2 mm are carefully photographed at several magnifications to provide the optimum samples for large-scale growth history-fluid inclusion studies such as those pursued in our laboratory. Long-focal-length condensers and fiber-optic illuminators provide optimal viewing conditions and the large sample chamber volume saves both documentation and sample-changeover time. Nitrogen gas, chilled by passage through a tank of liquid nitrogen, and air, heated by passage through a glass-encased, nichrome-wire heating coil, are used for freezing and heating runs, respectively. Precise control of temperatures and heating rates, as well as careful stage and thermocouple calibration, make it possible to achieve accuracies of ±2.0°C for heating runs and ±0.2°C for freezing runs. The use of gas to control temperature (1) permits rapid accumulation of abundant, accurate data, (2) ameliorates thermal gradient problems so often encountered in stages using convection and/or conduction for heat transfer, and (3) permits the use of a cyclical procedure to measure temperatures that would otherwise be unmeasurable. (Authors' abstract)

WRIGHT, T.L., 1981, Generation of Hawaiian tholetite: a metasomatic model (abst.): EOS, v. 62, p. 1068.

YARDLEY, B.W.D., 1981, Fluid inclusions in amphibolite facies metamorphic rocks from Ireland (abst.): Program 6th Symp. "Current Research on Fluid Inclusions," 22-24 April, 1981, Utrecht (unpaginated). Author at Sch. Environ. Sci., Univ. East Anglia, Norwich, U.K.

A heating/freezing stage study has been made of fluid inclusions from quartz veins in the Connemara Schists. In the study area pelites, marbles, psammites and pebble beds were folded together during amphibolite facies metamorphism (lower and upper sillimanite zone). The structure, structural/metamorphic history and conditions of metamorphism are all quite well known and the age of veins relative to metamorphism could be determined during sampling.

Fluids found include H_2O, usually with $T_f > -5°C$, CO_2, CH_4 (both probably rather pure) and some less pure H_2O. Mixed volatile fluids are rare, and only occur where the pure fluids are also present in the same grain suggesting they could result from accidental mixing. Systematic differences in fluid do occur according to the host rock, but many veins contain a wide diversity of fluid types occurring side by side. All the fluid types appear to have been present at the peak of metamorphism, although many inclusions are clearly later.

It is tentatively concluded that, although often the result of local segregation, many veins represent the pathways by which fluids liberated during metamorphism left the pile, and the diverse fluids trapped alongside one another result from the passage of separate packets of fluid from different sources passing along the vein at slightly different times. (Author's abstract)

YARDLEY, B.W.D. and LONG, C.B., 1981, Contact metamorphism and fluid movement around the Easky adamellite, Ox Mountains, Ireland: Min. Mag., v. 44, no. 334, p. 125-131. First author at Sch. Environ. Sci., Univ. East Anglia, Norwich NR4 7TJ.

Contact metamorphism in the aureole of the Easky adamellite produced andalusite at the expense of regional staurolite, kyanite, and garnet. In the inner aureole sillimanite and K-feldspar also grew. Cordierite is only rarely present. Conditions of metamorphism in the inner aureole have been deduced from five independent criteria as 595 ± 30°C and 2.5 ± 0.5 kb. The nearby Lough Talt adamellite was emplaced at slightly higher pressures. Some aureole rocks have undergone oxidation with conversion of regional garnet to magnetite and andalusite. The reacting assemblage buffered fO_2 near 10^{-17} bars. It is inferred that oxidation was caused by movement of H_2O from the country rocks into the intrusion. (Authors' abstract)

YASINS'KA, A.A., KALYUZHNYY, V.A. and NABATNIKOVA, T.B., 1981, Inclusions in glasses of the Jamanshin meteorite crater: Dopovidi Akad. Nauk Ukrains'koy RSR, Ser. B: Geol. Khimi. ta Bilogichni Nauki, v. 1981, no. 9, p. 37-39 (in Ukrainian; English summary).

Inclusions of gas (gas bubbles) and amorphous substance were studied in glasses of Jamanshin meteoritic crater (irgisite and jamanshinite). The gas composition in inclusions in irgisite is essentially nitrogen, in jamanshinite - CO_2. A conclusion is made on irgisite solidifying in the air and jamanshinite solidifying on the earth's surface. Gas pressure is calculated at the moment of its isolation from the melt. Data on density, optical and other properties of glasses are discussed. (Authors' abstract)

YAXLEY, G.M., 1981, The geology and mineralization of the Balfour district- a mineralogical and fluid inclusion study. Unpubl. Hons. thesis, Univ. of Tasmania, 156 pp. Abstract by C.J. Eastoe.

The Balfour mineralization (N.W. Tasmania) consists of veins bearing Sn, W and Zn in tourmalinized Precambrian sediments at Specimen Hill, and also of nearby unrelated Cu-bearing veins and replacements at Murray's Reward. At Specimen Hill, three paragenetic stages were distinguished:

I quartz veins with wolframite, cassiterite and arsenopyrite
II quartz veins with pyrite, sphalerite and chalcopyrite
III vugh fillings of pyrite, siderite and quartz.

Quartz of each stage contains CO_2-H_2O-NaCl inclusions of a broad range of compositions (0 to about 50 mole % CO_2). Fluid composition does not correlate with paragenetic stage. The fluid inclusion data are as follows:

Inclusion Type	Av. Salinity eq.wt.% NaCl			Tm ice mode °C		Tm clathrate mode °C		ThL mode °C			$ThCO_2$ °C Stages
	I	II	III	I	II	I	II	I	II	III	I & II
Aqueous L + V ±CO_2 (not visible)	8.6	3.9	5.9	- 7.5	-8.5	2.8	1.2	295-320	235-265	210-215	
Low density with LCO_2 ($\rho CO_2 \approx 0.32$)	2.3	13.0		-11.7	-8.7	9.5	2.1	320-332	200-208		25-31 (to V)
High density with LCO_2 ($\rho CO_2 = 0.62$)	6.3	14.5		-12.0	-8.8	-	2.1				25-31 (to L)
Aqueous + dm	4.8	4.8						261	225		

Vein deposition occurred from a heterogeneous system of H_2O- and CO_2-rich fluids which cooled progressively between stages I, II and III. The study also includes a review of regional and local geology, petrography, mineragraphy and S-isotopes.

YODER, H.S., Jr., 1981, Experimental methods for determination of transport properties of magma, in Chemistry and geochemistry of solutions at high temperatures and pressures, D.T. Rickard and F.E. Wickman, eds.; Physics and Chem. of the Earth, v. 13/14, p. 375-408. Author at Geophy. Lab., Carnegie Inst. of Washington, Washington, DC 20008, USA.

YONGE, C.J., 1981, Fluid inclusions in speleothem as paleoclimate indicators: Proc. of the 8th Internl. Congr. of Speleology, Vol. I, p. 301-304. Author at McMaster Univ. Geol., Hamilton. Ontario, Canada L85 4M1.

Stable isotope measurements of fluid inclusion and calcite pairs in speleothem have been used to calculate temperatures of deposition. Much of the paleoclimate work until now has been concerned with the interpretation of oxygen isotope profiles in speleothem calcite. Unfortunately, such spectra are complex and subject to a number of climatic variables such as the distribution of weather systems and polar ice volume, in addition to temperature changes. However, fluid inclusions are trapped remnants of the calcite forming groundwaters and as such have been used in conjunction with the calcite phase to determine unique temperatures of deposition. To avoid the possibility that there may have been isotopic exchange between the phases post-depositionally, hydrogen isotopes have been measured in the fluid inclusions and used to infer oxygen values at the time of speleothem formation. The latter is possible because there exists an empirical relationship between hydrogen and oxygen isotopic ratios known as the Craig-Dansgaard meteoric water line.

Discrepant results in previous fluid inclusion studies can be explained because of incomplete extraction of water after crushing the sample under vacuum. For this reason, a heat extraction method has been developed and tested for replication on a number of flowstones. As a definitive test of the paleothermometer, contemporary speleothem isotopic temperatures have been compared to those obtained in the host caves with favorable results. (Author's abstract)

YOSHIDA, Tetsuo, MUKAIYAMA, Hiromu and IZAWA, Eiji, 1981, Alteration in the Iwami kuroko mining district, Shimane Prefecture, Japan: Mining Geol., v. 31, no. 5, p. 367-381. First author at Dept. Mining, Faculty of Engrg., Kyushu Univ., Hakozaki, Higashi-ku, Fukuoka, Japan.

The Iwami kuroko mining district is in the Miocene Green Tuff region of southwest Japan. Around the kuroko-type deposits, the rocks are altered by hydrothermal solutions related to the mineralization. X-ray diffraction analyses of rock samples collected from 15 drill holes in the district reveal that the altered rocks consisting mainly of sericite, chlorite and quartz occur around the kuroko-type deposits. The chlorite is of Fe-Mg variety and Ia polytype is common while IIb polytype is detected from the rocks adjacent to the Iwami deposit. Interstratified chlorite-saponite is rarely found.

Diagenetic alteration of the Green Tuff formation in this district is characterized by the presence of zeolite and montmorillonite. The basal spacing data of montmorillonites indicate that the exchangeable ion ratio Na/Ca increases with depth and toward the ore zone, which is probably a marginal effect of the kuroko-type mineralization.

Filling temperature data ranging from 290° to 160°C are obtained for vein calcite and quartz from one of the drill holes (SI-31), which is in the area strongly influenced by the kuroko-type mineralization. The temperatures from 184° to 74°C or lower are measured for the samples from another drill hole (SI-30), the altered rocks in which consist mainly of zeolite, montmorillonite and quartz or low cristobalite.

Salinities for the inclusions having the filling temperatures higher than 160°C in SI-30 and SI-31 are 0.5-0.7 wt% NaCl equivalent. On the other hand, small inclusions with filling temperatures lower than 90°C in SI-30 seem to be composed of nearly the pure water indicating an extensive dilution of the hydrothermal fluid with ground water. (Authors' abstract)

YOUNG, L.M. and JACKSON, D.H., 1981, Fluid-inclusion temperature study of Paleozoic carbonates Llano Uplift, Texas: Transactions, Gulf Coast Assoc.

of Geol. Soc., 31st Annual Mtg., Oct. 21-23, 1981, Corpus Christi, Texas, v. 31, p. 421-425. First author at Northeast Louisiana Univ., Monroe, LA.

Homogenization temperatures of two-phase fluid inclusions in cement, recrystallized allochems, overgrowths, and vein and cavity fillings show that Paleozoic carbonates of the Llano Uplift have experienced at least three phases of temperature-related, pervasive crystallization-recrystallization. These phases have modes at 70 to 80°C, 110 to 120°C, and 200 to 210°C, with ranges of 60°C, 90°C, and 60°C respectively. These phases may represent distinct heating-cooling events, or they may be the results of a single, thermally complex event.

The lack of any discernable regional trends in the data and the fact that Cretaceous rocks locally have been heated up to at least 110°C suggest that heating was not related to regional metamorphism during the Ouachita Orogeny. Yet, these temperatures seem too high to result merely from heating due to depth of burial associated with any reasonable geothermal gradient.

We postulate that northeast-trending faults, which cut basement and overlying Paleozoic rocks in the region, provided avenues for pervasive heating by contemporaneous fluids from the lower crust. These faults, like those of the Balcones-Luling and Talco-Mexia zones to the east, may be genetically related to Late Paleozoic-Early Mesozoic opening of the Gulf of Mexico. Waning geothermal activity associated with this rifting would explain the localized heating of Cretaceous rocks. (Authors' abstract)

YU, C.-M., GUO, Y.-Q., LU, H.-Z. and XU, S.-J., 1981, Fluid inclusion studies of different types of quartz crystal deposits, China: Symp. of the Natl. Meeting of Experimental and Fluid Inclusion Studies of China, Scientific Publ. House, p. 205-214 (in Chinese).

The quartz crystal deposits in south China, according to their occurrence of vugs (in which quartz crystals grew), can be divided into six types: in granite, pegmatite, skarn, basic rock, limestone and dolomite, sandstone and shale. The quartz crystals occur in pegmatite, quartz veins (including feldspar-quartz veins, wolframite-quartz veins, quartz veins), in calcite veins and in rock cavities.

Detailed fluid inclusion studies indicated that five types of fluid inclusions were found: liquid-rich, gas-rich, CO_2-bearing, daughter-mineral-bearing, and organic. Th of fluid inclusions in quartz crystal of different type deposits are as follows: pegmatite, 318-358°C; skarns, 218-253°C; quartz veins, 153-322°C; calcite veins, 205-246°C; and cavities, 227-358°C. The salinity of fluid inclusions range from 1 to 11 wt.% NaCl equiv. It is concluded that the quartz crystal can form from low to high temperature and in different environments. (Abstract courtesy H.-Z. Lu)

YU, Tiejie, 1981, Fluid inclusion characteristics of some porphyry copper deposits in China and preliminary discussion of their ore-forming mechanisms: Bull. Geol. Research Inst., Ministry of Metallurgical Industry, (PRC), no. 2 (in Chinese).

The principal geologic and fluid inclusion data from eleven porphyry copper desposits in China have been studied in this paper. The results of the study show that the porphyry copper desposits can be divided into three temperature stages, i.e., high temperature (670-350°C), moderate-high temperature (350-250°C), and moderate-low temperature (250-150°C).

The principal stage of ore-formation is the moderate-high one. Generally, ore-forming pressure is ~200 atm. The salinity of the fluid inclusion may be divided into two kinds: high and low. The types of fluid inclusions, generally, are gas-rich, liquid-rich, daughter mineral-bearing and liquid CO_2. The main daughter minerals are halite, sylvite, pyrite, anhydrite and hematite etc. In composition the main cations in the fluid inclusions are K^+ and Na^+ (they range from thousands to twenty thousands ppm) and the K^+ is a little higher than Na^+. The Ca^{++} and Mg^{++} are lower (they range from hundreds to thousands ppm). And there are still other elements in the fluid inclusions, such as Cu, Mo, Pb, Zn, Fe, Al, Co, Ni, Cr, Ga, Ba, etc. The main anion is Cl^- (generally, it ranges from $1x10^4$ to $2x10^4$ ppm) and then F^- (generally hundreds of ppm), and$_4$ CO_3^{--} and$_4$ SO_4^{--}. The contents of CO_2 is very high (it ranges from $3x10^4$ to $10x10^4$ ppm). Other gases, such as H_2, CH_4 and CO, are present in traces.

According to the fluid inclusion data, we have divided the ore-forming hydrotherms into three types in this paper. The characteristics of the first type are that salinity is extremely high and there are gas inclusions existing throughout the minerals and the hydrothermal activities are characterized by multi-period and multi-stages and lower ore-forming pressure. Most of large porphyry copper deposits belong to the first type. The characteristics of the second type are lower salinity, singular stage of hydrothermal activity, greater ore-forming pressure, and generally there are no gas inclusions in the minerals. This kind of hydrothermal fluid can also form extremely large porphyry copper deposits, such as Duo Bao Shan deposits. The (main) characteristic of the third type is a large quantity of CO_2 in the fluid inclusion. This type is rare.

Based on the analysis of these data, it is concluded that ore precipitation in the porphyry copper deposits has two main forms. This paper emphasizes the possibility of boiling (during) ore-deposition, and shows that hydrothermal boiling is an important ore-forming stage of the porphyry copper deposits. We suggest also in this paper that the existence of high salinity and gas inclusions is an important mark for us to find the enrichment zone of mineralization and also the evidence to evaluate the intrusions. (Abstract courtesy Dr. H.-Z. Lu)

YU, Tiejie, LI, Kesheng and YE, Xin, 1981, Experimental research on the evaporation halo method of prospecting, in Symposium, National Meeting [1978] on Experimental Studies of the Inclusions in Minerals and the Genesis of Rocks and Minerals: Sci. Pub. House, Beijing, p. 8-14 (in Chinese). (See also Acad. Sinica, 1981, this volume.)

Based on the experiments using the evaporation halo as a prospecting tool at Fujiawu, No. 881 and Duobaoshan porphyry copper deposits, and Tongchang iron deposit and Wulong gold deposit, a new prospecting method has been set up. Experiments show that there are some remarkable anomalies in the evaporation halo in hydrothermal deposits and their surroundings. Location, range and peak of anomalies indicate, to certain extent, the position of blind hydrothermal ore bodies and the relative intensity of hydrothermal activities. Some anomalies extend tens of meters beyond the ore bodies or mineralization zone. Therefore, this method is useful in finding blind ore bodies, being comparable with the superior to other geophysical and geochemical prospecting methods. It may be used independently and jointly to survey blind ore bodies in some prospecting-evaluation areas. And it also may be helpful for exploration by measuring evaporation halos in depth from samples of drill cores, and hence guide drilling in the rocks. (Abstract courtesy Dr. H.-Z. Lu)

YU, C.-W., 1981, Mechanisms of ore formation and primary dispersion at the Dexing porphyry copper deposit, Jiangxi, and their implications in geochemical exploration. In A.W. Rose and H. Gundlach, eds., Geochemical Exploration 1980: J. Geochem. Explor., v. 15, p. 115-137.

Consideration of geochemical changes during wall-rock alteration together with paragenetic associations of the elements of various rocks and minerals in the Dexing deposit indicates that it is feasible and useful to divide the elements into ore-forming, ore-controlling and ore-transporting classes. The spatial distributions of these three classes of elements show distinct patterns. Evolution of the state of the mineralization system brings to light the changes of the ore-forming geochemical processes. Data presented in this paper reveal the mechanism of ore formation and primary dispersion at Dexing. Geochemical exploration of metallic mineral deposits should be based on: (1) spatial organization of ore-forming, ore-controlling, and ore-transporting elements; (2) temporal evolution of ore-forming geochemical processes; and (3) mechanism of ore formation and primary dispersion. The three classes of elements and the paragenetic associations of elements in some minerals may be used for discovering and evaluating geochemical anomalies. (Author's abstract)

YURKEVICH, Yu.R., 1981, Results of gas mapping in the Yakutian kimberlite province on the areas covered by traps: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 1, p. 137-138 (in Russian). Author at the Moscow Geol.-Prosp. Inst., USSR.

Distribution of H, He and CH_4 in the sub-soil gases was studied in 975 gas samples taken from 325 points in the central part of the Daldyno-Alaki region, covering the area 20,000 km^2; pertinent to gas composition in magmatic melts. (A.K.)

ZAGRYAZHSKAYA, G.D. and GRINENKO, V.A., 1981, Peculiarities of formation of sulfide-cassiterite deposits of the Komsomol'skiy region; data on isotopic composition of sulfur of sulfides: Geokhimiya, no. 10, p. 1524-1533 (in Russian, English abst.). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Th of inclusions in quartz in metasomatites was 340-380°C, tourmaline-300-360°C; Td of minerals of quartz-cassiterite ore associations: cassiterite 290-350°C, tourmaline 260-320°C, quartz 270-330°C, wolframite 310°C, arsenopyrite 240-270°C, chalcopyrite 250°C; quartz-sulfide-carbonate association: quartz 220-270°C, arsenopyrite 250°C, chalcopyrite 200-250°C, galena 120-150°C, fluorite 140-220°C. (A.K.)

ZAIKIN, I.D. and MOISEENKO, V.G., 1981, A mechanism of the process of decrepitation of gas-liquid inclusions in minerals: Akad. Nauk SSSR Doklady, v. 259, p. 456-459 (in Russian).

ZASEDATELEV, 1981 - See Appendix

ZATSIKHA, B.V. and VOVK, P.K., 1981, Crystallogenesis of calcite from the Transcarpathian mercury-containing province: Mineral. Zh., v. 3, no. 6, p. 93-105 (in Russian). Authors at Ivano-Frankovsk. Inst. Nefti Gaza, Ivano-Frankovsk, USSR.

Calcite from the Cu-polymetallic formation of the region is characterized by development of a {1011} + {0001} crystal habit; this crystd. from chloride solns. satd. with CO_2 at 270 to 240°. The calcite from the Hg formation has a rhombic crystal habit ({1011}) and crystd. as a result of normal and skeletal growth at 200 to 145° in the Vyshkovskoe field and 180 to 115° in other localities. The soln. from which this calcite crystd. had a Cl^{-}-SO_4^{2-} compn. and contained CO_2, N_2, CH_4, H_2, and carbonaceous material (petroleum, tars, and paraffins). At 80-60°, flat-rhombohedral {0112} calcite crystd., at 60-50°, crystals of acute-rhombohedral {0221} habit formed from solns. satd. with O_2. (C.A., 96: 107322r)

ZAYKIN, I.D. and MOISEENKO, V.G., 1981, Mechanism of process of decrepitation of gas-liquid inclusions in minerals: Akad. Nauk SSSR Doklady, v. 259, no. 2, p. 456-459 (in Russian). Authors at Amur Complex Sci.-Research Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Blagoveshchensk, USSR.

Decrepitation may be described by scheme: $[\Phi] \rightarrow (\Phi)+E$, where $[\Phi]$ - fluid in inclusion, (Φ) - fluid in gas phase, E - energy released during inclusion opening. If this energy stimulates opening of the following inclusions, it may be considered to be a kind of catalyst for decrepitation. The autocatalytic mechanism of decrepitation of gas-liquid inclusions describes well the experimental data and permits to characterize various groups of inclusions by their kinetic features. (From an abstract by A.K.)

Includes an elaborate attempt to express the speed of decrepitation in mathematical terms; the theory is said to check with experimental decrepitometry. (E.R.)

ZHABIN, A.G., 1981, Reflection of the eleven-year cosmogenic chronorhythm of the solar activity in sphalerite of vein deposit Kvaysa (Central Caucasus): Akad. Nauk SSSR Doklady, v. 259, no. 2, p. 453-456 (in Russian). Author at Inst. Mineralogy, Geochemistry and Crystallography of Rare Elements, Moscow, USSR.

Sphalerite in upper parts of the deposit Kvaysa is of collomorphic variety and yields Th 180-280°C. (A.K.)

ZHANG, Wenhuai, 1981, Fluid inclusion thermometry and geological applications at the Xushan W-Cu deposits, Jiangxi Province, The People's Republic of China: in Symposium, National Meeting [1978] on Experimental Studies of Inclusions in Minerals and the Genesis of Rocks and Minerals, Volume 1 [Collected Papers]: Scientific Publ. House, Beijing, 335 pp. (in Chinese).

Note: This translation, provided through the courtesy of Dr. Zhang, is of a paper that was presented at the symposium. It is probably equivalent to that by Zhang and Chen, p. 184-190, in the printed volume (see Acad. Sinica, 1981, this volume). (E.R.)

Deposits of tungsten-copper mineralization in quartz veins occur in the sandstone and shales of the Late Proterozoic Panchi Group rocks. Ore minerals are wolframite and chalcopyrite. There is no granite outcrop in the immediate vicinity of the deposit, but numerous outcrops of the Ziyunshan biotite granite lie about 800 m to the southwest. The realtionship between granite and ore deposits is not known.

The quartz-tungsten-copper veins are divided into three groups by their distribution and features: 1) South Group (single parallel veins); 2) Middle Group (single parallel or compound veins); and 3) North Group (the veins are only veinlets). The fluid inclusions in the Xushan deposits are of two types, type A, liquid-rich (10-30 vol.% vapor), and type

B, vapor-rich (>60 vol.% vapor). Th for type A inclusions (not corrected for pressure), ranges from 155° to 405°, with most between 200 and 310°C. Type B inclusions vary from 350 to 700°C, with a definite mode at about 650°C. Even when sampled from the same altitude above sea level, the three vein groups yield different homogenization temperatures. The South group is the highest temperature, and the North group is the lowest. Within a given vein the temperature varies with depth, indicating that a thermal gradient existed during vein formation. These data provide some evidence that ore-forming fluid moved from south to north and from bottom to top. This also indicates that the temperatures are higher toward the granite. We assume that veins of North group will get wider and show higher temperatures with increase in depth (changing from veinlet to single parallel veins) and the mineralization will also become richer, because the North group have not yet been eroded so deeply.

The Ziyunshan biotite granite may be the source of the ore-forming fluid, because 1) the veins and granite have a close spatial relationship, 2) the variations of temperatures, and 3) the features of fluid inclusions. (Author's abstract)

ZHIRNOV, A.M., 1981, Hypogene colloidal and metacolloidal gold: Zapiski Vses. Mineral. Obshch., v. 110, no. 3, p. 278-289 (in Russian). Author at the Trust "Severovostokzoloto" ("Northeastgold"), USSR.

Colloidal and metacolloidal gold are typical of subsurface deposits. Names of the studied deposits are not given. Early (colloidal) parageneses yielded Th 390-370°C, the second, major one - 370-300°C, and the third, drusy - 300-200°C. Another gold deposit bears colloidal gold in ores with Th 390-330°C. The paper bears also some other references to Th. (A.K.)

ZHU, Gu, FAN, Qinxuan, WU, Jiaquan and LEI, Kerun, 1981, The extraction and the determination of micro-amount sulfate ions in the liquid phase of fluid inclusions: J. Central-South Inst. of Mining and Metallurgy, no. 1, p. 17-21 (in Chinese; English abstract).

High temperature extraction in enclosed system after explosion and the improvement of the determination with barium iodate indirect method are reported in this paper. It is proved by experiments that the composition extracted is equal to that of the liquid phase of the inclusion and that the amount extracted is basically complete. The sensitivity is 0.25 pm. Determination error of the method is about ±15%. (Authors' abstract)

ZHU, Gu, WU, Jjaquan, FAN, Qinxuan and LEI, Kerun, 1981, The extraction and determination of mineral-forming elements - copper, lead, cadmium and zinc in the liquid phase of fluid inclusions: J. Central-South Inst. of Mining and Metallurgy, 1981, no. 3 (in Chinese; English abstract). Authors at Dept. Chem., Central-South Inst. Mining and Metallury, PRC.

A condition relating to the extraction of inclusions at high temperature and in enclosed system after decrepitation is discussed in this paper. It has been proved by experiments that the method is effective and quantitative in extracting the liquid phase composition of inclusion. We have drawn up a procedure relating to the extraction and determination. The amount of copper, lead, cadmium and zinc in the liquid phase composition of fluid inclusions was determined with the help of anodic stripping voltammetry method. The advantages of this method are as follows:

1. The sensitivity is high.
2. The sample weight is small.
3. The contamination is only small.
4. The procedure is simple and convenient.

(Authors' abstract)

ZHU, Jinchu and BARNES, H.L., 1981, Geochemical conditions of tin mineralization (abst.): Geol. Soc. Am. Abst. with Programs, v. 13, p. 587.

ZHUKOV, F.I., GNATENKO, O.V. and SAVCHENKO, L.T., 1981, Factors of formation of uranium concentrations in the Precambrian alkaline metasomatites from rocks (thermobarogeochemical and isotopic data): Dopovida Akad. Nauk Ukr. RSR Ser. B. Geol., Khim., Biol., 1981, no. 2, p. 19-22 (in Ukrainian).

Variations of $\delta^{13}C$ from -19.1 to -3.0% in rocks and ores of the deposit allow drawing a conclusion of a deep source of carbon dioxide in metasomatic solutions and the formation of uranium concentrations when changing physicochemical parameters of the environment. (Authors' abstract)

ZHUKOV, F.I., LESNOY, D.A., YUSHIN, A.A. and KOROSTYSHEVSKIY, I.Z., 1979, Changes in isotope composition of sulfur during the ore process: Geol. Rudnykh Mestorozhdeniy, 1979, no. 4, p. 104-108 (in Russian; translated in Internat. Geol. Rev., v. 23, no. 3, p. 343-346, 1981).

ZIEGENBEIN, D., 1981, Transport of carbon by fluids during rock metamorphism: Naturwissenschaften, v. 68, p. 521-522 (in English).

ZIL'BERSHTEYN, A.Kh., 1981, Density of fissures in impact-metamorphosed graphite crystals as a possible geobarometer: Akad. Nauk SSSR Doklady, v. 258, no. 4, p. 987-988 (in Russian). Author at All-Union Sci.-Research Geol. Inst., Leningrad, USSR.

A possible method of pressure evaluation in impact phenomena? (A.K.)

ZIL'BERSHTEYN, A.Kh., KRASHENINNIKOVA, G.Ye. and LEVITSKIY, Yu.F., 1981, Optical polarization method of determination of pressure of mineral-forming solutions in inclusions: Zapiski Vses. Mineral. Obshch., v. 110, no. 6, p. 740-746 (in Russian). (see Translations).

ZIMMERMAN, R.K. and KESLER, S.E., 1981 Fluid inclusion evidence for solution mixing, Sweetwater (Mississippi Valley-type) district, Tennessee: Econ. Geol., v. 76, p. 134-142. First author at Rosario Resources, Apartado 502, San Pedro Sula, Honduras.

Fluid inclusions in fluorite from the Appalachian Mississippi Valley-type fluorite-barite deposits of the Sweetwater district in east Tennessee indicate that the mineralizing solutions were sodium-potassium-chloride brines with an average temperature of 107°C and an average salinity of about 16 equiv. wt percent NaCl. A strong negative correlation of homogenization and freezing temperatures, which was observed for inclusions from the southeast part of the district, was interpreted to indicate that two solutions were present during fluorite deposition in this area: a warm

(160°C), less saline (12%) solution and a cool (80°C), more saline (30%) solution. A connate source is considered likely for both solutions and the warm, less saline solution appears to have come from at or beyond the east edge of the district. Mixing of these solutions could have caused ore deposition in the southeast belt, although cooling probably caused deposition elsewhere in the district. Published data suggest that two similarly distinct solutions were present in the nearby east Tennessee zinc district. (Authors' abstract)

ZIMMERMANN, J.-L., 1981, The liberation of H_2O, CO_2 and hydrocarbons from cordierites: kinetics, structural sites and petrogenetic implications: Bull. Mineral., v. 104, p. 325-338 (in French; English abstract). Author at Centre De Recherches Pétrogr. et Géochimi., C.N. S., B.P. 20, 54501 Vandoeuvre-les-Nancy Cedex, France.

Cordierites were analyzed from different geographical and genetical origins: amphibolite and granulite facies from Bamble (South Norway), low pressure metamorphism of the Velay granite (France), anthophyllite - biotite gneiss from Madagascar, very low grade metamorphism in Betique Cordillera (Spain), very high pressure in the internal Rif (Morocco).

Fluids were extracted under vacuum, 1) with step heating, 2) with linear heating, and analyzed by mass spectrometry.

The quantity and nature of these fluids vary with the facies. CO_2, CO and organic compounds are very abundant in granulite facies. On the contrary, fluids in granulite facies are essentially aqueous (85 to 90% H_2O, compared with 60% in granulite facies); however carbonic compounds are also present. In general the quantity of water in cordierite is proportional to the inferred pressure of aqueous phase at the time of formation. Kinetic study of gas liberation, especially dehydration gives information on the thermal history of mineral. Assuming dehydration is first order chemical reaction, temperature of maximum rate of dehydration is in several cases near the temperature of formation estimated from petrographic studies. Several maxima indicate different events during the mineral's history; but trace impurities in structural cavities also can modify kinetics of gas release. (Author's abstract)

ZIMMERMANN, J.L., CHEMINEE, J.L. and CHAIGNEAU, M., 1981, Study of the gas phase occluded in the lavas of the "l'Ardoukoba," an ephemeral volcano of an emerging ridge (Afar): Bull. Volcanol., v. 44, no. 3, p. 527-546 (in French, English abstract). First author at Centre de Recherches Pétrographiques et Géochimiques, B.P. 20, 54501 Vandoeuvre-lès-Nancy, Cedex, France.

Gases trapped in lavas of three main flows of the Ardoukoba eruption (8 to 15 November, 1978) have been analyzed by mass spectrometry. These analyses concern both plagioclase phenocrysts and microcrystalline mesostasis. Fluids are released between 500°C and 1200°C, and consist of H_2O, CO_2, CO, N_2, SO_2, HCl, H_2, CH_4 with traces of hydrocarbons and H_2S. The total content is less than 0.3-0.4 wt. % of samples with about 0.1-0.15 wt. % of H_2O. No significant variation among the three flows is observed. Plagioclase phenocrysts are less abundant in fluids than the mesostasis (~2/3). The gases trapped in these phenocrysts are richer in CO and organic compounds, whereas mesostasis contain more H_2O, CO_2 and SO_2.

CO is likely produced by reduction of CO_2 and H_2O with carbon during either analyses or eruption itself, or is of primary origin. In the latter case, gas composition suggests an entrapment temperature of about 1200°C ± 75°C. Kinetic study of the water and carbon dioxide release allows calculation of the diffusion characteristics of these fluids. Water and carbon dioxide behave rather similarly. Plagioclase gives a single activation energy value (8 Kcal/mole), while mesostasis gives two values (8 Kcal/mole, 15 Kcal/mole). Diffusion coefficients at 20°C are estimated to fall in the range $10^{-13} \cdot 10^{-12}$ $cm^2 \cdot sec^{-1}$. (Authors' abstract)

ZOLOTAREV, B.P., VOITOV, G.I. and STAROBINETS, I.S., 1981, Gases in recent basaltoids from the Gulf of California (according to the data of "Glomar Challenger" leg 65): Akad. Nauk SSSR Doklady, v. 260, p. 1466-1469(in Russian). See Appendix

ZOLOTAREV, B.P., VOITOV, G.I. and ZHOGINA, L.M., 1981, Gases of basaltoids of the Middle-Atlantic Ridge ("Globmar Challenger," leg 49): Akad. Nauk SSSR Doklady, v. 261, p. 194-197(in Russian). See Appendix

ZOZULENKO, L.B., 1980, Comparison of parameters of gas-liquid inclusions in quartz of veins and pebbles of conglomerates in the Yenisey region: Transactions of Geol. Inst. of Buryatian Division of Siberian Branch of Acad. Sci. of the USSR ("Geochemistry of rocks and ores of Transbaikalia"), v. 23, p. 82-90 (in Russian).

Proterozoic deposits of the Transangarian part of the Yenisey area bear several age levels of oligomictic quartz conglomerates and numerous veins filled by quartz ± ores. Quartz pebbles in conglomerates also were under action of hot solutions. Several vein quartz types were distinguished and specific features of fluid inclusions in those quartz types were determined such as Th, P, presence or absence of CO_2, and salinity of inclusion fluids. Generally Th is in range 100-470°C, P 15-540 to 1800 atm, salinity up to 35% NaCl, CO_2 from almost pure carbon dioxide fluids in lower levels to <2% in upper levels. Inclusions in conglomerates and in quartz-sulfide veins cutting them are the same, hence the genetic type of ores in conglomerates and veins is the same, although different in morphology. (Abstract by A.K.)

ZYRYANOV, V.N., 1981, Equilibria of cancrinite in the system cancrinite-nepheline-feldspar-water solution of potassium and sodium carbonates: Zapiski Vses. Mineral. Obshch., v. 110, no. 3, p. 331-337 (in Russian). Author at Inst. Experim. Mineralogy of Acad. Sci. of the USSR, Chernogolovka, USSR.

Th of inclusions in cancrinite from Botogol' massif ~400°C, from Vishnevye Mts - 380°C, from Synnyr massif - 420°C. (A.K.)

ZYRYANOV, V.N., 1981, Phase relations in the Lc_{ss}-Ne_{ss}-Fsp-(K, Na)Cl^m system and the pseudoleucite problem: Geokhimiya, 1981, no. 5, p. 662-670 (in Russian).

ZYRYANOV, V.N., 1981, Phase correspondence in the systems of feldspars and feldspathoids: Moscow, "Nauka" Pub. House (in Russian), 216 pp.

The six chapter titles, as follows, indicate considerable pertinence to fluid inclusion studies. (E.R.)

1. Experimental procedure and apparatus

2. Alkali feldspar - aqueous salt solution, alkali feldspar - alkali-haloid melt systems

3. Nepheline - aqueous salt solution, nepheline - alkali-haloid melt systems

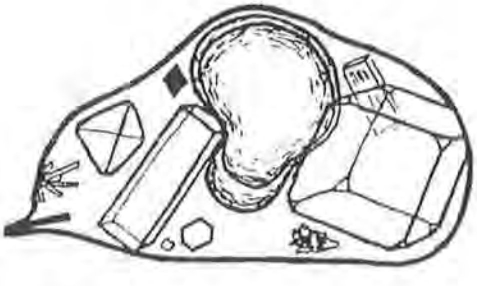
4. Phase correspondence in the nepheline - alkali feldspar system

5. Cancrinite - sodalite - aqueous salt solution, sodalite - leucite - alkali-haloid melt systems

6. Application of experimental data to estimating temperature conditions of alkali rocks formation.

ZYRYANOV, V.N. and KOZYREVA, L.V., 1981, Temperature conditions of formation of Khibiny alkaline massif: Izv. AN SSSR, no. 12, p. 35-46 (in Russian). First author at Inst. Exper. Mineral. of Acad. Sci. USSR, Chernogolovka near Moscow, USSR.

Temperatures were estimated by phase equilibria of nepheline and (K, Na) feldspar, silica excess in nepheline (Hamilton's method) and rock liquidus as ranging from 1085 to 1200°C for magmatic stage; Th from papers of Kogarko and Romanchev are quoted. (A.K.)



Appendix

The following group of abstracts was received after the preceding 246 pages had been prepared in photo-ready format. However, I have inserted a brief citation to each of these items in its correct alphabetical position, to simplify searching. (Ed.)

APLONOV, V.S., DILAKTORSKAYA, Ye.S. and SKUBLOV, G.T., 1981, Studies of gas-liquid inclusions in vein quartz of the scheelite stockwork Bogutinskoe: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter III, p. 3-5 (in Russian). Authors at Leningrad State Univ., USSR.

Quartz of post-scheelite, sulfide stage and carbonate stage in the deposit Bogutinskoe (S. Kazakhstan) bears numerous two- or three-phase inclusions with Th 310-220°C; by water leachates of inclusion fillings Ca>Na+Mg+K, HCO_3>Cl+F, CO_2>hydrocarbons. Decrepitation studies were performed and decrepitometric map of the deposit was made to reveal the occurrence of mineralization of various temperature stages. (Abstract by A.K.)

BAKUMENKO, I.T., BAZAROVA, T.Yu., KRASOV, N.F., KUZNETSOVA, I.K., MOTORINA, I.V. and POPOVA, N.M., 1981, Thermobarogeochemical studies of volcanites and subvolcanic rocks, in Thermobarogeochemical studies, Yu.A. Dolgov and I.T. Bakumenko, eds.: Novosibirsk, Siberian Br. of Acad. Sci. USSR, Inst. Geol. and Geophysics, p. 13-28 (in Russian). Authors at Inst. Geol. Geophy. of Siberian Br. of Acad. Sci. USSR, Novosibirsk-90, USSR.

Calc-alkaline, intermediate and basic volcanites were represented by basaltoids, andesites and andesite-dacites of the Kamchatka volcanoes Klyuchevskiy, Tolbachik, Bezymyannyi and Karimskiy, and late Ordovician lavas of Bayanaul subvolcanic complex (Central Kazakhstan). Pyroxenes from Kluchevskiy volcano bear melt inclusions with Th 1280-1200°C, rarely 1320°C, megacrysts of plagioclases from Tolbachik - Th 1200-1180°C, rarely 1305-1120°C; Bayanaul complex consists of liparite-dacites (quartz, Th 960-910°C, liparite composition of inclusion melt after homogenization) and basaltoids (quartz, Th 980-950°C, pyroxene 1315-1250°C, inclusion melt composition in quartz - liparite, in pyroxene - basalt). Appearance of acid melts in basaltoids cannot be explained by crystallization fractionation, but by mixing of basalt and liparite melts with preserved phenocrysts of quartz. Liquidus T of magmas of volcano Karymskiy are in ranges 1440-1400°C, and Bezlymyannyi - 1360-1340°C; the mechanism of magma crystallization differentiation is discussed. P during most intensive crystallization of the Karimskiy volcano magma was 800-600 atm at 1250-1200°C, what corresponds to andesite magma column about 2-3 km.

Volcanites and subvolcanic rocks of acid composition are characterized mostly by Th data from earlier published papers. Inclusions were studied in minerals of liparites, dacites, granophyres and quartz porphyries. Th of melt inclusions are in ranges 610-1370°C.

Alkaline volcanites from Chukotka (Great Anyuy River basin), basaltoids and phonolites from Armenia bear glass and crystallized inclusions in pyroxene; inclusion glass has high potassium composition typical of T ~1250°C. Melt inclusions represent frequently ideal models of crystallization fractionation: after crystallization of pyroxene, biotite and ore mineral, the remaining melt in inclusion has grano-syenite or syenite-trachyite composition. In several cases the magma hybridization was suggested on the basis of inclusion studies. (Abstract by A.K.)

BAKUMENKO, I.T., KOSUKHIN, O.N., KOSALS, Ya.A. and LKHAMSUREN, Zh., 1981, Contribution to genesis of rhythmic-banded textures in granitoids: Akad. Nauk SSSR Doklady, v. 260, no. 2, p. 444-448 (in Russian). First author at Inst. Geol. Geoph. of Siberian Branch of Acad. Sci. USSr, Novosibirsk.

In quartz porphyries and other subvolcanic granitoids and in granite pegmatites sometimes rhythmic-banded aggregates were found. The more common type I, of massive texture, has alternating coarse quartz bands and fine quartz-feldspar aggregates parallel to contact. Type II occurs in stockwork chamber pegmatites, forming horizontal quartz-feldspar bands with numerous vugs. Melt inclusions were found in quartz phenocrysts, quartz of quartz bands and quartz of quartz-feldspar bands of rhythmic textures of type I in quartz porphyry of Pervomaiskiy massif (Dzhida, Buryatia). The inclusions are filled by quartz-feldspar aggregate with fluid phase (LH_2O + LCO_2 + G) and their Th was ≤650°C, or for quartz bands - 740-770°C. The quartz bands crystallized first and between them the remaining melt gave quartz-feldspar aggregates (Th 700-650°C). Individual phenocrysts of quartz in quartz-feldspar zones yielded Th 770-750°C (from the center to the edge of grain). Similar porphyries from Mongolia have quartz with salt dms in melt inclusions; no L phase was discernible. Those inclusions have Th 1060-1050°C for thick monomineral quartz bands, sometimes down to 830°C in peripheries of quartz grains. Very thin quartz bands yielded Th 1000°C. Sometimes small quartz druses occurred in the bands; in quartz terminations melt inclusions homogenized at 920-875°C. Quartz from quartz-feldspar bands crystallized at 1000-800°C.

Banding of type II was studied on samples from endocontact zones of pegmatites from Bayan-Aul (N. Kazakhstan) and Adun-Cholon. Melt inclusions in quartz yielded Th 550-540 and ~620°C, respectively; those inclusions were coeval with fluid inclusions of low density (L<<G). Late zones of quartz crystals formed from post-magmatic fluids. (Abstract by A.K.)

BAKUMENKO, I.T., KOSUKHIN, O.N., SIMONOV, V.A. and CHUPIN, V.P., 1981, Thermobarogeochemical studies of gabbroids, granitoids and granite pegmatites, *in* Thermobarogeochemical studies, Yu.A. Dolgov and I.T. Bakumenko, eds.: Novosibirsk, Siberian Br. of Acad. Sci. USSR, Geol. and Geophysics, p. 38-53 (in Russian). Authors at Inst. Geol. Geophy. of Sib. Branch of Acad. Sci. USSR, Novosibirsk-90, USSR.

Anorthite from gabbro-pegmatites from the ophiolite series at the Tabash settlement, Sabzevar region, Iran, bears P melt inclusions with Th 1435-1380°C, PS inclusions have Th to 1260°C. Plagioclase An 95 in dike of pegmatoid gabbro-norite cutting serpentinites (in Koryak Upland, USSR) bears melt inclusions with Th 1310-1380°C; bytownite from fine-grain gabbro-norites-P melt inclusions with Th 1130-1180°C and PS melt-brine inclusions with Th >400°C, clinopyroxene from the same rock - 1050-1150°C; olivine gabbroids from marginal parts of gabbroid bodies: in olivines PS ?silicate-salt inclusions with Th >900°C, in plagioclase S G/L inclusions with Th 200-450°C, in clinopyroxene P melt inclusions with Th 1070-1030°C and inclusions of melts-solutions with Th 870-670°C. Similar Th were obtained for gabbroid ophiolite dike complex in Kuznetskiy Alatau. Next authors review Th data of melt inclusions for various types of granitoids (ranges 600-1000°C) and for magmatic stage of granite pegmatites (850-515°C), generally published in earlier papers of these authors. (Abstract by A.K.)

BARKAN, E.S. and YAKUTSENI, V.P., 1981, Perspectives of gas potential at great depths: Sovetskaya Geologiya, no. 4, p. 6-15 (in Russian). First author at All-Union Sci.-Res. Geol.-Prosp. Inst., Moscow, USSR.

The paper bears three tables of methane solubility in water NaCl solution (0-350 g/l), at T 40-255°C under hydrostatic pressure of 1000-8000 m water column. (A.K.)

BARSUKOV, V.L., POGUDINA, M.A. and RYZHOV, O.B., 1981, Overlapping of late albitites on haloes of near-ore argillization of one of the uranium-molybdenum deposits: Akad. Nauk SSSR Doklady, v. 261, no. 4, p. 953-956 (in Russian). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

The deposit (name and location not given) consists of veins in liparite volcanites. Pre-ore albitization developed at 230-240°C, argillization of albitized rocks with formation of uranium ores - 140-165°C. Late albitites developing after argillization yielded Th ≤100°C. (A.K.)

BAYDAKOV, V.G., SKRIPOV, V.P., KAVERIN, A.M. and KHVOSTOV, K.V., 1981, Influence of curvature of vapor nuclei on the value of surface tension: Acad. Nauk SSSR Doklady, v. 260, no. 4, p. 858-860 (in Russian). Authors at Div. of Physico-Tech. Problems of the Ural Sci. Center of Acad. Sci. USSR, Sverdlovsk.

Although experiments with liquid xenon are described, the mechanism is pertinent to some nucleation phenomena in fluid inclusions. (A.K.)

BESPALOV, V.Ya., 1981, Geologic peculiarities of tin ore mineralization of the Verkhnebadzhal'skiy ore junction (Priamur'ye): Geologiya i Geofizika, no. 8, p. 49-58 (in Russian). Author at Komsomol'sk Geol.-Prosp. Expedition, P.G.O. "Dal'geologiya." Komsomol'sk-on-Amur, USSR.

Verkhnebadzhal'skiy tin ore junction occurs in ranges of the North-Sikhote-Alin' ore province. Ores occur in volcanic-sedimentary beds. For the two tin ore formations found, Th are as follows: cassiterite-quartz formation 432-155°C, 59 determinations, cassiterite-silicate-sulfide formation 418-100°C, ~10 determinations. (A.K.)

BORDET, P., COLCHEN, M. Le FORT, P. and PECHER, A., 1981, The geodynamic evolution of the Himalaya; ten years of research in central Nepal Himalaya and some other regions, in Zagros, Hindu Kush, Himalaya Geodynamic Evolution, H.K. Gupta and F.M. Delany, eds. (Geodynamics Series Vol. 3): Washington, DC, Am. Geophys. Union, p. 149-168. First author at Facultés Catholiques - 21, rue d'Assas, F-75006 Paris, France.

Ten years of field and laboratory studies by French teams have yielded interesting and novel views on some of the long outstanding problems of Himalayan geology. Following original observations by Heim, Gansser and others, detailed investigations of the Ladakh ophiolite zone and the Main Central Thrust (M.C.T.) in Nepal, followed by analysis of fluid inclusions, petrofabrics and metamorphism have led to descriptions of the evolution of the M.C.T., to an explanation of the famous reverse metamorphism associated with the M.C.T. and of the leucogranite intrusions. A calender of the geodynamic evolution of the Himalaya is given in conclusion. (Authors' abstract)

BUNTIKOVA, A.F., PETROSYAN, R.V. and BELYAEVSKAYA, N.G., 1981, Beta-uranotile and meta-autunite in low-temperature calcite metasomatites: Izv. AN SSSR, Ser. Geol., no. 6, p. 107-118 (in Russian). (Continued)

For Th presented here see Petrosyan, R.V., 1981 and Petrosyan, R.V. and Buntikova, A.F., 1981, this volume. (A.K.)

DAVYDOV, A.S., 1981, Problem of genesis of deposits of gold-tungsten formation of the Aniuy zone: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter III, p. 8-10 (in Russian). Author at Far-East Geol. Inst. of Far-Est Sci. Center of Acad. Sci. USSR, Vladivostok.

Quartz veins with gold and tungsten mineralization occur in diabases and diorite dikes cutting sedimentary rocks. Main useful component is gold. Scheelite is distributed nonuniformly and mostly occurs in lower horizons of ore bodies, being included in quartz as nests of crystals. Moreover arsenopyrite, galena, sphalerite, chalcopyrite, pyrite, pyrrhotite, carbonates etc. occur in veins. Ore bodies formed during six stages under reducing conditions (Eh from -0.64 to -1.0), from almost neutral solutions (pH 6.0-8.2) at T 390-80°C and under P 1-1.5 kbar. (From the author's abstract, translated by A.K.)

DAVYDOV, Yu.V. and LESKOVA, N.V., 1981, Connection of post-sedimentation formations in carbonate rocks with lead-zinc ore mineralization: Izv. AN SSSR, no. 12, p. 106-118 (in Russian). Authors at Inst. Geol. of Yakutian Div. of Siberian Br. of Acad. Sci. USSR, Yakutsk, USSR.

The studied samples were collected at the Zn-Pb deposits Sardana and Pereval'noe in the Kyllakh zone of E slope of Aldan Shield. Th of inclusions in coarse dolomite in veins is 260-360°C, Td - 310-380°C (data quoted from Donets et al., 1977). (A.K.)

DERGACHEV, V.B. and MELENEVSKIY, V.N., 1981, Water and carbon dioxide in quartz from tungsten deposits of Gornyi Altai: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter IV, p. 57-58 (in Russian). Authors at Siberian Sci.-Research Inst. of Geology, Geophy. and Mineral Raw Materials, Novosibirsk, USSR.

By mass spectrometry, the ratio CO_2:H_2O and kinetics of release of water and carbon dioxide were studied in samples taken from the deposits: quartz-greisen rare-metal-molybdenite-wolframite (Kalgut), greisen scheelite (Dzhulalyu), quartz-wolframite (Buguzun), quartz-scheelite (Il'degem), cobaltite-scheelite mineralized zones (Olendzhular) and cobaltite-löllingite mineralized zones (Kuruuzek). During heating up to 700°C the highest water content was found in vein quartz (0.02-0.33%), the lowest in greisen quartz (0.006-0.06%), CO_2 content ranges from 0.002-0.016% without distinct connection with type of quartz. Temperatures of maximum gas release were as follows: 325-400°C, 560-580°C, 900-1000°C. (From the authors' abstract, shortened and translated by A.K.)

DOLGOV, Yu.A. and BAKUMENKO, I.T. (eds.), 1981, Thermobarogeochemical studies, 79 pp, 500 copies printed, price 70 kopecks (in Russian). Published by Siberian Br. of Acad. Sci. USSR, Inst. Geol. and Geophysics, Novosibirsk.

The book bears the main results of scientific studies performed in laboratories of mineral-forming solutions and mineralogy of the Inst. Geol. and Geophy. of Sib. Branch of Acad. Sci. USSR during the years 1976-1980 on the problems: "Thermodynamic parameters and analyses of mineral-forming processes in the Earth's crust," "Peculiarities of chemical composition and conditions of formation of minerals in magmatic processes," "Thermobarogeochemical studies of conditions of magmatic, metamorphic and authigenic-sedimentary mineral formation."

The book includes 7 papers describing studies of impact and regional metamorphism, magmatic crystallization of volcanites, subvolcanic and plutonic rocks of calc-alkaline and alkaline composition and studies of inclusions in pegmatites and post-magmatic deposits. A special paper concerns problems of analysis of gases in individual inclusions.(...) (Editors' note, translated by A.K.) Individual papers are abstracted and arranged in this volume alphabetically by the author's name. (A.K.)

DOLGOV, Yu.A. and GIBSHER, N.A., 1981, Studies of processes of post-magmatic mineral formation, in Thermobarogeochemical studies, Yu.A. Dolgov and I.T. Bakumenko, eds.: Novosibirsk, Siberian Br. of Acad. Sci. USSR, Inst. Geol. and Geophysics, p. 56-63 (in Russian). Authors at Inst. Geol. Geophy. of Sib. Branch of Acad. Nauk USSR, Novosibirsk-90, USSR.

The paper bears fluid inclusion data on pyrite-polymetal and strata-bound-polymetal deposits from Rudnyi Altai: Vavilonskoe, Zyryan, Tishin, Korbalikha, Rubtsovskoe, from Siberian Platform: Tychany, and from W. Pribaykal'ye: Barvinskogo and Novo-Anay, and presents the model of adiabatic mineral formation. This paper contains collected data from these authors' publications on the above themes from the years 1976-1980. (A.K.)

DOLGOV, Yu.A. and SHUGUROVA, N.A., 1981, Analysis of gases from inclusions in minerals, in Thermobarogeochemical studies, Yu.A. Dolgov and I.T. Bakumenko, eds.: Novosibirsk, Siberian Br. of Acad. Sci. USSR, Inst. Geol. and Geophysics, p. 63-66 (in Russian). Authors at Inst. Geol. Geophy. of Sib. Branch of Acad. Sci. USSR, Novosibirsk-90, USSR.

During the last years investigations were made to improve the absorption-volumetric method, especially during work with small volumes of gas. Gases from inclusions in minerals from copper-molybdenum and gold ore deposits, in tektites, in silicate spherules of various origin and in other objects were investigated. Especially thoroughly studied were glass and mineral particles from lunar soil (samples of "Luna-24"). From 26 analyses, five were one-component-nitrogen, one- one-component CO_2, eleven two-component H_2+N_2, three two-component CO_2+N_2, five three-component $CO+H_2+N_2$, two three-component CO_2+hydrocarbons+N_2, one three-component hydrocarbons+H_2+N_2, one CO_2+hydrocarbons+CO, four-component - one hydrocarbons+$CO+H_2+N_2$, two CO_2+hydrocarbons+H_2+N_2 (N_2 means always nitrogen plus rare gases). Acid sulfur-bearing gases are absent in the "Luna-24" samples. (Abstract by A.K.)

DOLGOV, Yu.A., VISHNEVSKIY, S.A. and TOMILENKO, A.A., 1981, Studies of processes of metamorphic mineral formation, in Thermobarogeochemical studies, Yu.A. Dolgov and I.T. Bakumenko, eds.: Novosibirsk, Siberian Br. of Acad. Sci. USSR, Inst. Geol. and Geophysics, p. 3-12 (in Russian). Authors at Inst. Geol. and Geoph. of Siberian Branch of Acad. Sci. USSR, Novosibirsk-90, USSR.

The paper consists of two parts. The first one presents results of fluid inclusion studies in impactites from Popigay and Riess craters. In the Popigay crater, impact glass bears solid, G, G/L and G+L+dms inclusions with very variable salt content (from very low to several tens of percent) and Th (from 150 to ⩾700°C), caused by alteration of inclusions of the parent rocks, boiling and fractional evaporation of various fluids present in pre-impact rocks. Also various (feldspar and other silicate) glass inclusions are present in impactites. Gas phase does not contain O_2 but H2, CO and hydrocarbons are common. Inclusions in the Riess material have also very variable gas composition: O_2 is absent, common are H_2 (up to 35 vol.%) and hydrocarbons (up to 33 vol.%), P of gases in inclusions are similar to some tektites.

The second part presents results of inclusion studies of metamorphic rocks. On the basis of Th of LCO_2 and LN_2 inclusions the following P values were found (in kbars): garnets from eclogites (Steblitz, GDR; Yakutia) >15, quartz from granulites (Chogar complex, Stanovoy Ridge) to 10-11, granulites from Sutama region (Aldan shield), sapphirine, plagioclase - to 8.5, garnet, sillimanite, quartz - to 7.5; garnet and quartz from granulites (Belomorie complex, region Pon'gomi River) - to 8.5; quartz and plagioclase from charnockites (S. Enisey area) - to 8.0; garnet, sillimanite and quartz from granulites (W part of Aldan shield) - to 6.0; quartz from rocks of amphibolite facies (W part of Aldan shield) - to 6.0; metamorphic rocks of the S. Chuy Ridge, kyanite - to 8.0, andalusite and quartz - to 5.5, quartz - to 6.0. "Granulated" quartz from Borus Ridge, W. Sayan, and probably the related jadeitites, formed under P up to 7 kbars. A series of Th of crystallized melt inclusions in quartz from migmatites was also presented: granulite facies, W. Aldan shield - 860-880°C; amphibolite facies, W. Aldan shield - 800-830°C, Mynchukur block of Dzhungarian Alatau - 700-710°C, S. Chuy Ridge - 700-710°C. Metamorphic fluids consist of water, salts, CO_2 as essential components, plus subordinate CO, CH_4, N_2 and rare gases, but eclogites from xenoliths in Yakutian kimberlites and in intercalations in peridotites from Zeblitz, GDR, formed with presence of N_2 fluid. "Granulated" quartz of Borus Ridge formed under action of H_2-CH_4 fluid, next altered to CO_2-H_2O-salt fluid. Salt concentration in metamorphic fluid usually does not exceed 10 wt.% and salts usually consist of NaCl, rarer of KCl, $CaCl_2$ and $MgCl^2$. (Abstract by A.K.)

DUBROVSKIY, M.I., 1981, Physico-chemical (PH_2O-T-X) model of mineral associations of high-alumina granites: Izv. AN SSSR, Ser. Geol., no. 5, p. 5-19 (in Russian). Author at Geol. Inst. of Kola Div. of Acad. Sci. USSR, Apatity, USSR.

The paper presents the analysis of the system: albite-anorthite-orthoclase-quartz-enstatite-ferrosalite-Al_2SiO_5-H_2O at T 650-750°C, PH_2O 1-8 kbar. (A.K.)

DUDYREV, A.H., KARASEV, A.A. and SEDYKH, A.N., 1981, Gases in rocks and waters of the polymetallic deposit Nikolaevskoe: Sovetskaya Geologiya, no. 10, p. 107-108 (in Russian). First author at TSNIIPP, USSR.

The deposit Nikalaevskoe (Primor'ye, Dal'negorsk region) occurs in sedimentary-volcanic Triassic-Paleogene rocks, cut by intrusions of quartz porphyries, felsites, gabbro-diorites and granite-porphyries. Contact rocks (hedenbergite skarns) formed at the contacts. Gases: H_2, CH_4, CO_2, Ar, N_2 were determined in mine waters, gases emanating from zones of rock fracturing and ground rocks samples. Methane is present continuously; hydrogen, only rarely. Also N_2, CO_2 and Ar are components occurring in almost all samples of gases, waters and rocks. Probably gas emanations have a volcanic nature [i.e., source?]. (Abstract by A.K.)

ENIKEEVA, L.N., 1981, Problem of conditions of formation of scheelite skarns of ore field Karatyube (Western Uzbekistan): Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter III, p. 12 (in Russian). Author at Inst. Geol. and Geoph. of Acad. Sci. of Uzbek SSR, Tashkent, Uzbekistan.

P-T conditions of magnesia skarns of magmatic stage (on the contact with granitoid intrusion) were as follows: T 650-750°C, total P 0.9-1.2 kbar, low fluorine activity and variable pH. Magnesia skarns were next altered under alkaline conditions. Lime skarns formed at T 600-550°C. (Note: method of obtaining of the above data is not indicated but it may be fluid inclusion study, A.K.). (From the author's abstract, translated by A.K.)

FAYZIYEV, A.R., KOPLUS, A.V., DZAYNUKOV, A.B. and ISKANDAROV, F.Sh., 1981, Bitumens in fluorite from endogeneous deposits of the USSR: Izv. AN SSSR, Ser. Geol., no. 5, p. 92-97 (in Russian). First author at Tadzhik State Univ., Dushanbe, Tadzhik SSR.

The samples for studies were collected at the Late-Hercynian and younger fluorite deposits in Uzbekistan, Transbaikalia, Gornyi Altai, Central Tadzhikistan, Kazakhstan and Primor'ye. Fluorite may bear both P and S inclusions of bitumens, usually one-phase (L, S, G), two-phase (G/L, L/S), or more rarely, polyphase. L bitumens are brownish to colorless, S - from brown to black. Bitumens were studied by luminescence-capillary method in chloroform and next in alcohol-benzene leachates. Content of luminescing bitumens in fluorite ranges from 6 to 300 g per t; ranges for various deposits are given, mostly average value equals 10-40 g per t. Analysis of chloroform leachate yielded elements in chloroform-free fraction: C to 85%, H_2 to 15%, N_2 to 1%, O_2 to 7%, S to 3%, G phase of inclusions in fluorite from the deposit Krasnye Kholmy (Central Tadzhikistan) by gas chromatography consisted of (in cm^3/kg of sample) He 0.0025, H_2 0.51, O_2 0.072, N_2 0.43, CH_4 0.42, C_2H_4 0.00079, C_2H_6 0.0044, C_3H_6 0.0009, C_3H_8 0.00057, iso-C_4H_{10} 0.000089, iso-C_5H_{12} 0.0005, n-C_5H_{12} 0.000027, CO 0.0011, CO_2 0.16. No connection was found between bitumen content and fluorite color or Th of inclusions (80-250°C. (Abstract by A.K.)

GOGISHVILI, V.G. and CHKHEIDZE, R.G., 1981, Genetic types of high-silica zeolites (on the example of Transcaucasus): Sovetskaya Geologiya, no. 9, p. 37-46 (in Russian). Authors at Caucasian Inst. of Mineral Raw Materials, Tbilisi, Georgian SSR.

The Transcaucasian zeolite deposits Tetri-Tskarao, Dzegvi, Noemberyan, Khvedureti, Chiatura bear barite crystals with G/L inclusions of Th 110-180°C. (A.K.)

GORBATYI, Yu.Ye. and DEM'YANETS, Yu.N., 1981, Structure factor of liquid and supercritical water under pressure 1000 bars and at temperatures from 298 to 773 K: Akad. Nauk SSSR Doklady, v. 260, no. 4, p. 911-915 (in Russian). Authors at Inst. Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka, Moscow Region, USSR.

Pertinent to fluid inclusion studies. (A.K.)

GUTSALO, L.K. and PLOTNIKOV, A.M., 1981, Carbon isotopic composition in the CO_2-CH_4 system as a criterion for the origin of methane and carbon dioxide in Earth natural gases: Akad. Nauk SSSR Doklady, v. 259, p. 470-

473 (in Russian). Authors at Inst. Geol. and Geochem. of Mineral Fuels of Acad. Sci. of Ukrainian SSR, L'vov, Ukraine.

Pertinent to studies of gases in inclusions. (A.K.)

HOLLOWAY, J.R., 1981b Volatile interactions in magmas, *in* Thermodynamics of Minerals and Melts, R.C. Newton, ed., in the collection Advances in physical geochemistry: Springer-Verlag, New York, NY, v. 1, p. 273-293.

A brief review of the nature of magmatic volatiles, their solubilities and their solution mechanisms in magmas. (E.R.)

IGNATOV, A.A., PITUL'KO, V.M. and BUYSKIKH, A.A., 1981, Dynamics of formation of endogenic haloes of hydrothermal deposits: Geologiya i Geofizika, no. 8, p. 132-136 (in Russian). Authors at North-East Complex Sci.-Res. Inst. of Far-East Sci. Center of Acad. Sci. USSR, Magadan, USSR.

Theoretical calculations pertinent to methods of revealing of haloes of hydrothermal impregnation by decrepitometric methods. (A.K.)

IONE, K.G., VOSTRIKOVA, L.A., PAUKSHTIS, Ye.A., YURCHENKO, E.N. and STEPANOV, V.G., 1981, Synthesis of hydrocarbons from methanol on crystalline silicates bearing B, Ga, Al: Akad. Nauk SSSR Doklady, v. 261, no. 5, p. 1160-1163 (in Russian). Authors at Inst. of Catalysis of Sib. Div. of Acad. Sci. USSR, Novosibirsk, USSR.

Catalytic properties of aluminosilicates (e.g. zeolites) are pertinent to thermal release of gases from fluid inclusions. (A.K.)

KOGARKO, L.N., PETROVA, Ye.N. and VENTURELLI, Zh.P., 1981, Phosphate content in magmatic melts: Akad. Nauk SSSR Doklady, v. 261, no. 6, p. 1430-1432 (in Russian). First author at Inst. Geochem. and Anal. Chem. of Acad. Sci. of USSR, Moscow, USSR.

Pertinent to composition of melt in inclusions. (A.K.)

KOKIN, A.V., 1981, Thermobarometry of native gold and co-occurring minerals from deposits of SE Yakutia: Geologiya i Geofizika, no. 5, p. 74-80 (in Russian). Author at Allakh-Yun' Geol.-Prosp. Expedition, Khandyga, Yakutia, USSR.

The studied gold deposits from SE Yakutia belongs to arsenopyrite, bismuth, antimonite and galena-sphalerite types of, respectively, sulfide-low gold-quartz, rare-metal, gold-antimony and polymetal formations. Thermobarometric studies were performed only for the three first formations. All the studied deposits occur in terrigenous Permian and Triassic sediments. Decrepigrams were obtained on a vacuum decrepitometer VD-3. Native gold was decrepitated before and after etching in $HCl+HNO_3$: gold from primary ore bodies displayed the same pattern before and after etching and gold from placer deposits lost decrepitation peaks at 30-100°C after etching probably due to dissolving of the envelope of sedimentary gold bearing water in pores. Decrepigrams of gold bear two groups of peaks; A) group of true inclusions in gold with Td comparable to Td of paragenetic quartz and sulfides, B) "inertion group" at T 415-800°C, high Td are connected with overcoming of elasticity of gold. Td of group A are as follows: deposits of arsenopyrite type 90-425°C (31 samples), galena-sphalerite type 50-330°C (104 samples), bismuth and gold-telluride types 50-350°C (13 samples), antimonite type 50-100°C (12 samples). (Abstract by A.K.)

KOL'TSOV, A.B., 1981, On the conditions of transport and precipitation of Au and Ag in certain low-temperature hydrothermal processes: Akad. Nauk SSSR Doklady, v. 261, no. 5, p. 1231-1234 (in Russian). Author at Leningrad State Univ., Leningrad, USSR.

Pertinent to studies of inclusion fluids of Au and Ag deposits. (A.K.)

KOROBEYNIKOV, A.F., 1981b, New type of gold ore mineralization in alkaline metasomatites: Akad. Nauk SSSR Doklady, v. 260, no. 1, p. 179-182 (in Russian). Author at Tomsk Polytechnical Inst., Tomsk, USSR.

Rocks of granitoid intrusions in Sayano-Altai and Tyan'-Shan' were submitted to K-feldspar, biotite, albite and sericite metasomatic development and they bear disseminated or veinlet-type gold-quartz mineralization connected with alkaline metasomatism. They formed in apical and marginal zones of intrusions. Gold ores occur mostly in greisenized albitites (Th 390-260°C) and in berezitized albitites. Generally alkaline metasomatism occurred at Th 480-300°C and gold ore formation at 390-250°C. Relations between Na and K (ratios 0.7:1 to 4:1) and Cl and F (ratios 25:1 to 1:1) and Cl, HCO_3 and SO_4 (ratios 1:1:0 to 13:30:1) in inclusion fluids are presented. Hydrothermal impregnation haloes around ore bodies yielded Td 360-70°C. (Abstract by A.K.)

KOSHELEV, Yu.Ya., CHEBOTAREV, M.V. and BARAS, Z., 1981, Borundur fluorite-bearing ore field in Mongolia: Sovetskaya Geologiya, no. 12, p. 69-75 (in Russian). First author at "Zarubezhgeologiya," Moscow, USSR.

The deposit Borundur occurs in the ranges of Mongolian-Transbaikalian fluorite province of late Paleozoic-Mesozoic age. Quartz-fluorite ore bodies cut leucocratic subalkaline granites, crystalline schists and gneisses, volcanites and clastic sediments. By homogenization and decrepitation of "bubble" (i.e. fluid, A.K.) inclusions in fluorites, two T ranges of fluorite formation were detected: 140-165°C and 120-140°C. (A.K.)

KOSUKHIN, O.N., 1981, On the genesis of graphic structures: Geologiya i Geofizika, no. 4, p. 46-50 (in Russian). Author at Inst. Geol. and Geoph. of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

One of the highest-temperature graphic aggregates was found as granophyric veins or accumulations of granite or diorite composition, widely developed in Siberian traps (Anakit massif on Lower Tunguska River, Vel'minskiy ridge on Podkamennaya Tunguska River, rocks from the River Gorbiachin). Granophyres frequently bear phenocrysts of hedenbergite and oligoclase. Coeval growth of quartz and feldspar was proved by crystallomorphologic studies of Bakumenko. P inclusions in quartz are filled by an aggregate of silicate phases with distinct birefringence and one or few fluid accumulations, mostly consisting of gas or, in melt inclusions in quartz-sanidine intergrowths, of LCO_2. PS inclusions frequently have glass>silicates. P and PS inclusions homogenize in silicate melt; their Th are 1150-940°C (Gorbiachin River), 1200-1080°C (Anakit), 1250-1100°C (Vel'minskiy ridge), 1280-1250°C (Gusinoe Lake dike). Th of P and PS inclusions are very close. Quartz from granophyres of the massif Anakit and of intrusion of the Vel'minskiy ridge bears high-temperature salt inclusions (birefringent salts+ore minerals+G; halite, sylvite and visible LH_2O were not found), usually of secondary origin, but in external zones of quartz such inclusions are primary. Probably salt inclusions represent the fluid separated from melt during crystallization of granophyres. Salts start to melt intensively at 250-200°C; at 600-590°C G bubble dissolves in salt melt and ore minerals and remainders of salts dissolve at 900-800°C (Th). Polyphase salt S inclusions, similar to the above ones, were found in quartz and sanidine of graphic aggregates from Gusinoe Lake, but they contain some LH_2O in interstices between birefringent salts, Th 660-650°C. Melt and salt inclusions frequently occur in the same mineral grain. The data obtained prove that quartz-feldspar graphic aggregates form from water-rich as well as from "dry" magmas at various temperatures. The formation of such aggregates does not depend on T but on such features as magma cooling and viscosity of silicate melt, when significantly more quartz nuclei than feldspar ones may form. (Abstract by A.K.)

KOVAL'SKIY, F.I., MOSKOVSKIY, G.A., RUMYANTSEVA, O.P. and GILETIN, A.M., 1981, Conditions of sedimentation of the Kungurian halide deposits in the Kuibyshe region of the Zavolzh'ye area (from a study of inclusions in minerals), in The structure and formation conditions of salt-bearing horizons: Pub. House "Nauka," Siberian Branch, Novosibirsk, p. 32-36 (in Russian).

Fluid inclusions in growth zones of hopper salt reflect the physico-conditions of salt precipitation. Studied samples came from the salt deposit Dergunovskoe. In this deposit halite beds are covered by sulfate layers. Halite rock has distinctly marked seasonal banding. Each second band consists of "feathery" or hopper halite, whereas the first band is clayey-sulfate. Sometimes third band (grainy halite) and fourth band (diagenetic coarse-crystalline halite) are present. "Feathery" halite bears only one-phase L inclusions showing its low T of crystallization. Hopper halite bears also one-phase inclusions of brine. In sedimentary (i.e. presumably primary) halite the content of K, Mg, SO_4 and Ca was determined in inclusion fluids by microchemical method. Ca content was always <1 g per liter, K ranges from 6.7 to 27.4 g per liter, Mg from 27.9 to 70.8 g per liter, SO_4 from 0.8 to 15.5 g per liter. The paper bears relatively detailed discussion of changes of the above ion concentrations in individual layers of salt. The conclusions are as follows: 1. Precipitation of salts started from concentrated brine, significantly changed due to movement of facies boundary of brine divided into layers from marginal zone of Forecaspian depression to adjacent territories. Depth of the salt precipitating basin was small. 2. The brine contained added clayey substances. 3. In the vertical section of the deposit two intervals of anomalous K ion content were distinguished at the depth ~540 m and ~470 m, in sulfate rocks. These horizons may be used as markers. (Abstract by A.K.)

KRASNOBAEV, A.A., 1981, Role of zircons from charnockitoids in solution of their genesis and age: Izv. AN SSSR, Ser. Geol. no. 4, p. 97-110 (in Russian). Inst. Geol. and Geochem. of Ural Sci. Center of Acad. Sci. USSR, Sverdlovsk.

Zircons bear solid and possibly G/L inclusions. Solid inclusions consist of prismatic apatite, rutile and (?)pyroxene. Some inclusions are secondary. (A.K.)

KRAUSE, W.B. and GNIRK, P.F., 1981, Domal salt brine migration experiments at Avery Island, Louisiana, in The Technology of High-Level Nuclear Waste Disposal, P.L. Hofmann, ed., v. 1, p. 110-135: U.S. Dept. Energy Tech.

Info. Center, DOE/TIC 4621 (Vol 1). Authors at RE/SPEC Inc., Rapid City, SD.

Three in situ brine migration experiments were performed in domal salt in the Avery Island mine located in southwestern Louisiana. The primary measurements included temperature, moisture collection, and pre- and post-test permeability at the experimental sites. Experimental data are discussed and compared with calculations based on the single-crystal brine migration theory. Comparisons indicate reasonable agreement between experiment and theory. (Authors' abstract)

KRAYNOV, S.R. and RYZHENKO, B.N., 1981, Use of physico-chemical modelling for studies of interaction in the system water-rock and hydrodynamic conditions of its application to the real hydrogeochemical processes: Lithology and mineral raw materials (Litologiya i poleznye iskopemye), no. 4, p. 72-84 (in Russian). First author at VSEGINGEO, Moscow, USSR.

Perspectives and limits of use of computer modelling of interaction in systems water-rock are shown, based on methods of physico-chemical thermodynamics, when applied to prediction of phase and chemical composition of products of hydrogeochemical processes. Limits of use of such modelling are determined by hydrodynamic conditions that distinguish real hydrochemical conditions and state of chemical equilibrium. Real filtration velocity of waters in rocks are very low, thus equilibrium may be achieved in nature. Modelling was made for surface conditions, mostly for CaF_2 in solutions of $NaHCO_3$, Na_2SO_4 and NaCl. (Abstract by A.K.)

KULIBAKINA, I.B. and CHAYKOVSKAYA, E.V., 1981, Vertical zoning in distribution of hydrogen sulfide-bearing gases: Izv. AN SSSR, no. 11, p. 138-143 (in Russian). Authors at All-Union Sci.-Res. Inst. of Natural Gases, Vidnoe near Moscow, USSR.

The paper reviews H_2S distribution in sulfate-bearing, oil-bearing, halite-bearing and carbonate rocks at various depths. (A.K.)

KULIKOV, I.V., 1981a, Mineralogy and genesis of scheelite-sulfide-fluorite ore mineralization at the deposit Tyrnyauz. - Synopsis of doctor's thesis, 24 pp. (in Russian). Moscow Geol.-Prosp. Inst., Moscow, USSR.

Formation of the deposit Tyrnyauz ended with late bismuth-scheelite-sulfide-fluorite stage. Complex mineralization of this stage is widely developed over the whole deposit, cuts all structures and the youngest magmatic bodies and essentially covers the area taken by Mo-W ores of the earlier skarn stages. The distinguished late stage consists of three mineral associations: a) bismuth-scheelite-fluorite, b) calcite-sulfide-fluorite, c) zeolite-quartz-calcite. Fluorite, garnet and partly calcite are minerals existing through all associations. Fluorite formed under unstable conditions of release of gases from mineral-forming medium at Th 700-350°C from highly concentrated heterogeneous solutions (NaCl+KCl up to 60-70%), rich in Ca and Fe; pH of liquid in inclusions was 3-3.5, P at lower levels during fluorite formation was 1200-1300 bars. Due to high-T formation of fluorite, this mineral is very poor in Mn and rare earths. Scheelite formed at 600-300°C calcite at 580-250°C. (Abstract by A.K.)

KULIKOV, I.V., 1981b, Genesis of bismuth-scheelite-sulfide-fluorite ore mineralization of Tyrnyauz: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter III, p. 21-23 (in Russian). Author at the Moscow Geol.-Prosp. Inst., Moscow, USSR.

Inclusion data the same as in Kulikov 1981a, this volume. (A.K.)

LAPIN, A.V., 1981, Processes of differentiation of carbonatites Izvestiya AN SSSR, Ser. geol., no. 1, p. 38-51 (in Russian). Author at Inst. Mineralogy, Geochem., Crystal. of Rare Elements, Moscow, USSR.

The paper presents examples of probable immiscibility of layered kamaphorite-carbonatite rock (Kovdor massif), ellipsoidal forsterite-magnetite accumulations in calcite and the same spherolites also in calcite, the same spherolites with outer rim of phlogopite in calcite, accumulations of apatite in carbonatite, calcite "drops" in melanocratic carbonatite (specimens from Vuorijarvi). (A.K.)

LAVRENT'YEVA, I.V. and PERCHUK, L.L., 1981, Phase equilibrium in the system biotite-garnet. Experimental data: Akad. Nauk SSSR Doklady, v. 260, no. 3, p. 731-734 (in Russian).

Pertinent to mineral geothermobarometers and then to comparison with fluid inclusion data. (A.K.)

LEVY, P.W., LOMAN, J.M., SWYLER, K.J. and KLAFFKY, R.W., 1981, Radiation damage studies on synthetic NaCl crystals and natural rock salt for radioactive waste disposal applications, in The Technology of High-Level Nuclear Waste Disposal, P.L. Hofmann, ed., v. 1, p. 136-167: U.S. Dept. Energy Tech. Info. Center, DOE/TIC 4621 (Vol. 1). First author at Brookhaven National Lab., Upton, NY.

A study of the radiation damage to salt at temperatures of 100-300°C and total doses up to 4×10^8 rads. Chlorine, hydrogen, and other products are formed on dissolution of such salt. (Modified from the authors' abstract)

LIKHOYDOV, G.G., PLYUSNINA, L.P. and MISHCHENCHUK, G.A., 1981, Conditions of formation of amphibolites in metabasites of the Ufaley complex: Izv. AN SSSR, no. 9, p. 14-25 (in Russian). Authors at Inst. Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka, USSR.

Amphibolite facies rocks in the Ural Mts. between rivers Ufa and Azyash yielded Th of fluid inclusions 430-480°C, P up to 4.5-5 kbar.(A.K.)

LITVINOVSKIY, B.A. and IZUPOVA, V.N., 1981, About pseudoautochthonous granitoids: Geologiya i Geofizika, no. 6, p. 67-77 (in Russian). Authors at Geol. Inst. of Buriatian Div. of Siberian Br. of Acad. Sci. USSR, Ulan-Ude, USSR.

Gases released from granosyenites of Svyatyi Nos massif on Baikal Lake, granosyenites of Barguza complex, quartz syenites of Zaza complex, subalkaline syenites of Kudun complex, alkaline syenites of Kunaley complex, granites of marginal zone of Barguza complex (Alla River), all but the first from Buriatian Transbaikalia, have the following composition (78 samples, analysis by gas chromatography, results in ml per g of sample): H_2O 0.31-5.75, CO_2 0.12-1.64, CO 0.03-0.30, CH_4 0.007-0.014, H_2 0.21-0.90, N_2 nil-0.06. The Svyatyi Nos granosyenites are proved to be autochthonous and they are richer in volatiles than most of the allochthonous granitoids. (Abstract by A.K.)

LYKOV, L.I., 1981, Problem of stages of mineral formation in the deposit Karaoba: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter III, p. 26-27 (in Russian). Author at the Central-Kazakhstan Producing Geol. Enterprise, Karaganda, Kazakh SSR.

Vein-stockwork deposit Karaoba genetically is connected with Permian three-phase leucocratic granite intrusion. It formed in four phases: molybdenite-quartz-feldspar (Th 400-250°C), cassiterite-molybdenite (Th 430-250°C), wolframite-quartz (Th 380-160°C) and sulfide-quartz (Th 280-120°C). (Abstract by A.K.)

MAKHNACH, A.S., KLIDEL'SKIY, A.V., MAKHNACH, A.A. and ZHOGLOV, V.G., 1981, Perspectives of oil occurrence in Pripyat' depression in the light of paleothermal studies: Izv. AN SSSR, Ser. Geol., no. 1, p. 107-121 (in Russian). First author at Inst. Geol. Geoph. of Acad. Sci. of Belorussian SSR, Minsk, Belorussia.

Th of gas-liquid inclusions in secondary halite from Pripyat' depression were 320-380°C. (A.K.)

MEL'NIKOV, E.P., OBOLKIN, V.D. and EVSTROPOV, A.A., 1981, Vein quartz deposit Gora Khrustal'naya: Sovetskaya Geologiya, no. 8, p 36-39 (in Russian). Authors at VPO "Uralkvartssamotsvety," USSR.

The quartz deposit Gora Khrustal'naya (E. slope of Middle Urals) occurs in amphibolites and diorites of the Verkhisetskiy granitoid massif. Th of inclusions in this quartz ranges from 490 to 560°C, the amount of G/L inclusions in quartz ranges from 0.003 to 0.052 wt.%, gases in inclusions consist of CO_2 45.7, Cl 0.7, O_2 5.7, H_2 47.7, N_2 0.3 (vol. %). (Abstract by A.K.)

MEL'NIKOV, F.P., KULIKOV, I.V. and GROMOV, A.V., 1979, Polyphase inclusions in fluorite of Tyrnyauz deposit: Paper No. "3965-79 Dep." in the VINITI archives, 12 p., price 2 Rb. 31 kopeck (in Russian). First author at the Moscow State Univ., Moscow, USSR.

Fluorite formed at Tyrnyauz deposit in the latest stage of tungsten mineralization formed after intrusion of El'dzhurtin granite and liparite bodies. At this stage andradite, scheelite, various sulfides, quartz and calcite crystallized with fluorite. Fluorite has octahedral habit with crystal size up to several cm. In upper levels fluorite bears two-phase G/L inclusions, rarer with 1-2 dms (NaCl, KCl), Th 200-300°C. But fluorite from lower levels bears three types of fluid inclusions: 1) similar to those from upper levels, Th 220-350°C in L, PS or S type; 2) moderate concentration of salts (3-6 dms), G phase 30-35 vol. %, Th 500-700°C, dms are NaCl, KCl, unidentified dendritic salt, ore mineral (which dissolves last at ~700°C). Phase composition varies strongly even in inclusions of the same crystal, only halite and sylvite are present continuously. Especially ore grains occur very irregularly and this suggests that it may be a trapped mineral. Hence, the real Th are those that were obtained for inclusions containing L+G+halite+sylvite, i.e. 480-530°C. 3) "Highly concentrated" solutions in inclusions were found in fluorite from the lowest (XII) level of the deposit. Associated quartz and calcite also bear polyphase inclusions. Inclusions in fluorite have 0.5-0.6 mm in size, L occupies 15-20%, G up to 30-40 vol. %, the remainder are solid phases (from 8 to 14 crystals) that include halite, sylvite dissolving at ~400°C, isometric anisotropic grains of unknown mineral dissolving at 500-600°C, various acicular and prismatic crystals with parallel extinction dissolve at 300-400°C, isometric grains of two different ore minerals dissolving at 700-720 and 770-810°C. At T>700°C G volume distinctly increases and at 880-960°C false homogenization(sic) of inclusions in gas occurs. Phase composition in various inclusions of this group changes strongly, suggesting crystallization of fluorite from heterogeneous (L+solids) mineral-forming medium. Heterogenization might occur due to rapid P decrease due to opening of new fractures. The P decrease was eliminated quickly in the higher levels. Similar polyphase S inclusions were found in Lesnyak in 1955 in quartz of the El'dzhurtin granite. That author proved that "dms" like pyrite and hematite that did not dissolve up to 600°C, were in fact trapped minerals. (Abstract by A.K.) Compare also Kulikov 1981a,b,c this volume and Kulikov 1980 in Fluid Inclusion Research-Proceedings of COFFI, v. 13, p. 138 (A.K.).

MIKHAYLOV, M.Yu., 1981, Alteration of habit of gas-liquid inclusions in beryls: Geologiya i Geofizika, no. 9, p. 127-132 (in Russian). Author at Inst. Geol. and Geoph. of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

Beryls for studies of G/L inclusions were found in quartz-topaz-beryl metasomatic veins in apical part of apogranite massif. The studied inclusions were of PS type, 5-120 μm long, inclusion faces are parallel to (0001), $(10\bar{1}0)$, $(11\bar{2}1)$ and $(11\bar{2}0)$, filling consists of G(1):LCO_2(7):LH_2O (12), ratio by vol., Th of $LCO_2 + G \rightarrow LCO_2$ is 26°C, total homogenization in L at 280-320°C. Studies were performed with phase contrast microscopy. The former boundary of inclusions was detected as thin line (rim), and an outline of more euhedral habit than the presently observed habit of inclusion. Ratio of fluid phases to the substance forming the rim varies from 6:1 to 3:1 in the same healed fracture. Hence the rims could not form due to precipitation of beryl from inclusion filling but rather due to redeposition of host mineral substance. Detailed geometrical analysis of change of inclusion habit is presented in this paper, and possible factors causing this process are discussed. (Abstract by A.K.)

MOTORINA, I.V. and YASHCHENKO, N.Ya., 1981, Physicochemical conditions of formation of quartz basaltoids and quartz liparite-dacites of the Bayanaul' region (Central Kazakhstan): Akad. Nauk SSSR Doklady, v. 261, no. 4, p. 961-965 (in Russian). Authors at Inst. Geol. Geophys. of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

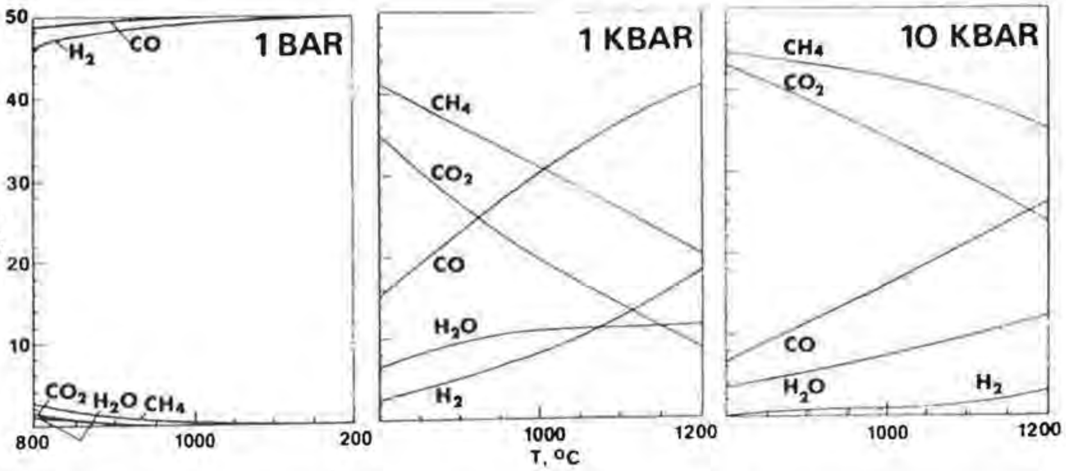
Rare variety of tholeiite basaltoids - quartz-pyroxene andesite-basalt porphyrites found in the Bayanaul' region bear in clinopyroxene and quartz P melt inclusions 1-20 μm long. Inclusion filling in pyroxene consists of G and several crystals which start to melt at 1100°C, Th 1315-1250°C; in quartz melting starts at 750-800°C, Th 980-950°C; hence the T interval between pyroxene and quartz crystallization is 250-300°C. Quartz liparite-dacites bear melt inclusions in quartz, Th 960-910°C. Homogenized and quenched melt inclusions were analyzed by electron microprobe. Chemical composition of inclusions in pyroxenes does not differ from basalt melts and that of inclusions in quartz from basaltoids is the same as of acid melts and as composition of inclusions in quartz from liparite-dacites. Quartz appeared in basalts either due to basalt and acid magmas mixing or due to separation of dacite melt from quartz basalt substrate. (Abstract by A.K.)

NIKOL'SKIY, N.S., 1981b, Parameters of equilibrium of fluid systems: Akad. Nauk SSSR Izvestiya, Ser. Geol., no. 2, p. 21-34 (in Russian). Author at Far-East Geol. Inst. of Far-East Sci.-Center of Acad. Sci.

USSR, Vladivostok.

The paper presents relations in four-component system H-O-C-S, especially composition of gases in equilibrium at T 800-1200°C, under P 1 bar, 1 kbar and 10 kbar, when starting mixture was CH_4 and CO_2 in ratio 1:1 by vol. In the discussion the reference data on G composition in melt inclusions in minerals of Dzhugdzhur anorthosites were used. (A.K.)

Fig. 1. Relation between equilibrium gas composition and T and total P, when initial gas composition was $CH_4:CO_2 = 1:1$.



OBOLKIN, V.D., MEL'NIKOV, E.P. and EVSTROPOV, A.A., 1981, Substantial composition of silexite from the deposit Gora Khrustal'naya (Middle Ural): Izv. AN SSSR, Ser. Geol., no. 6, p. 119-128 (in Russian). Authors at Ural Production Enterprise "Uralkvartssamotsvety," Sverdlovsk, USSR.

For inclusion data quoted here see Mel'nikov, E.P., Obolkin, V.D. and Evstropov, A.A., 1981, this volume. (A.K.)

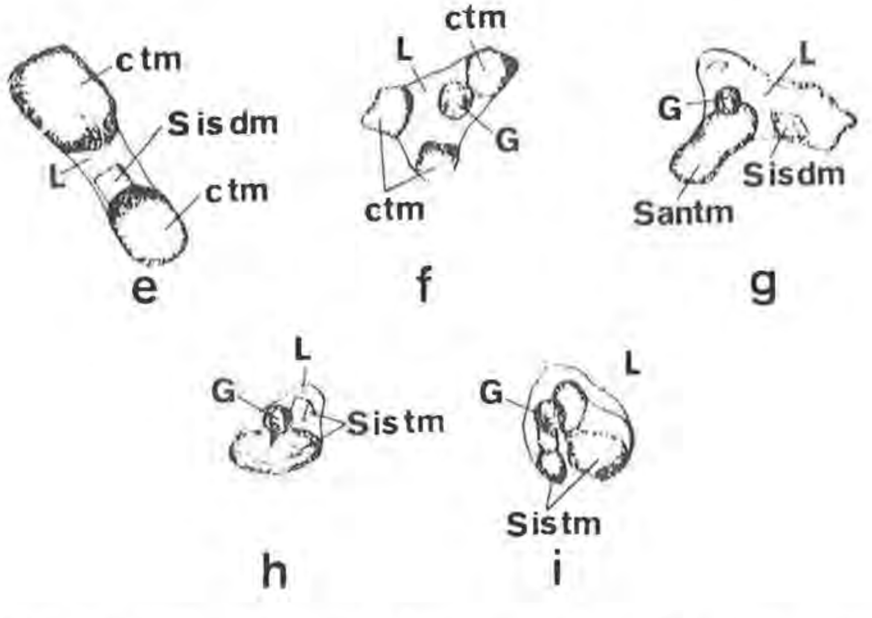
PANINA, L.I., PODGORNYKH, N.M. and BULGAKOVA, Ye.N., 1981, Thermobarogeochemical studies of alkaline plutonic rocks, in Thermobarogeochemical studies, Yu.A. Dolgov and I.T. Bakumenko, eds.: Novosibirsk, Siberian Br. of Acad. Sci. USSR, Inst. Geol. and Geophysics, p. 28-38 (in Russian). First author at Inst. Geol. Geoph. of Sib. Branch of Acad. Sci. USSR, Novosibirsk-90, USSR.

Studies of Th of inclusions in minerals of numerous samples of alkaline ultrabasic (carbonatite) rocks proved that sequence and T of mineral crystallization are always the same: olivine (≥1450°C) → pyroxene (1320-1300°C) → melilite (1230-1200°C) → nepheline (1200-1150°C) → apatite (1200-1170°C) → carbonates (somewhat above 750°C). Ijolite-porphyry from Turiy Cape bears fine crystals of pyroxene (Th 1320-1290°C) and nepheline phenocrysts (Th 1230-1090°C). Other inclusion data presented in this paper are quoted from earlier papers, which author or co-author is L.I. Panina; see previous volumes of Fluid Inclusion Research-Proceedings of COFFI. (Abstract by A.K.)

PARTSEVSKIY, A.I. and BEBIK, A.N., 1981, On the problem of genesis of the fluorite deposit Samodumovskoe (Central Aldan): Izv. AN SSSR, Ser. Geol., no. 7, p. 101-106 (in Russian). Authors at All-Union Sci.-Research Inst. of Mineral Raw Materials, Moscow, USSR.

The paper presents new interpretation of fluid inclusions in fluorite, earlier believed to be relics of magmatic carbonate melt (see Puzanov et al., 1977, Fluid Inclusion Research-Proceedings of COFFI, v. 10, p. 223-224). Quartz and fluorite from the studied deposit bear solid inclusions of hornblende, apatite, quartz, carbonate, hematite, goethite, halite and sylvite, G/L inclusions often with LCO_2. P and PS inclusions (polyphase with solids?-A.K.) have Th 730-870 and 450-520°C, respectively, and Th of $L + G \rightarrow L$ 240-380 and 310-380°C; S inclusions consist of $LH_2O + LCO_2 + G$ or $LH_2O + G$ with Th 130-325°C. Many G/L inclusions formed around solid inclusions. Solid inclusions without L or G often occur in growth zones of fluorite and quartz. Rounded grains of carbonate, earlier supposed to be droplets of melt, are in fact relics of wall rock. Many G/L inclusions trapped foreign crystals and they became "anomalous inclusions" (Ermakov's nomenclature) not suitable for thermometric studies. Hence, new Th data for Samodumovskoe deposit are 380-310 and 280-240°C for two stages of activity of F-bearing solutions, with carbonate wall rocks. These T are more comparable with geological facts observed in that deposit. The deposit belongs to the hydrothermal-metasomatic type, formed at 380-240°C with main stage of fluorite formation at 280-240°C. (Abstract by A.K.)

Figure (a-d are photos too pale for reproduction). Sequence of process of possible formation of polyphase inclusions due to trapping of foreign minerals by vacuoles: a - relics of carbonate, x800; b,c adhesion of esentially G vacuoles (i.e. inclusions) to trapped minerals, b - x1000; e,f - vacuole between nearby relics of carbonate, x800; d,g,h - partial surrounding of trapped mineral by inclusion vacuole, d,h - x630, g - x400; i - complete trapping of foreign mineral by inclusion vacuole, x800. S - solid phase, an - anisotropic, is - isotropic, tm - trapped (foreign) mineral, dm - daughter mineral, c - carbonate, G - gas, L - solution (liquid); authors' drawings made from photographs.



PAVLUN', N.N., 1981, Elements of stages and cycles during mineral formation at the tungsten deposit Akchatau (Central Kazakhstan): Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter III, p. 34-36 (in Russian). Author at L'vov State Univ., L'vov, Ukraine.

The deposit Akchatau formed in the following stages: 1) pneumatolytic-hydrothermal with molybdenite-quartz (>440-340°C, 1200-1000 atm) and complex rare metal (>480-250°C, 1600-500 atm) substages, 2) true hydrothermal with galena-sphalerite-quartz (310-150°C, 550-350 atm) and calcite-fluorite-quartz (180-60°C) substages of mineralization. Temperature and pressure often changed rapidly. First substage was characterized by Cl-Na solutions, the second one by F-Cl-K-Na solutions, total salt concentration varied from 27 to 65 wt.%; CO_2 was the main component of G phase. (Abstract by A.K.)

PERSIKOV, E.S., 1981, Connection of viscosity of magmatic melts with some regularities of acid and basic magmatism: Akad. Nauk SSSR Doklady, v. 260, no. 2, p. 426-429 (in Russian). Author at Inst. Exper. Mineralogy of Acad. Sci. USSR, Chernogolovka, Moscow Region, USSR.

Pertinent to physical properties of melts in inclusions. (A.K.)

PETROSYAN, R.V., 1981, Dynamics of formation of vein uranium ores: Sovetskaya Geologiya, no. 12, p. 60-68 (in Russian). Author at Geol. Ministry of USSR, Moscow.

Veins filled by stilbite, calcite, laumontite, β-uranotile, quartz, fluorapatite, and metaautunite occur in quartz-montmorillonite metasomatites. Th of fluid inclusions in calcite are 80-140°C, G phase of inclusions in calcite and stilbite bears low amount of CO_2 (1.6-1.24 g per 1); H_2, CH_4, O_2 and N_2 were not found. (A.K.)

PETROSYAN, R.V. and BUNTIKOVA, A.F., 1981, Zeolitization in uranium ore mineralization: Sovetskaya Geologiya, no. 3, p. 91-100 (in Russian). Authors at Mingeo, Moscow, USSR.

Calcite from ore veins filled by stilbite, calcite, laumontite, quartz, fluorapatite, beta-uranotile, meta-autumite and montmorillonite, bears G/L inclusions with Th 130-140°C. See also Petrosyan 1981, this volume. (A.K.)

PETROVA, M.G. and ROYZENMAN, F.M., 1981, Typomorphism of quartz from rare-metal pegmatites: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no 6, p. 39-44 (in Russian). Authors at Moscow Geol.-Prospecting Inst., USSR.

In pegmatites three generations of quartz were distinguished with Td: 1) 520-560°C, 2) 320-380°C and 3) 180-200°C. (A.K.)

POPOV, V.D., 1981, Peculiarities of geological structure and temperature conditions of formation of ore bodies of the fluorite deposit Egita (Western Transbaikalia): Geologiya i Geofizika, no. 4, p. 132-134 (in Russian). Author at Geol. Inst. of Buryatian Div. of Siberian Br. of Acad. Sci. of USSR, Ulan Ude, USSR.

Metasomatic fluorite deposit Egita occurs in leucocratic and biotite granites. Inclusions in fluorite homogenized in L phase in T interval 250-145°C and in late coarse columnar fluorite - 135-100°C (P inclusions). S inclusions in early fluorite homogenized at 225-115°C and in the late fluorite - at 125-95°C. (A.K.)

PUZANOV, L.S., 1981b, On origin of halite in magnetite ores of the deposit Korshunovskoe: Akad. Nauk SSSR Doklady, v. 261, no. 2, p. 483-485 (in Russian). Author at All-Union Sci.-Res. Inst. of Mineral Raw Materials, Moscow, USSR.

Halite occurring in the deep levels of the magnetite deposit Korshunovskoe is believed to come from salt-bearing Cambrian beds. Magnetite ore is supposed to be of metasomatic skarn origin. Ores are connected with eruption [breccia?] pipes. Fluid inclusions in diopside, calcite and mica, however, yield Th 650-950°C proving the magmatic origin of magnetite ore. This makes doubtful the exclusively hydrothermal origin of halite in the ores. Halite and muscovite bear following P inclusions: I - inclusions of melt-fluid stage of ore formation: a) gas from network of solid phase, b) solid-gaseous; II - inclusions of melt-intrusive stage of ore formation, a) magnetite and tremolite in halite, b) polyphase with magnetite, c) polyphase with isotropic solid phase. Ores bear also S pneumatolytic, hydrothermal and one-phase cold-water inclusions. At least part of the halite should be magmatic origin, and part might be transported to ore zones by hydrotherms from halide deposits of Cambrian age. (Abstract by A.K.)

REYF, F.G. and BAZHEEV, Ye.D., 1981, Tungsten-transporting solutions and prognostication of ore mineralization from thermobarogeochemical data: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter IV, p. 64-65 (in Russian). Authors at Geol. Inst. of Buryatian Div. of Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

Twenty granite massifs were studied by thermobarogeochemical methods to reveal the connection of wolframite deposits of Transbaikalia with intrusions. The deposits occur only in those parts of massifs, where intensive distillation of volatiles from magma developed for long time and since early stages of crystallization. Water concentration in ore-bearing intrusions is higher than in ordinary ones (2.5-3%) and reaches 4-5%. Proper thermobarogeochemical mapping is useful for ore prospecting, as it was tested in the Dzhida ore region. (From the authors' abstract, translated and shortened by A.K.)

RYZHENKO, B.N., 1981, Thermodynamics of equilibria in hydrothermal solutions: "Nauka" Pub. House, Moscow (in Russian).

Contents

(A.K.)

SHCHERBAKOV, Yu.G., ROSLYAKOVA, N.V., AGEENKO, N.F. PORTYANNIKOV, D.I., RADOSTEVA, N.Ye. and BORTNKIOVA, S.B., 1981, About the genetic relations of polymetal and gold ore mineralization in the Salair ore field: Geologiya i Geofizika, no. 5, p. 68-73 (in Russian). First author at Inst. of Geol. and Geoph. of Siberian Br. of Acad. Sci. USSR,. Novosibirsk, USSR.

Barite-polymetal ores of the Salair ore field formed at following Th: silicification, sericitization, pyritization - 550-400 or 300-200°C*, commerical barite-polymetal ores 400-250 or 200-270°C*, post-ore quartz-carbonate ≤150°C; gold ores at Th: early (white) quartz 500-260°C, commercial quartz-carbonate-sulfide-gold ore 270-145°C; quartz-carbonate veins in diabase dikes 427-160°C (in quartz) and 120-65°C in calcite. (Abstract by A.K.)

*Data taken from two different reference papers, other Th measured by the authors (A.K.).

SHEVEL'KOVA, L.V., RUMYANTSEV, A.N., VEDENEEVA, L.M., SOKOLOVA, V.M. and NAMETKIN, N.S., 1981, Evaluation of constants of velocity of reactions of hydrogen atom replacement in higher n-paraffin hydrocarbons: Akad. Nauk SSSR Doklady, v. 260, no. 2, p. 393-397 (in Russian). Authors at Inst. of Petroleum Chem. Synthesis of Acad. Sci. of USSR, Moscow.

Pertinent to pyrolytic decomposition of hydrocarbons released from fluid inclusions by decrepitation for following analysis of inclusion gases. (A.K.)

SHURUPOV, Yu.V. and KALININ, D.V., 1981, Hydrothermal crystallization of olivine: Geologiya i Geofizika, no. 8, p. 67-74 (in Russian). Authors at Inst. Geol. Geophysics of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

Olivine of various Fe content was experimentally crystallized in chloride hydrothermal solution at T of growth zone 420-504°C with autoclave filling F 0.35-0.7, on olivine nuclei. (A.K.)

SIDOROV, A.A., NOVOZHILOV, Yu.I. and GAVRILOV, A.M., 1981, On the connection of deposits of gold-bearing disseminated sulfide ores with volcanic gold-silver ore mineralization: Akad. Nauk SSSR Doklady, v. 261, no. 6, p. 1398-1401 (in Russian). Authors at Central Sci.-Research Geol.-Prosp. Inst. of Color and Precious Metals, Moscow, USSR.

In the Pacific Cenozoic and Mesozoic volcanic belts the peripheral zones bear 1) Au-Ag formation deposits, 2) deposits of gold-bearing sulfide disseminated ores, mostly of As-bearing pyrite and arsenopyrite, but often with antimonite, cassiterite, wolframite and molybdenite. Inclusions in quartz from zones of disseminated ores yielded Th 320-100°C and P 800-170 atm for ore-formation process. Very similar PT conditions were found for the root parts of the deposits of volcanic Au-Ag formation. (Abstract by A.K.)

SIMONOV, V.A., 1981a Conditions of mineral-formation in non-granitic pegmatites: Transactions of Inst. Geol. and Geophysics of Siberian Branch of Acad. Sci. of USSR, no. 478, ed. Yu.A. Dolgov, "Nauka" Pub. House, Siberian Div., Novosibirsk, 169 pp. (in Russian).

The monograph is devoted to the current problems of pegmatite formation. The genetic problems are solved by fluid inclusion studies, using the following methods: P determinations, atomic absorption analysis, laser microanalysis, cryometric, homogenization and decrepitation runs and gas analyses of individual inclusions. The question of leakage of inclusions at elevated temperature (1000-1400°C) is discussed. The author showed that dunite, pyroxenite and gabbro pegmatites of a number of gabbro-hyperbasite massifs (ophiolite complexes) of Siberia, Ural and Far East formed by various modes: without noticeable activity of volatiles, under action of high-temperature melts. Hornblendite, syenite and miaskite pegmatites of the Il'menskiy alkaline complex formed from the remnant pegmatite-forming melts altering next during T decrease to solutions-melts and melts. (Editor's note translated and extended by A.K.)

SIMONOV, V.A., 1981b Studies of inclusions in minerals of non-granitic pegmatites, in Thermobarogeochemical studies, Yu.A. Dolgov and I.T. Bakumenko, eds.: Novosibirsk, Siberian Br. of Acad. Sci. USSR, Inst. Geol. and Geophysics, p. 53-55 (in Russian). Author at Inst. Geol. Geophy. of Sib. Branch of Acad. Sci. USSR, Novosibirsk-90, USSR.

Minerals of pegmatites from ophiolites (Srednetersinskiy massif in Kuznetskiy Alatau, Kurtushuba in W. Sayan, Khopsek in Tuva, Kuyul' massif in Anadyr-Koryak folded area) sometimes bear either G/L or melt inclusions. Certain pyroxenite pegmatites formed in fractures between massive serpentinites under action of high-temperature hydrothermal solutions (Th 440-450°C); at lower T (Th 370-380°C) pegmatite clinopyroxene was replaced by hornblende. Gabbro-pegmatites of the Kuyul' massif formed from practically dry melts at T up to 1310-1380°C (Th in plagioclases, ortho- and clinopyroxenes). Pegmatites of alkaline complexes were studied using as an example the Il'menskiy alkaline massif. In hornblendite pegmatite the giant crystals of hornblende formed under action of melt-solutions, Th 470-480°C, P 1.5-1.9 kbar; mica formed at ~360°C, quartz at 320°C. Minerals of syenite pegmatites formed with presence of remnant melts-solutions. Pyroxenes yielded Th 590-620°C, P 1.5-1.6 kbar, quartz - 490-510°C, 600 bar, post-pyroxene hornblende - ~350°C, zircon and sphene - 740-780°C, apatite - ~340-380°C, monazite and corundum (blue and gray) - ~530°C, 1440-1880 bars; CO_2 was the main gas component. Miaskite pegmatites yielded Th 750°C, P ~3.1 kbar (gray nepheline and feldspar, melt inclusions), 700-740°C - change of melts to melt-solutions, 740-590 (color and finally light transparent nepheline), 500-510°C (cancrinite, from H_2O+CO_2 solutions), 370-440°C (sodalite, from $H_2O+NaCl$ solutions). Corundum-bearing miaskite pegmatites yield somewhat other Th: nepheline bears melt inclusions with Th 900-920°C, P ~2.5 kbar, rich in CO_2 (15% H_2O + 85% CO_2 in fluid composition). Silicate-salt melts poor in CO_2 appear at 840-850°C, P 2.3 kbar, accessory zircon forms at 720-750°C, corundum at 540-580°C, P 1.1-1.3 kbar. (Abstract by A.K.)

SOBOLEV, N.V., EFIMOVA, E.S. and POSPELOVA, L.N., 1981, Native iron in diamonds from Yakutia and its genesis: Geologiya i Geofizika, no. 12, p.

25-29 (in Russian). Authors at Inst. Geol. and Geoph. of Siberian Br. of Acad. Sci. USSR, Novosibirsk, USSR.

Globular inclusions of native iron found in Yakutian diamonds in association with inclusions of iron sulfide (mostly pyrrhotite) and garnets, formed in equilibrium with minerals of ultrabasic (dunite-harzburgite) paragenesis. Sometimes surface of iron globule is covered with magnetite. (A.K.)

SOKOLOV, B.A. and MEL'NIKOV, F.P., 1981, Hydrocarbon sphere of the Earth: Akad. Nauk SSSR Doklady, v. 261, no. 2, p. 471-474 (in Russian). Authors at the Moscow State Univ., Moscow, USSR.

The authors discuss distribution of hydrocarbons in various Earth environments, shortly characterizing also hydrocarbon fluid inclusions. (A.K.)

SONYUSHKIN, V.Ye., 1981, Electron microscopy of inclusions of mineral-forming medium in quartz: Izvestiya AN SSSR, Ser. Geol., no. 1, p. 85-95 (in Russian). Author at Inst. of Lithosphere of Acad. Sci. USSR, Moscow.

The studied samples consist of quartz phenocrysts from porphyries of Samshvil'do and Kafana, Transcaucasia, quartz from Volyn pegmatites and quartz of rock-crystal bearing hydrothermal-metamorphic deposits of Subpolar Urals and Aldan. Preparations were made by chipping of quartz along cleavage $\{01\bar{1}1\}$, $\{10\bar{1}1\}$ and $\{10\bar{1}0\}$ or accidental. Investigations were made by transmission and scanning electron microscopes. The paper describes morphology of inclusions, both negative crystals and those with irregular habit. The author distinguishes four types of vacuoles: euhedral, subhedral (=half-faceted), globular and irregular and notes that the smaller inclusions, the more euhedral habit. Around naturally decrepitated melt inclusions, a halo was found of small droplets of melt expelled from inclusions into the fracture. Various minerals trapped in inclusions (tourmaline, topaz, graphite) were identified by electron microprobe and microdiffraction. Also composition of precipitates from liquid inclusions was determined by electron microprobe. (Abstract by A.K.)

STEPANOV, G.N., 1981, Genetic types of physico-chemical conditions of formation of skarn scheelite-sulfide deposits of Far East of the USSR: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter III, p. 40-41 (in Russian). Author at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. USSR, Vladivostok, USSR.

Skarn scheelite-gold-pyrite deposits formed under reducing conditions. Skarn parageneses crystallized at 780-600°C (from iron content in pyroxene, garnet and epidote), greisens at 500-450°C from acid solutions (pH 3.5-5.0) as proved by paragenesis:biotite+muscovite+chlorite. Quartz-scheelite ores formed at 450-360°C (Th?) in near-neutral solution; sulfides at 340-180°C (Th?).

Skarn scheelite-cassiterite-polymetal deposits formed under oxidizing conditions at T 770-450°C; magnetite-fluorite ores formed at 400-320°C (Th?), galena-sphalerite at 310-210°C (Th?). (Abstract by A.K.)

TALANTSEV, A.S., 1981a Geothermobarometry on the basis of parageneses of dolomite-ankerite and calcite with isomorphic admixture of rhodochrosite component: Akad. Nauk SSSR Doklady, v. 260, no. 3, p. 734-738 (in

Russian).

May be useful for control of fluid inclusion determinations in carbonate minerals. (A.K.)

TALANTSEV, A.S., 1981b Geothermobarometry on the basis of dolomite-calcite parageneses: "Nauka" Pub. House, Moscow, 136 p.

The book describes various methods of determination of P and T, applicable to or derived from Ca-Mg carbonate parageneses. The method of homogenization of fluid inclusions is discussed extensively by the author on the basis of literature data, with special attention paid to the necessity of use of pressure corrections which, however, are not obtainable due to unknown value of P. Decrepitation method is treated more briefly and the conclusion is that "general precision of the decrepitation method gradually approaches, especially for carbonates, to the precision of homogenization method" (sic, A.K.). The author distinguishes "method of boiling solutions," which gives Th practically equal to T of crystallization and P of solution, "carbon dioxide method" of pressure determination from coeval LCO_2 and LH_2O inclusions and "solid phase method" of determination of P-T conditions, essentially as proposed by Lemmlein and Klevtsov. Next the author describes methods based on element partition in minerals: T determination from saturation of calcite by Mg component, method of paragenetic analysis of calcite with periclase, dolomite with quartz, calcite with talc etc., bimineral dolomite-calcite geothermobarometer, combined carbonate geothermobarometer (fluid inclusion Th data combined calcite-dolomite method) with extensive discussion of errors mostly from inclusion data evaluated by author as usually insufficently precise. The book concludes with a chapter presenting some results of application of geothermobarometers for reconstruction of evolution of PT conditions during near-vein berezite-listvenite metasomatism, as well a berezite formation in the deposit Vatikha, comparison of the geochemical thermobarometry data with data obtained from P fluid inclusions, changes of P and T within stages of hydrothermal mineral-formation and structural-metallogenic concepts derived from the data of geothermobarometry. (Abstract by A.K.)

TUGANOVA, Ye.V. and EGOROV, V.N., 1981, On the origin of nickel-bearing differentiated intrusions of the Noril'sk type: Geologiya i Geofizika, no. 4, p. 29-34 (in Russian). Authors at VSEGEI, Leningrad, USSR.

The paper bears some Th data of melt inclusions from literature sources, 1120-1350°C in Noril'sk intrusions. (A.K.)

VISHNEVSKIY, S.A., FEL'DMAN, V.I. and SHUGUROVA, N.A., 1981, Gases in inclusions from impact glasses of the astrobleme El'gygytgyn: Akad. Nauk SSSR Doklady, v. 261, no. 5, p. 1220-1223 (in Russian). First author at Moscow State Univ., Moscow, USSR.

Astrobleme El'gygytgyn with dia. ~18 km occurs in the central part of Chukotka; its age is 3.5 ± 0.5 mil. years. Very fresh impact glasses are common in the crater rocks. Glasses are colorless or pale brown or green, n ranges from 1.502 to 1.518. Gases were studied by 1) decrepitation and gas chromatography (CO_2, CO, CH_4, H_2O, H_2, O_2, N_2) and by 2) determination of gas composition and pressure in individual inclusions by crushing stage and microvolumetric method. Differences in results of gas analyses are probably connected with various methods used. By G chromatography (in vol.%) the ranges of content are as follows: CO_2 0.40-

5.43, CO traces 6.43, CH_4 nil-0.51, H_2 nil-7.62, H_2O 81.45-98.14, O_2 not found, N_2 nil-0.3, total gas release (in mg per 1 kg of rock) 13.7-1170; by analysis of individual inclusions: pressure in inclusions at 20°C 0.004-0.5 atm, components (in vol.%) CO_2 10-99.4, total hydrocarbons nil-55, O_2 not found, CO nil-26, H_2 nil to 32, N_2+rare gases 0.2-69, water was not determined. The possible sources of G are as follows: 1) fluids of the molten parent rocks, 2) products of various reactions in impact melt, 3) gases brought by the space object; and 4) air admixture (absent in the studied inclusions). G composition is distinctly reducing. Probably gases formed mostly from the fluids of parent rocks during impact. Their composition reminds distinctly of gases from the other impact structures (Riess and Popigay) and differs from volcanic atmospheres. (Abstract by A.K.)

VOEVODINA, S.A., GRANOVSKIY, A.G. and PROKOPOV, N.S., 1981, Thermobaric parameters of ore formation of wolframite mineralization in [Soviet] Far East: Abstracts of the Fourth Conf. on Mineralogy, Geochemistry, Genesis and Complex Use of Tungsten Deposits in the USSR, Leningrad, 24-25.XI.1981, Chapter IV, p. 53-54 (in Russian). First author at Far-East Inst. of Mineral Raw Materials, Khabarovsk.

By complex methods of thermobarogeochemistry (vacuum decrepitation, homogenization, gas-liquid chromatography) wolframites and co-occurring quartzes were studied; samples were taken at the deposits of Far East: Iul'tin, Svetkoe, Zabytoe, Uchamin, Nyarka, El'veney, Tigrinoe, Skalistoe. Wolframite ores bear G/L inclusions 2-14 µm long, G occupies 5-30% of inclusion vacuole, dms are rare. Th for all deposits are in the range 200-320°C. Maximum CO_2+H_2O content (up to 65 vol.%) was found in quartz and wolframite at deep levels of the deposits Iul'tin and Svetloe, minimum (up to 20%) in samples of the deposit Skalistoe. Highest salt content was found also in this deposit. Pressure of solutions in inclusions equals 120-56 MPa. (Authors' abstract, shortened and translated by A.K.)

VOLZHIN, D.D. and KOROLEV, K.G., 1981, Peculiarities of epigenetic uranium ore mineralization in jasper-quartzites: Sovetskaya Geologiya, no. 1, p. 42-49 (in Russian). Authors at Mingeo, Moscow, USSR.

The ores occur in Precambrian-Silurian quartzitic rocks, Th of inclusions in minerals associating with nasturan [i.e., pitchblende] are 100-200°C. (A.K.)

ZASEDATELEV, A.M., 1981, Metamorphic formation of lithium-bearing pegmatites: Sovetskaya Geologiya, no. 1, p. 91-97 (in Russian). Author at Inst. of Lithosphere of Acad. Sci. USSR, Moscow.

The paper presents tentative balance of rare alkalies from the sediment that formed Li pegmatites during metamorphic processes. Various pegmatites yield Th of inclusions in pegmatitic minerals of Li formation in the ranges 700-200°C, but most frequently 600-400°C under P of ten thousand hectopascals, total salt concentration in parent fluids up to ~24% by weight, with main components H_2O, CO_2, chlorides and sulfates of Na, Ca, Mg, K and Li; Li content in fluids is 0.15-1.92 wt.%. (Abstract by A.K.)

ZOLOTAREV, B.P., VOYTOV, G.I. and STAROBINETS, I.S., 1981, Gases in young basaltoids from California Gulf (data from the 65th cruise of "Glomar Challenger"): Akad. Nauk SSSR Doklady, v. 260, no. 6, p. 1466-1469 (in

Russian). Authors at Geol. Inst. of Acad. Sci. of USSR, Moscow.

Samll samples of the rocks (2 g) were ground in argon atmosphere in steel mills; analyses were made by gas chromatography. He content (in cm^3 per kg of rock) ranges from nil to 3.9, H_2 from 1.3 to 4.6, N_2 from 27.5 to 60.4, CH_4 from 0.07 to 0.09, other hydrocarbons from 0.008 to 0.016; hydrocarbon composition and concentrations (total hydrocarbons = 100%, all in %) are as follows: CH_4 82.6-92.0, C_2H_6 4.9-9.1, C_2H_4 0.4-1.6, C_2H_8 1.7-10.6, C_3H_6 nil-0.09, iso-C_4H_{10} nil-0.69, n-C_4H_{10} nil-1.48. Relation between CH_4 content in rock and FeO/Fe_2O_3 ratio is analyzed. Gases in the studied basaltoids are essentially similar to other ocean basalt samples. (Abstract by A.K.)

ZOLOTAREV, B.P., VOYTOV, G.I. and ZHOGINA, L.M., 1981, Gases of basaltoids of the Mid-Atlantic Ridge (materials of the cruise No. 49 of "Glomar Challenger"): Akad. Nauk SSSR Doklady, v. 261, no. 1, p. 194-197 (in Russian). Authors at Geol. Inst. of Acad. Sci. USSR, Moscow, USSR.

Gas composition in ground samples of 84 basalts was determined by gas chromatography. Ranges of gas content are as follows (in cm^3 per 1 kg of rock): H_2 0.57-1.16, N_2 53.4-126.3, CO_2 nil-1.36, CH_4 0.018-0.082, C_2H_6 0.001-0.014, C_2H_4 nil-0.0004, C_3H_8 0.0002-0.0021, C_3H_6 nil-0.007, iso-C_4H_{10}* nil-0.003, n-C_4H_{10}* nil-0.006. Gases of the Mid-Atlantic and Reykjanes Ridges do not differ from gases of other ocean basalts, i.e. probably mantle gases change little laterally. Age of basalts distinctly influences the hydrocarbon composition, because the older the basalts, the higher the content of methane homologs. Total content of various gases in basalts of various age changes slightly. Most representative gases are hydrogen and methane, CO_2 was not found in cases of the studied ocean basalt. (Abstract by A.K.)

*Here both gases are called "C_4H_{10}," but in previous paper of the same authors on gases in basalts from California Gulf, the first was iso-C_4H_{10} and the second n-C_4H_{10}. (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. 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.

KADIK, A.A., SHILOBREYLEVA, S.N., AKHMANOVA, M.V., SLUTSKIY, A.B. and KOROBKOV, V.I., 1981, Solubility of CO_2 in melts of acid composition on the example of the system albite-silica (65:35): Geokhimiya, no. 1, p. 63-70 (in Russian, English abst.). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

(...) Paper gives the results of experimental studies of solubility of CO_2 in melt of composition in wt.% albite 65 - silica 35, as the simplest model of acid magmas. Studies were made at T 1250°C and P 2 and 3 kbar, and at T 1350°C and P 16, 17, 26 and 35 kbar to evaluate influence of P on saturation of melts by CO_2 and the structural state of CO_2 in the melt.

METHODS

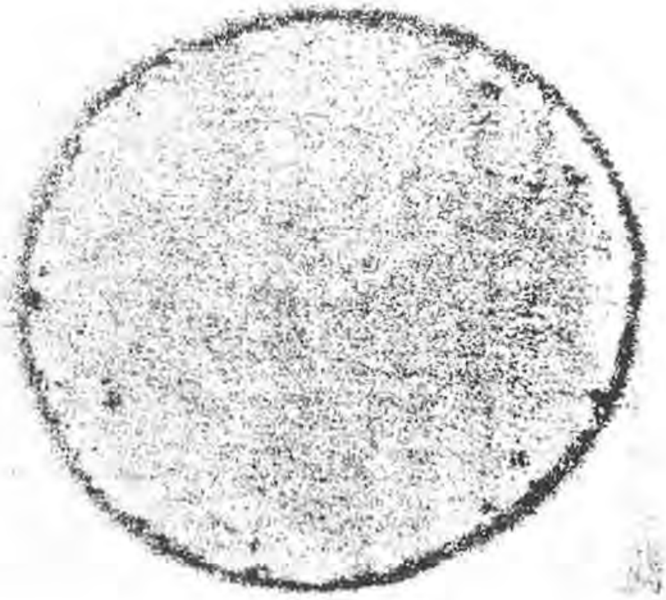
Experiments under P 2 and 3 kbars were made in apparatus with internal heating made by Ye.B. Lebedev (9). P was measured with accuracy ±50 bar, T measurement error $\leq \pm 10°C$. Experiments under P 16, 17, 26 and 35 kbar were made in the apparatus made by A.B. Slutskiy; accuracy of P measurements was ±5%, T - ±10%.

Experiments were made in platinum ampules. Starting material was prepared by mechanical mixing of Al_2O_3, SiO_2, Na_2CO_3 with a mixture of 0.97 wt.% of $Ba^{14}CO_3$ in Na_2CO_3. CO_2 content in glass was determined by autoradiography (10). In the apparatus used for high pressure determinations hydrogen formed in heating penetrates through walls of Pt ampule bearing the sample. (...) This fact causes reactions in the filling that may be summarized in equation (11):

$$3CO_2 + 7H_2 \rightarrow 5H_2O + CO + C + CH_4.$$

Those reactions preclude study of silicate melts in the presence of pure CO_2. Thus the important thing is to cause so low H_2 activities, that CO_2 may remain the essential volatile component of G mixture in Pt ampule.

Thermodynamic calculations and experiments (12, 13) showed that when O_2 activity was close to the buffer hematite-magnetite, during H_2 penetration through the Pt ampule walls the G phase forms which consists of 98 mole % of CO_2, 1 mole % of CO and 1 mole % of H_2O and trace amounts of CH_4, hence the conditions are approximate for experiments with distinct domination of CO_2 in G mixture. (...) Suitable "screens" from Pyrex glass were also added to the ampule (Fig. 2). Without the "screen" the uniform distribution of C compounds was observed in the central part of specimen and sharp enrichment in the contact with ampule (Fig. 1). Absence of a transitional diffusion zone may suggest a catalytic influence of Pt.



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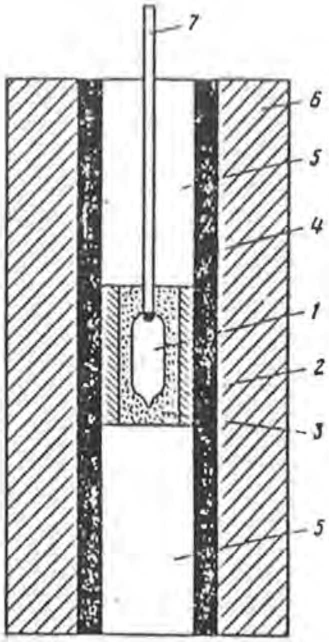

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Fig. 1. Autoradiogram of specimen of composition albite-silica after experiment under P 16 kbar, T 1350°C, time of exposition 25 hours, x30.

Fig. 2. Scheme of high-P chamber: 1 - Pt ampule, 2 - Pyrex glass, 3 - powdered Pyrex glass, 4 - graphite heating unit, 5 - pyrophyllite calcined at 860°C, 6 - pyrophyllite, 7 - central thermocouple.

Products of experiments after quenching were a glass droplet and a G phase. Graphite was found in glass, in gas vacuoles. This graphite may have formed during quenching, because graphite was found in short run experiments where H_2 diffusion should be minimum. (...)

RESULTS OF EXPERIMENTS

Results of determination of CO_2 content in melt of albite+silica are shown in the Fig. 3. Because the T influence on solubility is small under low P (14), results obtained at 1250 and 1350°C are presented in one figure. Small solubility of silicate in CO_2 vapor (~0.2 wt.%) (11) was also omitted. Thus, the obtained data show that CO_2 solubility in melt albite+silica increases linearly from 0.50 mole % at 2 kbar to 10.3 mole % at 35 kbar. Equation of the straight line obtained by the least squares method is as follows:

$$Y = (0.28 + 0.03)P^*$$

where P - pressure, kbars, Y - CO_2 content in glass, mole %.

Experimental studies of CO_2 solubility in melts of albite (14, 15), orthoclase and diopside (16), nepheline and jadeite (14) also show that CO_2 solubility increases with P increase. Nevertheless, it is significantly lower than H_2O solubility in those melts.

(...) Determinations of CO_2 solubility made by the authors in melts of basalt, andesite, dacite, granite and albite+silica under P 3 kbar and T 1250°C showed that CO_2 solubility changes from 0.76 to 2.5 mole % with change of basic index from 0.08 to 0.43, at the minimum on the solubility curve (Fig. 4). A similar minimum was found also for H_2O solubility in melts (20), and it is explained by two mechanisms for dissolution of water

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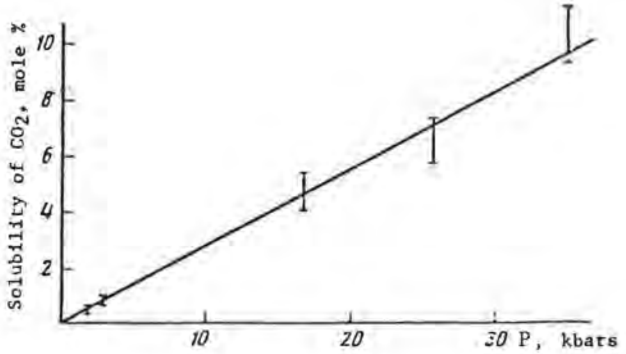
*Probably (0.28±0.03)P, A.K.



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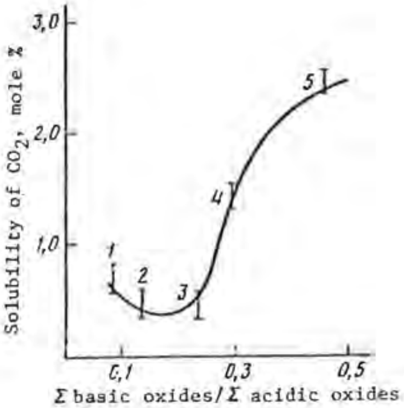

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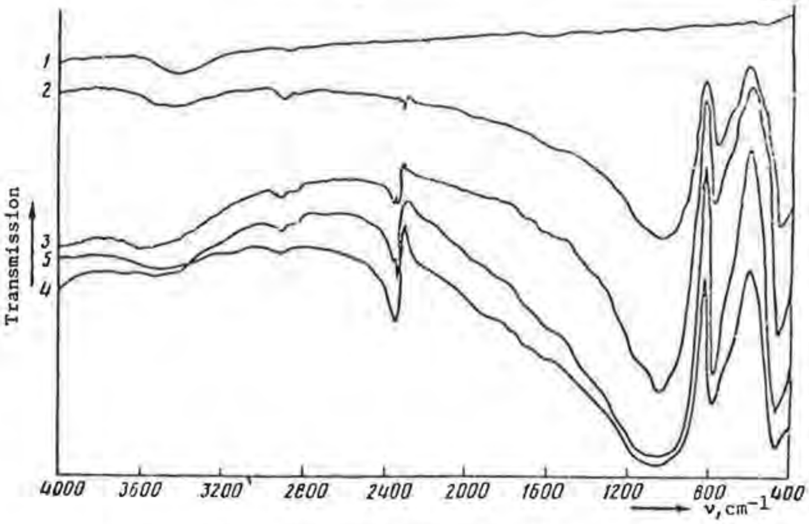

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Fig. 3. Relationship between CO_2 solubility and pressure at 1250 and 1350°C for melt albite+silica.

Fig. 4. Plot of CO_2 solubility versus basic properties of melt at 1250°C, 3 kbar. Melt composition: 1 - albite+silica, 2 - granite, 3 - dacite, 4 - andesite, 5 - basalt.

Fig. 5. IR absorption spectra of KBr pellet (1) and glasses albite+silica bearing CO_2 under pressures: 2 - 2 kbar, 3 - 17 kbar, 4 - 26 kbar, 5 - 35 kbar.

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in melts. Probably, the minimum on the CO_2 solubility curve is also caused by different mechanisms of CO_2 dissolution in silicate melts.

STRUCTURAL STATE OF CO_2 IN MELT

Dissolving of CO_2 in melt may occur due to several mechanisms: 1) individual CO_2 molecules in the melt; 2) replacement of Si by C in SiO_4 tetrahedra; 3) formation of carbonate anions during interaction between CO_2 and O_2 from melt (without cation action); and 4) during interaction of CO_2 with cations and anions (i.e., O_2) with formation of carbonate anions (16).

IR spectroscopy was used to determine the form of CO_2 in albite+silica melts. Literature IR data on CO_2 state in glass are controversial. (...)

CO_2 in gas state gives absorption band 2350 cm^{-1}. This band is caused by asymmetric valency vibration of molecule O-C-O. Carbonate group CO_3^{2-} absorbs in the range 1420-1450 cm^{-1} (valence asymmetric vibration $^{O}_{O}{>}$C-O). HCO_3^- absorbs in the range 1300-2500 cm^{-1} (valence asymmetric vibration $^{O}_{O}{>}$C-O-H) giving a wide band, and in the range 3000-3500 cm^{-1} (valence vibrations -O-H). Replacement of Si by C in tetrahedrons should cause additional absorption in the range 1000-1200 cm^{-1} (asymmetric valence vibrations of CO_4 groups). In this case one should obtain experimentally the short-wave shift of band edge in the range of absorption of valence Si-O bonds.

IR spectra of the studied glasses were obtained on the IR-75 spectrometer made by C. Zeiss-Jena, DDR (...), using samples of 1-2 mg of glass in 200 mg pressed pellets of KBr.

All obtained spectra have absorption bands with a maximum at 2350 cm^{-1}, from asymmetric valence vibration of CO_2 molecule (Fig. 5). This band may be connected with CO_2 as individual molecules in the glass matrix, in G bubbles in glass, and in the atmosphere due to incomplete compensation in spectrophotometer. The last possibility was excluded by thorough control with blank KBr pellets. Moreover, the 2350 cm^{-1} band does not display the fine structure which might be connected with rotation of molecules of G CO_2. Also G from bubbles should be evolved from glass during grinding of glass to 1-3 µm particle size, whereas bubble size is ≥10 µm. Hence, the observed band should be attributed to CO_2 dissolved in glass. Sometimes the observed splitting of the 2350 cm^{-1} band probably is due to different position of CO_2 in melt matrix rather than to rotation in G phase as was suggested by (21).

Shape of the SiO_4 vibration band does not change (Fig. 5), hence replacement of Si by C in tetrahedra is of low probability. Absorption bands of CO_3^{2-} and HCO_3^- groups are absent in infrared spectra of glasses albite+silica.

A small band in the range 3000-3600 cm^{-1} may be connected with minor water formed during the experiment. In those papers where HCO_3^- and CO_3^{2-} were found in albite glass, as a rule the H_2O absorption band was more intense than in albite+silica glass. Probably presence of carbonate or hydrocarbonate ions is connected with occurrence of H_2O or OH in melt structure. Thus the conclusion may be made that dissolving of CO_2 in acid melts occurs mainly in the molecular state. Formation of carbonate anions in those melts probably is connected with presence of significant amount of water in the melt. Recognition of structural state of CO_2 in melts of different compositions needs additional studies.

SEPARATION OF CO_2 FROM MELTS OF ACID COMPOSITION

The experiments performed on the solubility of CO_2 in the model melt of acid magmas also showed the limited solubility of CO_2, when compared with water; the experiments were made in over a wide range of P values and confirmed the studies of other investigators. The data obtained suggest that acid magmatic melts formed at great depth of the continental Earth's crust and upper mantle may transport much less CO_2 than water. Moreover, sharp differences in water and CO_2 solubilities should control degassing of acid magmas, and hence that under a wide range of P, CO_2 should be the prevailing component of magmatic fluid. Hence, formation of G/L inclusions in minerals of acid volcanic rocks with high CO_2 concentration in them may occur due to degassing of acid magmas under high P.

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MOSKOVSKIY, G.A. and SIROTIN, K.M., 1981, Use of the results of study of inclusions in mineral salts for ascertaining the conditions of deposition and subdividing sections (El'ton and Baskunchak areas and northwestern part of the border zone of the Caspian depression), in The Structure and Formation Conditions of Salt-Bearing Horizons, A.L. Yanshin and M.A. Zharkov, eds.: Izd. Nauka, Sibirsk. Otdel. Novosibirsk, USSR, p. 44-52 (in Russian).

Since 1975 the Laboratory of Thermobarogeochemistry of the Scientific Research Institute of Geology of Saratov University has been conducting an investigation of inclusions in minerals of the Kungurian salt rocks from a number of regions in the Caspian depression. This work is intended to establish the physicochemical conditions of deposition in a saline basin, make recommendations for prospecting for potassium salts and the possibility of using the particulars of the morphology and phase and chemical content of inclusions for purposes of subdividing and correlating various salt rocks. The urgency of such investigations, first begun in the areas of the pre-Carpathian and Dniepr-Donets basins by O.I. Petrichenko, has repeatedly been pointed out in the resolutions of several conferences of salt specialists.

[P. 45] The conclusions drawn here were obtained from the data of study of inclusions in salt minerals (mainly halite) from the cores of holes drilled on the El'ton and Baskunchak salt dome structures, in the border zone nearby (in the Saratov oblast), and in several other areas of the depression. We studied the chemical composition of a natural brine on the basis of fluid inclusions in halite (about 2000 analyses for K^+, Mg^{2+}, SO_4^{2+}, Ca^{2+}), determined the temperature of crystallization of the minerals by the homogenization method, and qualitative composition of the gas and pressure in essentially gaseous inclusions in sylvite and halite. The procedural methods of laboratory investigations which we used were developed earlier in the IGGI of the Ukrainian Academy of Sciences (L'vov) by O.I. Petrichenko and his colleagues [Petrichenko, 1973; Kovalevich, 1978].

Composition of fluid inclusions in zoned halite. The study made of the composition of primary fluid inclusions in halite from salt beds containing no accumulations of potassium minerals showed that the minimum concentration of brine in the saline basin (with the sum of K^+, Mg^{2+} and SO_4^{2-} less than 40-50 g/l) is observed only in isolated intervals of the section of the El'ton deposit of potassium salts (borehole 69, North sector, interval 488-780 m) and of the Baskunchak salt-dome structure (borehole 600, South sector, interval 331-640 m). The content of the main components of the brine was: K^+, 8.4-8.8 g/l; Mg^{2+}, 24.3-31; SO_4^{2-}, 6.4-9.3 (see table). Analysis of these data brings out the considerable direct alteration of the brine of the basin (SO_4^{2-}/Mg^{2+} equal to 0.38 and 0.30, respectively (see table), in these intervals, compared to 1.35 in the initial stage of precipitation of halite in concentrated modern ocean water) [Valyashko, 1962]. Analysis of the figurative points [i.e., plotted points?] obtained for the composition of the inclusions on a solar diagram (fig. 1) shows that the ratio of the main components of the brine here corresponded to that for points III and IV of the line of alteration of the brine by calcium carbonate (Ok-V), but with a relatively high amount of magnesium. The latter is identified from the location of the figurative points above the Ok-V line of the solar diagram and from the value of the $(Mg^{2+}+SO_4^{2-})/K^+$ ratio, which for the brine is equal to 4.56 and 3.93, respectively, and for point III of the diagram (calculated), 3.065.

The composition of the brine given above is not typical of the lowermost parts of the salt section, which have not been penetrated as yet by boreholes in the salt dome area. It can be considered probably to be similar to the initial stage of massive precipitation of halite in the areas studied (i.e., background), as in all the investigated regions we found no salts which crystallized from a brine of lower concentration.

Study of the inclusions in halite from salts in the northwestern part of the border zone of the depression showed that the potassium and magnesium contents here considerably exceed the background values. For the Volgograd rhythmic member* the amount of K^+, Mg^{2+} and SO_4^{2-} was 20.63, 30.33 and 6.08 g/l, respectively; for the Lugovaya member it was 11.08, 47.0 and 9.1 g/l; for the Balykley member, 18.6, 54.9 and 9.1 g/l. Analysis of the composition of inclusions in rock salt from the central part of the depression (hole 25, Kara-Tyube, intervals 1937-1944 and 2114-2120 m) showed a relatively low concentration of the brine. The sum of K^+, Mg^{2+}, and SO_4^{2-} here is 54.75 and 48.6 g/l (see table). Analyzing the location of the figurative points of these solutions on the solar diagram, it can be seen that they fall in the field of carnallite and sylvite, near line IV of crystallization of altered brine. The SO_4^{2-}/Mg^{2+} ratio here is 0.144 and 0.168, respectively, [p. 47] while at point IV it is 0.209. Relicts of the brine in halite from the rock salts of several stratigraphic intervals of El'ton (hole 158, "Chevron" salt), Baskunchak (hole 600, 1037-1202 m), and the border zone (Lugovaya member, holes 2 and 24, Yershovskaya) have approximately the same proportion of components.

Maximum concentration of brine in the Kungurian saline basin was reached only in isolated areas of the depression. Besides the El'ton potassium salt deposit, we studied inclusions with a highly concentrated brine, corresponding to the stages of precipitation of sylvite and carnallite, on the Baskunchak salt dome structure (hole 600, South sector; hole 556, North sector) and in some holes in the border zone (hole 16, Orlovskaya; hole 4, Yershovskaya, and others). A high concentration of the brine in inclusions in halite is recorded by the appearance of trapped minerals. When they were taken into account, the content of the main components in the brine came to: K^+, 35-50 g/l; Mg^{2+}, 70-90 g/l; SO_4^{2-}, 2-10 g/l (rarely up to 20 g/l). Thus the initial stages of halite pre-

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* The subdivision of the section of salt rocks from the zone near the edge of the depression, given here, is derived from Yu.A. Pisarenko et al. (1977).

cipitation in the saline basin began when the contents of potassium, magnesium and sulfate ions in the brine totalled about 40-50 g/l and the degree of alteration of the brine was minimal. The upper limit of barrenness (i.e., no potassium minerals) of halite precipitation is characterized by a total magnesium+sulfate ion content not more than 80-85 g/l and a higher degree of alteration of the brine (SO_4^{2-}/Mg^{2+} ratio not more than 0.2). When the potassium and magnesium salts were precipitated the sum of K^+, Mg^{2+} and SO_4^{2-} was 105-125 g/l, and here the SO_4^{2-}/Mg^{2+} ratio usually is not more than 0.1 [p. 48]. However, in isolated intervals of the sections, disruption of that regularity was noted and the brine was concentrated, apparently while retaining its degree of alteration. For instance, in the 3997-4000 m interval in hole 1, Sagiz, in the southeastern part of the depression, the SO_4^{2-}/Mg^{2+} ratio is 0.317, with the total of K^+, Mg^{2+} and SO_4^{2-} equal to 108 g/l.

From these data it can be concluded that the brine of the Kungurian saline basin in the Caspian area and adjacent regions at the time of precipitation of the main mass of the halite was magnesium-sulfate and contained a relatively larger amount of magnesium than would be expected in altered concentrated sea water. The extent of its direct alteration varied substantially in time, and apparently, areally.

Examining the location of the figurative points of all the relict brines we studied (see fig. 1), three not very distinct haloes can be seen. The first extends along the lines of alteration of sea water due to clay material (Ok-VI) and calcium carbonate (Ok-V), being situated nearly halfway between them. The location of the figurative points in the halo is clearly determined by the degree of alteration of the brine from which the given rocks crystallized. This is confirmed by comparison of the values of the SO_4^{2-}/Mg^{2+} ratios and the location of the points in the halo. The second halo joins the points of the composition of the brine from sulfate-free rock salt, sylvite- and carnallite-halite rocks of the producing horizon. The third halo includes the points of a brine composition with a much larger amount of magnesium. The anomalous location of the points of brine composition typical of the Volgograd member in the border zone and of the "Chevron" salt in hole 51 of El'ton has so far not found an explanation.

Concluding the consideration of the general regularities of the variation of the composition of the brine in the region, it should be noted that comparison of the well logs and results of study of the inclusions for hole 3, Limansk, in the border zone of the depression provides preliminary criteria for the presence of accumulations of polyhalite in the section. In this case a relative excess of sulfate ion (15-20 g/l or more) with more than 18-20 g/l of potassium is observed in the inclusions in the halite.

Composition of primary fluid inclusions in halites of the salts of the El'ton salt dome structure. In a composite section of the El'ton potassium salt deposit, S.A. Svidzinskiy et al. (1977) distinguished five horizons on the basis of lithologic criteria; from the bottom up, these are: the lower halite, producing, anthraconite (anhydrite-halopelite), potassic, and upper halite.

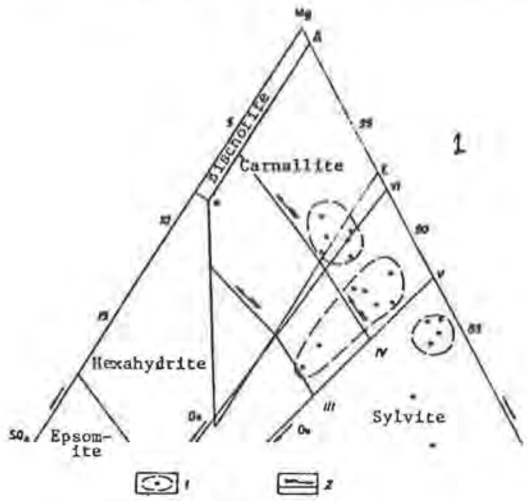
In the rocks of the lower halite horizon, which we studied only in the section of hole 51 in the North sector, relicts of sedimentary halite with solid-fluid inclusions are encountered. The contents of potassium, magnesium and sulfate ion (28, 71 and 3 g/l), the SO_4^{2-}/Mg^{2+} ratio (see table) and the location of the figurative points for that composition on

Ionic composition of solutions in inclusions in sedimentary halite

Region, member (horizon)	Interval tested, in m	Content, g/l			$K^++Mg^{2+}+SO_4^{2-}$	SO_4^{2-}/Mg^{2+}	$(SO_4^{2-}+Mg)/K^+$	Indices for entry on solar diagram		
		K^+	Mg^{2+}	SO_4^{2-}				$2K^+$	Mg^{2+}	SO_4^{2-}
Center of depression										
Hole 25 Kara-Tyube	1937—1944 2114—2120	0,35 10,02	38,80 33,71	0,54 4,87	54,75 48,60	0,108 0,144	4,85 3,85	6,7 8,2	89,5 88,0	3,8 3,2
Southeast part of depression										
Hole 1 Sagiz	3997—4000	22,57	64,90	20,58	108,0	0,317	3,78	0,1	84,2	0,7
Marginal zone (Saratov obl.)										
Balykley member*		18,0	54,0	9,10	82,6	0,166	3,44	0,2	87,1	3,7
Lugovaya member		11,8	47,0	9,10	68,9	0,194	4,75	0,9	88,8	4,3
Volgograd member		20,62	30,33	6,08	55,98	0,200	1,77	10,8	70,2	4,0
Western part of depression										
El'ton										
Lower halite horizon (hole 5D	1005—1109	28,0	71,0	3,0	102,0	0,042	2,04	10,1	88,0	1,0
Producing horizon (average)		43,0	81,0	4,0	128,0	0,049	1,98	14,0	85,0	1,0
Producing horizon (hole 58)	359—302	40,02	75,34	5,82	121,18	0,077	2,03	14,0	84,4	1,6
Potassic horizon, "Chevron" salt, (hole 51)	300—590	18,93	32,90	5,08	57,51	0,173	2,04	14,7	81,8	3,5
"Chevron" salt (hole 158)	1000—1031	12,43	60,65	8,80	81,88	0,145	5,59	5,8	90,9	3,3
Upper halite horizon, "Chevron" salt (hole 69)**	488—780	8,53	24,28	9,26	42,07	0,380	3,93	0,0	83,0	8,0
Baskunchak										
Northern sector (hole 600), horizon 1	1037—1202,8	13,55	49,95	5,65	69,15	0,113	4,11	7,5	89,8	2,7
Horizon 2	987,5—1037	20,53	56,24	8,05	84,82	0,143	3,13	9,8	87,0	3,2
" 3	660,0—0075	38,00	75,00	2,50	115,5	0,066	2,04	13,2	85,5	1,3
" 4	644,0—660	21,0	53,0	7,30	81,3	0,138	2,87	10,6	86,4	3,0
" 5	394,0—644	8,8	30,9	9,22	48,92	0,208	4,56	7,6	85,9	6,5
" 6	330,3—394	12,5	46,0	5,93	64,43	0,192	4,14	7,6	89,5	2,9
" 7	206,9—330,3	31,0	75,0	8,00	14,0	0,083	3,50	11,1	86,6	2,3

*Balykley member -- hole 33 Dolinnaya (1556-1559 m); Lugovaya member -- hole 24 Yershovskaya (755-759 m), hole 2 Yershovskaya (1160-1178 m); Volgograd member -- hole 1 Mavrinskaya (1528-1545 M), hole 1 S. Yershovskaya (1420-1422 m).

**For hole 60 the modal content is given for this interval, rather than the average.



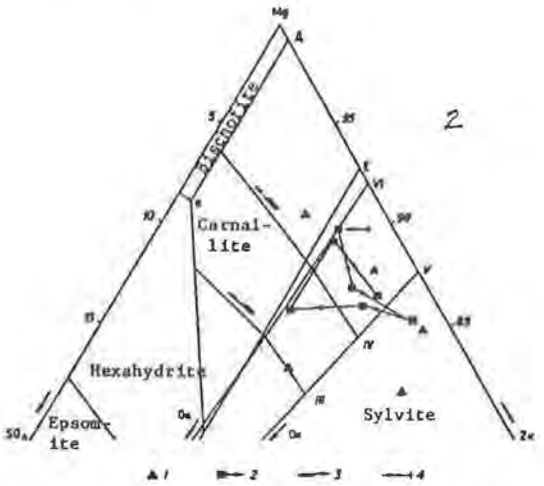


Fig. 1. Location of figurative points of the composition of the solutions in inclusions in sedimentary halite of some areas of the Caspian depression on a solar diagram (for t = 25°C).
1 - figurative points of the composition of the inclusions and their haloes; 2 - path of crystallization of ocean water, metamorphosed to a substantial extent. I-VI - lithostratigraphic horizons.

Fig. 2. Location of figurative points of the composition of solutions in inclusions in sedimentary halite of the El'ton potassium salt deposit and of the Baskunchak salt dome structure on a solar diagram (for t = 25°C).
1 - figurative points of the composition of solutions in inclusions in the El'ton saline rocks; 2 - figurative points of the composition of solutions in inclusions in halite of the salt rocks of the North sector at Baskunchak and trend of their evolution in time; 3 - path of crystallization of ocean water; 4 - samples from the lower parts of the horizon. III-VI -(fig. 1.

the solar diagram (fig. 2) indicate a high degree of concentration and direct alteration of the brine. The formation of the rocks of this horizon apparently corresponded to the final stages in the cycle of halogenesis.

The composition of the inclusions in the halite of the sulfate-free rock salts and mixed rocks (sylvite- and carnallite-halite) of the producing horizon (taking into account the minerals trapped in the vacuoles) indicates a high degree of concentration of the brine, corresponding to the stage of precipitation of sylvite and carnallite, and substantial direct alteration of the brine. In the halite from the sylvite-halite rock in hole 58 (359-362 m interval) the contents of K^+, Mg^{2+} and SO_4^{2-} are 40.2, 75.35 and 5.82 g/l, respectively, for a SO_4^{2-}/Mg^{2+} ratio of 0.08 (see table). In the producing horizon, so far we have established [p. 49] the chlorine-potassium composition of the brine from primary inclusions in just one case (El'ton deposit, hole 168, 517-520 m interval). The potassium content is 32.64-37.56 g/l, with an almost total absence of sulfate ion.

The anhydrite-halopelite horizon comprises a complex of rocks of anhydrite-dolomite, anhydrite, and halopelite composition. It records a sharp drop in concentration of the brine in the saline basin. The bands of rock salt in the rocks of this horizon sometimes contain relicts of primary sedimentary halite. However, the extremely small size of the inclusions in them (less than 0.01 mm) precluded determination of their composition. It is natural to assume that the concentration of the components in the brine we examined was close to the background composition. Rhythms of very small size, 2 and 3 times less than for normal "feathery" halite from other horizons, also are typical of the zoned halite of these rocks. This apparently characterizes its considerably slower growth rate.

Deposition of the rock salt of the potassic horizon indicates the beginning of a new stage of concentration of the brine. Its minimum concentrations are in inclusions in relicts of primary halite in the rhythmically banded rock salt. Here the contents of potassium, magnesium and sulfate ions are, respectively, 7-12, 25-30 and 7-10 g/l (on the basis of a single determination), i.e. they correspond to the background. In the overlying "Chevron" salt layer a relatively high potassium content is observed in some places (hole 51, North sector), and of magnesium in others (holes 158, 167, Ulagansk sector). This manifests either the existence in the basin of reserves [p. 50] of highly concentrated brine, or the beginning of the concentration which later led to precipitation of carnallite rocks (bed 7) [Svidzinskiy et al., 1977].

In the North sector at El'ton, the "Chevron" rock salt was penetrated in hole 69 (488-780 m interval), this apparently is the upper part of the El'ton section. As we have already pointed out, this rock was precipitated from the least concentrated brine, but bands with "anomalously" high contents of potassium (35.5 g/l) and magnesium (61.5 g/l) are encountered in the inclusions here.

The particulars of the lithologic composition of the section of the El'ton structure -- the presence in it of members of rhythmically banded rock salt of considerable thickness, the high degree of their deformation, and the almost total absence of relicts of primary inclusions in these rocks -- precluded a sequential reconstruction of all the details of the evolution of the brine of the saline basin. However, the generalized compositions of the brine which we give for certain parts of the El'ton composite section are valuable as markers and offer the possibility of their use as supplementary material in subdividing and correlating the sections. Analysis of the variations in the composition of the inclusions through the section also considerably facilitates the task of distinguishing the cycles of halogenesis. In addition to the quite obvious limit of the cycles represented by the halo-pelite horizon, the "Chevron" salts described above from the upper halite horizon can serve as the beginning of the next cycle, as a sharp decrease in concentration of the brine (to the background level) is observed here after the deposition of the canallite rocks of the upper part of the potassic horizon.

Composition of primary fluid inclusions in the halites of the salts of the South sector of the Baskunchak structure. On the Baskunchak salt dome structure, we studied in detail the section in hole 600 of the South sector. Here two horizons with layers of potassium salts are distinguished, occurring in normal stratigraphic sequence. Salts with almost universally preserved relicts of zoned halite and with far fewer (than on the El'ton) rhythmically repeated seasonal layers of anhydite and typical of the section in this hole. All this, plus the particulars of the composition of the fluid inclusions (higher amount of sulfate ion in the inclusions in halite from all parts of the section) and the absence in the section of analogs of the anthraconite horizon makes it possible to consider that salt accumulation in the Baskunchak area was more steady and that here precipitation of rock salts continued, while in the El'ton area there was a partial cessation (deposition of the anthraconite horizon). The degree of detail of the investigations made it possible to distinguish seven horizons on the basis of the variation in composition of the brine, the boundaries of these horizons not always coinciding with a change in lithology.

The first horizon (1202.8-1037.0 m) consists of banded rock salt. The inclusions in halite from these rocks have a fairly persistent composition. Here the contents of potassium, magnesium and sulfate ions are 13.55, 49.95 and 8.08 g/l on the average (see table), with pronounced alteration of the brine and relatively high magnesium concentration. According to our data, the latter is generally typical of the stage of salt accumulation preceding the precipitation of potassium salts. The figurative point of that brine composition falls on the line of alteration of ocean water by clay material (OI-VI).

The second horizon (1037-967.5 m) also comprises banded rock salt with packets and intercalations of anhydrite. The amount of potassium gradually increases from the bottom, with 16.01-16.55 g/l, to 20.3-22.95 g/l in the upper part of the interval. The total content of potassium, magnesium and sulfate ions also increases to 86-98 g/l, i.e. to the upper limit of "barren" precipitation of halite which we have mentioned, which indicates the possibility of sparse syngenetic dissemination of sylvite or carnallite here. Thus, concentration of the brine [p. 51] begins to appear in the section about 70 m before the precipitation of the first potassic layer. Perpendicularly, this is about 30-35 m.

The third horizon (967.5-660 m) consists of banded rock salt with intercalations of sylvinite and sylvite- and carnallite-halite rocks. At 967.5 m, trapped minerals (sylvite and carnallite) appear in the inclusions in halite, and the content of potassium, magnesium and sulfate ions increases on the average to 38.78 and 2.86 g/l, respectively. The figurative point of the composition of these inclusions falls in the sylvite field near the OK-V line between points IV and V. This characterizes a high degree of direct alteration of the brine. Such brine composition is characteristic of the whole "producing" interval of the section.

The fourth horizon (660-644 m) was distinguished on the basis of incipient diffusion of the brine, which is recorded by inconstancy of the composition of the inclusions in the "Chevron" rock salt. Here intercalations of salts deposited from a brine of low concentration (total ions 56 g/l) and from brines of average concentration are observed.

We have considered the composition of inclusions in the "Chevron" salt in the 644-394 m interval (fifth horizon) in the general description of the composition of the inclusions in the Kungurian salts of the depression. Not only is the minimum concentration of the brine characteristic of this interval of the section, but also the frequently observed phenomenon of depositional solution of the marginal parts of the "chevrons" of halite. Evidently, in the Baskunchak section this horizon plays the same role as the anthraconite horizon in the El'ton. The second cycle of halogenesis, penetrated in the South sector of the Baskunchak structure, begins with it. The variation in composition of the inclusions in the overlying part of the section repeats the regularities considered above.

The composition of the inclusions in the sixth (394-339.3 m) and seventh (339.3-206.9 m) horizons reflects the evolution of the brine, which becomes more concentrated, while the amount of potassium increases relatively. A phase of abrupt increase in concentration of the brine before precipitation of the potassic rocks of the seventh horizon is observed at a depth of 373-339.3 m. Insufficient data precluded distinguishing this interval as a separate horizon.

Thus, by means of a study of inclusions (illustrated by the South sector of the Baskunchak structure), the particulars of the evolution of the composition of the brine of a saline basin in which the concentration of the brine twice led to precipitation of potassium salts has been examined. All the variations in composition of the brine are illustrated in a solar diagram, in which two incomplete cycles of its evolution are seen. It can be noted that the thickest horizons are those deposited when the concentration of the components in solution was minimal (first and fifth), and the thinnest, the horizons reflecting progressive concentration of the brine before precipitation of potassium salts (second and fourth).

Summing up all that has been discussed, the following can be said:

When least concentrated, the brine had a very uniform salt composition in all the areas of the depression that were studied, and in the proportions of salts it was very similar to concentrated sea water. The concentration of the brine to the stage of precipitation of potassium salts began long before the first potassic layer was deposited, which is recorded by an abrupt relative and absolute increase in the amount of potassium in the inclusions. If sea water and fresh water broke into the basin, a highly concentrated brine could have persisted for a fairly long time.

The deviations in composition of the inclusions for rocks formed in similar stages of halogenesis in the different areas of the depression are less than for rocks of the same sector at different stratigraphic levels. This regularity makes it possible to correlate sections of fairly distant sectors of the saline basin on the basis of horizons of salts deposited from the least concentrated brine. Thus, it would be possible to correlate the El'ton anhydrite-halopelite horizon with the fifth horizon [p. 52] we distinguished in the South sector fo the Baskunchak structure. However, the insufficiency of geologic data on the latter makes this correlation tentative.

Translation of references (realphabetized):

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(...)Geometric probabilities are one of the oldest objects of studies in theory of probability. Simple methods of evaluation of density of the point objects along a line, on a surface and in space are well founded and known. Review of such methods may be found in the book of M. Kendall and P. Moran (1972). All the methods are developed on the basis of distribution of points on the surface as assumed to be dependent on the Poisson law. The following conditions are the evidence that accidentally distributed points form a two-dimensional Poisson field (Venttsel, 1964).

1. Probability of occurrence of a certain number of points on any section of the surface depends only on the size of the surface, but not on the position on the surface. In other words, points are distributed on the surface with the same average density.

2. Points are distributed independently one from another, i.e., the probability of occurrence of a given number of points on the given section does not depend on how many points occur on other sections that do not overlap the first one.

3. The probability of occurrence of two or more points on a minute section is so small that it may be omitted, if compared with the probability of occurrence of one point. This condition corresponds to the practical impossibility of coincidence of two or more points.

Numerous mineralogical and petrographic preparations meet those conditions, if the distribution is not zonal, sectional or similar. However, in that case we may use this method for individual separate stripes, zones or sectors.

Let us suppose that points are distributed on the surface randomly. Their number in every sector of the surface S has the Poisson distribution with mean λS. Thus λ may be assumed as the "density" of points, i.e., their number per surface unit.

Call 0 any point of the surface and r_1, r_2 ... - distances from it to the first, second, etc. random point. Thus, according to the theory (Kendall, Moran, 1972), distribution r_1 is the following: $2\lambda\pi r_1^2 \exp\{-\lambda\pi r^2\} dr_1$. The $2\lambda\pi r_1^2$ is distributed as χ^2 (chi) with two degrees of freedom. Similarly the distribution for r_k - distance to "k" closest point, $2\lambda\pi r_k^2$ is distributed as χ^2 with 2k degrees of freedom. Those theoretical results are the essential ones for the methods presented below.

Method of the closest neighbor. Initial point 0 is chosen randomly ("accidentally")and the distance is measured from it to the first closest or to the "k" closest point. It is simplest to measure the distance to the first closest point, i.e., to the "closest neighbor" (fig. 1).

Mean value of r_1^2 is equal $(\lambda\pi)^{-1}$. If we use several measurements, it is best to take the mean value for evaluation of λ^{-1}. Let us call y_1, ... y_n-n values for r_1^2, and $Y = n^{-1}(y_1 + \ldots + y_n)$. Thus mathematically [it is expected that] Y equals $(\lambda\pi^{-1})$, and πY is the evaluation for λ^{-1} and its dispersion is equal $(n\lambda^2)^{-1}$. However, we need reverse values, thus, the evaluation of point density is (1): $\lambda = \frac{1}{\pi Y}$, and for large n it has dispersion $D(\lambda) = \lambda^2/n$.

The random value $(2\lambda n\pi Y)$ is distributed as χ^2 with 2n degrees of freedom and from this the confidence limits for λ may be found. Let us call $2\lambda n\pi Y = V$. The distribution of the value V is shown on figure 2. We need to choose the interval i_β so that V falls within it with the given probability β. If the distribution of value V is symmetric, like a normal or Student's distribution, the interval i_β should be chosen symmetrically with respect to mathematic expectation. But the distribution of χ^2 is asymmetric. Let us choose the interval i_β so that the probabilities of falling of V out of this interval to the left or to the right side were the same and equal $\alpha/2 = 1-\beta/2$.

We use tables of the χ^2 distribution (Bol'shev, Smirnov, 1965; Korn, Korn, 1968, etc.) to choose the needed interval i_β*. The values χ^2 are such that $P(V/\chi^2) = p$ for value V, having χ^2 distribution with "m" degrees of freedom, here m = 2n. Next we find in the tables two values χ^2, one corresponding to the probability $p_1 = 1-\alpha/2$, and the second - to the probability $p_2 = \alpha/2$. Let us call them respectively χ_1^2 and χ_2^2. Interval i_β has χ_1^2 as the left limit and χ_2^2 as the right limit, i.e., $P(\chi_1^2 < V < \chi_2^2) = \beta$. Hence the needed confidence interval I_β for point density λ with limits λ_1 and λ_2 which covers λ with probability β, $p(\lambda_1 < \lambda < \lambda_2) = \beta$ will be equal

$$I_\beta = \left(\frac{\chi_1^2}{2n\pi Y} ; \frac{\chi_2^2}{2n\pi Y} \right) . \qquad (2)$$

Limiting values $\lambda_1 = \chi_1^2(2n\pi Y)^{-1}$ and $\lambda_2 = \chi_2^2(2n\pi Y)^{-1}$ may suggest the optimum number of measurements n of distances to the closest neighbor. Figure 3 may help in the evaluation of the measurement number, where the behavior of λ_2 (right limit of the confidence interval) for $\beta = 0.9$ is shown for the fixed value of Y (all y_k were accepted as equal 1). When $n<4$, a very rapid increase of λ_2 value is observed; when $n>4$ the decrease of λ_2 is not so essential; $n>10$ does not cause a special increase of accuracy of evaluation of λ.

Of course, the determination of n should be solved on the basis of the needed accuracy of the results. (...)

The method of cross (of four closest neighbors). Another method may be used (Kendall, Moran, 1972) where the measurement number is always

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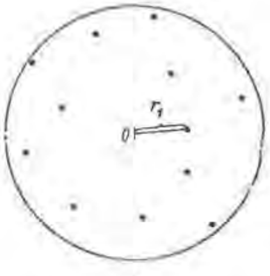
*The "t_β" given here in the Russian text is most probably a misprint, A.K.



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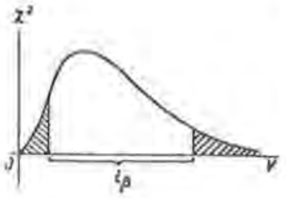
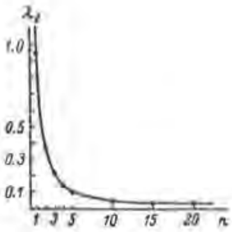


2



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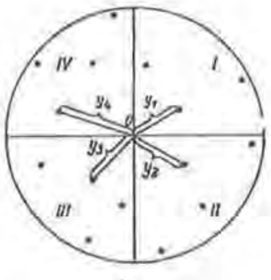

4

Fig. 1. Distance from the randomly chosen point 0 to the closest inclusion in the method of the "closest neighbor."
Fig. 2. Probability interval i_β for value V, distributed as χ^2.
Fig. 3. Change of values of the right limit λ_2 of the confidence interval for probability $\beta = 0.9$ and fixed value of Y.
Fig. 4. Measurements of the distances from the accidentally chosen point 0 to the four closest inclusions.

equal four. Initial point 0 is also chosen randomly, and through this point two perpendicular lines are made, in the same direction in each case. Distances y_1, y_2, y_3 and y_4 to the closest points, one in each section, are measured (fig. 4). Here the evaluation of density of the points is equal $\lambda = \frac{16}{\pi(y_1^2+y_2^2+y_3^2+y_4^2)}$, and dispersion of this evaluation is determined from the equation $D(\lambda) = \frac{\lambda^2}{4}$. Accidental values $1/2\lambda\pi y_j^2$ (j=1,2,3,4), are independent and distributed, like χ^2, with two degrees of freedom. Thus one may suppose that their total, included in the equation evaluating density of the points, is distributed similarly to χ^2 with 8 degrees of freedom. Hence the confidence interval I_β for point density λ with limits λ_1 and λ_2 embedding λ with the probability β will be similar to equation (2), only Y will be value of $1/16\Sigma y_j^2$ (j=1,2,3,4). (...)

Example 1. Six measurements of distances from the accidental points to the closest inclusions (the closest neighbor method) were made in vein quartz from the rock-crystal-bearing vein in a deposit of the Aldan (table 1, in mm). Average Σ of square distances is $Y = \frac{1}{n}\sum_{k=1}^{n} y_k = 0.0003$. Hence inclusion density per 1 mm² $\lambda = 1/\pi Y = 1061$. Accepting the probability $\beta = 0.9$ we get $\alpha = 0.1$, $\alpha/2 = 0.05$. From the χ^2 tables we get for m = 2, n = 12 degrees of freedom for $p = 1-\alpha/2 = 0.95$, $\chi_1^2 = 5.226$; for $p_2 = \alpha/2 = 0.05$, $\chi_2^2 = 21.026$. From equation (2) we find the confidence interval for point density:

$$\lambda_1 = \frac{\chi_1^2}{2n\pi Y} = \frac{5.226}{2\cdot6\cdot3.14\cdot0.003} = 460;\ \lambda_2 = \frac{\chi_2^2}{2n\pi Y} = \frac{21.026}{2\cdot6\cdot3.14\cdot0.0003} = 1862;$$

$$I_\beta = (460,\ 1862),$$

i.e., with a 90% probability the inclusion density was evaluated for interval between 460 and 1862 inclusions per 1 mm².*

Here it is necessary to explain that value of the point density is related to this surface which is measured in square units, used for measurements of distances between points (cm² if in cm, mm² if in mm).

Additional four measurements (0.021, 0.012, 0.016, 0.023 mm) yielded

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*Note: Apparently all these inclusion densities are only in terms of two dimensions. (E.R.)

Table 1. Distances from accidentally chosen 0 points to the closest inclusions in vein quartz

Measurement number, k	Distance, r_1	Square distance, y_k
1	0.01	0.0001
2	0.005	0.000025
3	0.02	0.0004
4	0.015	0.000225
5	0.012	0.000144
6	0.03	0.0009

Table 2. Distance from random point to the closest inclusion in each of the four sectors of the view field

Sector, j	Distance, y_j	Square distance, y_k
1	0.02	0.0004
2	0.03	0.0009
3	0.04	0.0016
4	0.02	0.0004

Table 3. Values of $\chi^2(2n\pi)^{-1}$ for calculation of the confidence limits for various β and n.

Number of measurements, n	$\chi_1^2(2n\pi)^{-1}$		$\chi_2^2(2n\pi)^{-1}$	
	β		β	
	0.9	0.8	0.9	0.8
1	0.016	0.034	0.953	0.733
2	0.057	0.085	0.755	0.619
3	0.087	0.117	0.668	0.565
4	0.109	0.139	0.617	0.530
5	0.125	0.155	0.583	0.509
6	0.138	0.167	0.558	0.492
7	0.149	0.177	0.539	0.479
8	0.158	0.185	0.523	0.468
9	0.166	0.192	0.511	0.459
10	0.173	0.198	0.500	0.452
11	0.179	0.203	0.491	0.446
12	0.184	0.208	0.483	0.440
13	0.188	0.212	0.476	0.435
14	0.192	0.215	0.470	0.431
15	0.196	0.219	0.464	0.427

from total 10 measurements the same both $Y = 0.0003$ and $\lambda = 1061$ inclusions per mm^2, but λ_1 and λ_2 will be 576 and 1666, respectively. The interval between λ_1 and λ_2 depends mostly on uniform distribution of inclusions in mineral and less on the number of measurements.

Example 2. The evaluaton of density of inclusions was made for the same quartz, but using the cross method (Table 2):

$$Y = \frac{1}{16}\sum_{j=1}^{4} y_j^2 = 0.0002, \quad \lambda = \frac{1}{\pi Y} = 1590.$$

Accepting $\beta = 0.8$, $\alpha = 0.2$, $\alpha/2 = 0.1$, we shall find for m = 8 the χ^2 distribution for $p_1 = 1-\alpha/2 = 0.90$, $\chi_1^2 = 3.490$, for $p_2 = \alpha/2 = 0.10$, $\chi_2^2 = 13.362$. From equation (2) we find the confidence interval for

$$\lambda_1 = \frac{\lambda_1^2}{8\pi Y} = \frac{3.490}{8\cdot 3.14\cdot 0.0002} = 695; \quad \lambda_2 = \frac{\lambda_2^2}{8\pi Y} = \frac{13.362}{8\cdot 3.14\cdot 0.0002} = 2650;$$

$$I_\beta = (695,\ 2650).$$

Thus, number of inclusions in quartz is 1590 per mm^2, with a 90% probability of occurring within interval between 695 and 2650 inclusions per mm^2. (...) Authors recommend the preparation of standard values in equations like in Table 3.

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(...)

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ZIL'BERSHTEYN A.Kh., KRASHENINNIKOVA G.Ye. and LEVITSKIY, Yu.F., 1981, Optical polarization method of determination of pressure of mineral-forming solutions in inclusions: Zapiski Vses. Mineral. Obshch., v. 110. no. 6, p. 740-746 (in Russian). Authors at All-Union Sci.-Research Geol. Inst. (VSEGEI), Leningrad, USSR.

(...) The paper describes a method of P determination in unopened inclusions. This method is founded on the studies of piezooptic effect in a crystal induced by the inclusion. Earlier methods using this effect (Rosenfeld, Chase, 1961, Rusinov, 1965) need complicated devices.

The proposed method is presented on the example of halite crystals from the Artyomovskoe salt deposit occurring at the depth ~350 m. Evaluation of lithostatic P calculated from density of overlying rocks and measured by Yu.F. Levitskiy by the load method (Kuznetsov, 1947) gave values ~90 and 150-160 bars, respectively. Halite crystals bear two-phase G/L inclusions of cubic habit. Observations under crossed nicols showed that a birefringent zone occurs around many of the inclusions. Presence of such zone in optically isotropic halite crystals may be caused by mechanical tension, whose source is the inclusion filling. The following experiment was made to check this supposition. A crystal with inclusions surrounded by birefringent zones was heated up to T at which one of vacuoles decrepitated. Observation of polarization effects showed no birefringent zone in the neighborhood of the opened inclusion, whereas non-opened inclusions of this crystal still displayed such a birefringent zone after heating. Thus one may suppose that the birefringent zone appears due to pressure (elastic) of inclusion on the host mineral and not a result of remnant stress present in the crystal (Zil'bershteyn, Khotina, 1979).

The birefringent zones surrounding all observed vacuoles in halite are flat zones of tension, whose perpendicular axes coincide either with the axes of the three-faceted angles formed by the junction of the faces of cubic vacuole, or with lines perpendicular to faces of this cube. Thus, such zones of tension appear due to uniaxial pressure acting either along [111] or along [100]. The value of this pressure is the pressure in inclusion.

Existence of this tension state causes the piezooptic effect (Born, Vol'f, 1973), i.e. change of the optic properties under mechanical stress. Piezooptic effect is described by the change of matrix of the polarization constants $\{a_{ij}\}$ when mechanical tension X_{kl} acts:

$$\Delta a_{ij} = \pi_{ijkl} X_{kl}, \tag{1}$$

where Δa_{ij} - addition to polarization constant a_{ij}; X_{kl} - element of tensor of the tension of the second range; π_{ijkl} - element of the piezooptic substantial tensor of the fourth range. In the equation (1) the summing after repeating indices is presumed.

Finding the values λ_i and vectors of the changed matrix of the polarization constants $\{a_{ij} + \Delta a_{ij}\}$ (Zil'bershteyn et al., 1976), one may calculate the new main refractive indices n_i of the crystal equal $n_i = \lambda_i^{-1/2}$ and orientation of the optical indicatrix.

For crystals of symmetry class m3m like halite, birefringence Δn_o induced by the uniaxial pressure X observed in the direction perpendicular to pressure direction, may be expressed as follows (Nay, 1960):

$$|\Delta n_o| = -1/2(n^o)^3 \, |X| \, \pi_{2323} \tag{2}$$

for pressure along [111], and:

$$|\Delta n_o| = -1/2(n^o)^3 \, |X| \, (\pi_{1111} - \pi_{1122}) \tag{2'}$$

for pressure along [100].

From the data given in the book of Nay (1960), components of the piezooptic tensor π_{2323} and $(\pi_{1111} - \pi_{1122})$ for halite equal -0.85×10^{-7} bar and -1.21×10^{-7} bar, respectively. Refractive index of the nondisturbed isotropic halite is $n^o = 1.544$. From those data, using equation (2) and (2') and birefringence of the tensile zone, the value of tension X equal the pressure in inclusion may be easily found.

The authors measured birefingence of the tensile zones in halite at Th of inclusions, using the Berek compensator and yellow filter for illumination. The relative error was ≤15%. Thickness of the birefringent zone (d) was determined on the basis of the width (l) of its section in a plane perpendicular to the direction of the light transmission. For layers parallel to faces {100} (vertical) of the vacuole, d = l, and for layers parallel to {111} (oblique), d may be calculated from l (see below).

For determination of l it is necessary to focus the microscope on the upper face of the vacuole and next to measure the distance between the vertical faces of the vacuole and the boundary of birefringent and nonbirefringent parts of the crystal. The boundary may be found with the accuracy of 0.5, i.e. difference between two interference bands. (...) For birefringent zones parallel to {111} the connection between d and l is as follows:

$$d = 2l \, \mathrm{ctg}\varphi, \tag{3}$$

where $\mathrm{ctg}\ g = \sqrt{2}$-ct$\varphi$ of the angle between tension surface and sample plane {001}; the figure 2 appears due to the fact that one measurement of optical path difference is influenced by two tension zones (upper and lower) corresponding to two tops of cubic vacuole occurring one above another. For zones parallel to vacuole faces

$$d = l. \tag{3'}$$

Due to fact that normal of the tension zone perpendicular to [111] forms an angle with the sample plane equal ~ arc $\cos\sqrt{2/3}$, the optical path difference (Γ') measured in the plane of the sample plate, is connected with the respective path difference of the main section of the indicatrix of the tension zone (r) by the following way (when birefringence is weak):

$$\Gamma = \frac{\Gamma'}{\cos^2(\text{arc}\,\cos\sqrt{2/3})} = \frac{3}{2}\Gamma'. \tag{4}$$

For zones parallel to vacuole faces:

$$\Gamma = \Gamma' \tag{4'}$$

From the measured values l and Γ' using equations (3-4') it is easy to find the value Δn_0. The latter permits determining, from the equations (2) and (2'), the value of the uniaxial pressure $|X|$, equal the pressure in inclusion. At Th which were different for various vacuoles (125-150°C), the average value of uniaxial P was calculated by the above method as equal 160 ±40 bars. (...) The obtained value may be a little too high due to influence of uniaxial mechanical tension along [111], since in the tops of the cubic inclusion there is a concentration of tension.

Birefringence at room T is different before and after heating, probably connected with disappearance of the remnant nonelastic deformation of the crystal.

Since the depth of occurrence of the halite deposit is small, the difference between Th and mineral-formation T is small due to small P corrections for Th. (...)

There are no essential reasons to invalidate this method of P determination for any transparent crystal. It was applied also for P determination for inclusions in fluorite of various origin, (...) from the deposits Abagaytuy (Transbaikalia), and Kent (Kazakhstan). Cleavage chips {111} were used with inclusions of tetrahedral habit and ore face parallel to the chip face and the others form the angles ~70°. The Γ' of the birefringent zone was determined by the compensation method, d was evaluated from l

$$d \cong 0.5l \text{ tg } 70° = 1.4l,$$

and hence $\Delta n_{[111]} = \Gamma'/d$ was calculated; it was acceptd that tension X is mainly $X^{[111]}$. Hence relation between Δn_0 and tension along [111] for the case $|X^{[111]}| = P$ may be written:

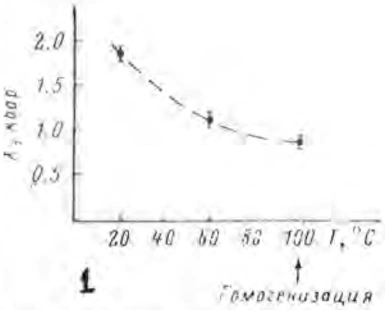
$$|\Delta n_0| = 0.5(n^0)^3\,\pi_{2323}, \tag{5}$$

n^0 - refractive index of nondeformed fluorite is equal 1.433; π_{2323} - piezooptic coefficient for [111] in fluorite equal $0.698\cdot10^{-7}$ bar^{-1} (Nay, 1960). For the aboved orientation of inclusion and birefringent zone the value Δn_0(5) is proportional to the measured birefringence Δn:

$$\Delta n_0 \cong \frac{\Delta n}{\cos \varphi}, \tag{6}$$

where $\varphi \approx 20°$ - the angle between chip face and line perpendicular to the birefringent zone. Hence, from (5, 6) P value in inclusion may be evaluated.

Figure 1 presents the relation between tension $|X|$ and T for fluorite from the deposit Abagaytuy. The value $|X|$ decreases with the T increment up to Th. Such relation may be partly explained by inclusion trapping at high T (>Th) and by the difference of thermal expansion coefficients of the inclusion filling and host crystal. Tension value for Th of the low-T Transbaikalian fluorite was 0.9 ± 0.2 kbar (Th = 100°C) and for moderate-T Kazakhstan fluorite -1.7 ± 0.2 kbar (Th = 250°C). (...) The above described studies sometimes help to evaluate the T of formation of the polycrystalline aggregate. The Abagaytuy fluorite bear rice-like inclusions of quartz syngenetic with the host mineral. Quartz inclusions are surrounded by birefringent zones in fluorite, caused by bilateral deformation durng change of conditions, mainly T decrease after formation of the aggregate, due to various values of thermal expansion coefficients of these two minerals.



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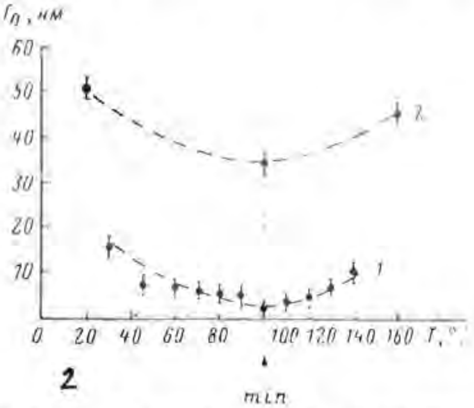

2

Figure 1. Relation between tension X of the inclusion in crystals of the Transbaikalian fluorite and T, obtained by use of the equation (5).

Figure 2. Plot of difference of optical path r_0 versus T near the solid quartz inclusion, specimens 1 and 2 of fluorite from the deposit Abagaytuy.

Piezooptic effect in quartz, due to its natural birefringence, is difficult to observe, thus the studies were made in fluorite (see Figure 2). The plot r_0 versus T has a distinct minimum at T very close to Th of inclusions in these crystals (Figure 1). Since the lowest r^0 occurs when the bilateral deformation of minerals is smallest, the observed minimum should indicate the T of formation of polymineral aggregate. The r_0 at T of minimum is not zero due to difference of P of formation and atmospheric P and it may be connected with plastic (non-elastic) deformation of fluorite. Correct interpretation of r_0 at the minimum point of the curve $r_0(T)$ may be used for evaluation of P of formation of the polymineral aggregate.

Similar values of Th and T of minimum $r_0(T)$ support the conclusions that tension 0.9 ± 0.2 kbar at Th may be considered the P of mineral formation.

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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 (or "x," for multiple entries) is put in parentheses after the page reference. Some items may continue on to following pages. Transliteration of Cyrillic has not been uniform in the various sources used, and hence the user must look under the several possible spellings, e.g., Ye and E, ...iy and ...ii, etc. As all entries in the Translation section are also entered in the Abstracts section in alphabetical order, no Author index is needed.

SUBJECT INDEX

See general notes above. I have tried to make this a user-oriented index rather than a documentalist's type index. Only data in the title and abstract are indexed, and then only if they appear to be of more than incidental mention. Misleading or erroneous translations may have resulted in occasional incorrect or omitted entries. Some entries are included under a given subject heading even though the index word does not occur in the abstract. The deposit type is indexed only where it is evident without research. The aim has been to err on the side of completeness and convenience to the user. Thus I have attempted to index some related or possible pertinent items, and even ones involving negative data or evidence, under each category. The ore type terms such as porphyry copper and Mississippi Valley are used loosely. Analyses for specific elements are indexed only when they are particularly unusual or significant; thus semiquantitative spectrographic analyses and statements of analyses as "Na-Ca-Cl fluids" are generally ignored. The mineral host for the inclusions studied is indexed except for quartz and decrepitation studies. Entries that would include too many page references are listed without page numbers. Some entries with broad and diffuse applicability (e.g., "Geobarometry, methods and comparisons") have only a few of the most pertinent page references.

LOCALITY INDEX

Notes: See page 291. 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. Soviet place names may be listed under various transliterations and in particular, with different endings; thus Began and Began'skii, Blyava and Blyavinsk, Kochkar and Kochkarskoje, Volhynia and Volyn.

Errata

Note: This errata section normally includes corrections to all published volumes, but does not reproduce errata published earlier. The editors would appreciate notice of any other errors or omissions.

TEXT Volume	Page	Item†	Line	
13	27	2	4	Change pagination to 6937-6943.
13	63	4	7	Change 1980 to 1978.
13	172	2	4	Change 1980 to 1981.
13	271	5	1	Change initials to B.W.D.
13	280	3	1	Change second author to ARNOLD, Michel.
14	128	-	-	Enter two following items as items 3 and 4.
14	186	3	1	Change SHAN, Lin to LIN, Shan, and enter on p. 128.
14	186	4	1	Change SHAN, Lin to LIN, Shan, and enter on p. 128.

†Partial items are also counted.

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