H BELKIN

FLUID INCLUSION RESEARCH

Proceedings of COFFI

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

Volume 13

1980

Fluid Inclusion Research

Volume 13

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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ANN ARBOR

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Preface

In 1968 the publication of Fluid Inclusion Research - Proceedings of COFFI was started as an offshoot of the Commission on Ore-Forming Fluids in Inclusions (COFFI) of the International Association on the Genesis of Ore Deposits (IAGOD). Although closely connected with COFFI and IAGOD, 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 mostly repaid, from the International Union of Geological Sciences.

The purpose of the publication is to provide entree to the literature with English abstracts or annotated bibliographic citations of all items from the world literature published during the volume year 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 meetings and symposia are also published.

Most of the 431 items from Russian sources in this volume were translated or abstracted by Associate Editor Kozlowski; this represents an enormous contribution 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 539 items from other foreign language sources and English language literature for a total of 970 abstracts, citations, or annotated citations, plus subject and locality indices.

Some cited items are listed as "Indexed under fluid inclusions." These items came from various computer searches but could not be looked up in time; they may involve only a trivial mention of fluid inclusions or they may be major items, since such distinctions are not normally made in computer data bases. Numerous persons and recent articles have suggested that with the rapid development of computerized data retrieval systems, bibliographical publications such as Fluid Inclusion Research--Proceedings of COFFI 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 there are several extensive geological literature computer data bases, and these 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, in particular, Dr. M. Fleischer, of the U.S. Geological Survey, who provided considerable help. Chemical Abstracts, of Columbus, Ohio, has most graciously permitted the use of a limited number of their copyrighted abstracts, as indicated in the abstract citations. Help has also been received from Drs. H.A. Stalder (Bern, Switz.); P. Lattanzi (Firenze, Italy); M.J. Logsdon (U.S. Nuc. Reg. Comm.); and A.P. Berzina (Novosibirsk, USSR). Many other individuals, too numerous to list here, have helped by sending books, reprints, references, individual translated abstracts, and copies of abstracts. I am also indebted to Professor Ermakov, Chairman Emeritus of COFFI, for copies of Russian books; and to Prof. J. Guha (Chicoutimi, Quebec); and to H.E. Belkin (U.S.G.S.) for literature searches. I thank Nancy Teed (U.S.G.S.) for most of the 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 lag time increased with this volume, due to my other commitments, but work on future volumes is already proceeding rapidly and I hope to become more current.

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.

June 11, 1984 Edwin Roedder, Editor

Contents

Notices of Meetings and Symposia

Past Meetings

A MAWAM (Mineralization Associated With Acid Magmatism) meeting was held at Univ. Exeter, U.K., December 1979. Aproximately 30 papers were presented, mostly on Sn-W mineralization, F and B in granitic melts, and the related hydrothermal processes. Those that are stated to involve fluid inclusion studies are given in this volume.

The Third International Symposium on Water-Rock Interaction was held in Edmonton, Canada, July 14-24, 1980. The Proceedings were published under the sponsorship of the IAGC and the Alberta Research Council (see IAGC 1980 in this volume).

During the 1980 Spring meetings of the Societa' Italiana di Mineralogia e Petrologia, held in Firenze, Italy, a special session was devoted to "Volcanic emanations." Six papers (one in English, the others in Italian with English abstracts) and three abstracts (two in Italian, one in English) presented at the session appeared in the Vol. 36 (1980) of the Rendiconti della Societa Italiana di Mineralogia e Petrologia.

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; the seventh meeting will be in Orleans (see below). The symposium was a very stimulating meeting; 65 participants from 14 countries were registered and 34 papers were presented. Part of the papers presented were published in a special issue of Chemical Geology (v. 37, 1982); others have been published elsewhere. Abstracts of the papers will be found in COFFI Vol. 14.

The Sixth Symposium of the International Association on the Genesis of Ore Deposits (IAGOD) was held in Tbilisi, August 30 - September 17, 1982. It included a meeting of the Commission on Ore-Forming Fluids in Inclusions (COFFI); abstracts will appear in COFFI Vol. 15.

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 involving fluid inclusion studies.

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 will be given in COFFI Vol. 15.

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 will be abstracted in COFFI Vol. 15.

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.

A meeting on European Current Research on Fluid Inclusions, sponsored by the Soc. fr. Minéral. Cristallogr., was held at Univ. Orléans, 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 will be found in COFFI Vol. 16.

Future Meetings

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

The next Quadrennial meeting of IAGOD, to be held in conjunction with the International Geological Congress in Moscow in 1984, will include a symposium "Molten and gas-liquid microinclusions in mineral-forming substances"(sic). Fluid inclusion papers will be handled as regular IGC papers, according to Congress organizers.

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. The numerous abbreviations used in earlier volumes have not been used here. Other than the normal scientific and reference abbreviations, we use only 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 (usually of ice).*
P	primary	Tn	temperature of nucleation.*
PS	pseudo secondary	Tt	temperature of trapping.*
S	secondary	(...)	part of author's abstract omitted.

*For explanation, please see the following item, reprinted from Volume 10.

Suggested terminology and abbreviations for future inclusion work.

The literature on fluid inclusion is expanding rapidly, and currently many different terms and abbreviations are in use for the temperatures at which various specific events occur within inclusions. The terminology, and hence also the abbreviations, in use in languages other than English obviously must differ, but the time has come for English-speaking inclusion workers to come to a consensus on terminology. After consultation with numerous inclusion laboratories, a consensus was reached on the following terminology, and it is suggested that if this terminology is used consistently in future papers, considerable ambiguity will be avoided. The overlap between the temperature ranges involved, and the similarities of the phase changes noted in gas-rich inclusions at very low temperatures, in "ordinary" aqueous inclusions below and above zero, in highly saline multiphase inclusions at ~300-600°C, and in melt inclusions at ~600-1200°C make it desirable to have the terminology and abbreviations compatible throughout. No terminology can cover all situations, but the recommended terms should be adequate to cover normal usage.

The lowest temperature normally recorded for aqueous inclusions is the temperature at which an inclusion first freezes on dropping the temperature. This usually occurs only after considerable (metastable) supercooling, and hence the temperature represents not a stable phase change but only the fortuitous event of nucleation of ice and salts. It will vary with inclusion size and with the time-temperature procedure used, but has some significance as a measure of either the freedom of the system from foreign nuclei (for heterogeneous nucleation) or the ease of homogeneous nucleation, without spurious nuclei. When used, it has been called, quite logically, the freezing temperature (i.e., "Tf"). This is the same term that I introduced in 1962 for a different temperature, that of stable, reversible ice-solution equilibria, in allusion to the temperature at which ice (or other phases) should form on cooling, under stable equilibrium (and subsequently abbreviated T_f, T_F, or T_{Frz}). My usage was not well chosen, however, and I believe it should be dropped, and the term temperature of nucleation (Tn) used. This covers any nucleation event, and can be further identified as Tn ice, etc.

The next higher temperature is normally that at which some liquid is first seen to be present on warming a formerly all-crystalline inclusion. I have used the term first melting temperature here, but for simplicity and consistency, I suggest changing to "Te" for eutectic temperature, since that is, in effect, what is being determined.

On further warming, specific solid phases may melt (i.e., dissolve) at recognizable temperatures. Several papers have used "Tm" as the general term for such melting temperatures, with a designation appended to indicate which phase melted (when identifiable), such as "Tm NaCl" or "Tm CO_2". I suggest we follow this usage, as it is descriptive and hence effective. (I realize that "melting" is not necessarily always a good descriptor, but the other term that has been used here, "solution" (i.e., Ts) is equally invalid in other cases, e.g., for the disappearance of pure solid CO_2 at its triple point of -56°C). My original usage of "freezing temperature" thus becomes "Tm ice", or where there is no chance of ambiguity, "Tm". Temperatures for unidentified daughter minerals would then become "Tm dms".

The usage of "homogenization temperature" has also been the source of considerable ambiguity, in that sometimes it is used to refer only to liquid and vapor phases, and other times to total homogenization. I thus suggest that whenever ambiguity may exist, the usage be clarified by adding the designation of which phases homogenize. Thus in low-temperature phase equilibria one could use "Th CH_4 L-V" or "Th CO_2 L-V", and for inclusions with a daughter mineral, "Th L-V" would refer to the homogenization of these two fluids without reference to the behavior of the daughter mineral, the behavior of which is independent, of course. "Th" without other designation should be reserved for actual homogenization, i.e., complete homogenization. As such it would follow most current usage.

The temperature at which an inclusion was trapped is sometimes abbreviated "T_F", for temperature of formation. This causes confusion with the temperature of freezing, so I suggest "Tt" be used, for temperature of trapping. Thus inclusions were formed at Tt and Pt.

The temperature of decrepitation has usually been abbreviated Td, and this seems adequate. Specific details on how such a temperature is determined, e.g., the start of decrepitation, the most rapid rise of decrepitation rate, or the maximum number of impulses per unit increase in temperature, will vary with the technique used and will have to be specified in each paper.

Tentative summary of recommended designations (for ease of typewriting and typesetting, I suggest not using subscripts.)

Th - temperature of total homogenization. The phase into which homogenization occurs should also be stated as well (e.g., Th L or Th V).

Th L-V, Th CO_2 L-V, etc. - temperature of homogenization of the stated pair of phases only. The phase into which homogenization occurs should also be stated as well (e.g., Th CO_2 L-V (V), or Th CO_2-H_2O (CO_2)).

Tt - temperature of trapping.

Td - temperature of decrepitation.

Tm - temperature of melting (or dissolving).

Tm NaCl, Tm dms, Tm ice, etc. - temperature of melting (pure phase) or of solution (mixed system) of specific phases indicated.

Te - temperature of eutectic, i.e., first recognized formation of liquid on warming a completely crystalline inclusion; this 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 - temperature of nucleation in fluid, generally on cooling (i.e., in a normally supercooled, metastable fluid). Thus Tn for an aqueous inclusion "freezing temperature" would be Tn ice; the heterogenization of a previously homogenized inclusion would be Tn V, Tn NaCl, Tn CO_2 V, etc.

E. Roedder, Editor

Abstracts, Translated Abstracts, or Annotated Citations to World Literature, 1980

Note: Some items from previous years that were missed earlier are included, as are items for which a full English translation has become available, even if the item was previously abstracted from the original Russian.

ABORENKO, N.V., 1980, Interdependence of structure and properties of natural organometallic compounds: Dok. Akad. Nauk SSSR, v. 253, no. 4, p. 960-963 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 230-232 (1982).

AHMAD, S.N. and ROSE, A.W., 1980, Fluid inclusions in porphyry and skarn ore at Santa Rita, New Mexico: Econ. Geol., v. 75, p. 229-250.

Fluid inclusions of apparent primary origin in quartz from both porphyry copper and skarn ore at Santa Rita are filled with two main types of liquid which differ markedly in salinity. Filling temperatures for both fluids are mostly in the range of 250° to 450°C but extend from about 200°C to over 550°C. The high salinity fluid generally contains 32 to >60 percent NaCl equivalent and was apparently saturated with NaCl below about 300°C. The moderate salinity fluid, which is the most common type in most specimens, contains 1 to 20 percent NaCl equivalent. Many vapor-rich inclusions homogenizing to a vapor accompany the liquid-rich inclusions indicating that at least one of the fluids was condensing or boiling. High salinity, moderate salinity, and vapor-rich inclusions with a wide range of filling temperatures are intimately associated on a microscopic scale. Obvious secondary inclusions contain the same three types of fluids but tend to fill at lower temperatures. Data from critical behavior of two inclusions and from boiling of solutions containing 35 to 45 percent NaCl at 350° to 450°C indicate pressures of 120 to 520 bars.

This same large range of temperature and salinity is shown by apparently primary inclusions in quartz from all major periods of deposition including: (1) early quartz veins associated with potassic alteration, (2) later quartz veins associated with sericitic and pyritic alteration, and

(3) quartz-magnetite-sulfide veins cutting skarn. Filling temperatures in early quartz are no higher than in late quartz, both being predominantly in the range 250° to 450°C. In contrast, most inclusions in early garnet of the skarn are of the lower salinity type and fill to a liquid at 325° to 425°C. Necking down of inclusions and trapping of vapor-liquid mixtures may account for some or all of the high filling temperatures (>450°C), but they cannot account for the range of salinity within each type of fluid. Trapping of solid NaCl along with liquid appears to explain some very high salinity inclusions that fill at temperatures 20° to 165°C lower than halite dissolves, although trapping at high pressures may account for some of these inclusions. Unrecognized secondary inclusions are a possibility, but the inclusions considered primary are clearly an earlier set of inclusions than the many obvious secondary inclusions. Also, the filling temperatures of primary inclusions are in reasonable agreement with temperatures estimated from oxygen isotopic fractionation and annite content of biotite. It is concluded that at least two major types of fluid, one with moderate and one with high salinity, deposited the quartz of the deposit and that at least the high salinity type was accompanied by vapor.

The high salinity fluid probably formed as a condensate from a supercritical fluid emitted by an underlying magma and following a P-T path that intersected the two-phase field for the fluid, under conditions approaching hydrostatic pressure. Alternative origins for this fluid are boiling of lower salinity fluid which was heated by magmatic vapor or by encountering very hot rock. The lower salinity fluid can be explained as a similar supercritical fluid that remained near lithostatic pressure and followed a P-T path that did not intersect the two-phase field. Boiling and mixing with high salinity fluid and meteoric water may explain some occurrences of the lower salinity fluid. Fluctuation between hydrostatic and lithostatic conditions caused by recurrent episodes of emission of fluid from magma, fracturing to the surface, and finally choking of the fractures by quartz deposition can explain the intimate association of the two types of fluid, the large range in pressure, and the range in temperature. The large volume changes associated with condensation and/or boiling of hydrothermal fluids may be responsible for the extensive shattering at this and other porphyry copper deposits. (Authors' abstract)

AINES, Roger D. and ROSSMAN, George R., 1980, The structural and chemical behavior of hydrous components in minerals at temperatures up to 1000 K (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 377.

AITKEN, Bruce G., 1980, T-XCO_2 phase relations of carbonate scapolites (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 377-378.

AKINCI, O.T., 1980, The mineralogy and crystallization processes of the Bulancak sulphide veins: Bull. Min. Res. & Explora. Instit. of Turkey, v. Oct. 1979-Apr. 1980, no. 93/94, p. 8-18.

Ore microscopy, X-ray diffraction and electron microprobe studies and chemical analyses of the vein samples collected from the rocks of the lower basic and dacitic series of the Eastern Pontid Volcanism to the south of Bulancak, Giresun led to the discovery and identification of ore minerals such as betekhtinite and aikinite for the first time in Turkey and idaite and tennantite which were not previously reported from the area.

Ore microscopy studies of the gangue and ore minerals, carried out together with fluid inclusion study, showed lateral temperature zonation and mineralization through oxide-sulphate-sulphide and carbonate stages (Th≤350°C and salinity ≤13.4 wt % NaCl).

History of mineralization along with general characteristics of the veins affected by temperature and physicochemical conditions are discussed and the optical, structural and textural properties of the ore and ganque minerals are given. (Author's abstract)

ALEKHIN, O.S., LVOV, S.N. and ZAREMBO, V.I., 1980, Volumetric properties of water solutions of calcium chloride at 298.15K and pressure range 0.1 to 100 MPa: Geokhimiya, 1980, no. 10, p. 1554-1556 (in Russian).

ALEKSANDROVA, E.S., BANNIKOVA, L.A. and SUSHCHEVSKAYA, T.M., 1980, Some errors of analysis of gases with thermal opening of inclusions in minerals: Geokhimiya, no. 11, p. 1710-1716 (in Russian, English abst.). Authors at Inst. of Geochem. and Anal. Chem., Moscow, USSR.

Estimation of errors due to thermal decomposition of organic matter in the process of gas-chromatographic analysis of gas phase of the inclusions in minerals was made using chloroform extracts of organic matter from mineral assemblages of ore deposits. It was determined that decomposition of the studied organic matter accompanied by evolution of CO_2, CH_4 and H_2O, begins at 200°C, and causes serious limitations on the use of thermal opening of inclusions. It was shown that removal of significant part of organic matter from samples of quartz of hydrothermal ore deposits can be reached in the treatment by organic solvent (e.g., acetonitrile). (Authors' abstract)

ALEKSEENKO, V.A., SEDLETSKIY, V.I., KHOVANSKIY, A.D. and KLEVTSOV, S.F., 1978, Genesis of stratiform polymetallic deposits on the basis of vacuum decrepitometry data (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 101-102 (in Russian). Authors at Rostov Univ., Rostov-on-Don, USSR.

Studies of 20 stratiform polymetal deposits from Karatau, Dzhungarskiy Alatau, Central Kazakhstan, Siberia and Yakutia revealed regional impregnation haloes with Td 80-180 and 390-490°C, and "hydrothermal" impregnation haloes with Td 220-280 and 300-380°C, developed with various intensity at various deposits. (A.K.)

ALEKSEYENKO, V.A., SEDLETSKIY, V.I., KHOVANSKIY, A.D. and KLEVTSOV, S.F., 1978, Thermobarogeochemistry of stratabound lead-zinc deposits: "Nauka" Publ. House, Leningrad, 336 pp., 1000 copies printed, price 2 rbls. (in Russian).

By the method of vacuum decrepitometry (device VD-2) numerous samples of Zn-Pb ores from various stratabound deposits were studied. In the Karatau area, intensive gas release from fluid inclusions in ores was found at the following Td for the individual deposits: Mirgalimsay 380-480°C and 320±50°C; Shalkiya 70-160°C, 390-490°C (marbles), 190-290°C (all samples), 270-370°C (hydrothermal impregnation); Bayzhansay 280-350°C; Aksuran 50-195°C, 230-280°C, 280-370°C and 370-470°C; Bugun'skoe 60-190°C, 200-280°C, 280-360°C and 380-410°C; Achisay 50-160°C, 200-290°C, 290-390°C and 390-490°C. The deposit of Central Kazakhstan were characterized by the following Td: Zhayrem 75-200°C, 200-290°C250-390°C and rarely 400-550°C; deposits of Dzhungarian Alatau: Tel'man 50-140°C and

270-340°C; Usek 50-140°C and 300-370°C; Koksu 20-170°C and 300-660°C; Bol'shoi Usek 100-160°C, 200-290°C, 320-380°C and 420-520°C; Kyuely 50-150°C and 225-290°C plus locally 165-215°C, 290-235°C and 420-490°C; Central Suuktyube 50-175°C, 180-290°C, 300-330°C, 370-430°C and 430-480°C; N. Suuktyube 40-180°C, 240-340°C and 390-490°C; Tekeli 75-165°C, 180-280°C, 260-380°C and 380-480°C; W. Tekeli 50-170°C, 180-270°C, 280-360°C and 360-480°C; Yablonovoe 50-180°C, 200-270°C, 280-360°C and 360-460°C. The Siberian Zn-Pb deposits yielded the Td ranges: Kholodzinskoe 120-190°C (regionally widespread) and in ores and some rocks: 60-115°C, 220-300°C, 310-380°C and 420-500-°C; N. Akatny and Mikhaylovskoe 150-170°C (weak), 250-300°C and 390-460°C (very intensive) plus 510-540 and 570-605°C for galena; Tabornoe 175-300°C and 350-480°C; Yenisey area generally 120-610°C. Same data for the Yakutian deposits may be listed the following way: Sardana 50-170°C, 200-320°C, 320-400°C and 400-480°C. Pereval'noe 60-140°C, 220-320°C, 320-400°C and 400-480°C; Uruy 40-190°C, 240-330°C, 330-380°C and 390-490°C. Polish Zn-Pb stratiform deposits from Upper Silesia were characterized by three Td intervals (samples - dolomites of various origin): 80-230°C, 230-290°C, 310-390°C, and at T>400 to 450°C the abundant gas release from samples is due to decomposition of disseminated organic matter. The authors explain the Td intervals by tectonic events, ore mineralization, regional metamorphism, metasomatism, hydrothermal impregnation, etc. The authors suggest also vacuum decrepitometry for routine studies of deposits. (Abstract by A.K.)

ALISKEROV, A.A., 1978, Peculiarities of mineral-forming solutions which formed subvolcanic ores in the South-Eastern Kamchatka (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 198-199 (in Russian). Author at Volcanolog. Inst. of Far-East Sci. Center of Acad. Sci. USSR, Petropavlovsk-Kamchatskiy, USSR.

In hydrothermal Miocene deposits associated with shallow intrusions two types of quartz-sulfide mineralization may be distinguished: disseminated monosulfide and polysulfide veins. Veins formed in five stages, the ore stage is quartz-sulfide. Td and Th are in ranges 330-250°C. Measurements of pH of water leachates suggest that early ore-forming were alkaline, next changed to acid and next to weakly alkaline. Solutions were of $Na-Ca-SO_4-CO_2$ type. (Abstract by A.K.)

ALISKEROV, A.A., 1980, Mineralization of magmatism at shallow depth; Avachinskaya-Kitkhoiskaya zone of uplift: Izd. Nauka, 94 pp. (in Russian). Indexed under Fluid Inclusions. (E.R.)

ALPERS, C.N., 1980, Mineralogy, paragenesis, and zoning of the Lus vein, Uchucchacua Peru: B.A. thesis, Harvard Univ., 138 pp.

Th range = 259-292°C; up to 32% NaCl equivalent, in Pb-Zn skarns (as quoted by Einaudi, 1981). (E.R.)

ALYEKHIN, O.S., L'VOV, S.N. and ZAREMBO, V.I., 1980, Volume properties of water solutions of calcium chloride in pressure interval 0.1-100 MPa at 298.15K: Geokhimiya, no. 10, p. 1556-1557 (in Russian). Authors at Leningrad Technology Inst., Leningrad, USSR.

Pertinent to studies of solutions in inclusions. (A.K.)

ANDERSON, R.Y. and KIRKLAND, D.W., 1980, Dissolution of salt deposits by brine density flow: Geology, v. 8, p. 66-69. First author at Dept. Geol., Univ. New Mexico, Albuquerque, NM 87131.

The origin of collapse structures and breccias that vertically penetrate or occur within impermeable evaporites has never really been understood. The density of the brine that develops as salt deposits are dissolved can generate continuous gravitational brine movement. If the source of the dissolving water is artesian, or continuous, a flow cycle is developed in which the salt itself supplies the density gradient that becomes the vehicle of its own dissolution. The Delaware Basin in western Texas and southeastern New Mexico provides a particularly good example of how brine density flow can produce dissolution chambers that collapse to form breccias. The potential for dissolution by brine flow is an inherent property of partly exhumed evaporites and may constitute a risk factor in the storage of radioactive waste in evaporite deposits. (Authors' abstract).

ANDRUSENKO, N.I., 1978a Temperature zonation of gold-silver deposits: Sovetskaya Geologiya, 1978, no. 6, p. 48-59 (in Russian; translated in Internat. Geol. Rev., v. 21, no. 7, p. 815-824, 1979). Author at Central Sci.-Res. Geol.-Explor. Inst.

Two near-surface volcanogenic gold deposits were studied. Th ranged from 425-90°C in one and 490-50°C in the other. Decrepigraphs were obtained as well, and correlated with grade. (E.R.)

ANDRUSENKO, N.I., 1978b, Comparative characteristics of thermobarogeochemical conditions of formation of gold-silver ore in shallow deposits of various regions, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 181-182 (in Russian). Author at Central Sci.-Res. Geol.-Prosp. Inst., Moscow, USSR.

Fluid inclusions were studied in minerals from numerous shallow deposits of three geochemical types: Au-Te, Au and Au-Ag. Commercial ores formed mostly from LH_2O solutions, but sometimes LH_2O-LCO_2 fluids were found (Kamchatka, Zakavkaz'ye). Dominance of light Ar isotope proves contamination of ore-forming fluids with meteoric waters. Hydrocarbons were found in inclusions by gas chromatography. For Au-Te type of deposits HCO_3-Na-Ca fluids are typical, for Au-Ag - SO_4-K and for Au - SO_4-HCO_3-Cl(F)-Ca-Na(K). P varies from 20 to 440 atm; boiling was noted at 360, 320, 290°C, and these temperatures represent the initiation of ore precipitation. The highest Th was found for Au-Te and Au-Ag deposits (420-200°C), lower ones - for Au deposits (360-120°C). (From the authors' abstract translated by A.K.)

ANDRUSENKO, N.I., 1980a, Thermobarogeochemical conditions of formation of gold-silver ores at the shallow deposits in the USSR, <u>in</u> Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 105-110 (in Russian).

See <u>Fluid Inclusion Research-Proceedings of COFFI</u>, v. 13, 1980. (A.K.) (See also previous two items.)

ANDRUSENKO, N.I., 1980b, Gas-liquid inclusions as indicators of physicochemical conditions of formation of shallow gold-bearing deposits: Novy Dannye Tipomorfizne Mineralov, A.D. Genkin, ed., Izdatel. "Nauka," Moscow, p. 58-72 (in Russian).

Early stages were high temperature (Td=420-520°C), and later stages were lower temperature. Pressures calculated to be ≤500 bars. (E.R.)

ANDRUSENKO, N.I., MOSKALYUK, A.A. GONCHAROV, V.I. and VILENKIN, V.A., 1978, New data on chemical composition of gold-ore forming solutions at the subsurface deposits of the North-East USSR, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 179-180 (in Russian). First author at Central Sci.-Res. Geol.-Prosp. Inst., Moscow, USSR.

Water leachates (55 samples, analyzed simultaneously in two different laboratories) from a gold-argentite deposit (name not given). Average results from samples of the four commerical associations present in the deposit yielded a sulfate-potassium composition of solutions with the ratios SO_4:HCO_3:Cl = 5.7:2.4:1.5 and K:Na:(Ca+Mg) = 4:1:1. That composition is present throughout the upper levels but in the lower levels in the final stages the composition changes to HCO_3-alkaline earth solutions. NH_4 occupies up to 25%-equiv. and F and B are present. Total salinity varies strongly, from 2.5 to 10 wt% (SVKNII lab.) and 18-23 wt% (VSEGEI lab.); pH of water leachates ranges from 6.1 to 7.8. Contents of Au and Ag by atomic absorption determinations are 0.02-0.07 µg Au/ml and 0.02-3.3 µg Ag/ml, Au:Ag ratio varies from 1:4 to 1:100. Correlation between Au, K, SO_4 and Ag, Na, Cl was noted. Gold and silver occur as sulfide and chloride complexes and NH_3 content may control contemporaneous precipitation of Au and Ag. (From the authors' abstract translated by A.K.)

ANDRUSENKO, N.I., MOSKALYUK, A.A., VILENKIN, V.A. and POLYVYANNYI, E.Ya., 1980, New data about chemical composition of gold-bearing solutions at the deposit of silver-argentite type, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 111-120 (in Russian). See previous items.

APLONOV, V.S. and ERLIKH, E.N., 1980, Temperature conditions of formation of minerals, rocks, and ores of the Tomtor massif: In "Alkalic magmetism and apatite-bearing rocks of northern Siberia": Nauchno-Issled Inst. Geol. Arkteki, Leningrad (in Russian).

Includes data on decrepitation of carbonates, nepheline, pyroxene, magnetite, etc. (E.R.)

APLONOV, V.S., MIKHAYLOVA, N.G. and ETINA, V.I., 1978, Thermodynamic analysis of evolution of ore-forming solutions on the basis of results of studies of inclusions in rocks of the Talnakh intrusion (NW Siberian Platform) (abst.): Abstracts of the Sixth All-Union Meeting Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 93-94 (in Russian). Authors at "Sevmorgeo," Leningrad, USSR.

Minerals of the Talnakh differentiated intrusion of basic composition bear P melt inclusions with Th 1280-1040°C, P ≥200 atm, P and S G inclusions with Th ~600°C and P and S G/L inclusions with Th 470-80°C. G/L inclusions are typical of Cu-Ni sulfide ore minerals; P was equal 2000-3000 atm. Main ions in solutions were Cl and Mg. (A.K.)

APLONOV, V.S., MIKHAYLOVA, N.G. and ETINA, V.I., 1980, Thermodynamic parameters of ore-forming solution at the Talnakh copper-nickel deposit, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 66-69 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980, Aplonov et al., 1978. (A.K.) See previous item.

ARKHIPCHUK, R.Z., 1980, Genesis and zoning of some fluorite deposits of the Western Transbaikalia: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 3, p. 63-74 (in Russian). Author at Buryatian Geol. Office, USSR.

The studied samples were collected in veins and cataclastic fluorite-mineralized zones of the following deposits: Ivolga, Manzha, Barun-Ul', Khonkhor, Kharanga. Crystallization of vein minerals developed from hydrothermal water-salt solutions of low concentration at (Th) 250-80°C, pH of water leachates from fluorite 5.50-8.12. Fluorite crystallized from HCO_3-F-Ca-K-Na solultions at (Th) 250-105°C, main mass of fluorite formed at 180-130°C. Vertical and horizontal T zoning was observed in the deposits. (Abstract by A.K.)

ARMBRUSTER, T. and BLOSS, F.D., 1980a, Channel CO_2 in cordierite: Nature, v. 286, no. 5769, p. 140-142.

ARMBRUSTER, T. and BLOSS, F.D., 1980b, Effects of channel H_2O and CO_2 in cordierite (abst.): Fortschr. der Min., v. 58, pt. 1, p. 708.

ARNOLD, M., GUILLOU, J.J., PERNETT, A. and ZIMMERMANN, J.L., 1980, Barite veins, sulfo-antimonides and reworked Stephanian sediments of Rouvergue; inventory, general discussion and conclusion: in Paleosurfaces and Their Metallogeny, Fr. Bur. Rech. Geol. Minieres, Mem. 104, p. 206-210 (in French).

Indexed under Fluid Inclusions. (E.R.)

ARNOLD, M., GUILLOU, J.J. and ZIMMERMANN, J.L., 1980, Barite veins, sulfo-antimonides and reworked Stephanian sediments of Rouvergue; difference between chemistry of visible fluid inclusions and that of micropores in quartz crystals: in Paleosurfaces and Their Metallogeny, Fr. Bur. Rech. Geol. Minieres, Mem. 104, p. 204-205 (in French).

Indexed under Fluid Inclusions. (E.R.)

ARNOLD, M. and PERNETT, A., 1980, Barite veins, sulfo-antimonides and reworked Stephanian sediments of Rouvergue; content of the veins: in Paleosurfaces and Their Metallogeny, Fr. Bur. Rech. Geol. Minieres, Mem. 104, p. 183-191 (in French).

Indexed under Fluid Inclusions. (E.R.)

ARUTYUNYAN, L.A., PETRENKO, G.V. and BALABONIN, N.L., 1980, Laboratory evidence on the behavior of major ore-forming and associated elements in Cu-Ni sulfide ores during hydrothermal redeposition: Geokhimiya, no. 6, p. 798-807, 1980 (in Russian; translated in Geochem. Internat., v. 17, 1980, no. 3, p. 109-116, 1981). Authors at Geol. Inst., Kola Branch, Acad. Sci. USSR, Apatity, USSR.

Laboratory experimentation at 300-500°C and 800 atm, in solutions of NH_4Cl and $MgCl_2$. A thermal gradient was established and used to move ore metals in the autoclave. (E.R.)

ASPDEN, J.A., 1980, The mineralogy of primary inclusions in apatite crystals extracted from Alnö ijolite. Lithos, v. 13, p. 263-268. Author at Inst. Geol. Sci., Keyworth, Nottingham, England.

Apatite crystals extracted from altered Alnö ijolite pegmatites contain primary aqueous saline inclusions and solid inclusions. The solid inclusions consist mainly of calcite, but the aqueous saline inclusions contain a variety of daughter minerals which include nahcolite ($NaHCO_3$), kalicine ($KHCO_3$), alkali halides and sulphates. These inclusions represent samples of a concentrated, highly alkaline aqueous solution and were originally trapped as homogeneous liquids during the growth of apatite. In the samples studied these fluids are late-stage and are thought to be responsible for the alteration seen in the host ijolite. (Author's abstract)

AUTRAN, A., ed., 1980, Genesis of tungsten skarns in the Pyrenees, in Johan, Z., ed., Mineralization in Granitoids: Memorie du BRGM no. 99 (in French).

AVDONIN, V.V., GAIDUKOVA, V.S. and DUBINCHUK, V.T., 1980, The submicroscopic inhomogeneity of volcanic glasses and its relation to liquation processes: Vestnik Moskovskogo Universiteta. Geologiya, v. 35, no. 1, p. 44-52 (in Russian; translated in Moscow Univ. Geol. Bull., v. 35, p. 43-50).

This paper presents the results of a study of submicroscopic structures of liquational genesis in volcanic glasses of rhyolite composition. Several varieties of structural inhomogeneities are distinguished, the most common of which is the emulsion-droplet structure that arises as a result of precrystallizational liquation. (Authors' abstract)

BABADZHANOV, A.A., 1980, Peculiarities of thermoluminescence and decrepitation of contact marbles as one indicator of hidden skarn-rare-metal ore mineralization: Zapiski Vses. Min. Obshch., v. 109, no. 1, p. 116-120 (in Russian). Author at Inst. Geol. Geoph. of Acad. Sci. of Uzbek SSR, Tashkent, Uzbekistan.

Contact marbles from rare-metal deposits Koytash, Lyangar, Ingichka and Khasantepa were studied to find indices for prospecting. The paper presents results from the deposit Lyangar at the SW contact of the Aktau granitoid massif. Limestones not altered by contact metamorphism yield the lowest decrepitation activity, $\leqslant$800 impulses per 1 cm^3 of sample, marbles from zones of "dry" contact $\leqslant$1200 impulses, and near the ore bodies $\geqslant$2000 impulses. Four possibly ore-bearing zones in the deposit were contoured on the basis of decrepitation activity. (Abstract by A.K.)

BABANSKIY, A.D., SOLOVOVA, I.P., BYABCHIKOV, I.D. and BOGATIKOV, O.A., 1980, Parental magma of rocks of the alkaline-earth series, as shown by study of melt microinclusions: Dokl. Akad. Nauk SSSR, v. 253, no. 4, p. 945-947 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 162-164 (1982). Authors at Instit. Econ. Geol., Petrol., Mineral. and Geochem., USSR Acad. Sci., Moscow, USSR.

A study of melt inclusions in plagioclase phenocrysts from andesite and high-alumina basalt from a volcano in Kamchatka. The inclusions contain silicate and ore daughter minerals. Partial Th (silicate part only) = 1250-1270°C, complete Th (ore minerals) 1330-1350°C. Two electron microprobe analyses of homogenized inclusions are listed. (E.R.)

BACHINSKI, D.J., 1980, Sulfur isotopes in Canadian Caledonian-Appalachian volcanogenic stratabound sulfide deposits, (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Program with Abstracts, v. 5, p. 41. Author at Dept. Geol., Univ. New Brunswick, Fredericton, New Brunswick, E3B 5A3.

The giant metamorphosed Bathurst base metal massive sulfide deposits are enriched in δ^{34}S (overall mean of larger deposits ~+13‰). Individual deposits show limited spreads in δ^{34}S (6 to 8‰) regardless of metamorphic grade. There is little variation stratigraphically: footwall Cu-rich ores (stringers, massive) are not consistently different than hanging wall banded PbZn-rich ores. Some deposits lighten-up (Heath Steele B-1) and some seem to heavy-up (Caribou). Deposits characterized by large amounts of pyrrhotite usually have high mean δ^{34}S values (BMS12, +16‰; Heath Steele, +13‰) whereas those lacking much pyrrhotite and characterized by pyrite-magnetite assemblages have much lower values (Caribou, +8‰). Exceptions like Chester (+9.5‰) locally display textures indicating pyrrhotite generation during metamorphism. Much of the pyrrhotite in deposits like BMS 12, and Heath Steele is therefore considered primary: ore fluids contained a higher proportion of reduced sulfur than those at Caribou.

Small metamorphosed Ordovician ophiolitic Cu deposits in Newfoundland are also variously enriched in heavy sulfur (means of individual deposits: +5‰ to =13‰). Except for Tilt Cove these deposits have spreads (5 to 9) akin to the Bathurst deposits. The increased spread at Tilt Cove is probably due to variations in fO_2 coupled with declining temperatures during the course of mineralization. Buchans kuroko deposits (Silurian) have a mean sulfide δ^{34}S value of +6‰ and a range of 6‰. Barite has the same sulfur isotopic composition as Silurian seawater.

Sulfur isotopic systematics displayed by sulfides in all these ores require heavy sulfur sources. Coeval seawater is likely the dominant sulfur source. A biologic reduction of seawater sulfate is preferred in all deposits since spreads are limited and since even the Bathurst ores contain little organic carbon. (Author's abstract)

BAGDASAROV, N.Sh. and PUGIN, V.A., 1980, Mechanism of extrusion and intrusion of immiscible magmas: Geokhimiya, no. 10, p. 1468-1480 (in Russian, English abst.). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Pertinent to immiscibility of melts in inclusions. (A.K.)

BAILEY, D.K., 1980, Volatile flux, geotherms, and the generation of the kimberlite-carbonatite-alkaline magma spectrum: Min. Mag., v. 43, p. 695-699. Author at Dept. Geol., Univ. Reading, Whiteknights, Reading, RG6 2AB.

A comparison of shield geotherms with the experimentally determined vapor-present solidus for kimberlite, indicates conditions of grazing incidence between 150-200 km, precisely where the mineral geotherms become disturbed. This relationship permits a new interpretation of kimberlite activity, by which volatiles migrating through cratonic lithosphere cause first metasomatism, and then incipient melting in the zone of incidence. Production of localized pockets of near-solidus liquid, erupted by accelerating crack propagation through the overlying lithosphere, is consistent with the unique set of features that characterize kimberlite. Volatile fluxing along steeper geotherms (away from craton nucleii) produces entirely different modes of magma eruption and development, by which highly undersaturated alkalic melts can reach the surface as liquids. Kimberlite activity is thus revealed as the limiting case of cratonic magmatism. (Author's abstract)

BAILEY, J.C., 1980, Formation of cryolite and other aluminofluorides: A petrologic review: Bull. geol. Soc. Denmark, v. 29, p. 1-45. Author at Instit. for Petrologi, Øster Voldgade 10, DK-1350, København K, Denmark.

Petrologic reviews are provided for 17 confirmed localities of cryolite, and for occurrences of 19 other aluminofluorides. Four environments can be recognized: granitic, carbonatitic, volcanic and aqueous.

Cryolite, partly replaced by other aluminofluorides, forms at the post-magmatic stage of granite evolution in alkali granite pegmatites, albitized riebeckite granites and hydrothermal bodies. The associated magmatic granites are post- or non-orogenic, late intrusions often associated with regional faulting. They are rich in Na and F, poor in Ca, and low in normative anorthite, acmite and sodium silicate. High contents of Rb, Zr, Nb, REE and Li are characteristic. They equilibrated at 1-2 kb P H_2O in agreement with their epizonal setting. Experiments in the granite-H_2O-HF system develop aluminofluorides in coexisting dense vapors. Equivalent fluids cooled to multi-phase inclusions in the Volyn pegmatites, Ukraine, and contain cryolite and elpasolite. Post-magmatic autometasomatism extracts and then redeposits F, Na and other elements probably via fluids containing fluoriferous complex ions. Quartz-feldspar metasomatites in E. Siberia are related to regional metamorphism and deep faulting.

Rare carbonatites and silico-carbonatites with high contents of Na concentrate F in late hydrothermal solutions and produced cryolite at Goldie, Colorado and Francon quarry, Montreal.

Ralstonite is widely reported, and elpasolite and weberite rarely reported, from fumaroles and HF-metasomatized lavas of basic to intermediate volcanoes. Deposition occurred at 300-100°C. Thermal springs and surface runoff from volcanoes carry relatively high F contents and occasionally form gearksutite and creedite by reaction with aluminosilicate materials.

Cryolite is a rare authigenic mineral in sediments of the Green River Formation, W. USA. F-rich interstitial brines, developed as in the modern Lake Magadi, Kenya, probably reacted with the host aluminosilicate sediments. Gearksutite and creedite, plus five other recently discovered aluminofluorides, occur within or just below the oxidation zones, or in the weathering crusts, of some F-rich mineral deposits. Low-temperature precipitated aluminofluorides have been produced synthetically but are unknown in nature.

The only economic aluminofluoride, cryolite, was present as several million tons at Ivigtut, S. Greenland. Fluorine was concentrated immediately below the sealed roof of a narrow granite pipe. (Author's abstract)

BAKUMENKO, I.T., 1980, Peculiarities in volcanic rock crystallization (with reference to melt inclusion study) (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6

July, 1980, p. 121.

The study of the temperatures of homogenization, the composition and some parameters of the melt inclusions in minerals of volcanic rocks permitted one to obtain some direct evidence on the temperatures of their crystallization, the dynamics of fluid regime and some other changes in magmatic crystallization. The data were obtained for the original dry state and high-temperatures of crystallization of basaltoidal melts with wide temperature variations and the water contents in granitoid magmas as a function of both the conditions of their generation and the grade of later differentiation.

The primary inclusions contained in the magmatic minerals permitted one to fix boiling and separation of crystallizing magmas to generate essentially carbonic, aqueous, aqui-saline and intermediate fluids of various density with essentially saline melts. The phenomena of separation resembling liquation with separation of ore or silicate melts are more uncommon for inclusions.

The melt inclusions in the minerals of some granitic and non-granitic pegmatites, also carbonatites and migmatites reveal the presence of magmatic stage of their formation. The temperatures and the peculiarities in their formation were established, such as the temperatures would drop to 790-710°C for migmatites of amphibolite facies and to 540°C for granitic pegmatites. Trigonal quartz crystallized directly from the melt. (Author's abstract) (Quoted verbatim)

BAKUMENKO, I.T., CHUPIN, V.P. and KOSUKHIN, O.N., 1979, Conditions of generation and crystallization of acid magmas, in: Problems of deep magmatism: "Nauka," Moscow, p. 206-221, price 3 rbls 20 kopecks, 900 copies printed (in Russian).

The authors discussed possible ways of volatile (water) loss from melt inclusions and they found that either molecular water or H from dissociated water did not migrate through crystal lattice, since experiments with overheating of G/L inclusions (Th 350-450°C) in quartz to 1200-1250°C, almost did not change the initial Th in inclusions which did not decrepitate (Dolgov's experiments). Chepurov made experiments with pyroxene crystallization at 1000-1100°C, P_{H_2O} ~1 kbar, melt: albite 70%, diopside 25%, NaCl 5%, and Th of melt inclusions in pyroxenes were in the range of T of growth (± determination error). Possible water loss during necking down of inclusions is also evaluated. The above considerations lead to conclusion that such processes of fluid release from melt inclusions are not typical. Thus results of melt inclusion studies may be used as valuable basis of the petrologic considerations. Melt inclusions in minerals of the anatectic granites from the Aldan Shield yielded Th 910-810°C (granulite facies) and 830-760, rarely 700°C (amphibolite facies), main volatile is CO_2, hence $P_{H_2O} \approx 0.2$ total P of the fluid; inclusions of LCO_2 were found with density 0.91 g/cm^3. Granites formed under thermal action of intruding basalts (Onega Lake, Dedovets Island) bear melt inclusions with low Th = 640±20°C; those melt inclusions have high volatile P causing their frequent decrepitation before homogenization. Phenocrysts in porphyry rocks bear melt inclusions with high Th (1200-1300°C), but granite intrusives yield Th below 1000°C. Magmas enriched in water during intrusion may yield T of final crystallization as low as 610°C (for late phase of leucocratic pegmatite-bearing granites in Kazakhstan). The decrease of Th in apical and marginal zones of intrusives, when compared with inner part, of the interval 100-200°C is very common, due to enrichment of magmas in H_2O and F. For fluorite-bearing pegmatites magmatic crystallization was recognized even at T 540°C. Sometimes the concentration of volatiles is so high that in magmatic pegmatites next to high quartz (Th 640-600°C), the low quartz crystallized from melt (Th 620-560°C, Kalba pegmatites in N. Pribalkhash'ye). Also retrograde boiling of acid magmas is characterized, mostly on the basis of reference or earlier published authors' data. The lowest Th of melt inclusions found (600-540°C) make possible a magmatic origin of muscovite, albite and low-quartz. (Abstract by A.K.)

BALASUBRAMANIAM, K.S., 1980, Geological studies pertaining to the utilization of certain barite deposits from Chandrapur district, Maharashtra State: Met. Miner. Rev. (Calcutta), v. 19, no. 12, p. 12-14.

Indexed under Fluid Inclusions. (E.R.)

BALASURBAMANIAM, D.S. and VEKARIA, G.R., 1980, Fluorite mineralization in Ambadongar, Gujarat State; a critical study: in Seminar on mineral resources of Gujarat and its exploitation, C.K. Shah, ed., Ahmedabad, India, Oct. 14-15, 1980, Gujarat Min. Serv. Gazetted Off. Assoc., p. 1-12.

Indexed under Fluid Inclusions. (E.R.)

BANNIKOVA, L.A., BARSUKOV, V.L., GALIMOV, E.M. and KOZERENKO, S.V., 1980, Distribution of isotopes in hydrothermal carbonates as an indicator of conditions of ore deposition: Dokl. Akad. Nauk SSSR, v. 250, no. 1, p. 193-196 (in Russian; translated in Doklady Acad. Sci. USSr, Earth Sci. Sect., v. 250, 1980, p. 186-188 (1982). Authors at Instit. Geochem. and Analy. Chem., USSR Acad. Sci., Moscow, USSR.

Isotopes (^{13}C and ^{18}O) in carbonates and Th of associated inclusions were measured for six mineral associations from three stages in an Armenian gold-sulfide deposit. Th ranged from 370°C (preore) to 150°C postore). CO_2 in inclusion fluid ranged from 60 to 140 g/1H_2O. (E.R.)

BARABAS, A.H., 1980, Mineralogical and experimental approach; III, late fluids in intrusive mafic complexes of the Lynn Lake region; Manitoba, Canada: Facteurs Controlant Les Mineralisations Sulfurees de Nickel Fr., Bur. Rech. Geol. Minieres, Mem. 97, p. 219-237 (in French with English abstract).

Indexed under Fluid Inclusions. (E.R.)

BARANOVA, N.N., KOZERENKO, S.V., GRIGORYAN, S.S., DAR'INA, T.G. and SAVEL'YEV, B.V., 1980, Experimental data on gold and silver concentration in hydrothermal solutions (results of analysis of gas-liquid inclusions): Geokhimiya, no. 8, p. 1146-1157 (in Russian; English abst.; translated in Geoch. Internat., v. 17, no. 4, p. 93-103). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow.

Samples for studies were quartz and calcite specimens taken from two gold ore deposits of hydrothermal subvolcanic Au-S-Te formation in Zakavkaz'ye. Main mineral associations yielded Th 380-140°C, commercial ores - 350-280°C. Weight of leached sample was 2 g, quartz samples were cleaned by HCl 1:3 and by three water leaches, next leachate of inclusion content was made by use of 0.5N HCl for Au determination and by use of water for Ag determination. Au and Ag were determined by inverse voltamperometry with sensitivity $2x10^{-10}$ g of Au and $3x10^{-8}$ of Ag; maximum error of determination ~30%. Control determinations were made by neutron activation method. Water was determined by gas chromatography. The determined concentrations of Au vary from 10^{-6} to 10^{-4} (here and throughout, gram-ion per liter); Ag 10^{-5} to 10^{-3}. Maximum Au and Ag concentrations in solutions of G/L inclusions ($7.8x10^{-5}$ Au and $6.3x10^{-3}$ Ag) were found in early high-T pre-ore quartz and they decrease one-two orders of magnitude to the stage of formation of the main mass of the Au-Ag mineralization. One of the two studied deposits had high Au and Ag concentrations in G/L inclusions in quartz of the low-T quartz-calcite-antimonite ores, where concentrations of Au are $6.4x10^{-5}$ and Ag $2.0x10^{-3}$. Positive correlation occurs between Au and Ag concentrations in inclusion solutions and Mn content in mineral samples, that may be connected with the role of Mn compounds as the oxidizing agents of Au and Ag at a certain solution pH interval. The Au and Ag concentrations found are comparable to those calculated from thermodynamic data based on complex ion formation, solution composition and T. (Abstract by A.K.)

BARBIER, E. (ed.), 1980, Cerro Prieto geothermal field: Proceedings of the First Symposium, 20-22 September 1978, San Diego. Part II: Geothermics, v. 9, p. 1-220.

A collection of 18 papers dealing with geophysical and recharge study of the Cerro Prieto field. Part I of the Proceedings appeared in Vol. 8 of Geothermics, and was included in the previous volume.

BARDE, J.P., CLIN, M., HUMBERT, L., LENGUIN, M. and SABOURAUD, 1979, Successive fracturing and decreasing temperatures during the formation of calcitic fissure-fillings in the western Pyrenees (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France (in French).

BARDINIZEFF, J.-M., BROUSSE, R., CLOCHIATTI, R. and WEISS, J., 1980, Evolution of phenocrysts and their melt inclusions in the "dacite" from the Santiaguito dome (Guatemala): C.R. Acad. Sc. Paris, v. 290, Ser. D, p. 743-747 (in French). Authors at Lab. Pétrographie, Univ. Paris-Sud, Bat 504, 91405 Orsay, France.

Three kinds of vitreous inclusions, showing different degrees of evolution are described in plagioclases, pyroxenes and apatites of Santiaguito dome. A two-stage crystallization at depth, with possibility of magma mixing is deduced. (Authors' abstract)

BARDINTZEFF*, J.-M. and CLOCCHIATTI, Robert, 1980, Melt inclusions in plagioclase phenocrysts of the April 1979 "nuée ardente" deposits at Saint-Vincent Soufrière (Antilles): a new approach for a dynamic model: C.R. Acad. Sc. Paris, v. 291, Ser. D, p. 529-532 (in French).

In the "nuée ardente" deposits of the April 1979 eruption, four coexisting types of plagioclase crystals were found. The first one originates from the former 1971 dome which was pulverized by the eruption, while the three others are associated with the younger magma. In the latter are found high-pressure xenolitic plagioclases and two kinds of plagioclases characterized by melt inclusions of either andesitic (An 95-90; melt: SiO_2 = 54%, MgO = 4%, K_2O = 0.7-1%) or dacitic (An 90-60; melt: SiO_2 = 62%, MgO = 1-2%, K_2O = 1.1-1.7%) compositions. A model is proposed where this type of eruption is assessed to be triggered by an intrusion of basic magma in a reservoir undergoing differentiation. (Authors' abstract) (*Name spelled Bardinizeff elsewhere.)

BARDINTZEF*, J.-M. and CLOCCHIATTI, R., 1980b, Data on the triggering mechanism of nuees ardentes from study of silicate melt inclusions in plagioclases: The eruption of 13 April 1979, Soufriere, Saint-Vincent (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 122-123.

See previous item. (E.R.)

(*Name spelled Bardinizeff elsewhere. E.R.)

BARKER, Colin, 1980a, Distribution of organic matter in a shale clast: Geochimica et Cosmo. Acta, v. 44 ,p. 1483-1492. Author at The Univ. Tulsa, Tulsa, OK 74104, USA.

The mechanism of petroleum migration is not fully understood. One approach has been to study the distribution of organic matter near contacts between rocks with source character and those with reservoir character. Published studies have been restricted to profiles across the bedding, but the ease of movement of hydrocarbons along and across the bedding may be very different. Gradients for volatile bitumens and kerogen both along and across shale bedding have been established by analyzing a shale clast encased in a sand matrix. In this case, the distribution of volatile bitumens is not controlled by the distribution of kerogen but shows evidence of bitumen movement through the clast. The amount and composition of the volatile bitumens and their distribution suggest that in part they have been introduced into the clast from the surrounding medium, and that the movement of hydrocarbons occurs preferentially along the shale bedding. The composition of the material moving into the clast is not the same as the bulk composition of the external supply but shows a preferential enrichment in normal alkanes, particularly those of shorter chain length. (Author's abstract)

BARKER, C., 1980b, Primary migration-the importance of water-mineral-organic matter interactions in the source rock: AAPG Studies in Geology No. 10, p. 19-32.

BARKER, R.G., BRATHWAITE, R.L. and TORCKLER, L., 1980, Gold-silver mineralization at Neavesville, Coromandel Peninsula, N.Z.: The Aust. I.M.M. Conference, New Zealand, May 1980, p. 25-xy. First author at Amoco Minerals New Zealand Ltd.

At Neavesville gold-silver (electrum) mineralization occurs in steeply-dipping zones of intense fracturing, brecciation and quartz veining within rhyolitic pyroclastics, carbonaceous shales and andesites. Hydrothermal alteration extends over an area of greater than 3 by 1.5 km. In rhyolitic tuffs, highly silicified zones containing quartz-adularia-illite assemblages are flanked by less silicified assemblages composed of albite, illite-montmorillonite and chlorite. The mineralogy and sequence of alteration are comparable with the alteration zones which envelop the steam-producing fissures of the active Wairakei and Broadlands geothermal fields. Primary fluid inclusions in quartz from five fissure veins in the Neavesville field show maximum homogenization temperatures ranging from 220-260°C and salinities of 0.0-1.1 wt.% NaCl equivalent, which cover a similar range to actual measured temperatures and salinities in geothermal fluids at Wairakei and Broadlands. The age of the rhyolitic pyroclastics and related alteration and mineralization is probably Pliocene and Neavesville therefore represents a fossil geothermal system.

The intensely fractured zones containing the gold-silver mineralization probably produced by hydraulic fracturing generated by accumulation under pressure of hydrothermal fluid in blind fault zones. Study of fluid inclusions indicates that hydrothermal quartz associated with electrum was deposited under boiling conditions. High grade electrum mineralization at Graces workings appears to be localized by reaction of hydrothermal fluid with sedimentary marcasite in black shale. (Authors' abstract)

BARR, L.W., MILLER, D.G. and MILLS, Reginald, 1980, Tracer (self)-diffusion of potassium ion in NaCl-KCl-H_2O mixtures at 25°C: J. Solution Chem., v. 9, no. 2, p. 75-80.

BARSUKOV, V.L., KOGARKO, L.N. and ROMANCHEV, B.P., 1981, Physicochemical parameters of differentiation of alkaline-basalt magmas from the islands of Southern Atlantic: Geokhimiya, no. 12, p. 1816-1844 (in Russian, English abst.). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

On the basis of studies of melt inclusions in phenocrysts it was determined that during formation of the rock series: ankaramite → phonolites, occurring in the islands: Gran Canaria, St. Helen and Tristan da Cunha, the evolution of the primitive magma developed in the intermediate magmatic chambers at a depth of 10-20 km during T decrease from 1300 to 900°C. Initially magmas contained 1-2% H_2O and 1-3% CO_2. In the final stages of differentiation the magmas were enriched in volatiles, including F, Cl and S, resulting in the crystallization of sodalite- and hauyn-rich phonolites due to supposed liquation of magmatic melts, since immiscibility phenomena were found in inclusions (salt+silicate melts) at T 1000-960°C (Authors' abstract).

The authors described inclusions in olivines, pyroxenes, plagioclase, apatite and nosean of ankaramites, basalts, trachybasalts, trachyandesites, ordanchites, trachytes and phonolites. Inclusions were of solid, gas and melt (glass and partly crystallized) types. In the crystallized inclusions the following dms were determined by electron microprobe: Ti-augite, apatite, nepheline, spinel, calcite, kaersutite, magnetite, garnet and plagioclase, plus sometimes glass or L CO_2. The sequence of melting of dms was studied and sequences of equilibria crystals-melts were determined, providing a basis for the evolution scheme of magmas.(A.K.)

BARSUKOV, V.L., SUSHCHEVSKAYA, T.M., KNYAZEVA, S.N. and VOLOSOV, A.G., 1980, Mechanism of precipitation of cassiterite from hydrothermal solutions, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 87-92 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 11, 1978, p. 17, Barsukov, Volosov et al. (A.K.)

BATZLE, M.L., SIMMONS, Gene and SIEGFRIED, R.W., 1980, Microcrack closure in rocks under stress: direct observation: J. Geophys. Res., v. 85, no. B12, p. 7072-7090.

BAUMER, A., CARUBA, R. and ARGIOLAS, R., 1980, Melt and solid inclusions in synthetic chlorapatite (ClAp) crystals (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 124-125 (in French; translation courtesy of R. Clocchiatti).

Current work on inclusions of minerals and rocks urged us to describe the following defects contained in crystals of hydrothermal synthetic ClAp.

Melt inclusions: Crystals are obtained from a brine of chemical composition: "S" = $10CaCl_2 + 6H_3PO_4 + 143H_2O$. This solution, under T and P conditions ranging from 250 to 850°C and 1 to 3000 bars, forms squat and acicular crystals over 400°C according to experimental conditions. Two kinds of intracrystalline cavities are noticed:

1. Primary inclusions corresponding to automorphous lack of growth and parallel to the 6-axis; they are bounded by sharp faces.

2. Secondary inclusions corresponding to cavities with undefined shapes, they are bound to one another by fine channels and result probably from a dissolving process.

Using the "S" chemical environment, solid phases are never observed in the cavities, but the degree of fill Vliq/Vliq+Vgaz depends on experimental conditions. Thus a lowering of pressure at a fixed temperature or a rise of temperature at fixed pressure induces a reduction of the degree of fill.

T°C	P bars	Duration (h)	Degree of fill Occupancy ratio
500	1000	20	.50
550	"	"	.45
600	"	"	.40
700	"	"	.33
"	2000	"	.66
"	3000	"	.80

Solid inclusions: Experiments ranging from 500 to 700°C for P = 1200 bars with the following chemical solution: S + 10^4 ppm $UO_2Cl_2 \cdot H_2O$; S + 5.10^4 pm $UO_2Cl_2 \cdot H_2O$; S + 10^4 pm $Th(NO_3)_4 \cdot 4H_2O$; S + 5.10^4 ppm $Th(NO_3)_4 \cdot 4H_2O$, allow synthesis of ClAp crystals with solid inclusions. In the case of crystals enriched in uranium, sheaf-shaped inclusions appear, 10 to 20µm in size and emerging from the prism faces. This phase was identified by Xray to correspond to $CaU(PO_4)_2$ (ningyoite, ASTM 12-279). In the case of thorium, crystals are octahedral, brown colored and are believed to correspond to ThO_2 (thorianite). For high amounts of Th (10^5 ppm), apatite forms together with $CaTh(PO_4)^2$. (Authors' abstract)

BAZAROV, L.Sh., CHEPUROV, A.I., SENINA, V.A. and KAZIMIROVA, V.A., 1978, The influence of ambient hydrostatic pressure and temperature on the inclusions of mineral-forming environments in spodumene (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemisty in geology: Vladivostok, Acad. Sci. USSR, p. 199-200 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

The main problem of thermobarogeochemistry at all stages of research is the problem of preservation of the inclusion content in minerals from outside influence. We have studied the influence of ambient hydrostatic (water) pressure on the alteration of Th of inclusions in spodumene from rare metal granite pegmatites.

The experiments have been made at a high pressure plant with internal low ohm heater in the temperature range 200-600°C and water pressure of

500-2500 atm. Before and after the experiments the samples were studied in microthermochambers and the temperatures of disappearance (partial homogenization) of gas bubbles (accuracy of determination ±5°C) were determined.

It was established that the hermiticity of inclusions in spodumene was not disturbed at heating plates up to 300°C at ambient hydrostatic pressure up to 2500 atm.

Under the conditions of comparatively low temperature (up to 450°C) and increased pressure (1500-2000 atm), refilling of inclusions, measured by a decrease of the gas bubble and temperature of partial homogenization, is registered.

On heating to the upper 500°C (i.e., near 600°?; E.R.) and pressure of water vapor of the order of 1000-1500 atm, most inclusions in spodumene leak and the temperature of partial homogenization increases.

Besides the change of Th of inclusions depending on the degree of heating the samples at fixed ambient pressure, the change of Th due to the value of ambient pressure at constant temperature was registered.

After the experiments, the measurements on inclusions with increased (decreased) temperature of partial homogenization, as a rule, did not change (within the error of measurement ±5°C) after repeated (3-5) homogenizations. On the basis of the research carried out, the following conclusions have been made:

1. One of the reasons for leakage of inclusions in spodumene is the transformation of the latter at the temperature range of 700-900°C. Cleavage microcracks are likely to occur in plates at temperatures over 300°C.

2. Another reason for leakage of inclusions in spodumene at high temperature is the high internal pressures that develop. From the results obtained, inclusions in spodumene seem to leak if trapped at 300-500°C and over, and pressure over 1500 atm.

3. It should be noted that this pressure is not the limiting pressure for the formation of spodumenes of rare metal granite pegmatites, and experimental data testify to high pressures for natural spodumene growth.

Thus, when studying inclusions in spodumene one should interpret carefully the results obtained by thermometry on natural samples. (Translation courtesy Dr. A.P. Berzina)

BAZAROVA, T.Yu., KAZARYAN, G.A. and KUZNETSOVA, I.K., 1978, Crystallization conditions of alkaline extrusives of South Armenia (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 110-111 (in Russian). First author at Novosibirsk.

1. Experiments were made on melt inclusion homogenization in phenocrysts of Tertiary extrusives of the phonolitic series, to ascertain temperature of crystallization of such rock-forming and accessory minerals as apatite, sphene, two clinopyroxenes (varying in composition), garnet, amphibole, biotite, sanidine and nosean. Temperature intervals of melt inclusion in these minerals are given in Table I.

2. Glass and crystalline inclusions from various stages in nosean-bearing syenite-porphyry were made by electron microanalyzer XA-5a. Dms included apatite, sanidine, nosean and pyroxenes.

3. The crystallization conditions of the same typical rock-forming minerals of the phonolitic series (extrusive analogues of nepheline syenites) and alkaline basaltoids (extrusive analogues of alkaline gabbroids) has been made (Table II).

Table I

Mineral	Th (°C)	Mineral	Th (°C)
Apatite	1150-1200	Pyroxene II	1030-1100
Sphene	1120-1150	Amphibole	750-950
Pyroxene I	1140-1240	Biotite	780-950
Garnet	930-1070	Sanidine	930-1050
(Marginal zones)		Nosean	930-1060

Table II (Comparison of minerals of phonolites and alkaline basalts)

Phonolites	Th (°C)	Alkaline Basalts	Th (°C)
Pyroxene II	1030-1100	Pyroxene	≥1200
Amphibole	750-950	Amphibole	1140
Biotite	780-950	Biotite	≥1200
Sanidine	930-1050	Potash feldspar	1220-1250
Nosean	930-1050	Nepheline	800-1080

In the inclusions of all minerals of the rocks of phonolite series a free liquid phase (not CO_2) is observed, while basaltoid inclusions in minerals do not have such liquid. Sodium feldspars are an exception, i.e., their inclusions always have a free liquid phase. A considerable amount of water in the melt (up to 10%) is likely to be the main reason for the crystallization temperature differences of the same minerals of similar in composition. (Translation courtesy Dr. A.P. Berzina).

BAZHEEV, see BAZHEYEV

BAZHEYEV, Ye.D., 1980, Evolution of hydrothermal solutions during formation of tungsten ore deposits (on the example of the Soktuy ore field): Geokhimiya, no. 10, p. 1461-1467 (in Russian, English abst.; translated in Geochem. Int'l., v. 17, no. 5, p. 114-119). Author at Geol. Inst. of Buryatian Div. of Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

Soktuy ore field in the central part of the Mesozic E. Transbaikalian area belongs to the Kukul'bey ore region of W, Sn and W-Sn deposits. Ores occur in greisen zones and quartz veins. Greisens consist of quartz, muscovite, siderophyllite and topaz; veins contain quartz, wolframite, pyrite, arsenopyrite, fluorite, muscovite, cassiterite and topaz. Topaz from greisens bears P inclusions filled by G+L+halite dm+anisotropic dm, Th >470°C, Te -59.0 to -58.3°C, Tm of last ice crystal -22.0°C, P >2200 atm, and S G+L inclusions with Th 368-137°C. Quartz from quartz-wolframite vein bears PS inclusions G+L+halite dm+anisotropic dm, Th 683-665°C, Te -24.5 to -23.8°C, Tm -19.2°C, P 2300 atm: PS G+L, Th 354-340°C, Te -23.8 to -23.2°C, Tm -2; P G+L, Th 327-320°C, Te -22.5°C, Tm -2.8°C; S G+L, Th 295-142°C, Te -21.8 to -18.5°C, Tm -0.7 to -0.2°C; P G+L, Th 160-150°C, Te -21.1°C, Tm -0.7°C. Main anions were halides (Cl>F). (Abstract by A.K.)

BEALES, F.W. and HARDY, J.L., 1980, Criteria for the recognition of diverse dolomite types with an emphasis on studies on host rocks for Mississippi Valley-type ore deposits: SEPM Special Publication No. 28, p. 197-213. First author at Univ. Toronto, Toronto, Canada M5S 1A1.

Dolomites are the favored host rocks for low-temperature lead/zinc ore deposits, probably because many dolomites have formed in evaporitic environments. Association with a local sulfur source probably enhanced the chances of ore formation. Reduction of sulfate in the presence of organic matter such as gas or oil is the most likely intermediate step. If so, the presence of sulfide ores in apparently sulfate-free dolomites may indicate a former sulfate abundance. Ore bodies are commonly associated with solution-collapse breccias, which are often attributed to evaporite solution. The nearly complete subsequent removal of the evaporites makes this difficult to prove, but in the large, breccia-hosted ore deposits of southeastern Missouri, the evidence is highly suggestive of former evaporitic conditions.

A majority of randomly selected host dolomites that we have examined contain minute solid inclusions of gypsum or anhydrite. These can be released by solution of the enclosing carbonate, and greatly enlarged recognizable crystal aggregates can be cultured from the insoluble residues. In the Lockport Dolomite of southern Ontario, gypsiferous vugs are common, and chloride ions are so abundant that serious corrosion problems arise when structural steel is encased in concrete produced from crushed-stone aggregate derived from this source. Fluid inclusions within sphalerite in Mississippi Valley-type ore deposits typically indicate ore precipitation from strongly hypersaline brines. Geological evidence supports the growth of white sparry dolomite gangue contemporaneously with such sphalerite. We conclude that most ancient dolomites were formed in association with evaporitic facies and/or hypersaline brines. (Authors' abstract)

BEALES, F.W., HARDY, J.L., ZENGER, D.H., DUNHAM, J.B. and ETHINGTON, R.L., 1980, Criteria for the recognition of diverse dolomite types with an emphasis on studies on host rocks for Mississippi Valley-type ore deposits: In Concepts and Models of Dolomitization, Special Publication - Society of Economic Paleontologists and Mineralogists No. 28, p. 197-213.

Indexed under Fluid Inclusions. (E.R.)

BEANE, Richard, 1980, The evolutionary nature of alteration, mineralization, and fluid characteristics in intrusion-related porphyry copper deposits of the southwestern United States (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 384.

Fluid inclusion and stable isotope data record a shift in characteristics of hydrothermal fluids responsible for formation of porphyry copper deposits of the southwestern United States. The change is marked initially by a sharp decline in fluid salinity which is provisionally considered to correspond to replacement of magmatic fluids by meteoric waters in the hydrothermal systems. The salinity break is accompanied by deletion of biotite from the developing orthoclase-biotite-iron oxide alteration. Subsequent assemblages consist of orthoclase-chlorite followed by quartz-sericite-pyrite. The entire paragenetic sequence evolves in the approximate temperature range 300-450°C where transport properties of fluids are optimized. Fluid inclusion studies reveal sulfide mineralization is tied chiefly to chemical changes in hydrothermal fluids having salinities ≤ 3m NaCl equiv. and temperatures in the range 300-400°C. The spatial association of hypogene mineralization with potassic alteration is not temporal, but instead correlates with replacement of early biotite by chlorite. The point at which overprinting of intrusion-defined potassic alteration by meteoric-water controlled by phyllic alteration ceases appears to be largely determined by the occurrence and intensity of late-stage fracturing which, if extensive, may lead to replacement or remobilization of original low-grade mineralization having relatively high chalcopyrite:pyrite ratios. (Author's abstract)

BEANE, Richard, REYNOLDS, T.J., BODNAR, Robert, PREECE, Richard and WALKER, Valerie, 1980, Temporal variations in fluid characteristics from some porphyry copper deposits of southern Arizona and New Mexico, USA (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 904.

Detailed fluid inclusion studies of four porphyry copper systems have revealed systematic changes in properties of hydrothermal solutions with time which can be paragenetically correlated with mineralization. Three solution types have been identified in and near the intrusive centers based on homogenization temperatures (T) and NaCl equivalent salinities (w) of fluid inclusions: 1) $T \geqslant 800^\circ C$, $w = 37\text{-}68$ wt %, 2) $T \simeq 200\text{-}550^\circ C$, $w = 32\text{-}65$ wt %, and 3) $T \simeq 250\text{-}400^\circ C$, $w = 3\text{-}15$ wt %. The distinction between high and low salinity fluids in a given deposit is usually clearcut with little evidence of transition between them. Within the intrusions and adjacent wallrocks, either two or three of the above classes of fluids are observed. Whenever a given class is present, so too are all later generations in the order given above, from early to late. In the overlying lithocap region, however, only the second and third fluid types are seen, and the saline variety is sequentially late. Based upon thermosaline characteristics and association with magmatic features, the first of the fluid types given is considered to be of igneous origin. Mineralization is always related to the last class of fluids, regardless of salinity, despite the fact that saline fluids characteristically carry on the order of 10,000 ppm copper. (Authors' abstract)

BEATY, D.W. and TAYLOR, Jr., H.P., 1980, The oxygen isotope geochemistry of the Kidd Creek mine: evidence for a high-$^{18}O/^{16}O$ ore-forming solution and implications regarding the genesis of volcanogenic massive sulfide deposits (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 384.

Whole-rock oxygen isotopic data from the Kidd Creek mine indicate a well-developed $^{18}O/^{16}O$ stratigraphic zonation. The mafic rocks overlying the massive, banded ore have $\delta^{18}O \approx +9$, similar to mafic volcanic rocks elsewhere in the Abitibi greenstone belt. Stratigraphically downwards from the banded ore (in rhyolite), $\delta^{18}O$ broadly increases from +11 to a maximum of about +15 (200' depth), and then decreases to about +13.5 (600' depth). The +13.5 to +15 portion of this profile suggests interaction with a single high-^{18}O fluid (+6 to +9) under a normal temperature gradient (300-350°C). The $\delta^{18}O$ reversal near the ore horizon requires additional complications, however. In detail, the altered rhyolite pile consists of high-^{18}O, chlorite-rich massive rhyolites enclosed within lower-^{18}O, sericite-rich fragmental rhyolites (oxygen isotopic disequilibrium and different alteration styles). Late-stage quartz veins cutting the altered zone are lighter (+12) than many of the rhyolites, again the reverse of the expected distribution. These observations suggest that hydrothermal alteration was accomplished by two different fluids, a deep-seated, high-^{18}O fluid, and normal-^{18}O seawater (0‰). The mixing of these two fluids appears to have been responsible for the precipitation of the ore.

The three most plausible origins for the high-^{18}O solution are: Seawater which has gained ^{18}O either through 1) evaporation or 2) exchange with high-^{18}O country rocks, or 3) metamorphic water. All of these origins are atypical for volcanogenic massive sulfide deposits, which generally form from recirculated seawater. This unusual origin may be responsible for Kidd Creek's unusual size, and the distinctive alteration style may provide a powerful exploration tool. (Author's abstract)

Note added in proof: the above is an incomplete duplicate of the following.

BEATY, D.W., TAYLOR, H.P., Jr., and COAD, P., 1980, The oxygen isotope geochemistry of the Kidd Creek mine: evidence for a high-^{18}O ore-forming solution and implications regarding the genesis of volcanogenic massive sulfide deposits (Abst.): Geol. Soc. Amer. Abstracts and Programs, v. 12, p. 384.

Whole-rock oxygen isotopic data from the Kidd Creek mine indicate a well-developed ^{18}O/^{16}O stratigraphic zonation. The mafic rocks overlying the massive, banded ore have $\delta^{18}O \approx +9$, similar to mafic volcanic rocks elsewhere in the Abitibi greenstone belt. Stratigraphically downwards from the banded ore (in rhyolite), δ^{18}O broadly increases from +11 to a maximum of about +15 (200' depth), and then decreases to about +13.5 (600' depth). The +13.5 to +15 portion of this profile suggests interaction with a single high-^{18}O fluid (+6 to +9) under a normal temperature gradient (300-350°C). The δ^{18}O reversal near the ore horizon requires additional complications, however. In detail, the altered rhyolite pile consists of high-^{18}O, chlorite-rich massive rhyolites enclosed within lower-^{18}O, sericite-rich fragmental rhyolites (oxygen isotopic disequilibrium and different alteration styles). Late-stage quartz veins cutting the altered zone are lighter (+12) than many of the rhyolites, again the reverse of the expected distribution. These observations suggest that hydrothermal altertion was accomplished by two different fluids, a deep-seated, high-^{18}O fluid, and normal-^{18}O seawater (0‰). The mixing of these two fluids appears to have been responsible for the precipitation of the ore.

The three most plausible origins for the high-^{18}O solution are: Seawater which has gained ^{18}O either through 1) evaporation, or 2) exchange with high-^{18}O country rocks, or 3) metamorphic water. All of these origins are atypical for volcanogenic massive sulfide deposits, which generally form from recirculated seawater. This unusual origin may be responsible for Kidd Creek's unusual size, and the distinctive alteration style may provide a powerful exploration tool. (Authors' abstract)

BECKER, R.H., 1980, Light elements in Lunar soils revisited - carbon, nitrogen, hydrogen and helium: Proc. Eleventh Lunar Sci. Conf., p. 1743-1762.

BELEVTSEV, Y.N., ZHUKOV, F.I., GNATENKO, O.V. and SAVCHENKO, L.T., 1980, Sources of ore materials in the formation of metamorphic uranium deposits from isotope and geochemical data: Geol. Zh., v. 40, no. 3, p. 55-64 (in Russian).

Indexed under inclusions. (E.R.)

BELIK, D.M. and ANUFRIYEV, Yu.N., 1978, Temperature and geochemical zoning of a group of rock crystal deposits of the Ural; gas-liquid inclusion data, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 151-152 (in Russian). Authors at VNIISIMS, Alexandrov, USSR.

Three fields of rock-crystal deposits: Smezhnoe, Yuzhnoe and Akzharskoe, occurring respectively 2, 6 and 11 km from Adamovskiy gneiss-granite massif were studied. With increasing distance from the massif, G content in inclusions decreases from 20-25 to 10-15 vol. %, LCO_2 disappears and Th decreases from 280 to 195°C. Na content in inclusions in vein quartz (in %-equiv.) changes from 39 for Smezhnoe, 50 for Yuzhnoe and 54 for Akzharskoe; similarly Mg 1.55, 1.98 and 4.59; Ca - 55, 44 and 38; Cl - 34, 44 and 57; SO_4 28, 10 and 5; in rock crystals Na content is 21 for Smezhnoe and 68 for Akzharskoe; similarly, Ca is 60 and 16, Cl 25 and 53, and SO_4 57 and 18. Also above features vary in quartz varieties in individual fields. (From the authors' abstract translated by A.K.)

BELOZEROV, N.I., RODIONOVA, L.N. and YUROCHKIN, Yu.D., 1978, Certain peculiarities of gold ore mineralization of the Un'ya-Bom region (Priamur'ye) (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 203-204 (in Russian). Authors at Far-East Inst. of Mineral Raw Materials, Khabarovsk, USSR.

Quartz veins and veinlets form the zone which is investigated over the vertical interval of 600 m. Ores formed at Th 290-390°C, changing from 290-330°C in the deep levels to 350-390°C in the upper levels. (A.K.)

BENCINI, A. and DUCHI, V., 1980, Geochemical study of some waters from Porretta Terme, Bologna, Italy: Atti Soc. Tosc. Sci. Nat. Mem. (A), v. 87, p. 365-374 (in Italian). Authors at Istituto di Mineral. Petrografia e Geochimica, Univ. di Firenze, Italy.

Na-K-Ca geothermometer was applied to these waters, but it was unable to furnish reliable information about the temperature of the reservoir, as shown by several authors for waters which undergo mixing with a superficial component. (From the authors' abstract)

BENNETT, J.N. and GRANT, J.N., 1980, Analysis of fluid inclusions using a pulsed laser microprobe: Min. Mag., v. 43, p. 945-947.

Qualitative data (three categories of concentration) obtained on inclusions from four localities. Fe, Mn, B, Al, Ca, Ti, Cu, and Sn reported. (E.R.)

BENY, C., PREVOSTEAU, J.M. and DELHAYE, M., 1980, Applications of the Mole microprobe in the earth sciences: Actual. Chim., 1980, no. 4, p. 41-43 (in French).

BERDNIKOV, N.V., KOSYGIN, Yu.A. and LAPKOVSKIY, V.V., 1980, Composition of fluids in minerals of metaplutonic and other metaigneous rocks of the Soviet Far East, as related to the problem of the origin of oil: Dokl. Akad. Nauk SSSR, v. 254, no. 4, p. 953-956 (in Russian; translated in Doklady Acad. Sci., Earth Sci. Sect., v. 254, 1980, p. 101-103 (1982). Authors at Instit. Tect. & Geophy., Far Eastern Sci. Center, USSR Acad.

Sci., Khabarovsk, USSR.

A study of CO_2 inclusions in metamorphic rocks shows that CH_4 contents increased with increasing depth and increasing metamorphic grade, suggesting a flow of reduced gases from deep. (E.R.)

BERZINA, A.P., SOTNIKOV, V.I. and SHUGUROVA, N.A., 1980, Gases in mineral-forming process at the copper-molybdenum deposits, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Fair East Sci. Center of Acad. Sci. USSR, p. 70-75 (in Russian).

On the basis of results of gas analysis of one- and two-phase inclusions in zircons and apatites from granitoids and metasomatites, the evolution of gas components is considered in late-magmatic and early post-magmatic processes. Relations between volatile components are determined by character of the source and degassing phenomena during endogene process. Degassing caused the loss of hardly soluble components and diminished their role in the early high-temperature solutions. During T decrease usually the role of CO_2 and N_2 + rare gases increased. (Authors' abstract translated by A.K.)

BESPALOV, V.Ya., KOKORIN, A.M., KOROSTELYOV, P.G. and SEMENYAK, B.I., 1980, Geologic-structural conditons of localization of tin ores, main composition and genesis of the deposit Blizhneye (Priamur'ye), p. 17-34 in: Structure, composition and genesis of tin-ore deposits of the Far East, publ. by Far-East Sci. Center, Vladivostok, 136 pp., 500 copies printed, price 1 rbl. 25 kopecks (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

The deposit Blizhneye in the Badzhal'skiy ore region, Khingano-Badzhal'skaya volcanic zone consists of veins and ore zones of the greisen type, formed from pneumatolytic-hydrothermal fluids. Th of inclusions in quartz from the ore zone Yubileynaya are 470-400°C (inclusions with halite), 465-450°C (in G) and 420-175°C (in L), in quartz veinlets in tourmalinites 440-400 (in G) and 450-160°C (in L), in cassiterite 450-370°C. Vein quartz from ore zone Liparitovaya yielded Th 470-400°C (in G) and 400-260°C (in L), quartz paragenetic with chlorite and cassiterite from ore zone Akkordnaya 435-390°C (P incs., in G or L) and 365-110°C (s incs., in L). (Abstract by A.K.)

BETHKE, P.M., 1980, The Creede mining district, Colorado: studies of the evolution of a hydrothermal system (Abst.): EOS, v. 61, p. 1145-1146.

Studies of the 26.4 m.y.-old Creede silver/base-metal ores, which were deposited along the top of a fault-controlled convecting hydrothermal system, allow estimates of time constraints and therefore complement studies of active geothermal systems. The ore-forming system was one of the latest of several distinct hydrothermal systems related to the central San Juan caldera complex. It postdated the latest known volcanic event in the district by 1-2 m.y. Fluid-inclusion studies indicate that temperatures along the top of the system fluctuated between 190° and 280°C and salinities between 4 and 12 wt.% NaCl equivalent and that they are correlated positively. At times, the fluids boiled along the top of the system, about 500 m below the water table. The isotopic compositions of fluids in equilibrium with sphalerite, quartz, and carbonate minerals are substantially different from one another, implying that each mineral precipitated from fluids of diverse origin: the carbonate minerals from deep (magmatic?) fluids, and quartz and sphalerite each from fluids dominated by meteoric waters, but from different reservoirs. As the minerals alternate in the paragenesis, the fluids must have occupied the ore zone alternately and episodically. Estimates of the maximum rate of fluid flow, based on the size of hematite flakes settled on paleogrowth surfaces in sphalerite, suggest times on the order of 1 year for a complete convective cycle, and the interpretation of rhythmic banding in sphalerite as resulting from such overturn leads to an estimate of $10^{3.3 \pm 0.8}$ years for the duration of ore deposition. Emplacement of all small stock beneath the district has been postulated as the event which initiated and then maintained the convecting system. However, an alternative hypothesis based on an abnormally high regional thermal gradient and extensional faulting related to emplacement of the San Juan batholith but not requiring a specific, late intrusion should also be considered. (Author's abstract)

BIZOUARD, H. and METRICH, N., 1980, Chlorine and fluorine in some intracrystalline inclusions and glassy matrix (abst.): Internat. Mineralog. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 126 (in French; translation courtesy of R. Clocchiatti).

Systematic determination of both fluorine and chlorine by electron microprobe were undertaken on intracrystalline silicate melt (glassy inclusions) of rhyolitic and tephritic composition. These samples were metallized with nickel. A natural scapolite (Cl=1.57%) and synthetic MgF_2 were used as analysis standards. Results were corrected according to the ZAF method of Ruste (1979). Determination of chlorine presented no analytical difficulty. Such was not the case however for the determination of fluorine, for the F k ray is greatly absorbed, particularly by elements like Ca and K, which induces very large correction factors. However, fluorine measured by microprobe on samples (1R50=603 ppm, 1R52=1408 ppm) is comparable to results obtained on the same samples by atomic absorbtion (1R50=490 to 525 ppm, 1R52=1370 to 1450 ppm).

Measures made on different silicate melts are given in the following table:

	F (ppm)	Cl (ppm)	F/Cl	
Pantellerite (Ethiopia)				
RV 313	3313	2200	1.5	Melt inclusion
" IR 52c	8100	4750	1.71	Matrix
Comendite (Sardinia)	3200	3900	.83	Melt inclusion
Alkal. Rhyolite (Ethiopia)	600	870	.69	Matrix
Tephrite (Vesuvius)	3000	2360	1.27	Melt inclusion

Primary results indicate that hyperalkaline and tephritic melts are greatly enriched in chlorine and fluorine with respect to melts of alkaline rhyolitic composition.

This method is to be extended to the systematic study of melt inclusions (original magma) and matrix (residual melt) of a same rock in order to qualify the volume of gas emitted during an eruption. (Authors' abstract)

BLOUNT, Charles W., WENGER, Lloyd M., TARULLO, Michael and PRICE, Leigh C., 1980, Methane solubility in aqueous NaCl solutions at elevated temperatures and pressures (Abst.): Geol. Soc. Amer. Abstracts with Programs,

v. 12, p. 267.

The solubility of methane has been experimentally measured at temperatures from 100 to 240°C, pressures from 2,000 to 22,500 psi, in water and aqueous NaCl solutions ranging from 0.3 to 25 weight percent. The solubility of methane shows a regular and systematic relationship toward variations in pressure, temperature and NaCl concentration. Increasing pressure and increasing temperature both result in an increase in the solubility of methane. Increasing the NaCl concentration at constant temperature (T) and pressure (P) markedly lowers the solubility of methane. The relationship between logarithms of methane saturation concentrations and temperature, pressure and salinity is generally simple. An empirical equation was derived from the solubility data using a computer and a regression method of analysis. The empirical equation obtained was as follows:

$$\log_e CH_4 = 3.6003 + 1.1176E\text{-}03\ T \log_e P + 0.10002\ X - 0.01634\ T + 1.6574E\text{-}05\ T^2 - 0.2828E\text{-}03\ T\ X - 0.01124\ X \log_e P + 2.1262E\text{-}05\ X\ T \log_e P.$$

Methane (CH_4) is in Standard Cubic Feet per petroleum barrel (SCF/bbl), Temperature (T) is in degrees Kelvin, Pressure (P) is in psi, and NaCl concentration (X) is in weight percent. The standard deviation of this equation is about ±6% of the value. In water, methane solubilities range from a low of 19.7 SCF/bbl at 100°C, 2,000 psi to a high of 205.8 SCF/bbl at 240°C, 22,500 psi. In a 25% NaCl solution, solubilities ranged between 9.16 to 61.37 SCF/bbl at the same respective experimental conditions. (Authors' abstract)

BOCTOR, N.Z. and FRANTZ, J.D., 1980, Mineral-solution equilibria in the system Mn_3O_4-H_2-H_2O-HCl: Carnegie Inst. of Washington Yearbook 79, for 1979-80, p. 345-347.

BOCTOR, N.Z., POPP, R.K. and FRANTZ, J.D., 1980, Mineral-solution equilibria - IV. Solubilities and the thermodynamic properties of $FeCl_2^0$ in the system Fe_2O_3-H_2-H_2O-HCl: Geochim. Cosmo. Acta, v. 44, p. 1509-1518. Authors at Geophysical Lab., Carnegie Inst. Wash., Wash., DC 20008.

The solubility of hematite in chloride-bearing hydrothermal fluids was determined in the temperature range 400-600°C and at 1000 and 2000 bars using double-capsule, rapid-quench hydrothermal techniques and a modification of the Ag + AgCl buffer method (Frantz and Popp, 1979). The changes in the molalities of associated hydrogen chloride (m_{HCl^0}) as a function of the molality of total iron in the fluid at constant temperature and pressure were used to identify the predominant species of iron in the hydrothermal fluid. The molality of associated HCl varied from 0.01 to 0.15. Associated $FeCl_2^0$ was found to be the most abundant species in equilibrium with hematite. Determination of Cl/Fe in the fluid in equilibrium with hematite yields values approximately equal to 2.0 suggesting that ferrous iron is the dominant oxidation state.

The equilibrium constant fo the reaction

$$Fe_2O_3 + 4HCl^0 + H_2 = 2FeCl_2^0 + 3H_2O$$

was calculated and used to estimate the difference in Gibbs free energy between $FeCl_2^0$ and HCl^0 in the temperature range 400-600°C at 1000 and 2000 bars pressure. (Authors' abstract)

BODNAR, R.J. and BEANE, R.E., 1980, Temporal and spatial variations in hydrothermal fluid characteristics during vein filling in preore cover overlying deeply buried porphyry copper-type mineralization at Red Mountain, Arizona: Econ. Geology, v. 75, no. 6, p. 876-893. First author at U.S. Geol. Survey, MS-959, National Center, Reston, VA 22092.

Alteration and lithologic characteristics suggest that Red Mountain, Arizona, represents the upper level lithocap region of a porphyry copper system, and this interpretation is reinforced by recent disclosure of deeply buried porphyry copper-type mineralization at this locality. Heating/freezing tests on 1,131 fluid inclusions in sulfide-bearing quartz veins from drill core samples and surface outcrops indicate that two fluids, distinctly different in their physicochemical properties, attended alteration-mineralization at Red Mountain. The early fluids had salinities of 10±5 equiv. wt percent NaCl and boiled at ~375°-425°C. Based on these inclusions, a geothermal gradient of ~25°C/km and pressures of 275±75 bars prevailed during this early stage of vein filling. With passing time, boiling ceased and the fluids cooled to ~300°C. A later fluid with temperatures of ~375°-250°C and salinities of ~30-50 equiv. wt percent NaCl was responsible for deposition of chalcopyrite. Atomic K/Na ratios of these later hydrothermal fluids, as determined from sylvite and halite dissolution temperatures, ranged from 0.52 to 1.76. The time-temperature-salinity relationships observed from fluid inclusion studies at Red Mountain are consistent with those predicted for similar geologic environments by numerical simulation and suggest that the earliest vein-filling fluids at Red Mountain had sources in the nearby volcanic wall rock and that later, higher salinity fluids originated in more distant wall rocks or in an as yet unseen intrusion at depth. (Authors' abstract)

BODNAR, R.J. and BETHKE, P.M., 1980, Systematics of "stretching" of fluid inclusions as a result of overheating (Abst.): EOS, v. 61, p. 393.

In 1973, Larson, Miller, Nadeau, and Roedder showed qualitatively that homogenization temperatures of fluid inclusions in fluorite and sphalerite may be subject to errors if overheated by an unknown amount. This error is due to an apparently permanent, non-elastic deformation of the walls of fluid inclusions in response to the increase in internal pressure of the inclusion as the temperature is raised above the homogenization temperature. In the present study, more than 1300 measurements on fluid inclusions in fluorite and sphalerite indicate that this increase in volume, or "stretching," proceeds in a systematic and somewhat predictable manner. The amount of overheating necessary to initiate stretching depends on the PVT-properties of the inclusion fluid, inclusion size, and physical properties of the host mineral. The data show that the internal pressure necessary to initiate stretching of inclusions in fluorite is inversely related to inclusion volume. Once begun, the amount of stretching (ΔT_H) as a function of the amount of overheating (ΔT_{OH}) is constant at $\Delta T_H/\Delta T_{OH} = 0.5$. Sphalerite is more resistant to stretching than fluorite and the data are less systematic. The results of this study show that the measured homogenization temperature of a fluid inclusion may be considerably higher than the "true" homogenization temperature if the inclusion has been overheated, either accidentally in the laboratory or naturally by later thermal events. Furthermore, criteria commonly used as evidence that a fluid inclusion has not leaked are invalid for the inclusions examined in this study. However, the systematic relationship between the internal pressure necessary to initiate stretching and inclusion volume provides a means of recognizing previously stretched inclusions and estimating the magnitude of post-entrapment thermal events. (Authors' abstract)

BOETTCHER, A .L, ROBERTSON, J.K. and WYLLIE, P.J., 1980, Studies in synthetic carbonatite systems: Solidus relationships for $CaO-MgO-CO_2-H_2O$ to 40 kbar and $CaO-MgO-SiO_2-CO_2-H_2O$ to 10 kbar: J. Geophys. Res., v. 85, B12, 1980, p. 6937.

BOGATIKOV, O.A., FRIKH-KHAR, D.I., ASHIKHMINA, N.A., DIKOV, Yu.P., LAZ'KO, Ye.Ye. and SVESHNIKOVA, Ye.V., 1980, Role of volatiles in formation of the lunar rocks: Zapiski Vses. Min. Obshch., v. 109, no. 1, p. 30-36 (in Russian). Authors at Inst. Geol. of Ore Deposits, Petrography, Mineralogy and Geochemistry of Acad. Sci. of USSR, Moscow.

The paper presents mainly collected literature data on H_2O, S, NaCl, KCl, etc. in lunar rocks, pertinent to fluid inclusion studies. (A.K.)

BOGDANOV, Bogdan, BOGDANOVA, Rajna and KRASTEVA, Margarita, 1980, Temperatures of formation of the Asarel porphyry copper deposit: Ore Forming Processes and Mineral Deposits (Bulgaria), v. 12, p. 44-52 (in Russian with English abstract).

The paper presents a study of the Th of fluid inclusions in quartz from the mineral paragenetic associations in the Asarel porphyry copper deposit, Central Sredna Gora region.

The following temperature intervals are measured: 213-193°C for the pre-ore secondary quartzites and quartz-feldspar veinlets, 311-293°C for the quartz-pyrite-chalcopyrite paragenesis which is the main ore paragenesis, 230-215°C for the quartz-sphalerite-galena paragenesis, and 173-152°C for the quartz-pyrite (vein) paragenesis. Tt decreased from the earlier towards the later paragenesis. The pre-ore alterations of wallrocks took place at lower temperatures (230-193°C) than the deposition of copper mineralization (311-293°C).

On the basis of the temperature conditions of mineral formation during the pre-ore and ore stages, the Asarel deposit can be referred to the hydrothermal medium-temperature deposits showing transitions towards high- and low-temperature conditions at the beginning and the end of ore deposition during the ore stage. (Authors' abstract)

BOGOCH, R. and MAGARITZ, M., 1980, Evidence for immiscible carbonate-silicate liquid in diabase dykes from the Sinai Peninsula (Abst.): EOS, v. 61, p. 1155.

BOGUSH, I.A., TRUFANOV, V.N. and KULIKOV, V.A., 1980, Conditions for the formation of the stockwork zone of the Khudesskoe chalcopyrite deposit of the northern Caucasus: Dokl. Akad. Nauk SSSR, v. 255, no. 6, p. 1463-1467 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

BONDAREV, V.B., PORSHNEV, N.V. and NENAROKOV, F.D., 1980, Chromatographic analysis of the gas and steam discharge in the thermal fields of Kamchatka: Dokl. Akad. Nauk SSSR, v. 253, no. 5, p. 1204-1207 (in Russian, translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 233-235 (1982). Authors at Instit. Space Res., USSR Acad. Sci., Moscow, USSR.

Analyses presented for (O_2+Ar), N_2, CO_2, CH_4, C_2H_6, C_3H_8, and three higher hydrocarbons, from three fields. The ranges for major components (%) are: N_2 6-18, CO_2 72-93, CH_4 0.1-15. (E.R.)

BONEV, Ivan, 1980, Crystal morphology of galena from the Central Rhodopes lead-zinc ore deposits. I. Growth forms: Geol. Balc., 1980, no. 1, p. 33-56 (English abst.).

The habit is influenced by anisotrophy of the ore-forming medium and by boiling of the medium. (E.R.)

BONI, C., BONO, P., CALDERONI, G., LOMBARDI, S. and TURI, B., 1980, Hydrogeological and geochemical study of the relationships between karst and hydrothermal circulation in the Pontina Plain, southern Latium: Geol. Appl. Idrogeol., v. 15, p. 204-230. Authors at the Instituto di Geologia e Paleontologia, Universita di Roma, Italy.

The waters of this shallow circuit are believed to undergo mixing processes with thermal waters circulating through the network of fractures existing at depth in the Graben and in the sedimentary units of the "Sabine facies." These latter waters are rich in alkali chlorides, strontium, fluoride and appear to be nearly saturated with respect to calcium sulfate. $^{18}O/^{16}O$ and D/H analyses clearly indicate that the waters of this circuit are of meteoric origin; their residence times, on the basis of the tritium contents, are higher than about 30 years. Geothermometric investigations* indicate, at depth, temperatures ranging from 180° to 200°C, distinctly higher than those observed when the waters of the hydrothermal circuit reaches the surface. (From the authors' abstract)
(*Note by P. Lattanzi: "geothermometric investigations" refer to applications of Na-K and Na-K-Ca geothermometers. Silica geothermometer gave unreliable results.)

BORSHCHEVSKIY, Yu.A. and POKALOV, V.T., 1978, Oxygen isotope composition of quartz as an indicator of origin and phase evolution of ore mineralization: Sovetskaya Geologiya, 1978, no. 7, p. 144-147 (in Russian; translated in Internat. Geol. Rev., v. 21, no. 7, p. 790-794, 1979). Authors at Leningrad Pedagogical Inst. USSR Acad. Sci. and All-Union Instit. Mineral Raw-Materials (VIMS).

The oxygen isotope composition of vein quartz may be used as an index of the origin of the hydrothermal solutions and as a possible criterion for recognizing phases of the ore process in molybdenum and copper-molybdenum deposits. (Authors' abstract)

(See also Geochem. Int'l., v. 17, no. 6, 1980, p. 40-50.)

BOUCHER, M., BOULANGER, D., SAINTIVES, J.P. and KUNTZ, P., 1980, Lacunae and inclusions in the halite from Valence and Bresse saliferous basins, in Symposium on Salt 5, v. 1, p. 21-30.

BOWMAN, J.R., ESSENE, E.J. and O'NEIL, J.R., 1980, Origins and evolution of metamorphic fluids in dolomitic marbles, Elkhorn, Montana (abst.): EOS, Trans. Am. Geop. Union, v. 61, p. 391.

Applications of phase equilibria and calcite-dolomite thermometry to metamorphosed siliceous dolomites in the Black Butte stock aureole define a prograde T-$X(CO_2)$ path from T = 425 ± 30°C, $.6 < X(CO_2) < .8$ (tremolite isograd) to T = 590 ± 25°C, $.03 < X(CO_2) < .1$ (periclase isograd). This decrease in $X(CO_2)$ is inconsistent with internal buffering of pore fluid composition by isogradic reactions and requires influx of water-rich fluids. Mass-balance calculations of external H_2O and carbon, hydrogen, and oxygen isotope analyses of calcite and hydrous silicates constrain the amounts and origins of this external H_2O: 80 to 210 moles $H_2O/10^3$ cm^3 marbles: $\delta^{18}O$ (calcite) = +21.0 to +23.7; $\delta^{13}C$ (calcite) = 3.8 to -1.2; δD (amphibole) = -97 to -72. Mass-transfer estimates are based on changes in measured mineral modes, reaction stoichiometries, and estimates of the mass and $X(CO_2)$ of pore fluids initially present. No systematic decrease in either $\delta^{18}O$ or $\delta^{13}C$ accompanies the increase in metamorphic grade (T) or increasing calcite abundance (extent of reaction). These features suggest that devolatilization reactions did not simply involve systematic removal of ^{18}O or ^{13}C by progressive evolution of CO_2-dominated fluids. Masses of external H_2O estimated to reduce $X(CO_2)$ are sufficiently great that substantial decreases in both $\delta^{18}O$ and δD would result in the marbles if these external fluids were relatively unaltered meteoric or magmatic H_2O ($\delta^{18}O$ only). Rather both petrologic and isotopic data suggest that the mineralogic and isotope characteristics of the marble have been significantly influenced by interaction with ^{18}O- and H_2O-rich metamorphic fluids from surrounding nearly pure dolomitic marble. (Authors' abstract)

BOYADZHAN, M.T., 1980, Structure and formation conditions of skarns in the Razdan contact-metasomatic iron deposit (Armenian SSR): Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 5, p. 50-57 (in Russian). Author at the Moscow State Univ., Moscow, USSR.

The contact rocks developed between volcanogenic-sedimentary rocks and gabbro-diorites. Skarns formed in two stages: pyroxene-garnet and pyroxene-epidote, both associated with magnetite formation. Usually garnet content > pyroxene (diopside + 18-24% of hedenbergite molecule, garnet is 40-65% andradite molecule, generally very variable in composition). A total of 26 determinations of Td of garnet were made: garnets from lateral parts of skarn zone decrepitate at 640-700°C, from central part at 580-640°C. (Abstract by A.K.)

BOYARKIN, A.P. and POLYANIN, V.A., 1978, Thermobarogeochemical conditions of formation of carbonate rocks and ores of the Bakalo-Satkin region (Southern Urals), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 168-169 (in Russian). First author at Geol. Inst. of Bashkirian Division of Acad. Sci. of USSR, Ufa, USSR.

Stretching of inclusions causes systematic error (increase) in Th (of as much as) 100° to 400°C in carbonates. Rocks and ores recrystallized at $T \leq 150°C$, P of gas phase in equilibrium with solution ≤5 atm. (A.K.)

BOYD, F.R. and MEYER, H.O.A., eds., 1979, Proceedings of the Second International Kimberlite Conference, v. 1, Kimberlites, diatremes, and diamonds: Their geology, petrology, and geochemistry, 399 pp, and v. 2, The mantle sample: Inclusions in kimberlites and other volcanics, 423 pp.

BOYKO, S.M., 1978, Peculiarities of composition of gas-liquid inclusions in minerals in the deposits of Eastern Transbaikalia (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 110-111 (in Russian). Author at Inst. Geochem. of Siberian Branch of Acad. Sci. USSR, Irkutsk.

Studies of fluid composition in inclusions in ore-bearing quartz revealed high concentrations of Na and HCO_3 for Au deposits, high Cl and Na and very low Li and Rb for Mo deposits, high F, K, Li and Rb for Sn and W deposits, high Na, Cl and HCO_3 for Zn-Pb deposits. (A.K.)

BRADY, John D. and FRANTZ, John D., 1980, A microanalytical technique for determination of aluminum in aqueous solutions : Am. Mineral., v. 65, p. 1249-1251. Authors at Geoph. Lab., Carnegie Inst. of Washington, Washington, DC 20008.

A flow-cell colorimetric technique has been developed by which Al concentrations of 0.0003 to 0.1 wt. percent can be analyzed in one-microliter fluid samples. An Al-complexing reagent (Ferron) continuously flowing through teflon capillary tubing is spiked with one-microliter aliquots of solutions containing Al. The sample reacts with the reagent and subsequently passes through a microcolorimeter. Measurement of less than one nanomole Al is possible by comparing the integrated absorbance of unknown samples with standard solutions. (Authors' abstract)

BRAGINA, G.I. and ANFILOGOV, V.N., 1980, Phase relations and exsolution in the system Na_2O-Al_2O_3-SiO_2-NaF: Geokhimiya, no. 9, p. 1402-1407 (in Russian). Authors at Inst. of Geol. and Geochem. of Urals Sci. Center of Acad. Sci. USSR, Sverdlovsk, USSR.

Pertinent to studies of immiscibility in melt inclusions. (A.K.)

BRASS, G.W., 1980, Stability of brines on Mars: Icarus, v. 42, p. 20-28. Author at Rosenstiel Sch. of Marine and Atmospheric Sci., Univ. of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149.

The detection of high chlorine and sulfate abundances and duricrusts on Mars strongly suggests the occasional presence of brines on the Martian surface. Ternary phase diagrams for the likely chloride and sulfate brines indicate that the minimum temperature at which a brine can be stable is near 210 K with a water concentration of approximately 70 wt% and a high concentration of calcium chloride. The dominance of sulfate over chlorine in the Martian regolith suggests precipitation of salts at temperatures higher than the minimum. (Author's abstract)

Includes data on binary and ternary eutectics and other invariant points for many systems of interest to low-temperature inclusion studies. (E.R.)

BRAY, C.J., 1980, Mineralization, greisenization and kaolinization at Goonbarrow china clay pit, Cornwall, U.K.: Doctoral dissertation, Univ. Oxford.

Goonbarrow, a China Clay pit situated within the St. Austell granite China Clay region and on the site of two nineteenth century tin mines, is the subject of a varied geochemical and isotopic study to determine the mode of genesis of the tin, tungsten and kaolinite.

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 - a biotite-muscovite and a lithionite granite. Situated at this junction is an unusual assymmetric curved-feldspar-crystal pegmatite. The direction of growth and branching of feldspars show that it developed on a hanging wall of biotite-muscovite granite and was followed by crystallization of lithionite granite. Elvans at Goonbarrow, Gunheath, Melbur and Dorothy China Clay pits, within the St. Austell granite, are shown from petrographic studies to be intruded during hydrothermal activity and, at the first three locations, after some major vein formation - unlike other areas of Cornwall. Three main types of vein were recognized in Goonbarrow (1) quartz/tourmaline ± cassiterite/wolframite veins with greisen borders, spatially associated with zones of intensely kaolinized granite, (2) multimineral veins (fluorite, topaz, apatite, lollingite, arsenopyrite, wolframite), with no greisen borders and not associated with kaolinization zones, (3) barren quartz veins with no greisen borders.

A potassium/argon age study showed that the granites, pegmatite and greisens (and therefore the associated tin/tungsten mineralization) were formed at about 280 ± 10 m.y. Previous U-Pb dates for Cornish mineralization, producing ages between 50 and 290 m.y., were reinterpretated using more modern graphical techniques to give an age of 290 m.y. The elvans at Goonbarrow, Gunheath, Melbur and Dorothy were dated at around 272 m.y. and are in excellent agreement with conventional rubidium-strontium dates on unkaloinized Cornish elvans. In this case the elvan dates place further constraints on the date of tin/tungsten mineralization since they crosscut these veins. It is considered on mineralogical and textural grounds that the elvans were intruded during hydrothermal activity, and that the major kaolinization event occurred between 301 m.y. (the Rb/Sr intrusion date of the St. Austell granite) and 272 m.y. Fine grained muscovite from kaolinized granite, produced predominantly during kaolinization, and a combined sample of several kaolinized potassium feldspars (a mixture of sericite and kaolinite) also gave Hercynian ages. All these results indicate that kaolinization at Goonborrow is of Hercynian age.

A novel adaptation of scanning electron microscopy was utilized to determine the composition of daughter minerals in fluid inclusions from vein, greisen and granite quartz from Goonborrow. This 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. This suggests that the chalcophile elements were deposited in rock above the present land surface which has since been eroded away and is in agreement with classical Cornish mineralization theories.

The fluid inclusion study can be summarized as follows:

1. Boiling was much more intense in kaolinized granite than unkaolinized granite.
2. All veins and greisens were formed from boiling fluids.
3. Quartz/tourmaline and multimineral veins formed at between 140°

and 440°C and salinities of 6-40 wt % NaCl.

4. Cassiterite veins formed from similar fluids to the quartz/tourmaline - multimineral veins i.e., 8-42 wt % NaCl and from temperature of 140°-480°.

5. The wolframite veins are distinct from other veins in the pit being formed within a very close temperature range 220°-300°C but still from a wide range in salinity, 12-40 wt %.

6. Inclusions within the elvan were probably a secondary origin, chemically much simpler than the vein fluids, of about 22 wt % NaCl, were not boiling and were trapped at between 360° and 440°C.

7. Barren quartz veins contained no fluid inclusions.

The presence of boiling inclusion assemblages enabled the calculation of pressure and therefore depth at time of intrusion. The quartz/tourmaline ± cassiterite/wolframite veins were shown to have been intruded at 450°C, 450 bars (1.7 km depth) and 10 wt % NaCl equivalent, and by boiling and irreversible adiabatic expansion to have cooled to 200°C and increased their salinity to 40 wt % NaCl equivalent. The elvan was formed at a minimum of 250 bars pressure. The quartz/tungsten veins were formed at about the same depth as the elvan and around 300°C, and were probably intruded after the elvan.

The hydrogen isotopic compositions of fluid inclusion waters, released by decrepitation at about 500°C, for vein quartz vary between δD = -30 and +4‰, although the oxygen isotopic compositions of the mineral vein quartz have a very restricted range ($\delta^{18}O$ = +13.2 to +13.9‰). The δD values for greisen muscovites associated with these veins range from -57 to -62‰ and are much more negative than values obtained by other workers for Cornish alteration micas.

Reinterpretation of previous work coupled with this new data on the hydrogen/oxygen isotopic compositions of vein fluids and greisens produced a new model for kaolinite genesis which was in excellent agreement with the fluid inclusion study. This involved the intrusion of boiling hydrothermal fluids, which cooled, concentrated NaCl and produced the large hydrogen isotopic fractionation. The vapor phase of the boiling fluids was considered to have deeply penetrated the granite altering it to the large areas of kaolinized granite found today. The hydrogen isotopes indicate that the veins were produced from the liquid fraction and the greisens from an early fraction of the boiling fluid.

Previous work in favor of a hydrothermal or weathering origin for the genesis of Cornish China Clay is discussed in the light of this new data. Data previously considered in favor of a weathering origin is able to be reinterpretated in favor of the alternative view. In conclusion a hydrothermal origin is favored for Cornish China Clay genesis which is intimately associated in this area with tin/tungsten mineralization of Hercynian age. (Author's abstract)

BRIL, Hubert, 1980, First thermometric results on the metallogenesis of the polymetallic district of Brioude-Massiac (Massif Central francais) (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 913 (in French).

The temperatures of mineralization, in °C, (presumably from fluid inclusion determinations) are: wolframite, >400; arsenopyrite, 350-380; and stibnite, 350-270. Boiling occurred at about 3 km depth. Some of the fluids contained 20% equiv. NaCl. (E.R.)

BROWN, Philip E. and BOWMAN, John R., 1980, Origin and evolution of tungsten skarn-forming fluids at Pine Creek, California-stable isotopic evidence (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 393-394.

Traditionally, Sn-W deposits are considerd to form at relatively deep levels in the upper crust, associated with S-type intrusives. Stable isotopic data for carbonates and silicates across the zoned Pine Creek, California, tungsten mine place constraints on the magmatic and fluid sources as well as fluid/rock interactions during the formation of the skarn. C and O stable isotope data for calcites from the marble, calcsilicate and garnet-pyroxene skarn units show a mixing trend from unaltered diopside marble ($\delta^{18}O$ = +2 ‰ (SMOW), $\delta^{13}C$ = +3.5‰ (PDB)) to values in equilibrium with magmatic fluids at 600°C ($\delta^{18}O$ = +8‰, $\delta^{13}C$ = -6‰). The data are not consistent with simple equilibrium devolatilization of marble and suggest an input of magmatic carbon as well as oxygen. Calculated minimum fluid/rock ratios for carbon (1:1) and oxygen (30:1) depletions are broadly consistent with mole fraction CO_2 ratios less than 0.1 as determined by phase equilibria. The isotopic gradients (±8‰ $\delta^{18}O$) preserved over distances of 1-2cm in banded marble/calcsilicate away from the igneous contact demonstrate the impermeability of the marble and support channelized vs pervasive flow. Isotopic thermometry is not possible in the contact rocks due to the lack of applicable calibrated systems - the garnet/pyroxene/quartz analyses suggest disequilibrium and give temperatures from 300-950°C. ΔD of replacement epidote (-140‰) indicates that the late skarn fluids had significant meteoric input. Analyses of the Tungsten Hills Quartz Monzonite ($\delta^{18}O$ = +7.5‰) suggest a dominantly I-type magma, consistent with the Rb-Sr data of Kistler and Peterman (1973) and the bulk chemical analyses of Bateman (1965). All of the data support a deep crustal/possibly upper mantle magma source and complex or multiple sources for the fluids. (Authors' abstract)

BRYNDZIA, L.T. and SCOTT, S.D., 1980, Geochemical evolution of Zn+Pb and Cu stockwork mineralization in the Uwamuki #4 deposit, Hokuroku district, Japan (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 394.

The compositionally zoned stockwork of the Uwamuki #4 deposit incorporating Cu, Zn+Pb and Ba zones contrasts with the typical Cu-py stockworks underlying most Kuroko and other massive sulfide deposits. Mineralogy is dominated by pyrite, sphalerite, chalcopyrite, galena, barite, tetrahedrite, quartz and sericite. Within the Zn+Pb stockwork zone, mole % FeS in sphalerite (in equilibrium with pyrite) decreases from 0.62±0.10 on the -100 m level to 0.22±0.02 on the -55 m level paralleling a decrease of fluid inclusion filling temperatures in sphalerite from 262°±18°C to 230°±13°C, respectively (Marutani & Takenouchi, 1978). Within experimental error, the decrease of FeS in sphalerite has occurred under conditions of nearly constant fS_2 of $10^{-9.5}$ atm. On the -100 m level, the area of highest fS_2 values coincides with maximum Zn+Pb deposition, whereas the Ba zone formed under lowest fS_2 conditions. $\delta^{34}S_{pyrite}$ decreases paragenetically from +8 o/oo in the Cu zone to +5.5 o/oo in the Zn+Pb zone. Barite from the Ba and Zn+Pb zones has a mean $\delta^{34}S$ of +22.7±0.66 o/oo which is indistinguishable from sulfate minerals (barite, anhydrite and gypsum) forming syngenetic horizons in the Hokuroku district. Combining these data with mineralogical and paragenetic information, the important variations with time of the ore forming fluid are simultaneous decrease in T, increase in total dissolved sulfur ($10^{-2.5}$ to $10^{-2.2}$m), increase in fO_2 ($10^{-35.5}$ to $10^{-33.5}$ atm) and decrease in pH (~6 to 4.6). Mineralization appears to have involved progressive domination of the ore fluid by sea water with time, giving rise to the decrease in $\delta^{34}S_{py}$ as well as sea water characteristics for $\delta^{34}S_{barite}$ in the stockwork. (Authors' abstract)

BUADZE, V.I. and KAVILADZE, M.Sh., 1979, Sulfur isotopes and problems of origin of pyrite deposits of the Urup region (Northern Caucasus): Geologiya Rudnykh Mestorozhdeniy, 1977, v. 19, no. 4, p. 76-88 (in Russian; tranlated in Internat. Geol. Rev., v. 21, no. 7, p. 795-805, 1979).

BUCHANAN, L.L., 1980, Ore controls of vertically stacked deposits, Guanajuato, Mexico (abst.): Program and Abstracts, AIME-SEG Meeting, Feb. 24-28, 1980, p. 24.

Three levels of precious and base metal orebodies exist in veins at Guanajuato, Mexico: 2100-2350 m (Au-Ag), 1700-2200 m (Ag-Au), and below 1700 m (Pb-Zn-Cu-Ag). Where more than one level exists in a vein, shoots are usually separated by subore gangue. The lowest ores precipitated from non-vaporizing brines over 230°C containing 702 ppm Cu+Pb and 1 ppm Ag. The middle and upper ores precipitated at 230°C from repeatedly vaporizing dilute solutions containing 12 ppm Ag and 70 ppm Cu+Pb. Numerous cycles of vein sealing followed by fracturing and consequent lithostatic pressure release led to solution vaporization at depths greater than hydrostatic. Each period of vaporization resulted in a period of metal deposition. Application of this concept to exploration is stressed. (Author's abstract)

BULAKH, A.G., 1979, Thermodynamic properties and phase transitions of H_2O up to 1000°C and 100 kbar: Vses. Mineral. Obshch. Zapiski, 1977, v. 4, p. 448-459 (in Russian; translated in Internat. Geol. Rev., v. 21, no. 1, p. 92-101, 1979).

BURCH, C.R., 1980, Inclusions - an aid to the identification of gemstones: Gems (London), v. 12, no. 5, p. 29-30.

BURNHAM, C.W. and OHMOTO, Hiroshi, 1980, Late-stage processes of felsic magmatism: Mining Geol. (Japan) Spec. Issue, no. 8, p. 1-11. Authors at Dept. Geosci., Penn. State Univ., Univ. Park, PA 16802.

The formation of hydrothermal ore deposits, whether of the geothermal, vein, skarn, or porphyry type, is dependent largely upon processes that operate during the late stages of felsic magmatism. The effectiveness of these processes depends, in turn, upon numerous factors, principal among which are: (1) magma composition, including metal, sulfur, chloride, and especially H_2O contents; and (2) geologic environment, including depth, of magma emplacement. The importance of H_2O content lies in its control of the stage of crystallization, at a given depth, when an aqueous phase (hydrothermal fluid) is evolved by second boiling, which in turn determines the extent of wallrock fracturing and subsequent hydrothermal activity.

Second boiling releases large amounts of mechanical energy ($P\Delta V_r$) which, for $X_\omega^m>0.24$ (>2 wt. %), may produce explosive volcanism at P (load pressure) <0.5 kbar or extensive fracturing at P<2 kbar. It also produces an aqueous phase into which chlorides and sulfur are strongly partitioned. Chlorides exist predominantly as neutral complexes with alkalies, iron (and other chalcophile metals), hydrogen, and calcium, whereas sulfur exists as both H_2S and SO_2. The metal carrying capacity of these aqueous fluids is directly dependent upon their chloride content and the SO_2/H_2S fugacity ratio. This latter ratio is dependent, in turn upon fO_2 and may exceed 100 by diffusive loss of H_2.

Escape of these chloride- and sulfur-bearing fluids into cooler wallrocks results mainly in potassium and hydrogen metasomatism of aluminosilicates (potassic and phyllic alteration) and Fe-silicate metasomatism of carbonates (skarns). Cooling of these fluids causes precipitation of metal sulfides (also anhydrite) from the chloride complexes, mainly through hydrolysis of SO_2 to H_2S and H_2SO_4. Also, the HCl produced in this hydrolysis promotes additional phyllic alteration.

Magmatic fluids that are less than approximately 0.3 molal in ΣCl are not effective ore-forming fluids. They may acquire greater effectiveness, however, by condensation at low pressures and temperatures. (Authors' abstract)

BURRUSS, R.C. and GOLDSTEIN, R.H., 1980, Time and temperature of hydrocarbon migration fluid inclusion evidence from the Fayetteville Formation, NW Arkansas (abst.): Geol. Soc. America Program and Abstracts, v. 12, no. 7, p. 396.

Hydrocarbon liquid-vapor inclusions with 3 distinct fluorescent colors occur in two generations of carbonate mineralization lining septarian veins, fossil cavities and oil-filled vugs in the Mississippian Fayetteville Fm. In Washington Co., AR, rare aqueous and abundant dull-blue fluorescent, hydrocarbon inclusions with T_H (liq.) ≈ 50°C occur on growth zones in 1st gen., euhedral, sideritic calcite. These are cut by yellow-gold fluorescent inclusions on minor healed microfractures. Extensive healed microfractures crossing both 1st gen. calcite and 2nd gen. dolomite contain blue-white fluorescent inclusions with T_H (liq.) ≈ 100°C. In Searcy Co., AR, 1st gen. bladed, sideritic calcite is followed by 2nd gen. sparry calcite each with no primary inclusions. Both are cut by healed microfractures containing the 3 fluorescent types of hydrocarbon inclusions and rare aqueous inclusions. In these samples dull blue fluorescent inclusions have T_H (liq.) ≈ 40°C and blue-white inclusions have T_H (liq.) ≈ 80°C.

Fluorescence emission spectra allow correlation of the inclusion types between samples and with the oil in vugs. In Washington Co. the dull blue fluorescent hydrocarbon type was present during 1st gen. calcite growth, but clearly postdates both generations in Searcy Co. The vug oil correlates with the blue-white fluorescent inclusions and apparently migrated into the vugs along microfracture systems postdating all of carbonate vein filling at both localities. The consistent differences of T_H and fluorescence between the dull blue and blue-white hydrocarbon inclusions at each locality suggest these inclusions record distinct hydrocarbon migration events. The differences in T_H and mode of occurrence of inclusions between localities appears to document regional differences in time and temperature (depth?) of hydrocarbon migration. (Author's abstract)

BURRUSS, R.C., TOTH, D.J. and GOLDSTEIN, R.H., 1980, Fluorescence microscopy of hydrocarbon fluid inclusions: relative timing of hydrocarbon migration events in the Arkoma Basin, NW Arkansas (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 400.

Oil-filled vugs and fluid inclusions containing vapor, hydrocarbon liquids, aqueous liquids, or all 3 (3-phase inclusions) occur in multiple generations of septarian vein filling in the Mississippian Fayetteville Formation, northwest Arkansas. In Washington Co., AR, veins are filled first by euhedral sideritic calcite and second by dolomite. Fluorescence microscopy reveals dull blue fluorescent hydrocarbon inclusions and nonfluorescent aqueous inclusions along growth zones in first generation calcite. These growth zones are cut by minor microfractures with yellow-gold fluorescent inclusions. Extensive microfractures with blue-white fluorescent hydrocarbon inclusions cross both the calcite and the dolomite. These 3 fluorescent types of hydrocarbon inclusions also occur in septarian veins from Searcy Co., AR, where all inclusions occur on healed microfractures cross-cutting both a first generation bladed, sideritic calcite and a second generation sparry calcite.

Fluorescence spectra of individual inclusions allow correlation of the 3 hydrocarbon types between both localities (~120 km apart). Clearly, in Washington, Co., a hydrocarbon phase was present *during* first generation calcite growth, whereas at Searcy Co., all hydrocarbon types *postdate* both generations of vein fill. Fluorescence spectra of the oil from vugs correlate with the blue-white fluorescent inclusions along healed microfractures crossing *all* generations of vein fill at *both* locations. The oil in the vugs apparently migrated on microfracture systems postdating all generations of carbonate vein filling. (Authors' abstract)

BYEDA, V.D., 1980, Gold-bearing mineral associations and conditions of their formation in one of regions of the Central Kamchatka, p. 46-53 *in:* Mineralogy of native elements, publ. by Far-East Sci. Center, Vladivostok, 154 pp., 500 copies printed, price 1 rbl. 40 kopecks (in Russian).

In the W. part of one of the regions of Central Kamchatka (region not named) the Au mineralization occurs in veins that formed in propylitized rocks and sericite quartzites. Barren pre-ore quartz yielded Th 400-330°C, quartz-pyrite with gold and gold-chalcopyrite-pyrrhotite aggregates - 360-260°C, gold-telluride aggregates 280-180°C, gold-quartz aggregates 230-180°C, drusy quartz 190-150°C, post-ore quartz 220-120°C and amethyst 180-150°C. Water leachates from quartz gave the following compositions of salts in fluid inclusions (in g per kg H_2O): K 7.3-22.4, Na 3.5-17.5, Ca not found-3.9, Mg 1.2-3.5, NH_4 not found-1.0, HCO_3 28.6-74.7, Cl 3.0-8.3, F, SO_4, and BO_3, not found, H_2O, % of sample weight 0.122-0.347, total mineralization, % 4.8-11.1. (Abstract by A.K.)

CARIGNAN, Jacques, KHEANG, Lao, BROWN, Alex and GELINAS, Leopold, 1979, Preliminary microthermometry of inclusions associated with the volcanogenic Millenbach orebody (abst.): Geol. Assoc. Canada/Min. Assoc. Canada Abstracts, v. 4, p. 42 (in French).

A Chaixmeca fluid inclusion stage was used to determine filling temperatures and to estimate fluid composition for sphalerite and quartz in the stockwork mineralization of the volcanogenic Cu-Zn deposit at Millenbach. Th for over 500 inclusions in quartz ranged from 110° to 420°C. Inclusions intimately associated with sulfide grains indicate that most of the sulfide precipitation occurred between 180° and 300°C. Tm ice(?) averaging -25°C show that the mineralizing fluid ranged from 0.9 to 1.6 molar in NaCl and bivalent cations. Additionally, there is a correlation between the physico-chemical characteristics of the fluids and proximity to the ore deposit. (Authors' abstract, translated by M. Logsdon)

CARLSON, E.H., 1980, The areal distribution of celestine and gypsum in the Silurian rocks of Northwestern Ohio (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 221.

Preliminary results from studies of fluid inclusions in celestine indicate that the solutions were moderately warm. (From the author's abstract).

CARLSON, S.R. and SAWKINS, F.J., 1980, Mineralogic and fluid inclusion studies of the Turmalina Cu-Mo-bearing breccia pipe, northern Peru: Econ. Geol., v. 75, p. 1233-1238. Authors at Dept. Geol. and Geophy., Univ. Minn., Minneapolis, Minn. 55455.

Most of the 280 fluid inclusions studied were in quartz, but some were in tourmaline, calcite, apatite, beryl, and sphalerite. Three types of P-PS inclusions were recognized: Type I = Halite ± sylvite, liquid-rich, and may have 3 additional phases. These include hematite, sericite, dawsonite?, chalcopyrite?, and calcite?. None of these dissolve on heating and may not be dms. Th in liquid at avg. 416°C; avg. Tm NaCl = 230°C, Tm KCl = 75°C; salinity 27-50 wt.%, average 39%. Type II = Also liquid-rich, but dms = small. Salinity 1-12%, avg. 5.2%; Th in liquid at avg. 412°C. Type III = Vapor dominated (>90%) Th in vapor at 400-450°C; avg. 421°C; salinities range from <0.2 to 3.5% and avg. <0.04%(sic.). Some type III contain <10 atm pressure. Types I and III are assumed to be from the splitting of type II fluids. (E.R.)

CAROTHERS, W.W. and KHARAKA, Y.K., 1980, Stable carbon isotopes of HCO_3^- in oil-field waters-implications for the origin of CO_2: Geochim. Cosmo. Acta, v. 44, p. 323-332. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

The $\delta^{13}C$ values of dissolved HCO_3^- in 75 water samples from 15 oil and gas fields (San Joaquin Valley, Calif., and the Houston-Galveston and Corpus Christi areas of Texas) were determined to study the sources of CO_2 of the dissolved species and carbonate cements that modify the porosity and permeability of many petroleum reservoir rocks. The reservoir rocks are sandstones which range in age from Eocene through Miocene. The $\delta^{13}C$ values of total HCO_3^- indicate that the carbon in the dissolved carbonate species and carbonate cements is mainly of organic origin.

The range of $\delta^{13}C$ values for the HCO_3^- of these waters is -20-28 per mil relative to PDB. This wide range of $\delta^{13}C$ values is explained by three mechanisms. Microbiological degradation of organic matter appears to be the dominant process controlling the extremely low and high $\delta^{13}C$ values of HCO_3^- in the shallow production zones where the subsurface temperatures are less than 80°C. The extremely low $\delta^{13}C$ values (<-10 per mil) are obtained in waters where concentrations of SO_4^{2-} are more than 25 mg/l and probably result from the degradation of organic acid anions by sulfate-reducing bacteria ($SO_4^{2-} + CH_3COO^- \rightarrow 2HCO_3^- + HS^-$). The high $\delta^{13}C$ values probably result from the degradation of these anions by methanogenic bacteria ($CH_3COO^- + H_2O \rightleftarrows HCO_3^- + CH_4$).

Thermal decarboxylation of short-chain aliphatic acid anions (principally acetate) to produce CO_2 and CH_4 is probably the major source of CO_2

for production zones with subsurface temperatures greater than 80°C. The $\delta^{13}C$ values of HCO_3^- for waters from zones with temperatures greater than 100°C result from isotopic equilibration between CO_2 and CH_4. At these high temperatures, $\delta^{13}C$ values of HCO_3^- decrease with increasing temperatures and decreasing concentrations of these acid anions. (Authors' abstract)

CARTER, J.S., 1980, Hydrocarbon gases and mineralization (abst.): I.M.M. Trans., B, v. 89, p. B-136.

A study of hydrocarbon gases (C1-C4) in the limestones of the northern Pennine orefield has been undertaken to test for sulphate reduction. The reaction between SO_4^{2-} and organic matter, in the mineralizing brine, catalysed by H_2S at the site of mineralization, seems the most likely mechanism to provide reduced sulphur to precipitate metal sulphides. This reaction should also yield gaseous hydrocarbons. The results have revealed a very large regional anomaly over the orefield, with a large increase in methane at the expense of the other species. This can be explained if sulphate reduction has occurred within the orefield. The method seems to have considerable potential as a new exploration technique. (E.R.)

CASADEVALL, T., MALINCONICO, L., LeGUERN, F., SATO, M., STOIBER, R., McGEE, K. and HAZLETT, R., 1980, Volcanic gas studies in Hawaii: 1978-1979 (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 67.

CASADEVALL, Tom and RYE, R.O., 1980, The Tungsten Queen deposit, Hamme district, Vance County, North Carolina: A stable iostope study of a metamorphosed quartz-huebnerite vein: Econ. Geol., v. 75, p. 523-537.

The Tungsten Queen mine, Vance County, North Carolina, is a large quartz-huebnerite vein deposit of late Precambrian or early Paleozoic age that has undergone middle Paleozoic regional metamorphism of amphibolite grade. The preservation of large banded huebnerite crystals and the low $\delta^{18}O$ values in the vein minerals and wall rocks indicate a premetamorphic hydrothermal origin for the vein which involves meteoric waters. Quartz-sericite oxygen isotope distributions in the vein and wall rocks indicate metamorphic temperatures of 550° ± 50°C. All other isotope distributions except possibly those for hydrogen appear to reflect primary hydrothermal distributions that were not significantly disturbed by the metamorphic event. The stable isotope systematics of the vein are remarkably similar to those of younger huebnerite/wolframite-quartz veins associated with shallow intrusions in orogenic belts. Sulfur isotope fractionations among coexisting sulfides in two mineral assemblages may indicate primary mineralization temperatures of about 260° and 320°C. The hydrothermal sulfur was derived from a deep-seated source. The carbon isotope data suggest that a sedimentary organic component was present in the fluids during carbonate deposition. Except for reequilibration between coexisting quartz and sericite, the ^{18}O systematics of the vein minerals appear to reflect primary hydrothermal distributions and indicate that the vein was largely a closed system during metamorphism. Hydrous minerals and waters in fluid inclusions in the vein minerals show nearly a 50 per mil range in δD values which may also reflect primary variations in the hydrothermal vein system. (Authors' abstract)

CASEY, William H. and TAYLOR, Bruce E., 1980, Stable isotopic investigation of hydrothermal ore fluids in massive sulfide deposits of the West Shasta Cu-Zn district, California (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 101.

Volcanogenic massive sulfide deposits in the West Shasta Cu-Zn district are hosted by Devonian Balaklala Rhyolite (dacite) and underlain by basaltic-andesites of the Copley Greenstone fm. Ore bodies comprised essentially of pyrite plus subordinate sphalerite and chalcopyrite are found in the immediate vicinity of, and at distance from, stockwork-like hydrothermal vent areas. Alteration is often pervasive (quartz-pyrite ± chlorite); vent areas are characterized by a high density of veins and the presence of sericite.

Whole-rock $\delta^{18}O$ values for greenstone and dacite vary from +3.65 to +11.00‰; greenstone becomes isotopically lighter with increasing chlorite content. Quartz-chlorite pairs indicate temperatures of 375°C for vein formation in the greenstone. $\delta^{18}O$ of vein quartz in dacite ranges from +7.00 to +11.52‰, and the calculated $\delta^{18}O$ for fluid in equilibrium with vein quartz at 375°C is +1.0 to +5.5‰. Whole-rock δD values vary from -44 to -60‰ and show no correlation with wt. % H_2O. Chlorites have $\delta D = -45$ to -48‰ and for epidote $\delta D = -9$‰. The hydrothermal fluid is thus indicated to be sea water. No evidence for admixture of meteoric fluid during ore deposition is found.

Pyrite in the vent area typically varies in $\delta^{34}S$ from +4.0 to +5.3‰. Fine-grained ore from one ore body is depleted in ^{34}S ($\delta^{34}S$ = +2.0 to 2.9‰) relative to other, coarser grained and brecciated deposits. Pyrite-chalcopyrite pairs indicate temperatures for massive sulfide formation of 370°C. Enrichment of pyrite in ^{34}S in wall rock relative to pyrite in adjacent vein may indicate thermal disequilibrium between hydrothermal fluids and host rock. (Authors' abstract)

CAVARRETTA, G., GIANELLI, G. and PUXEDDU, M., 1980, Hydrothermal metamorphism in the Larderello geothermal field: Geothermics, v. 9, p. 297-314. First author at CNR, Centro Studi Geologia dell'Italia Centrale, Roma, Italy.

The various tectonic units underlying the Larderello-Travale geothermal region have undergone hydrothermal metamorphism. The hydrothermal mineral assemblages are generally consistent with the temperatures now measured in the wells, leading to the hypothesis that solid phases deposited from a liquid medium during a hot-water stage that preceded the vapor-dominated one. (Authors' abstract)

CAWTHORN, R.G., 1980, High-MgO Karroo tholeiite and the formation of nickel-copper sulphide mineralization in the Insizwa Intrusion, Transkei: S. African J. Sci., v. 76, p. 467-470.

The composition of the chilled margin of the Insizwa Intrusion indicates that the parental magma was anomalously high in MgO compared to most intrusions of the Karroo Sequence. It is further atypical in being enriched in SiO_2, Na_2O and K_2O, suggesting that crustal contamination may have occurred. This contamination may have caused an immiscible sulphide liquid to separate, producing the nickel-copper sulphide deposits once mined in the area. The Ni/Cu ratio of this sulphide is higher than observed in sulphides associated with normal tholeiitic magmas, but is consistent with formation from a more magnesian magma. (Author's abstract)

CELLINI, L.P., MARTINI, M. and PICCARDI, G., 1980, Heavy metal contents in phreatic waters at Vulcano: the influence of hydrothermal fluids. Rendiconti Soc. Ital. Mineral. Petrol., v. 36, p. 253-260 (in Italian).

CHAIGNEAU, M. (ed.), 1980, A collection of papers on the geochemistry of volcanic gases: Boll. Volcanol., v. 43, p. 197-274.

CHAIGNEAU, M., HÉKINIAN, R. and CHEMINÉE, J.L., 1980, Magmatic gases extracted and analyzed from ocean floor volcanics: Bull. Volcanol., v. 43-1, p. 241-253. First author at Lab. des Gaz, Univ. Descartes, 4, ave. de l'Observatoire, 75006 Paris.

Magmatic gases extracted and analyzed from basaltic rocks collected in the FAMOUS area near 36°50'N in the Atlantic ocean show that the total amount of gas included in the samples varies between about 500 ppm to 1600 ppm. The main gaseous phases included in the various types of basalts consist of CO_2 (270-700 ppm), CO (150-800 ppm), HCl (100-1000 ppm), H_2 (0-50 ppm), SO_2 (up to 175 ppm), N_2 (up to about 213 ppm). The relative amount of CO, CO_2 and SO_2 varies with both the degree of crystallinity of the rock and with fractional crystallization and/or fractional melting. The glassy margin of pillow lavas have a higher CO/CO_2 ratio than the more crystalline interior. The most fractionated rocks of the series rich in clinopyroxene are depleted in the CO/CO_2 ratio and have a higher SO_2 content than do the most mafic end members rich in olivine. Early-formed olivine was crystallized in a reducing environment rich in CO and H_2 with respect to later formed mineral associations. It is likely that the carbon and sulfur oxidation is taking place at a relatively shallow depth during magmatic ascent or during volcanism. The ocean floor volcanics when compared to subaerial basalts are depleted in SO_2 and have on the average ten times more H_2. (Authors' abstract)

CHAIGNEAU, M., MASSARE, D. and CLOCCHIATTI, R., 1980, Contribution to the study of glass inclusions and of volatile elements within quartz phenocrysts in acid volcanic rocks: Bull. Volcanol., v. 43, p. 233-240. First author at Service d'Analyse des Gaz, CNRS, Paris, France.

Three samples of quartz containing glass inclusions from acid volcanic rocks have been studied. A chemical analysis of major elements in the glass by means of electron microprobe, and the study of their physical behavior under the heating stage microscope, suggest, for two of them, the existence of dissolved volatiles.

These, extracted by vacuum pyrolysis, were determined by means of mass spectrometry to be H_2O, CO_2, CO, etc. The sample which is richest in CO_2 has been found to contain separate gas inclusions not enclosed in glass; these have been studied by cryometry. Results are discussed and possible secondary reactions and different sites (glass, dislocations, lacunae, subgrain boundaries in the mineral) origin are considered. (Authors' abstract)

CHANYSHEV, I.S., 1978, Composition of gas-liquid inclusions in quartz from gold mineralization formed at various depths (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 202-203 (in Russian). Author at Far East Inst. of Mineral Raw Materials, Khabarovsk, USSR.

Studies of G/L inclusions in gold-bearing quartz from one of regions* of the Far East revealed that G in inclusions consists of CO_2 (prevailing), CO, CH_4, H_2 and N_2. With decrease of depth and Th CO_2 content also decreases. Th ranges from 240 to 155°C. Gold precipitation occurred after boiling and LH_2O-LCO_2 heterogenization. Solutions were of alkali-chloride-hydrocarbonate composition; moreover Ca, Mg, NH_4, some F and in one sample traces of SO_4 were found. Total salt concentration increases with decreasing depth. F and K content are the highest in solutions that formed commercial ores (F content exceeds 86% of total anions). Content of HCO_3 increases in quartz of commercial stage of the subsurface deposits. (From the author's abstract, translated by A.K.)

*Name not given, A.K.

CHAROY, B., 1980, Fluid inclusion studies and their interpretation in hydrothermal problems (porphyry copper, tin and tungsten deposits) (lecture summary): Warta. Geol. (Kuala Lumpur), v. 6, no. 4, p. 103-105.

CHEPUROV, A.I., LAVRENTYEV, Yu.G. and KHMELNIKOVA, O.S., 1978, X-ray spectral microanalysis in thermobarogeochemical investigation (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 160 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

The possibilities of quantitative X-ray spectral microanalysis of solution inclusions and magmatic melts in minerals of rocks of various composition are discussed, after a brief review of previous work in the USSR, Japan, USA, France and other countries.

Specific methods for sample preparation and analysis are considered. Special attention is paid to the accuracy of determinations and the interpretation of the data obtained. Results are given on the composition of melts in minerals of ultrabasic, basic, alkaline and other rocks as well as of the glass and crystalline phases are given, as well as the advantages and details of quantitative X-ray spectral microanalysis in studying crystalline phases and deposit border in inclusions in minerals of rare-metal granite pegmatites. (Translation courtesy Dr. A.P. Berzina)

CHEREPANOV, A.A., 1978, Temperature zoning of fluorite deposits from Transbaikalia, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 136-137 (in Russian). Author at Transbaikalian Complex Sci.-Res. Inst., Chita, USSR.

Most fluorite deposits formed in several stages: high-temperature 300-160°C, moderate-temperature 180-140°C, low-temperature (120-40°C). Horizontal T zoning was revealed very distinctly both in individual ore bodies and in whole deposits: the first zone appears as higher T parageneses in central part of veins, the second one, representing a pulsating character of ore formation, is expressed by occurrence of high T bodies near faults and low T ones far from faults. Vertical T zoning is more complicated; T gradient varies from 10°/100m for early parageneses to 1-3°/100m for late ones. (Author's abstract translated and shortened by A.K.)

CHIZHIK, O.Y. and LEKUKH, Z.V., 1980, The genesis of emeralds in micaceous types of deposits: Gems and precious stones, Petrov, V.P., ed., Moscow, Izd. Nauka, p. 158-174 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

CHOJECKA, Ewa, 1980, Fluorite origin temperatures in some barite veins in the Sudetes: Acta Geologica Polonica, v. 30, no. 1, p. 53-59 (in English).

The minimum crystallization temperatures of fluorite from barite veins at Boguszów and Stanislawów in the Sudetes Mts., determined by the homogenization method, permitted the recognition of this mineral as a product of the activity of moderate- to low-temperature hydrothermal solutions. The determined temperatures varied along the vertical extent of the veins, making possible the calculation of the gradient of crystallization temperature, and to suggest the gradual cooling of the mineral-forming solutions. (Author's abstract)

CHUPIN, V.P. and MATRENITSKIY, A.T., 1980, Crystallization temperatures of granitoid rocks of the Orhon-Selenga trough, Mongolia, and their relationship to ore deposition: Dokl. Akad. Nauk SSSR, v. 250, no. 3, p. 686-698 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 250, 1980, p. 125-128 (1982). First author at Instit. Geol. and Geophy., Siberian Div., USSR Acad. Sci., Novosibirsk, USSR.

Melt inclusions in quartz of various plutons yielded Th mostly 580-650°C (granites, granosyenites, and aplite); syenite 680-720; and gabbro 1070-1110°C. Tm daughter crystals in lower temperature inclusions 510-520°C. (E.R.)

CHURCHILL, Ronald K., LANDIS, Gary P., and SAWKINS, Frederick J., 1980, ^{18}O and precious metal data from rocks underlying the Tayoltita Au/Ag deposit, Mexico:--implications for ore genesis (Abst.): Geol. Soc. Amer. Abstrats with Programs, v. 12, p. 403.

A sequence of calc-alkalic volcanic and intrusive rocks 1,500 m below the productive horizon of the Tayoltita Au/Ag vein deposit in Mexico are exposed by structural tilting and deep erosion. Whole-rock $\delta^{18}O$ data (+2.0 to +9.0 permil) indicate the former presence in these rocks of a convective cell dominated by meteoric water (MW) 3 km outward from the center of the mineralized zone and 1.5 km below it. Within this zone our data indicate pervasive interaction of MW with the volcanic rocks, but rather limited interaction (5-10 percent by vol.) with underlying batholithic rocks. Fractures containing chlorite and epidote with 1-2 cm alteration selvages have been identified as the pathways of MW flow. Precious-metal contents of two of the volcanic units at Tayoltita appear anomalous. Andesite that hosts the productive horizon averages 1.5 ppb Au (compared to 4.5 ppb for av. andesite) both within and beyond the zone of propylitic alteration. A thick ($\approx$1,000 m) section of rhyolite between the mineralized zone and underlying batholith is relatively Au rich ($\approx$1 ppb above av. rhyolite), but is locally depleted by $\approx$1ppb Au adjacent to fractures. In all the rocks, Au values from analyzed alteration selvages indicate a strong net enrichment of Au as a function of the alteration process. Eight of the 16 selvage zones analyzed for Au exhibit no clear depletion or enrichment. Four zones exhibit strong Au enrichment (2.7-34 ppb) and these are characterized by high $\delta^{18}O$ values, suggestive of a magmatic source. Selvages characterized by Au depletions (<1 ppb) or those that are unchanged are associated with low $\delta^{18}O$ values indicating meteoric water. Our results suggest that host-rock leaching of gold is inadequate to account for the bulk of the 1.6×10^5 kg of gold in the Tayoltita ore deposit. (Authors' abstract)

CLARK, M.E., 1980, Localization of gold, Mt. Charlotte. Kalgoorlie Western Australia: B.S. thesis, Univ. Western Australia.

The Mt. Charlotte deposit, Kalgoorlie, Western Australia, is a stockwork of quartz veins, with associated gold-bearing alteration selvages, in Archaean greenstone. The nature of the host rock, conditions of fluid flow and physical and chemical conditions of mineralization have been investigated at Mt. Charlotte. The results of this study place important constraints on the processes of gold localization at Mt. Charlotte.

Gold mineralization is restricted to the iron-rich granophyric zone of a differentiated tholeiitic dolerite, the Golden Mile Dolerite. Field, mineralogical and chemical data support an intrusive origin for the dolerite and accord with crystallization from a single magmas pulse. Early settling of pyroxene and possibly olivine together with crystallization inward from the margins produced a mafic granophyre above the centre of the sill.

Veins developed as extension fractures during oblique faulting and post-date regional folding and low-grade metamorphism. Pre-existing west-dipping faults acted as channelways to the ore fluid and locally influenced vein density and orientation. Vein fabrics and terminations indicate that fractures were produced at high fluid pressure by hydraulic fracturing. The branching and forking of veins at the edges of the granophyric zone imply that brittle failure was restricted to this zone.

Three stages of vein development are recognized. Vein minerals and relative volumes of these stages are: 1) quartz-ankerite-calcite-pyrite (2%); 2) quartz-pyrite (pyrrhotite)-sericite-calcite-scheelite (97%); 3) quartz-pyrite-chlorite-calcite (1%). Stages 1 and 2 are associated with gold-bearing alteration assemblages of quartz-pyrite-sericite-ankerite-siderite-calcite and an outer barren alteration zone containing scattered sulfides. Pyrrhotite is increasingly stable with depth.

Fluid inclusions in vein quartz indicate that Stages 1 and 2 were deposited from a supercritical fluid containing 20-30 mol% CO_2 and less than 4 wt% dissolved salts. Th for Stage 1 inclusions is 340-360°C and 295-320°C for Stages 2 and 3. The simultaneous trapping of two fluids in Stage 3 quartz indicates Tt of 350°-420°C and Pt of 1.2-2 kb. Pressures of 1.5-2 kb imply that Stages 1 and 2 quartz were deposited at 360-440°C.

Alteration assemblages and fluid inclusion data show the ore fluid was near-neutral to slightly acid (pH = 4.7 to 5.9) and relatively reduced ($m_{\Sigma S}$ = 0.02 molal, $a_{O_2} \sim 10^{-27}$, $a_{S_2} \sim 10^{-7}$). Gold transport as chloride complexes would be negligible under these conditions. Gold thio-sulfide complexes ($Au(HS)_2^-$) would account for significant gold transport.

The data are consistent with an ore fluid derived during low- to medium-grade metamorphism of a dominantly mafic pile. 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 assemblage of the granophyric zone is the most likely mechanism for precipitation of gold. (Author's abstract)

CLIFTON, C.G., DURNING, P.W. and BUCHANAN, L.J., 1980, Controls of mineralization and exploration procedure in the Oatman mining district, Oatman, Arizona (abst.): Program and Abstracts AIME-SEG Meeting, Feb. 24-28, 1980, p. 24.

The Oatman district produced approximately 2.2×10^6 oz of gold and 0.8×10^6 oz of silver between 1897 and 1942. A total of 3.8×10^6 tons of ore averaging 0.58 O/T gold and 0.17 O/T silver was extracted from eight major orebodies and a number of lesser deposits.

Oatman lies at the center of an andesite-rhyolite volcanic complex which may contain several collapsed calderas, at least one of which is resurgent. The orebodies are typical epithermal quartz-calcite load(sic) deposits which are completely devoid of base metals and occupy dilatant zones in faults which radiate from one proposed caldera center. Fischer-Watt Mining approached the Oatman district with an integrated exploration program utilizing four basic procedures to define the characteristics of past productive areas, the results of which were applied to unexplored portions of the vein system. These procedures, listed in their order of usefulness in defining known and prospective mineralized zones are: vein contouring, detailed alteration mapping, geochemical sampling, and fluid inclusion temperature determinations. All known deposits were found to be positioned at particular points of curvature on the veins, and all, where suitably exposed by erosion, exhibit a distinctive vertical and lateral alteration zonation. Geochemical sampling defined the location of known ore bodies only where the orebody was partially exposed. Vein material above orebodies possessed no diagnostic geochemical signature. Fluid inclusion studies indicated points of boiling along the veins and, by establishing a geothermal gradient to the ore horizon, provided a depth control for drilling. Approximately one man year was expended in establishing these relationships before drilling was recommended. (Authors' abstract)

CLOCCHIATTI, Robert, 1979, Petrogenesis of basaltic lava from the November, 1978, eruption in the Asal Rift, based on a study of intra- and inter-crystalline magmatic liquids (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France (in French).

CLOCCHIATTI, R., 1980, Glassy inclusions in plagioclase and pyroxene phenocrysts in the chilled margin of a pillow lava from Hole 417D, Deep Sea Drilling Project: in Legs 51, 52, 53, Part 2 of the cruises of the drilling vessel Glomar Challenger, San Juan, Puerto Rico to San Juan, Puerto Rico, November 1976-April 1977: Deep Sea Drill. Proj., Initial Rep. 53, v. 2, p. 1063-1067.

CLOCCHIATTI, R. and BIZOUARD, H., 1979, A basaltic fissure eruption from the Asal Rift, Djibouti: mineralogical and geochemical evidence concerning the nature of the parent magma and its evolution by fractional crystallization and magma mixing: C.R. Acad. Sc. Paris, v. 289, Série D, p. 647-650 (in French). Authors at Lab. Pétrographie, Bat 504, Univ. Paris Sud, 91405 Orsay Cedex, France.

Porphyritic lavas of the last eruption of Asal are characterized by fractional crystallization, crystal settling of plagioclase mega- and phenocrysts and mixing between tholeiites and similar basalts derived from less evolved magmas. The nature of parental magma and the importance of the settling phenomenon are inferred from mineralogical and chemical studies. Evidence is given for the reinjection of magma in a chamber already containing fractionated products. (Authors' abstract, modified by J. Touret) (Editor's note - the above data based in large part on silicate melt inclusion studies.)

CLOCCHIATTI, R., BIZOUARD, H., HAVETTE, A. and BROUSSE, R., 1980, Simultaneous presence of different glasses in the mesostasis and the inclusions of basic plagioclase in calc-alkaline lavas. Immiscibility of silicate liquids (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 127 (in French).

The immiscibility of natural silicate melts was discovered in lunar basalts by Roedder and Weiblen (1970-71) and then pointed out on several occasions in the groundmass of tholeiitic basalts (De 1974, Philpotts 1977-78-79). The purpose of this paper is to call attention on the fact that immiscibilities are also typical of the matrix of basic andesitic lavas, in the form of melt inclusions entrapped in plagioclases (bytownite, labradorite). Concerning the latter, the crystallization of a host mineral from the included andesitic melt lead to a residual melt that falls in the immiscibility field (Clocchiatti and Krasov, 1978); globules of basic glass, characteristic of a rather small enrichment in TiO_2 and P_2O_5 are then observed in an alkaline rich rhyolitic glass. Such are, for instance, the inclusions of plagioclases from four andesitic domes presently active: the Soufriere St. Vincent; Santiaguito, Guatemala; Karimski, Kamchatka and Merapi, Java.

On the other hand, if in the matrix of several other andesitic rocks (Mt. Arci, Sardinia; Erromango, New Hebrides) and in some basalts (Rattlesnake, England; Philpotts) the crystallization of plagioclases leads, like previously, to a melt falling in the immiscibility field, this domain seems more important than for the former suite of rocks and the fractionated basic glass is highly enriched in TiO_2 and P_2O_5 (Clocchiatti, 1979). This relation was experimentally established by Koster and Van Groos (1979).

It is noticed also that sulfur and manganese show a remarkable affinity for the basic glass, which was also demonstrated experimentally by Watson (1976). Basic glasses being less stable than acid glass, have the propensity to crystallize rapidly to form apatite, magnetite and pyroxene. In general, such a paragenesis forms the microlitic phases of residual glass of andesitic matrix. (Translation by R. Clocchiatti)

CLOCHIATTI, R. and KRASOV, N., 1980, Fractional crystallization and immiscibility in calc-alkaline magmas trapped in phenocrysts of plagioclase in lavas of the Karimski volcano (Kamchatka, USSR): C.R. Acad. Sc. Paris, v. 289, Ser. D, p. 1-4 (in French). First author at Lab. Pétrographie, Univ. Paris Sud, Bat 504, 91405 Orsay Cedex, France.

During the magma ascent and slow cooling, feldspar phenocrysts keep on crystallizing at the expense of andesitic melts trapped in crystals. According to the composition of phases which crystallize on the cavity walls, the formation of either basic or acid residual melts, or even immiscibility between both can be noticed. The most evolved terms of the series are becoming richer in volatile elements: this is shown by the appearance inside the inclusions of hydrous phases (amphiboles, biotites) and of magnetite, potassic feldspar and quartz crystallization. The description of the glass inclusion evolution is typical of many calc-alkaline series and shows physical and chemical conditions of crystallization identical in the lavas generated in subduction regions. Optical, thermometrical and chemical studies of the intermediate stages and more particularly, the important immiscibility phenomena, are discussed. (Authors' abstract)

COBB, J.C., STEELE, J.D., TREWORGY, C.G. and ASHBY, J.F., 1980, The abundance of zinc and cadmium in sphalerite-bearing coals in Illinois: Illinois Mineral Note 74, March 1980, Urbana, IL 61801.

Includes a brief discussion of inclusion data by Roedder (1979) and photomicrographs of inclusions in sphalerite (p. 9-10). (E.R.)

COBB, J.C., 1980, Geology of sphalerite in coal (abst.): Geol. Soc. Am., Abstracts with Program, v. 12, p. 222.

The mineral paragenesis (kaolinite-pyrite-sphalerite-calcite) is the same for all veins in these coals. Preliminary data from fluid inclusion studies indicate that sphalerite was deposited from brine having Na>Ca>K> Mg, total salinity of about 3.4 molal, and Na:K of 44.

The ratio of gases extracted from these fluid inclusions not condensable at the temperature of liquid nitrogen (i.e., CH_4, N_2) to those condensable at the temperature of liquid nitrogen (i.e., CO_2, CH_2) ranges from 0.29 to 3.57. The principal gases produced in the coalification reaction are H_2O, CO_2, CH_4, and N_2; these gases may be the sources of the gases in the fluid inclusions.

Homogenization temperatures of fluid inclusions from selected sphalerites range from 83° to 95°C. The mean reflectance of vitrinite in adjacent coals ranges from 0.54 to 0.63 percent (R_0max). Estimated maximum temperatures of coalification of the coals, derived from correlations of reflectance, temperature, and duration of burial, are in close agreement with the measured temperatures of fluid homogenization in the sphalerite inclusions. This agreement suggests that formation of the sphalerite coincided approximately with the time of maximum burial of the coal.

Deposition of the sphalerite probably resulted from connate brines which prevailed in the sedimentary basins of the time of maximum burial and maximum temperature. Brittle fracturing of lithotype banding accompanying mineralization suggests that the coal had achieved at least the rank of sub-bituminous coal. (Author's abstract)

CODY, R.D. and HULL, A.B., 1980, Experimental growth of primary anhydrite at low temperatures and water salinities: Geology, v. 8, p. 505-509.

COMBS, Jim, 1980, Heat flow in the Coso geothermal area, Inyo County, California: J. Geophys. Res., v. 85, no. B5, p. 2411-2424.

COOLEN, J.J., 1980, Chemical petrology of the Furua granulite complex, southern Tanzania: GUA papers of Geol., Series 1, 1980, no. 13, 258 p.

The Furua Granulite Complex in southern Tanzania consists of Precambrian banded hornblende-pyroxene granulites, generally garnet- and scapolite-bearing. Metapelites, calc-silicate rocks, banded gneisses and amphibolites are present in minor amounts. The complex is part of the belt of "Eastern Granulites," a N-S trending 1000 km long trail of high-grade metamorphic rocks in the centre of the Mozambique mobile belt.

This thesis deals with the petrology of the complex, studied by means of petrographic, mineral chemical and whole-rock chemical methods, supplemented by microthermometric data on fluid inclusions.

The rocks are believed to represent a volcano-sedimentary sequence affected by two major metamorphic events. The older event, of unknown age, reflects a prolonged equilibration in a lower crustal environment under intermediate- to high-pressure conditions of amphibolite-facies and granulite-facies metamorphism. A gabbro was emplaced on the central part of the complex and completely (re)crystallized under the prevailing PT-conditions. The younger event, probably related to the Pan-African thermotectonic episode of 500-600 Ma, is a rather static event at slightly lower PT-conditions of the intermediate- to high-pressure amphibolite facies, locally reaching the granulite facies. Intrusions of pegmatite and granodiorite and development of mylonites are related to this event.

Microthermometric data on fluid inclusions (Chapter VII) indicate that CO_2 is the principal constituent of the fluid phase trapped in the well-faceted inclusions in quartz, plagioclase and garnet from the metavolcanic and the metapelitic rocks. Uniformly low homogenization temperatures down to -53°C prevail and the inferred CO_2 density data are consistent with the postulated PT-conditions of the first phase of metamorphism.

A petrologic evaluation of the available data is presented in Chapter VIII. Bulk dependent phase relations and PT controlled mineral reactions are discussed. The PT-conditions of metamorphic (re)equilibration are estimated by means of different types of mineral geothermometers and geobarometers, in combination with a comparison of relevant experimental data. Resulting estimates for the first metamorphic event are: T 660-740°C, P 6-8 kbar, $PH_2O > 2$ kbar for amphibolite-facies zone A, T 750-850°C, P 9-12 kbar, $PH_2O \simeq 2$ kbar for almandine-clinopyroxene granulite subfacies zone B, T 750-850°C, P 7-11 kbar, $PH_2) \simeq 2$ kbar for orthopyroxene-plagioclase granulite subfacies zone C.

The influence of the second metamorphic event (T ± 600-700°C, P 5-7 kbar, PH_2O variable) is expressed by compositional zoning in the rims of first generation garnet and clinopyroxene and by different types of mineral reactions such as the alteration of orthopyroxene to biotite aggregates, the development of garnet-quartz symplectites around opaque oxides, the alteration of scapolite to stilbite and pyrrhotite and the local development of secondary orthopyroxene and clinopyroxene at the expense of hornblende of suitable compositions. The reactions are quantified by means of analytical data on reactant and product phases. The results show that siliceous alkaline fluids may have played an important role during the second metamorphic event. (From the author's abstract)(E.R.)

CRAIG, J.R., LIGHT, J.F., PARKER, B.C. and MUDREY, Jr., M.G., 1975, Identification of hydrohalite: Antarctic Jour., July-Aug., p. 178-179.

Studies of the formation and optical properties, as well as X-ray diffraction data for hydrohalite. (E.R.)

CRISS, R.E. and TAYLOR, H.P., Jr., 1980, Implications of $^{18}O/^{16}O$, D/H and K-Ar data on ancient hydrothermally-altered terranes to the nature of modern geothermal systems at deep levels (Abst.): EOS, v. 61, p. 1146.

Ancient hydrothermally-altered terranes provide information about the inaccessible deep portions of modern geothermal systems. An example is the Idaho batholith, where a series of gigantic hydrothermal systems were developed around several Eocene granite plutons. $\delta^{18}O$, δD and K-Ar data show that: (1) radial migration of meteoric ground waters occurred over distances of at least 50 km; (2) the circulation persisted to depths of >7 km, where T was 250°-350°C; (3) alteration effects are discernible over ~15,000 km^2; (4) >1/3 of the thermal energy of the fluids was provided by the ordinary geothermal gradient in the older rocks, although the Eocene magmas supplied the driving force for the circulation; (5) the most intense activity occurred within a ~50 km diameter annular zone (caldera ring fracture?) and along the margins of the Eocene plutons (resurgent domes?) interior to this ring; (6) important Au-Ag ore bodies were formed at the edge of the ^{18}O anomaly. The annular pattern of intense deep circulation in Idaho contrasts with the shallow present-day hydrothermal activity associated with resurgent domes at Yellowstone, and suggests that significant geothermal reserves might be tapped by deep drilling into the ring fracture zones of modern calderas. Several contrasts may be drawn between the granite-related geothermal systems in Idaho and those developed around gabbroic plutons elsewhere, primarily because mafic magma bodies are hotter and generally smaller than those of granitic composition. Zones of intense circulation in gabbros are comparatively localized, and typically affect the fractured intrusion while T is still high (>500°C); thus chloritic and sericitic alteration assemblages are uncommon. Ore deposits are rarely formed in gabbroic systems, indicating that the time-T history of hydrothermal activity plays a critical role in the development of ore fluids. (Authors' abstract)

CUNEY, M., 1980a, Preliminary results on the petrology and fluid inclusions of the Rössing uraniferous alaskites: Trans. Geol. Soc. S. Afr., v. 83, p. 39-45.

Petrography, radioactivity distribution and fluid inclusions have been studied in three samples of the Rössing alaskites from the S.H. anomaly outside of the Rössing deposit. After the crystallization of the alaskitic magma which involved oligoclase, biotite, orthoclase and quartz, a deuteric alteration produced a quartz, microcline, albite, muscovite, calcite ± chlorite mineral association similar to those observed in several French uraniferous granites. Uranium redistribution occurred during this alteration. From fluid inclusion data, the pressure at the time of the intrusion is estimated to have been at least 6 kbar for a temperature of 625°C. Reaction of the magma with the marbles of the Rössing formation led to the boiling of the magma by an increase in the CO_2 partial pressure as well as to its crystallization. Immiscibility between a dense saline (>30 per cent NaCl) and a CO_2-rich fluid is proposed to have occurred simultaneously or after the fluid oversaturation of the magma. Part of the uraninite formed at the magmatic stage, another part crystallized from the magmatic fluids in the biotite-rich selvages of the alaskites or in the uraninite-fluorite veins. Uraninite crystallization appears to be mainly controlled by the oxygen fugacity prevailing in the magma and in the surrounding rocks. (Author's abstract)

CUNEY, M., 1980b, Physicochemical characterization of the fluids associated with high-grade metamorphic terrains, based on the example of Mont Laurier, Quebec (abst.): 26th Int. Geol. Congr. Abstr., v. 1, p. 34 (in French).

Inclusion studies show CO_2-rich fluids at ~750°C and 8 kb. (E.R.)

CUNNINGHAM, C.G. and CAROLLO, Clyde, 1980, Modification of a fluid-inclusion heating/freezing stage: Econ. Geol., v. 75, p. 335-337.

A series of design modifications are described that decrease thermal gradients in the Chaixmeca heating/freezing stage. (E.R.)

CUNNINGHAM, C.G. and HEYL, A.V., 1980, Fluid inclusion homogenization temperatures throughout the sequence of mineral deposition in the Cave-In-Rock area, southern Illinois: Econ. Geol., v. 75, p. 1226-1231. Authors at

U.S. Geol. Surv., Box 25046, Denver Fed. Center, Denver, CO 80225.

Fluid inclusion Th data were obtained on samples collected at the same time and place as those used by Hall and Friedman (1963). Th for aqueous inclusions in all stages of fluorite, quartz, and sphalerite studied ranged from 100.7 to 150.1°C. Four hydrocarbon inclusions gave Th of 93.4 to 101.0°C. A slight increase in Th with time was noted. Fluorite and barite from breccia in the nearby cryptovolcanic structure (Hicks Dome) had Th 175°C at the top and 220-270°C at 713 m depth, suggesting mixing of fluids. Quartz crystals paragenetically intermediate within the several fluorite stages had Th 115-118°C, suggesting a different fluid, in agreement with the isotopic data of Hall and Friedman (1963). (E.R.)

D'AMORE, Franco and PANICHI, Costanzo, 1980, Evaluation of deep temperatures of hydrothermal systems by a new gas geothermometer: Geochim. Cosmo. Acta, v. 44, p. 549-556. Authors at Istituto Intern. Ricerche Geotermiche, Via del Buongusto 1, 56100 Pisa, Italy.

The chemical composition of gas mixtures emerging in thermal areas can be used to evaluate the deep thermal temperatures. Chemical analyses of the gas compositions of 34 thermal systems were considered and an empirical relationship developed between the relative concentrations (vol.%) of H_2S, H_2, CH_4 and CO_2 and the reservoir temperature. (From the authors' abstract)

DANCKWERTH, P.A. and RYERSON, F.J., 1980, REE partitioning between coexisting silicate liquids (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 398.

DANGIC, Adam, 1980, The model of genesis and evolution of hydrothermal systems in ore-bearing volcanic area (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 924.

Polymetallic hydrothermal ore deposits, special of lead-zinc, connected with Neogene andesite-dacite masses are very frequent and important in the world. This paper presents a model of genesis and evolution of respective ore-hydrothermal systems, based on mineralogical, petrological and geochemical studies of ores and wall-rock alteration as well as fluid inclusion study, in Srebrenica area, an important lead-zinc area in Yugoslavia.

The andesite-dacite suite - subvolcanics, flows, and pyroclastites in this area is situated in Paleozoic parametamorphics. Hydrothermal parageneses, ranged in temperature from pneumatolytic-hydrothermal to low-temperature stage, occur in typical veins which are predominantly localized in volcanic rocks.

The hydrothermal fluids have been generated in depth and with development of hydrothermal activity their temperature and composition was regular changed. Through fractures which were successively opened, successive portions of fluids ascended and formed a lot of in time and space separate ore-alteration systems. The temperature of fluids was at initial stage around 450°C and progressively decreased, and their density was high. The composition of fluids was characterized by high activity of H^+, K^+, Fe^{++}, and sulfide-ion in all stages, Mg- and B-ion in initial, and ore-metal ions and CO_2 in main stage of hydrothermal activity. The ratio K^+/H^+ was in the stability field of K-mica (illite), only in the late stage reached the stability field of kaolinite(sic). (Author's abstract)

DANIELSSON, L.-G., DYLRSSEN, David and GRANÉLI, Anders, 1980, Chemical investigations of Atlantis II and discovery brines in the Red Sea. Geochim. Cosmo. Acta, v. 44, p. 2051-2065.

DAROT, M.C., 1980, Plasticity of forsterite single crystals: flow laws and dislocation microstructures (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 1128.

DAVIDENKO, N.M., 1980, Gold-bearing hydrothermal veins of Chukotka: Sov. Geologiya, no. 2, p. 45-53 (in Russian). Author at All-Union Sci.-Research Inst. of Marine Geol., USSR.

The hydrothermal vein mineralization occurs in the Mesozoic folded area of the Anyuy, Chaun and Oloy territories. The veins belong to the gold-quartz low-sulfide formation of significant depth and they bear, in addition to gold and quartz: arsenopyrite, galena, pyrite, chalcopyrite, sphalerite, ilmenite, magnetite, anatase, rutile, calcite, dolomite, ankerite, siderite, scheelite, apatite, chlorite, prehnite, muscovite, kaolinite, dickite, feldspar, epidote, sphene, axinite and hornblende. Th in quartz (~100 measurements) are 400-350°C in G phase and 340-290°C in L phase. Long prismatic quartz crystals bear zones with inclusions of native gold, chlorite and light mica - G/L inclusions in these zones homogenize in L at 260-250°C and 190-170°C. Commercial gold association gave Th 175-145°C (upper levels) and 270-200°C (lower levels). P for early quartz was 1000-1200 atm., for commercial association - 280-320°C. Gases in inclusions (by mass spectrometry) are in following ranges (vol.%): CO_2 2.39-95.06, N_2 2.42-11.22, CH_4 0.91-70.82, H_2 0.10-68.48; ions (in % of total salt) Na 12.00-33.10, K 0.80-13.40, Ca 0.00-5.30, Mg 1.10-7.70, SO_4 9.40-55.40, HCO_3 9.70-53.30, CO_3 0.00-1.70, Cl 2.50-21.20, F 0.20-3.30; total mineralization (mg/kg) 14.40-142.92, pH of leachate 7.50-8.75. (Abstract by A.K.)

DAVISON, W., 1980, A critical comparison of the measured solubilities of ferrous sulphide in natural waters: Geochim. Cosmo. Acta, v. 44, p. 803-808.

DAWSON, J.B. and FUGE, R., 1980, Halogen content of some African primary carbonatites: Lithos, v. 13, p. 139-143. First author at Dept. Geol., Univ. Sheffield, Sheffield S1 3JD, U.K.

Colorimetric analyses have been made for F, Cl and I in a suite of African carbonatites specially selected for their freshness. F and Cl vary widely both in absolute and relative amounts between intrusions, but F/Cl ratios are usually consistent in samples from the same intrusion. Although samples from both the 2 b.y. Phalaborwa complex and the modern Oldoinyo Lengai lavas have low F/Cl values, there is considerable variation during geological time. Iodine (up to 1.8 ppm) has been found in the carbonatites of Phalaborwa, Sukulu and Oldoinyo Lengai; the only common factor seems to be the high sulphur content of the carbonatites at these localities. (Authors' abstract)

DAY, H.W. and FENN, P.M., 1980, Determination of P-T-X(H_2O) of crystallization for low calcium granitic magmas: the Scituate granite, Rhode Island (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 410.

One outstanding problem of granite petrology is the absence of reliable indicators for P, T, and $X(H_2O)$ of crystallization. In a magma of known composition, these variables may be limited by the equilibrium among two feldspars and melt. The method is useful for low Ca granites and is applied to the Scituate granite. Analysis of seven experimentally determined liquidus surfaces shows that Burnham's (1979) equations adequately describe water solubility in granitic magmas and that depression of the liquidus T by H_2O is similar in all compositions. Projection of liquidus surfaces from P-T-$X(H_2O)$ onto the P-T plane for Ca-bearing compositions near the thermal minimum shows that the two-feldspar boundary curve (BC) has a steep positive slope (ca 16°C/bar) across which isopleths of $X(H_2O)$ change slope. Intersection of the BC with the saturated liquidus defines a minimum P for alkali feldspar and a maximum $X(H_2O)$ for plagioclase on the liquidus. Intersection of the solidus with the solvus limb for feldspar of known composition fixes the maximum P at which hypersolvus crystallization can be completed. Petrographic evidence suggests that crystallization of the hypersolvus Scituate granite began in the plagioclase field. The solvus for Scituate feldspar (Or50), the intersection of the BC with the saturated liquidus estimated from James and Hamilton (1969), and the solubility of H_2O in Scituate magma require that crystallization began in the plagioclase field at $T \geqslant 760°C$ from a magma with $X(H_2O) \leqslant 4$ wt.% and that it was completed in the hypersolvus field at $P \leqslant 3$ kbar. (Authors' abstract)

DECHOMETS, R., 1979, Tectonic and lithologic control of the Trebas fluorine deposits of the Albigeois region (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France, p. 151 (in French).

DEICHA, G., 1980, Absorption of rocks by mineral fluids and evolution of their intracrystalline cavities (abstr.): Int. Geol. Congr. Abstr., 26th, v. 1, p. 35 (in French).

DELANEY, J.R. and KARSTEN, J.L., 1980, Ion microprobe determination of water in silicate glasses (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 128.

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

Using this technique, two types of studies have been initiated. (1) Preliminary results on the diffusivity of water as a function of concentration and time have been calculated from measured water diffusion profiles in rhyolite glasses prepared at 850°C and 700 bars PH_2O (Shaw, 1974). (2) A parallel study of water concentrations in glass inclusions trapped in phenocrysts from the glassy rinds of submarine pillow basalts is intended to constrain the pre-eruption water content of the magma. Results indicate that glass inclusions within phenocrysts from basalt dredged near Bouvet Island contain water contents less than or equal to that of the matrix glass which contains about 0.5% wt % H_2O. (From the authors' abstract)

DELE-DUBOIS, M.-L., DHAMELINCOURT Paul and SCHUBNEL, H.-J., 1980a, Raman spectrography studies of inclusions in diamonds, sapphires, and emeralds, I: Rev. de Gemmologie a.f.g., no. 63, p. 11-14 (in French).

Inclusions of chromite, olivine, diopside, hematite, graphite, and pyrope in diamond, and calcite, zircon, and apatite in sapphire were identified by Raman. (E.R.)

DELE-DUBOIS, M.-L., DHAMELINCOURT Paul and SCHUBNEL, H.-J., 1980b, Raman spectrography studies of inclusions in diamonds, sapphires, and emeralds, II: Rev. de Gemmologie a.f.g., no. 64, p. 13-16 (in French).

Inclusions of apatite, $CO_2 + N_2$, and hydrocarbons in Colombian emerald were identified by Raman, and spectra for many different pyroxenes are given. (E.R.)

DELE, M.L., DHAMELINCOURT H.J. and SCHUBNEL, H.J., 1980c, Application of Raman spectroscopy to the identification of inclusions in various gems: Gem Minerals, Nauka, Leningrad, p. 5-17 (in French).

DELE-DUBOIS, M.-L., DHAMELINCOURT, P. and SCHUBNEL, H.-J., 1980d, Raman spectrographic studies of inclusions in diamonds, sapphires and emeralds (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 205 (in French).

See same authors, 1980a, b. (E.R.)

DELHAYE, M., BARBILLAT, J. and DHAMELINCOURT, P., 1980, Identification of inclusions and particles by Raman microprobe: Analytical Techniques in Environmental Chemistry, Proc. Internat. Congress, Barcelona, Spain, November 1978, p. 515-522. Authors at Lab. Spectrochimie Infrarouge et Raman, C.N.R.S., Univ. Sci. Tech. de Lille, Bt C.5, BP36, 59650, Villeneuve d'Ascq, France.

A new microanalytical technique based upon Raman scattering is presented. This nondestructive technique founded upon a molecular property brings us information about the polyatomic structures present in a microsample. The Raman microprobe MOLE perfected in our laboratory does not only give Raman spectra of microsamples (about one µm) but also the microscopic distribution of the heterogeneous sample components. Many applications illustrate inclusions and particles in situ analysis in geological, biological and synthetic materials. (Authors' abstract)

DELITSYN, L.M., DELITSYNA, L.V. and MELENT'YEV, B.N., 1980, Petrologic significance of the coexistence of immiscible liquid phases in the system pyroxene-apatite villiaumite: Dokl. Akad. Nauk SSSR, v. 252, no. 3, p. 712-716 (in Russian: translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 151-154 (1982).

DELITSYN, L.M. and MELENT'YEV, B.N., 1979, A mechanism for the formation of banded rocks: Moskov. Obshch. Ispytateley Prirody Byull., otdel. geol., v. 54, no. 4, p. 102-113 (in Russian; translated in Internat. Geol. Rev., v. 22, no. 11, p. 1346-1354, 1980).

We demonstrate a mechanism for the formation of rhythmic banding, caused by dissociation of a melt into immiscible liquid phases. The disassociation of the melt (L_0→L_1+L_2) can be described by equations from the theory of turbulent flow of liquids. Subsequent dissociations of liquids L_1 and L_2 during cooling of the magma into liquids of lower orders, create thinner and thinner bands and rhythms. The shape and dimensions of the magma chamber determine the scale of the phenomenon. The principal measure for determining the scale of diverse differentiation processes is a quantitative phase analysis of individual layers, rhythms, and their series. (Authors' abstract)

DELLWIG, L.F. and KÜHN Robert 1980, A depositional mechanism for the Muschelkalk salt: 5th Int'l. Symposium on Salt, Northern Ohio Geological Society, p. 41-48.

Depositional temperatures of 20-50°C are mentioned in abstract but not in text. (E.R.)

DEMIN, Yu.I. and ZOLOTAREV, V.G., 1980, Zones of isothermal stabilization in gradient fields of granitoid bodies and possibilities of finding ore deposits in them: Geol. Rudn. Mest., v. 22, no. 5, p. 3-17 (in Russian). First author at Moscow State Univ., USSR.

Pertinent to temperature conditions reconstructed on the basis of fluid inclusions. (A.K.)

DEMSKI, C., 1980, Fluid inclusion investigations on fluorite of the "Gottesehre" mine south of St. Blasien in the Black Forest: Dipl.-Arb., Hamburg, 111 p., Mineralogisch-Petrographisches Institut. (in German).

Fluid inclusion measurements in fluorite, calcite, and quartz. (E.Horn)

DENIS, Michel, PICHAVANT, Michel, POTY, Bernard and WEISBROD, Alain, 1980, The Sierrita-Esperanza porphyry copper, Arizona, U.S.A. Comparison with other porphyry coppers: Bull. Mineral., v. 103, p. 613-622 (in French). First author at Minatome, 69-73, rue Dutot, 75015 Paris, France.

The present study of the Sierrita-Esperanza porphyry copper deals first with the distribution of the alterations and mineralizations. An important potassic alteration (growth of K-feldspar) is more or less overprinted by a pervasive quartz-sericite alteration. Actually, the growth of muscovite may result in two opposite processes, according to the nature of the altered minerals:

- plagioclase → muscovite (input of K),
- K-spar → muscovite (leaching of K, input of H).

The first must be related to the early potassic alteration; the second one to a later alkali-leaching process. Most of the mineralization (chalcopyrite, molybdenite) is associated with the potassic alteration.

There is no doubt about a bulk zonal distribution of the alteration and mineralization. But it is also clear that post magmatic evolution of the porphyry is mainly controlled by circulation of colder and colder fluids throughout an extremely dense network of fractures.

The fluid inclusion study is the most important part of this work. Three main sorts of inclusions have been recognized:

Type L: 2 phase aqueous inclusions (liq + vap, with liq > vap). They are very common.

Type V: 2 phase aqueous inclusions (liq + vap, with vap > liq).

They are quite rare.

Type S: multiphase inclusions, with liq > vap, halite ± sylvite, chalcopyrite...Although they are more common than type V, they are not very abundant.

Homogenization temperatures are in the 120-420°C range. The higher ones (above 300°C) were measured in the best mineralized samples.

Chemical analyses of inclusions ("crushing and leaching" technique) yielded the following results: K/Na at.ratio ~0.1; Ca/Na ~0.05; cations other than Na, K, Ca, Mg make about 30% of the total positive charges; chlorine is the essential anion.

On the basis of the various results of the study, the following evolution is tentatively proposed:

The earliest recorded fluid is a brine (40 wt% NaCl eq.) with high copper content (250 ppm), trapped under late magmatic conditions (about 700°C, 2 kbar). Moderate boiling of this fluid occurred as a result of a sudden drop of the fluid pressure due to important fracturing. At about the same time, an input of cold and moderately saline waters diluted and cooled the system down to 300-400°C. This stage was responsible for both the deposition of the ore (by supersaturation of the liquid phase), and for the potassic alteration.

The next stage was characterized by increasing and continuous cooling and dilution of the solutions (300 to 100°C, pressure lower than 100 bars) and was responsible for the "leaching type" alteration and most of the pyrite deposition. A few restricted "active" areas were still submitted to an important hydrothermal activity.

The same kind of evolution, with minor differences, accounts for the facts observed in the Santa Rita, Tyrone and Copper Cities porphyries. It supports a method of prospecting based upon some typical features of fluid inclusions, particularly:

- the occurrence of concentrated brines with high copper content,
- the evidence of significant boiling of the fluids at a later stage of the evolution. This method, applied to a prospect located in Arizona (Chiricahua Mountains) yielded interesting results. (Authors' abstract)

DES MARAIS, David J., DONCHIN, Jason H., NEHRING, Nancy L., and TRULESDELL, Alfred H., 1980, Carbon isotopes in individual hydrocarbon gases from geothermal systems (Abst.): Geol. Soc. Amer. Abstracts and Programs, v. 12, p. 412.

DICKINSON, J.E., HESS, P.C. and RUTHERFORD, M.J., 1980, REE partitioning between zircon, whitlockite and two liquids (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 397.

DIMOV, V., BRESKOVSKA, V. and MALEEV M., 1980 A microdiffraction study of the phase composition of precipitates from fluid inclusions in minerals from the Madjarovo ore deposit: Geochem., miner. and petr. (Bulgaria), v. 13, p. 37-44 (in Russian; English abstract). First author at Bulgarian Acad. of Sci., Lab. of Experimental and Technical Mineralogy, Sofia.

The phase composition of the mineral precipitates obtained by evaporation of aqueous extracts from galena, sphalerite, quartz and pyromorphite from the Madjarovo ore deposit, Eastern Rhodope Mountains, have been identified. Crystalline phases, corresponding structurally to the minerals villiaumite, sylvine, halite, fluorite, calcite, vaterite, bradleyite, ewaldite (whewellite?), huanhite (Juanite?), anhydrite, fairchildite, cryptohalite, bararite, hieratite and marshite, have been identified by electron microdiffraction. The minerals studied from the main hypogene stage - quartz, sphalerite and galena, and the "supergene" pyromorphite have anionic and cationic compositions similar to those of the mineral precipitates. (Authors' abstract)

DOLGOV, Yu.A., 1980, Inclusions of intermediate melt-solution states (abst.): 26th Int. Geol. Congr. Abstr., v. 1, p. 123.

The intermediate melt-solution states are well defined by the inclusions in high-temperature minerals. Topaz, quartz, beryl, minerals of granite pegmatites, contain on the initial stages of genesis inclusions with varying quantities of highly volatile components. The latter are represented by gaseous, liquid and solid phases of the inclusions. During the contractional deformation (expansion) of a constant pegmatite chamber volume, volatile components leave the system, obeying Lewis-Rendall rule. In the pegmatite chamber there remain less volatile components, also trapped in inclusions, indicating the loss of volatiles with the expansion of the system; the study of inclusions in the minerals of metamorphic genesis close to the anatectic transitions field indicates the existence of silicate and salt file(sic) components (water, CO_2). The evolution of melt inclusions occurs against a background of growth of volatile components cooling of the system. In the inclusions of the first stages of partition the volatile components are represented by the condensed gases forming compressed liquids, which allows determination of the pressures of anatectic melts and early metamorphites. The condensed carbon dioxide and methane allow determination of the pressures of each metamorphic stage for definite temperature. (Author's abstract)

DOLGOV, Yu.A. and TOMILENKO, A.A., 1978, Types of inclusions in metamorphic minerals (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 116-118 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

The study of inclusions in minerals of metamorphic rocks (garnet, kyanite, sillimanite, andalusite, hypersthene, quartz, plagioclase, etc.), which were formed in different facies (eclogitic, granulitic, amphibolitic, epidote-amphibolitic), showed that during the process of metamorphism metamorphic minerals trap inclusions as fluids of high density. These inclusions vary in density and composition from "pure" carbonic, nitrogen and hydrogen-hydrocarbon (liquid or gas and liquid at room temperature) through mixtures of $CO_2+CH_4+H_2+H_2O$ to "pure" H_2O and water-salt inclusions.

Inclusions in metamorphic minerals are in Ermakov's (1972) class V of inclusions, called metamorphogenic inclusions.

According to the present state of the dominate matter in the vacuoles, there are 4 kinds of metamorphogenic inclusions: carbonic, hydrocarbon (methane-rich), nitrogen, and water-salt.

At ordinary temperatures carbonic inclusions have eight varieties of independent inclusions and hydrocarbon, nitrogen and water-salt inclusions - 4 varieties of independent inclusions.

1. LH_2O inclusions are represented by homogeneous water-salt solution; 2. LH_2O+K solid phase is present besides liquid phase (chloride?); 3,4. LH_2O+G, $(LH_2O+G)+K$ usually a small gas bubble often in Brownian movement. Disappearance of the gas bubble in the given inclusions always occurs on

heating to 100°C.

When interpreting the data from metamorphogenous inclusions (as well as from inclusions of other classes) it is necessary to clarify the relative time and mechanism of their formation in minerals, and that can be done by elucidation of their morphology and spatial distribution in each host mineral.

Singling out species and varieties inside a class of metamorphogenous inclusions, dividing them into primary, primary-secondary and secondary, and also normal and anomalous ones, provides abundant information on the P-T conditions of rock metamorphism and anatexis, and also about conditions and evolution of the fluid in metamorphic processes at different P and T. (Translation courtesy Dr. A.P. Berzina)

Metamorphogenic Class of Inclusions

Type I carbonic	II hydrocarbonic (methane-rich)	III nitrogen	IV water-salt
LCO_2	LCH_4	LN_2	LH_2O
LCO_2+K	LCH_4+LH_2O		
LCO_2+LH_2O	LCH_4+K	LN_2+LH_2O	LH_2O+G
LCO_2+GCO_2	LCH_4+LH_2O+K	LN_2+K	LH_2O+K
(LCO_2+GCO_2)+K		LN_2+LH_2O+K	LH_2O+G+K
$(LCO_2+GCO_2)+LH_2O$			
LCO_2+LH_2O+K			
$(LCO_2+GCO_2)+LH_2O$+K			

(K = solid phase)

1. LCO_2, LN_2, LCH_4 inclusions contain mainly wet gases of high density - carbon dioxide, methane and nitrogen. Water in the form of independent liquid phase was not discovered, though it may be present in the form of a film.

2. LCO_2+K, LCH_4+K, LN_2+K - these inclusions contain solid phase (usually anisotropic), its nature being not clear.

3. LCO_2+LH_2O, LCH_4+LH_2O, LN_2+LH_2O inclusions are complex systems of two immiscible liquids.

4. (LCO_2+LH_2O)+K, (LCH_4+LH_2O)+K, (LN_2+LH_2O)+K - solid phase is present besides two immiscible liquid phases.

5,6,7,8. LCO_2+GCO_2, (LCO_2+GCO_2)+K, $(LCO_2+GCO_2)+LH_2O$, $(LCO_2+GCO_2)+LH_2O$+K inclusions contain a small gas bubble (CO_2), which is often in Brownian movement.

DOLOMANOVA, Ye.I., BOGOYAVLENSKAYA, I.V., GROSHENKO, A.R. and ROZHDESTVENSKAYA, I.V., 1980, Comparison of temperatures of formation of tin ore deposits of Transbaikalia from the data of homogenization, decrepitation of gas-liquid inclusions in minerals and isotope-oxygen geothermometer: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 10, p. 67-74 (in Russian). First author at IGEM AN SSSR, Moscow, USSR.

The studied specimens were collected at the following Transbaikalian cassiterite deposits: Bel'skoe, Zavitaya, Adun-Cholon, Little Kulinda, Imalka, Etyka, Shumilovskoe, Molodyozhnoe, Zun-Undur, Dedova Mt., Asaka, Aldakacha, Ushmun, Budyumkan, Onon, Privalovskoe, Angatuy, Uval'noe, Badzhiraevskoe, Sherlovaya Mt., Berein, Sokhondo, Ingoda, Tarbal'dzhey, Khapcheranga, S. Kharatuy; Khabarovsk county deposits: Karadub and

Mikoyanovskoe; GDR deposit Ehrenfriedersdorf. Temperatures obtained by isotope-oxygen geothermometers agree with data form G/L inclusions in minerals from deep tin ore deposits of high-T formations bearing relatively large vacuoles with salt- and G-bearing solutions and high total salt concentrations, and sharply differ with the data obtained from similar minerals from subsurface deposits, where dimensions of grains and vacuoles are much smaller. Decrepitation reveals various types of inclusions, [but] more exact characteristics may be derived from homogenization measurements. Under tectonic action part of large vacuoles have decrepitated in the deposit and the remaining small ones decrepitate at higher T than the large ones. Probably, small vacuoles mostly are one-phase and bear G or solutions of low concentration. Temperature of formation of cassiterite and syngenetic quartz in pegmatite formation is close or the same as in deposits of quartz-cassiterite formation, probably due to fact that in both processes the two minerals form during greisenization. Most probably the tin ore deposits of cassiterite-pegmatite formation develop at 450-370°C, cassiterite-quartz-feldspar and cassiterite-quartz at 400-300°C, cassiterite-quartz-sulfide <300°C and cassiterite-sulfide <200°C. (Authors' conclusions translated and extended by A.K.)

DOLOMANOVA, Ye.I., BORISOVSKIY, S.Ye., BOYARSKAYA, R.V. and TSEPIN, A.I., 1980, Physical methods for study of inclusions of mineral-forming medium in minerals: p. 135-155 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The authors discuss the use of electron microscopy (transmission and scanning), electron microprobe and microspectrographical emission analysis for studies of fluid inclusions. By the replica method the morphology of inclusions may be studied, however, frequently the vacuoles are too deep for preparation of good replicas; this method is most applicable to small inclusions (<1.5 μm). Frequently the dms, trapped minerals, or phases crystallized from inclusion solution after inclusion opening, stick on the replicas. Included crystals may be released from matrix and placed on replicas by additional treatment like selective etching, thermal shock, etc. Then they may be studied by electron microscopy. Methods of scanning microscopy and microprobe analysis are briefly characterized, including possible errors in the determinations (e.g., "side effect" etc.). The authors recommend studies of inclusion contents by electron microprobe on inclusions opened by breaking rather than on polished surfaces, since polishing causes extraction of dms from vacuoles and filling vacuoles by polishing media. Especially good for determinations are salts from evaporated inclusion fluids on the cleavage surface; the composition of the crystallized salts may be found this way. Inclusions occurring sufficiently close to the preparation surface may be investigated without opening. The problem is that light elements may be poorly detectable in unopenedd inclusions. For emission spectral analysis a piece of mineral with a single type of inclusion is chosen, washed in bidistilled water, and finely ground between two corundum plates. A drop of bidistilled water (0.1 cm^3) is placed on the resulting powder. The prepared water leachate is taken by micropipette and possible particles of mineral are removed by filtering through thin paper strip. Two drops of the leachate from the micropipette are placed on a polished plate of optical silica glass and the water is evaporated. Each of the two dots of salts is then placed on copper electrodes and analyzed in the spark mode. The following elements were found this way in fluid inclusions: Cl, F, B, C, S, Na, K, Ca, Mg, Al, Be, Fe, Cr, Mn, Ni, Ga, Sn, and CN. (Abstract by A.K.)

DONETS, A.I., KONKIN, V.D., DRUTYI, V.M., RUCHKIN, G.V. and ZAIRI, N.M., 1978, Temperature conditions of formation and certain problems of zoning of lead-zinc ore mineralization at the Sardan ore region (SE Yakutia) (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 120-121 (in Russian). Authors at Central Sci.-Research Geol.-Prospecting Inst., Moscow, USSR.

The ores occur in metasomatic dolomites, which were formed at maximum Th 260-360°C. Ores formed during three stages with Th: first stage 150-220°C, second stage 310-360°C to 220-260°C, third stage 130-90°C. Ore-forming solutions migrated from SE to NW across the ore region, i.e., from the deposit Uruy to Pereval'noe. (A.K.)

DONNELLY, T.H. and FERGUSON, J., 1980, A stable isotope study of three deposits in the Alligator Rivers uranium field, N.T.: Uranium in the Pine Creek Geosyncline; Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline I.A.E.A., Proc. Ser. Pub. 555, p. 397-406.

Indexed under Fluid Inclusions. (E.R.)

DOROGOVIN, B.A., BYDTAEVA, N.G. and SHATAGIN, N.N., 1978, Thermobarogeochemical zoning of rock-crystal deposits in the Southern Yakutia, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 157-158 (in Russian). First author at VNIISIMS, Alexandrov, USSR.

Rock crystals grew in quartzites at 200-300°C from "pure" HCO$_2$-Cl-Na-CO$_2$ solutions. Two distinct Td intervals were found: 20-320 and 320-480°C. By experimental runs (thermal influence on CO$_2$-bearing inclusions in quartzites) at 200-300°C and 80-600 atm, the probable depth of rock crystal formation was evaluated for 500-1000 m(sic.). (From the authors' abstract translated by A.K.)

DREIER, J.E., 1976, The geochemical environment of ore deposition in the Pachuca-Real del Monte district, Hidalgo, Mexico: Ph.D. dissertation, Univ. Arizona.

The Pachuca-Real del Monte district, located in Hidalgo, Mexico, has produced about 1,300 million ounces of silver and is second in total world silver production. The district occurs wholly within a calc-alkaline volcanic rock sequence of possible Miocene-Pliocene age. The ore deposits occur in veins and are localized in dilatant zones in faults. The dilatant zones occur at fault intersections or where faults undergo changes in strike or dip. Orebodies terminate laterally and upward where the dilatant zones pinch out, whereas downward, they terminate due to a decrease in grade.

As indicated by stratigraphic reconstructions, veins appear to have formed beneath a cover of 400 to 500 meters of preore volcanic rock. This is also supported by the presence of fluid inclusions indicative of boiling from the 100-meter level of the Dios Te Guie vein.

Veins are composed of angular rock fragments (50%), fine-grained cloudy quartz + adularia + johansennite (20-30%), coarse-grained clear quartz + adularia + prehnite (10-30%), pyrite + galena + sphalerite + chalcopyrite + argentite (1-3%), and calcite. According to fluid inclusion filling data, cloudy quartz + adularia + johansennite were deposited between 320°C and 250°C, clear quartz + adularia + prehnite were deposited at about 250°C, and sulfides and calcite were deposited between 250°C and 200°C. Quartz-calcite stringers above veins were deposited at about 200°C. During deposition of clear quartz, the geothermal gradient in the veins was low and may have approximated an adiabatic gradient. At that time the temperature in the veins was regulated by the hydrostatic pressure at the highest point in the veins.

Freezing temperature determinations showed that the salinity of the hydrothermal fluids was below 0.4 molal NaCl-KCl equivalent. Coupling salinity determinations with mineral dissociation reactions in the system K_2O-Na_2O-CaO-Al_2O_3-SiO_2-H_2O-Cl-S-Ag-O_2 reveals that pH of the hydrothermal fluids was about 5.8 and total dissolved silver was about 1 to 100 ppb.

Wall-rock alteration occurred in fractured and otherwise permeable rock. Adjacent to veins, alteration minerals are adularia, albite, quartz, calcite, epidote, chlorite, prehnite, and pyrite. Above veins alteration minerals are calcite, illite, quartz, and pyrite. Wall-rock alteration adjacent to veins was principally accomplished by potassium metasomatism and reduction of iron from Fe^{+++} to Fe^{++}. Wall-rock alteration above veins was accomplished by H^+ metasomatism and the introduction of sulfur. The required H^+ ions could have been derived by the cooling of upward migrating vein-forming fluids. (Author's abstract)

DRUMMOND, S.E. and OHMOTO, H., 1980, Chemical modeling of hydrothermal fluid mixing (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 417.

The chemical processes accompanying fluid mixing have never been fully evaluated despite the abundant isotopic, fluid inclusion and mineralogical data suggesting that many ore deposits are formed by mixing two contrasting fluids. A computer program has been developed to determine the speciation and pH changes during mixing and to model the effects of mixing on mineral deposition in the system Na-K-Ca-Mg-Cl-C-S-O-H-metals. Mixtures of various hydrothermal fluids (Kuroko, Mississippi Valley, geothermal, etc.) with meteoric or seawater have been modeled. For example, when a Kuroko ore fluid (Pisutha-Arnond and Ohmoto, this abst. vol.) is titrated with 0°C seawater, pH rises initially from 4.5 (300°C) to 4.9 (T_{mix}=250°C) due to SO_4^{2-} addition from seawater but then acid dissociation gradually lowers pH to 4.7 (T_{mix}=130°C). Carbonates do not reach saturation levels during mixing. Anhydrite and barite precipitation results from the large SO_4^{2-} input from seawater. 90% of the metal sulfides and native metals precipitate in the first 10% mixing.

In general titrating typical hydrothermal fluids with cold solutions produces only small (±0.5) pH shifts. pH effects on mineral deposition are subordinate to the cooling effects which can increase free metal activities abruptly and cause quantitative deposition of native metals and sulfides in the initial stages of mixing. The order of sulfide deposition during mixing depends on the relative abundance of each metal and the temperature dependence of individual mineral solubilities. Fe and Cu sulfides usually precipitate before sphalerite and galena. The number of sulfide phases precipitated is controlled by the $\Sigma H_2S/\Sigma$metals ratio. Carbonates and sulfates may or may not attain saturation depending on the composition of each mixture end member. (Authors' abstract)

DUBESSY, Jean, GEISLER, Dominique, KOSZTOLANYI, Charles and VERNET, Michel, 1980, Determination by Raman spectroscopy (M.O.L.E. microprobe) of the sulphate ion in the fluid inclusions of recent halites (Camargue, France): Sciences de la Terre, v. 24, no. 2, p. 197-212 (in French). First author at Centre de Recherches sur la Géologie de l'Uranium, B.P. 23, F-54501 Vandoeuvre-lés-Nancy, Cedex, France.

It is necessary to know the chemical characteristics of the brines from which halites have formed to be able to determine precisely their original environment. The fluids in primary inclusions are generally considered as being samples of the mother brines of crystallizing halite. This fact is demonstrated in the case of a solar salt works (Salin-de-Giraud, France) by comparing the values of SO_4^{--} in the open brine and in the solutions trapped in the crystallizing halites. The SO_4^{--} concentration in the brines of the inclusions is determined by Raman spectroscopy with the M.O.L.E. microprobe. A regression line is drawn after the intensity ratio of the Raman signal of water and sulphate as a function of the SO_4^{--} concentration in sodium chloride saturated solutions.

Knowing the SO_4^{--} concentration of a brine saturated with respect to gypsum and using concordant thermodynamic data relating to $CaSO_4, 2H_2O \rightleftharpoons Ca^{++} + SO_4 + 2H_2O$ equilibrium, it is possible to anticipate the Ca^{++} concentration of the solution. The good agreement between the analytical results and the calculations in the case of a sampled brine supports the use of simple calculations in the investigation of natural examples. (Authors' abstract)

DUBESSY, J., PAGEL, M., POTY, B., KOSZTOLANYI, C. and BENY, J.M., 1980, Evidence, by Raman spectroscopy, of free hydrogen and free oxygen in fluid inclusions from two uranium deposits (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 129.

Studies of volatile components in fluid inclusions are making great progress with the use of the laser excited Raman microprobe. Among these volatiles, the presence of free hydrogen and free oxygen are very interesting because it has been suggested that H_2 could diffuse from quartz and consequently, modify the fluid inclusions representativity.

These two components have been discovered in fluid inclusions in quartzes from two uranium deposits: the Oklo deposit (Gabon) (Openshaw, Pagel et Poty, 1978) and the Rabbit Lake deposit (Canada) (Pagel, Poty and Sheppard, 1980).

Oklo: H_2 is very abundant; the presence of inclusions containing only free H_2 is remarkable. O_2 is present in trace amounts in one fluid inclusion. CH_4 has been observed in some other fluid inclusions.

Rabbit Lake: H_2 and O_2 have been detected in the gaseous phase of inclusions containing two fluid phases. The H_2/O_2 ratios are very variable.

The formation of free H_2 and free O_2 by the radiolysis of water and/or organic matter and the subsequent effects on uranium mobility are discussed for these two uranium-rich deposits.

These data support the following observations:

a) The diffusion of H_2 from fluid inclusions in quartz must be very limited since H_2 under pressure has been retained in fluid inclusions since Precambrian times.

b) The presence of H_2 in fluid inclusions, undetectable by microthermometry, may greatly affect the interpretation of microthermometry data.

c) The presence of free H_2 must also not be overlooked in the interpretation of δD from fluid inclusions. (Authors' abstract)

DUCKWORTH, E.G. and ROBINSON, B.W., 1980, Stable isotope studies; some applications and examples (abst.): In Abstracts and Timetable; 1st New Zealand Geophysics Colloquium, Sept. 1-3, 1980; Victoria Univ. at Wellington, Inst. Geophys., Wellington, New Zealand, unpaginated, summary only.

Indexed under Ore-Forming Fluids. (E.R.)

DURASOVA, N.A., SUSHCHEVSKAYA, T.M. and SHARAS'KIN, A.Ya., 1980, Chronicle: XIV Pacific Science Congress: Geokhimiya, no. 5, p. 778-784 (in Russian).

The review contains, among others, short abstracts of lectures on fluid inclusions from various sections of XIV PSC. (A.K.)

DVOROV, V.I. and PAVLOV, D.I., 1979, Near-fault zones of sulfide enrichment and a possible mechanism for formation of metalliferous brines: Sovetskaya Geologiya, 1978, no. 6, p. 97-107 (in Russian; translated in Internat. Geol. Rev., v. 21, no. 7, p. 806-814, 1979).

EADINGTON, P.J. and WILKINS, R.W.T., 1980, The origin, interpretation, and chemical analysis of fluid inclusions in minerals: Technical communication 69 - CSIRO Institute of Earth Resources, 30 pp.

EASTOE, Christopher, 1980, Chemistry of magmatic fluids in the Panguna (Bougainville) porphyry copper deposit (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 929.

The boiling, salt-rich liquid which deposited quartz, anhydrite and chalcopyrite in the Panguna (Bougainville) porphyry copper was evolved unsaturated in NaCl from quartz-diorite and granodiorite magma. The partitioning of elements between liquid and vapor appears to be an important factor in accounting for porphyry-deposit mineralogy. At conditions inferred from Panguna mineralogy and fluid-inclusion data, the transport of Fe and probably Cu in the vapor is insignificant, but Mo, Zn and probably Pb appear to undergo significant vapor transport. This may explain the separation of Mo from Cu in certain deposits. Most of the S in the magma is lost to the vapor as SO_2. Vapor-transported elements are available to form deposits higher in the hydrothermal system under suitable conditions. Vapor transport of H_2 leads to the oxidation of the magma and later volatiles; at Panguna copper was deposited only from more oxidized fluids. Deposition occurred as boiling salt-rich liquid cooled and mixed with groundwater, largely between 430°C and 500°C, from salt-rich liquid which appears to have been supersaturated in NaCl. (Author's abstract)

EBY, G. N., 1980, Minor and trace element partitioning between immiscible ocelli-matrix pairs from lamprophyre dikes and sills, Monteregian Hills petrographic province, Quebec: Contrib. Mineral. Petrol., v. 75, p. 269-278.

EDMOND, J.M., 1980, Ridge crest hot springs: the story so far: EOS, v. 61, no. 12, p. 129-131.

An excellent summary of the knowledge to date of the geochemistry of these heavy-metal-bearing hot springs (up to 350°C). (E.R.)

EFIMOVA, M.I., BLAGODAREVA, N.S., VASILENKO, G.P. and FEDCHINA, G.N., 1980, Mineral parageneses of the deposits of lead and zinc in Primorie (USSR): Arch. Mineralogiczne, v. 36, pt. 1, p. 99-121 (in Polish with English abstract). Authors at Far-East Geol. Inst. Far-East Sci. Centre of the Acad. Sci. USSR.

Primorie, mainly consisting of the young folded areas of the Sikhote-Alin' Mts., is the part of the circumpacific ore belt. The area of Primorie includes the following structural-facial zones: 1) Grodekovskaya, 2) Khanka crystalline massif, 3) Daubikhinskaya synclinal zone, 4) Sikhote-Alin' anticlinorium, 5) Sikhote-Alin' synclinorium, 6) Coastal anticlinal zone (Fig. 1). In general, the deposits of lead and zinc occur in the internal parts of the geosynclinal system. On the basis of the geological, mineralogical and geochemical studies three main formations of the deposits were distinguished and their structural and paragenetic features as well as peculiarities of their generation are presented (Figs. 2-4 and Tabl. 1-5). The formations are as follows: a) skarn-sulfide formation with the typical deposits in the Coastal zone, Dalnegorsk and Olga regions; b) cassiterite-sulfide formation with the typical deposits in the Sikhote-Alin' synclinorium and Coatal zone (Smirnovskoe, Monastyrskoe, Lidovskoe); c) apocarbonate-greisen formation with the typical deposit in the Khanka crystalline massif (Voznesenskoe).

The deposits of the skarn-sulfide formation formed during one or two skarn stages and the subsequent main ore stage was usually connected with the origin of metasomatic propylites. Garnet, wollastonite, hedenbergite, axinite, ilvaite, quartz and calcite form the skarn parageneses, propylites consist of calcite, clinozoisite, epidote, K-spar, albite, prehnite, chlorite, biotite and actinolite. Galena and sphalerite, the essential ore minerals, often associate with chalcopyrite, pyrrhotite, arsenopyrite, pyrite and marcasite. Fluid inclusion studies yielded homogenization temperatures from 670-640K (397-367°C) for skarn minerals down to 470K (197°C) for ore minerals and 320K (47°C) for late gangue minerals; calculated pressure varied from 33 to 2 MPa during ore stage.

Ore bodies of the cassiterite-sulfide formation usually present veins, bearing quartz, sphalerite, galena and pyrrhotite with subordinate cassiterite and arsenopyrite. The deeper parts of veins consist of the quartz-chlorite-tourmaline and quartz-cassiterite-tourmaline associations. Wall-rocks are strongly metasomatized: the first pre-ore stage of metasomatism caused biotitization, and the second one, simultaneous with crystallization of the ore minerals, resulted in origin of the topaz-fluorite-chlorite, muscovite-fluorite-chlorite and tourmaline-muscovite-chlorite rocks. Temperature ranged from 680 to 330K (407-57°C).

The deposit of the apocarbonate-greisen formation occurs in Riphean limestones, partly altered to skarns, but also to greisens due to extensive influx of Al, Si, Fe etc. in the fluorine-rich hydrotherms. Four stages of the deposit formation were distinguished: pegmatoid-, skarn-, greisen- and sulfide stages. Sulfides precipitated at temperature 570-470K (297-197°C).

The deposits of lead and zinc commonly associate with dikes of porphyrites. Extensive geochemical studies suggest the mesocratic magma has been probably the source of Pb and Zn in the deposits of the Primorie area. (Authors' abstract)

EFIMOVA, M.I., BLAGODAREVA, N.S., VASILENKO, G.P., KOKORIN, A.M., KOKORINA, D.K., NAUMKIN, P.A., STEPANOV, G.N., STEPANOVA, M.V. and FAT'YANOV, I.I., 1980, Temperature parameters of formation of endogene ores of the Far East, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Pub. House of Far East Sci. Center of Acad. Sci. USSR, p. 3-19 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 11, 1978, p. 57-58, Efimova et al. (A.K.)

EFIMOVA, M.I., MIKHAYLOVA, V.A., NAUMKIN, P.A. and YAKOVETS, V.A., 1978, Temperature fields of the metasomatites surrounding ores in a gold-ore deposit in Primor'ye, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 182-183 (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. USSR, Vladivostok.

The deposit* occurs in effusive-sedimentary Paleozoic rocks, terrigenous Mesozoic rocks and various magmatic rocks. Th in quartz yielded 3 stages of the ore formation: 1) 320-300°C, early gold-pyrite-quartz veins, 2) 230-220°C, quartz veins with rare disseminated sulfides and gold, 3) 120-80°C, practically ore-free quartz veinlets. Metasomatic haloes, especially as rocks consisting of quartz, muscovite, tourmaline, apalite, andalusite, and chlorite, with finely dispersed commercial gold, formed at 230-240°C. (From the authors' abstract, translated by A.K.) (*Deposit name not given, A.K.)

EFIMOVA, M.I., MOISEENKO, V.G. and FAT'YANOV, I.I., eds., 1980, Thermobarogeochemistry and ore genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, 236 p., 1000 copies printed, price 2 rbls. 70 kopecks (in Russian).

The books consist of the texts for 36 of the lectures presented during the VIth All-Union Meeting in Vladivostok in 1978. Abstracts of those lectures were published in a two-volume edition in 1978 before the meeting and then translated into English and published in Fluid Inclusion Research - Proceedings of COFFI vols. 11, 12 and 13. For individual references see entries in this volume arranged alphabetically by the authors' name. (A.K.)

EFIMOVA, M.I., SOLYANIK, V.A., NAUMKIN, P.A., PORECHIN, A.A., YAKOVETS, V.A., 1980, Physico-chemical conditions of formation of metasomatites at one of the gold ore deposits of Primor' ye, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 130-134 (in Russian).

See Efimova, Mikhaylova, Naumkin and Yakovets, 1980, Fluid Inclusion Research- Proceedings of COFFI, v. 13. (A.K.) See previous item.

EGGLER, David H, BAKER, Don R., and WENDLANDT, Richard F., 1980, FO2 of the assemblage graphite-enstatite-forsterite-magnesite: experiment and application to mantle FO2 and diamond formation (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 420.

ELDERS, W.A., 1980, Hydrothermal minerals, temperature and flow regime in the Cerro Prieto geothermal field: a model for greenschist metamorphism (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 389-390.

Study of active hydrothermal processes in modern geothermal fields provides new insights into greenschist facies metamorphism.

More than 60 boreholes, 1-3 km deep, have encountered temperatures $\geq$350°C and brines with $\leq$2% total dissolved solids in the Cerro Prieto geothermal field of the Salton Trough intracontinental rift system, in Baja California. Temperature dependent dehydration and decarbonation reactions have produced a regular sequence of mineral zones in sediments of the Colorado River, mappable across the field in the subsurface.

These mineral assemblages also depend upon water/rock ratio, P_{CO_2}, and location within the flow regime. At the same temperature, minerals in sandstones differ from those in shales because of permeability differences. Similarly, patterns of mineral zones in regions of horizontal flow, or of vertical discharge or recharge, are quite characteristic.

Water/rock ratios can be estimated using $\delta^{18}O$ in water and minerals. In addition to direct downhole measurements, temperatures have been estimated from isotope ratios, fluid inclusions, and vitrinite reflectances, giving us the temperature history. The age and duration of heating is being estimated from fission track annealing studies. Thus we are using hydrothermal minerals to record temperature, fluid chemistry, fluid flow, and heating time, in a modern analogue of an environment which was widespread in the Precambrian. Seeing the output of a geothermal well makes metasomatism less mysterious. (Author's abstract)

ELINSON, M.M., POLYKOVSKIY, V.S., MEL'NIKOV, F.P., VALYASHKO, W.M., SOKOLOV, V.A. and IVANOVA, N.A., 1978, Peculiarities of variations of gas composition of inclusions in minerals in process of formation of the Kyzylbaur fluorite deposit, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 141-142 (in Russian). First author at Moscow State Univ., USSR.

The Kyzylbaur fluorite deposit occurs in the structural zone Bel'tau-Kuramin, and is connected with the Upper Carboniferous granitoids. Ore bodies form lenses and veins. Violet fluorite has Td 360-340°C, G content in mm^3/g: CO_2 3.6-12.7, H_2 3,0-7.0, CH_4 0.2-0.85; H_2O 150-427 mg/kg, CO_2/H_2O 0.01-0.06; dark green fluorite - Td 260-240°C, CO_2 4.3-4.7, H_2 0.03-0.3, CH_4 not found, H_2O 78-223, CO_2/H_2O 0.02-0.06; pale green fluorite (with carbonate) - Td 180, CO_2 6.5-13.5, H_2 0.07-0.09, CH_2 not found, H_2O 60-105, CO_2/H_2O 0.09-0.14. (A.K.)

ENJOJI, M., 1980, Fluid inclusions in hydrothermally synthesized quartz crystals: Tsukuba, Univ., Inst. Geosci., Annu. Rep., v. 6, p. 75-78.

EPEL'BAUM, M.B., 1980, Silicate melts with volatile components, 256 pp. (in Russian), "Nauka" Publ. House, Moscow, price 3 rbls, 700 copies printed.

The book presents solubility of H_2O and other gases in melts and their influence on melt properties, influence of acidity of fluid on eutectic features of silicate melts, structure of "dry" and water-bearing melts and glasses, mechanism of dissolution of water in aluminosilicate melts, experimental studies of transport properties of magmatic melts and mass exchange between fluid phase and magmatic melt. (Abst. by A.K.)

EREMENKO, G.K., CHEREMITSYN, V.G., CHMYREV, V.M. and AZIMI, N.A., 1978, Related inclusions in the volcanic carbonatites of Hanneshin (Afghanistan) and vertical zonality of open-type carbonatite complexes: Akad. Nauk Ukr RSR, Dopovidi, Ser. B., Geol., Geofiz., Khim., Biol., 1978, no. 1, p. 11-14 (in Ukrainian).

The Hanneshin Pliocene-Quaternary volcanic complex is a monocarbonatite complex composed by carbonatites of the surface (effusive) and near-surface (orifice) facies.

The early TR-Sr-Ba ankerite-calcite carbonatites contain xenoliths of sevites, phenites, glimmerites-fragments of endo- and exocontact metasomatic formations of shallow facies.

Late silicate calcite carbonatites contain xenoliths (nodules) and mineral disintegrates of magnetite, apatite-magnetite, apatite-magnetite-pyroxene and pyroxene rocks related to deep kamaphorites.

It is established that the composition of the Hanneshin volcanic material, as well as of other open-type complexes, is a complex function of deep carbonatite-forming processes and exchange reactions with the enclosing rocks taking place in the magmatic column of large vertical extent.

Explosion carbonatite orifices evacuate the deepest material to the surface as xenoliths. (Authors' abstract) (Sic.)

EREMENKO, G.K., CHMYRYOV, V.M., AVTONOMOV, V.A., POLVANOV, A.M., SHCHERBONOS, V.D. and ASSODULLO, S., 1980, Fluorite deposit Bakhud in the Southern Afghanistan; Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 8, p. 65-71 (in Russian). First author at the Lumumba University of the Friendship of Nations, Moscow, USSR.

Fluorite mineralization in the Bakhud region occurs in stratabound metasomatic ore bodies in carbonate Mesozoic rocks. Mineralization is moderate-T, and it formed during two stages: commercial sulfide-carbonate-fluorite (Th 205-180°C) and quartz-fluorite (Th 120-90°C). (A.K.)

ERMAKOV, N.P., 1980a, Methods of dynamic phasometry of inclusions of mineral-forming media: p. 5-11 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The author describes his fluid inclusion studies, starting from early 1940's, especially the significance of the homogenization method and so-called "dynamic phasometry," i.e., measurements of phase volumes in inclusions during heating, and presenting the results as T-volume plots (curves). With this background he describes inclusion homogenization in L phase, in G phase and "phasometry" of various types of melt inclusions. (Abstract by A.K.)

ERMAKOV, N.P., 1980b, Significance of data of thermobarogeochemistry for development of theory of endogene ore formation, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 218-225 (in Russian).

The use of certain results of studies of solution and melt inclusions in minerals for theory of endogene ore formation is discussed. (Author's abstract translated by A.K.)

ERMAKOV, N.P., 1980c, Thermobarogeochemistry of minerals of the Earth and space: Priroda (Moscow), 1980, no. 5, p. 56-65 (in Russian).
A review. (E.R.)

ERMAKOV, N.P. and DOLGOV, Yu.A., 1979, Thermobarogeochemistry: "Nedra" Publ. House, Moscow, 272 pp., 1700 copies printed, price 3 rbls. 30 kopecks (in Russian).

This textbook starts with characteristics of development of thermobarogeochemistry in the USSR and role of the All-Union meetings on thermobarogeochemistry, next discussing the sources of thermobarogeochemical information. This includes the presentation of "information sequences of inclusions," types of inclusion fillings and their possible use with extensive classification, relative time and methods of trapping, homogeneity of mineral-forming media and its importance for fluid inclusions. Next chapter shows the methods of studies of inclusions with historical review starting from Al Biruni (973-1048) and describing homogenization method and heating stages, theoretical aspects and verification of this method, so-called "semantics of thermobarogeochemistry" and "dynamic phasometry," i.e., measurements and plotting of phase ratios in inclusions on heating, types of homogenization, including two-page copy of notes in the laboratory diary as the recommended example and its half-page shortened version. This chapter includes also description of the decrepitation method (visual, acoustic, thermovacuum) and its use in mineralogical thermometry. Similarly the cryometric method is characterized, as well as methods of pressure determinations by use of fluid inclusions. The chapter is closed by discussion of corrections to Th. Following part describes the methods of studies of inclusion composition: spectrographic, microspectrographic, laser emission, laser-excited Raman spectroscopy, electron microprobe, X-ray diffraction microanalysis, flame photometry, liquid and G chromatography, atomic absorption, infrared spectroscopy, mass spectrometry, electron microscopy, etc., and chemical analysis of water leachates, analysis of L and G in individual inclusions. Next chapter gives the typical ways and examples of inclusion studies in magmatic, pneumatolytic, hydrothermal, metamorphic, cosmic, impactitic and ocean-floor authigenic minerals and mineraloids. Practical use of inclusions for prospecting purposes (decrepitophonic method of prospecting, use of the CO_2/H_2O ratio for finding of quartz bodies and zones of hydrothermal alterations, decrepitation of heavy fraction in sediments, and example of complex use of geochemical and inclusion study methods at the polymetal deposits of the Sadon group) are described in the penultimate chapter. The concise presentation of the future ways of practical and theoretical development and use of thermobarogeochemistry is given in the last chapter. (Abstract by A.K.)

ERNST, W.G., 1980, Mineral paragenesis in Franciscan metagraywackes of the Nacimiento block, a subduction complex of the southern California Coast Ranges: J. Geophys. Res., v. 85, no. B12, p. 7045-7055. Author at Dept. Earth & Space Sci., Inst. Geophys. & Planet. Phys., Univ. Calif., Los Angeles, Calif. 90024.

On the basis of experimental phase equilibrium data, temperatures of 150±50°C are estimated to have attended recrystallization, with lithostatic pressures increasing eastward from about 2-3 kbar on the west to approximately 5 kbar, and locally approaching 8 kbar, on the east. Absence of zeolites in the lowest grade zone I metagraywackes may indicate dilution of the aqueous fluid phase by CO_2 during the metamorphism. (From the author's abstract)

ETMINAN, Hashem, 1980, Distribution of Cu-Mo porphyry deposits in Iran; characteristic features of alteration and mineralization in different deposits (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 930.

Cu-Mo porphyry type deposits in Iran have been found in three metallogenic provinces represented by Kerman Region, Central Iran and northern Azarbaidjan. The most important zone is the Kerman copper region which is characterized by a dense distribution of porphyry type deposits. The geological features, genesis and age of mineralization appear to be identical throughout the Kerman region. In deposits of this region the potassic alteration represented by secondary biotitie ± K feldspar + chalcopyrite is systematically superimposed by phyllitic alteration. The most important porphyry type deposits in Kerman region are Sar Cheshmeh, Lachah and Darreh zar. In central Iran Cu-Mo porphyries are relatively rare. The Kal-e-Kafi Cu-Mo porphyry is characterized by more acidic composition for the porphyry stock, intense development of K feldspar in veins, weak development of phyllitic alteration and higher grade of molybdenum. In Azarbaidjan among the several occurrences discovered recently (H. Etminan 1977, 1978), the Songun Cu-Mo porphyry appears to be the most promising. These porphyries show many common characters with those of Kerman Region. The age is estimated to be identical to those of lesser Caucase deposits (42-19 m.y.).

Based on the mode of emplacements, hydrothermal mineral assemblages and fluid inclusions data, genetic models are proposed for different deposits. The comparison between these models reveal interesting points, applicable as possible prospecting tools. (Author's abstract)

EUGSTER, H.P., 1980, The role of fluids in crustal metamorphism (abst.): Int'l Geol. Cong., 26th, Abstracts, v. 1, p. 41.

Constituents of metamorphic fluids participate in nearly all metamorphic reactions and hence affect mineral equilibria, reaction kinetics and mass transport (metasomatism). Compositional information is obtained from fluid inclusions as well as from mineral assemblages. Most fluids can be modelled in the system C-O-H-Cl-S-F. Individual fugacities are calculated either from mineral buffers (mass action equations) or from compositional (mass balance) constraints. In addition, metamorphic fluids contain mineral constituents derived from mineral dissolution. Compositions of fluids are evaluated by combining information on mineral equilibria, mineral solubilities and solute dissociation constants.

H_2O and CO_2 are abundant species, while H_2 governs redox reactions. Judging from fluid inclusion data, chloride often is the dominant anion. In aqueous fluids, mineral solubilities, dissociation constants and hydration reactions depend primarily on temperature and fluid density and hence H_2O fugacity, fH_2O. Experimental calibrations are now available for chloride-rich fluids in equilibrium with Mg-silicates, alkali-Al-silicates and iron oxide-sulfide assemblages. Significant changes occur in solute speciation between sub- and supercritical conditions. High T, low fH_2O and high chloride values favor associated species such as NaCl, KCl, $FeCl_2$, $MgCl_2$. Application of experimental data to rocks is severely hampered by lack of definition of fH_2O for most natural rock systems. Current attempts involving measurement of intrinsic fH_2 may alleviate this difficulty. (Author's abstract)

EUGSTER, H.P., HARVIE, C.E. and WEARE, J.H., 1980, Mineral equilibria in a six-component seawater system, Na-K-Mg-Ca-SO_4-Cl-H_2O, at 25°C: Geochim. Cosmo. Acta, v. 44, p. 1335-1347.

EVANS, A.M., HASLAM, H.W. and SHAW, R.P., 1980, Porphyry style copper-molybdenum mineralization in the Ballachulish igneous complex, Argyllshire, with special reference to the fluid inclusion: Proc. Geol. Ass., v. 91, nos. 1 & 2, p. 47-51.

Full paper for abstract given in Fluid Inclusion Research--Proceedings of COFFI, v. 12, p. 52. (E.R.)

EWALD, A.H. and HLADKY, G., 1980, Solubility measurements on sphalerite: CSIRO Division of Mineralogy Invest. Rept. 136.

The solubility of sphalerite has been measured between 100 and 250°C in carefully deoxygenated water and in brines containing between 1 and 4 mol/kg NaCl. Numerous experimental problems were encountered, particularly in attaining equilibrium. (E.R.)

FARR, J.E., 1980, The geology and geochemistry of the stockwork of the Uwamuki #2 deposit, Kosaka mine, Japan: Research in partial requirement for the degree Bachelor of Science, Univ. of Toronto, May 1980.

The Uwamuki #2 deposit is composed of siliceous ore occurring in two concentrically zoned stockwork pipes: yellow siliceous ore occurs in the centre of the pipes surrounded by black siliceous ore.

Geochemical data indicate the stockwork is depleted in Na_2O, MgO and CaO, while the surrounding host rocks have been silicified and enriched in MgO. Ternary Al_2O_3-MgO-(Na_2O-K_2O-CaO) plots indicate the two mineralized pipes have significantly different bulk compositions. The northern stockwork has suffered K_2O depletion at a constant K/Al ratio similar to that found in stoichiometric sericite and illite, which corresponds to the illite + sericite + quartz mineral assemblage observed.

The southern stockwork shows no K_2O depletion and plots on the ternary diagram close to the "unaltered" average lava dome composition in the Kosaka area determined by Tatsumi and Clark (1972).

Filling temperatures from fluid inclusions in the YSO average 291° to 313°. Salinities of these inclusions ranged from 3.85 to 6.72 wt% NaCl. Temperatures calculated from sulfur isotope pairs ranged from 420°C to 465°C.

Textures and geochemical data indicate mineralization and alteration was restricted to two narrow vertical zones at Uwamuki #2 and the fluids were composed dominantly of sea water with a 5-13% magmatic component. (Author's abstract)

FAT'YANOV, I.I., 1980a, Magnesium metasomatites at the gold-ore deposit of the Ul' volcanic-tectonic structure (Lower Priamur'ye), p. 74-80 in: Mineralogy of native elements, publ. by Far-East Sci. Center, Vladivostok, 154 pp., 500 copies printed, price 1 rbl. 40 kopecks (in Russian).

The deposit (name not given) in the N. margin of Sikhote Alin' volcanic belt belongs to the gold-quartz sulfide-poor formation. Maximum T of hydrothermal-metasomatic process was 500-700°C, hydrotherms were of alkaline earth-HCO_3-CO_2 type. Gold ore stage development at 500-140°C, tourmaline stage at 400-110°C. (A.K.)

FAT'YANOV, I.I., 1980b, Stages and temperature conditions of formation of one of gold ore deposits of the Lower Priamur'ye, *in* Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 162-169 (in Russian).

See Fat'yanov and Makiyevskiy in *Fluid Inclusion Research-Proceedings of COFFI*, v. 13. See next item.

FAT'YANOV, I.I. and MAKIYEVSKIY, V.P., 1978, Stages and temperature regime during formation of a gold-ore deposit* of the Lower Priamur'ye, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 183-185 (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Vladivostok.

Formation of the deposit was connected with origin of the differentiated volcanic-plutonic complex, including Bekchi-Ul granitoid massif. Gold-bearing associations formed at (Th) 500-140°C, and the Bekchi-Ul intrusion that rose during the deposit formation, interrupted it (at Th 700-550°C) and next renewed the ore process which finished at 135°C. Next hydrotherms of the Bekchi-Ul massif of Th 400°C overlapped the previous activity and finally Th decreased to 110°C. (From the authors' abstract translated by A.K.) (*The deposit name not given, A.K.)

FAYZIEV, A.R., 1978, Physico-chemical conditions of formation of deposits in the Central Tadzhikistan, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 132-133 (in Russian). Author at Technical State Univ., Dushanbe, USSR.

Fluorite deposits in the Central Tadzhikistan formed at 450-50°C, P 1000-40 atm; fluorite crystallized at 360-50°C, 450-80 atm, quartz 450-80°C, 1000-180 atm, calcite 325-50°C, 380-50 atm, barite 310-75°C, 390-140 atm, sphalerite 165-110°C. The above intervals include T ranges typical of the various genetic groups in the fluorite deposits. The parent solutions had $HCO_3>SO_4>Cl>F>NO_3$ and Ca>Na>K>Mg, with certain variations in individual formations (water leachate method). Fluorite from quartz-fluorite deposits bears mostly CO_2; from calcite-barite-fluorite - CH_4-CO_2; from sulfide-fluorite - N_2; from mercury-antimony and optical fluorite - N_2-CO_2. Total salt concentration varies from 7 to 24%. Bitumens occur in concentrations 0.0006-0.025% (of sample weight probably, A.K.). (Author's abstract translated and shortened by A.K.)

FAYZIEV, A.R. and ISKANDAROV, F.Sh., 1978, Physico-chemical and thermobaric parameters of fluorite crystallization at the deposits of the Fayzbad ore region (Tadzhikistan), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 133-135 (in Russian). Authors at Technical State Univ., Dushanbe, USSR.

The deposits are of calcite-fluorite, sulfide-fluorite or quartz-fluorite. Fluorite in the deposits of the calcite-fluorite type crystallized at 135-215°C, 175-400 atm; water leachates yielded solution composition Cl, HCO_3, SO_4, Ca, Na, K, Mg; gases consist of CO_2, N_2, CH_4, C_2H_6, C_3H_8, total salt concentration 7-15% (cryometric determinations), bitumens occur in concentrations 0.0036-0.0068% (deposits Oktyabr'skoe, Daraision, Dzhavoni, Garmova). Fluorite in the sulfide-fluorite deposits (Khodzha-Yakub, Shakhizar, Koshkak, Moskovskoe) formed at 115-120°C and 170-420 atm; solutions were of chloride-Na-Ca type; N_2 is the main gas; salt concentration 11.5-33.6%; bitumens 0.0037-0.0075%. Fluorite in the quartz-fluorite deposit (Khodzha-Abdullo) formed at low T 135-150° and 235-250 atm, from solutions of low concentration 3.2%; solutions were of Cl-Na-Ca type. (Authors' abstract translated and shortened by A.K.)

FAYZIEV, A.R., KALYUZHNYI, V.A. and SVOREN', I.M., 1978, Gas composition of inclusions in fluorite, important factor for determination of the genetic, formation and mineral types of the fluorite deposits in the Central Tadzhikistan, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 135-136 (in Russian). First author at Technical State Univ., Dushanbe, USSR.

Fluorite from calcite-barite-fluorite deposits bears mostly CO_2 (52-57%), next CH_4 (20-30%), N_2 (6-28%), plus sometimes C_2H_6 (up to 13%) and C_3H_8 (7-9%); from mercury-antimony deposits - CO_2 (40-67%), N_2 (32-57%), CH_4 (1-3%); from quartz-fluorite deposits - CO_2 (85-88%), N_2 (~4%), CH_4 (8-9%); from sulfide-fluorite deposits - CO_2 (0-29%) N_2 (44-79%), CH_4 (0-29%); from pegmatites of alkaline rocks - CO_2 (1-12%), N_2 (0-14%), CH_4 (41-91%), plus O_2 (5-45%). (Authors' abstract translated and shortened by A.K.)

FENOGENOV, A.N. and YEMEL'YANENKO, P.F., 1980, Primary inclusions in olivine of layered mafic and ultramafic traprock intrusions in the northwestern part of the Siberian platform: Dokl. Akad. Nauk SSSR, v. 255, no. 6, p. 1467-1470 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 255, 1980, p. 192-195 (1982). Authors at Univ. Moscow, USSR.

Crystallized silicate melt inclusions from the Talnakh intrusives were examined. The dms include plagioclase, orthopyroxene, clinopyroxene, magnetite, apatite, and hornblende, biotite, and chlorite, the last three indicating hydrous melts. (E.R.)

FERGUSON, J., EWERS, G.R. and DONNELLY, T.H., 1980, Model for the development of economic uranium mineralization in the Alligator River uranium field: Uranium in the Pine Creek Geosyncline; Proceedings of the International Uranium Symposium on the Pine Creek Geosyncline I.A.E.A., Proc. Ser. 555, p. 563-574.

Indexed under Fluid Inclusions. (E.R.)

FINASHIN, V.K., KOKORIN, A.M., ANAKHOV, V.V. and SHLEMCHENKO, S.D., 1978, Greisens of the Dubrovskoye deposit: in Geology, magmatism, and ore genesis of the transition zone from continent to ocean P.G. Korostelev, et al., eds., Akad. Nauk. Dal'nevost. Nauchn. Tsentr., Vladivostok, p. 190-192 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

FLEET, M.E., 1980, Orientation of inclusions in minerals (abst): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 427.

FOLEY, N.K., 1980, Mineralogy and geochemistry of the Austinville-Ivanhoe district, Virginia: M.S. thesis, Virginia Polytech. Inst. and State Univ. Blacksburg, VA.

The Austinville-Ivanhoe District represents the longest continuously mined base-metal deposit in North America. Zinc-lead mineralization occurs as disseminated dolomite replacements and as crustiform coatings along fractures in and around breccia fragments of the Cambrian Shady Formation. The ore bodies of the district are contained within a 400 meter stratigraphic interval of the Patterson and Austinville Members of the Shady Formation. Individual ore bodies are crudely lens-shaped and are situated on the flanks of the Austinville Anticline. Sphalerite, pyrite, galena, marcasite and locally chalcopyrite were deposited during three periods of mineralization separated by intervals of sulfide dissolution and dolomite deposition. Iron contents (0.3 to 3.3 weight %) of the delicately banded sphalerite appear to be inversely correlated with the cadmium contents (0.0 to 0.3 weight %). The color of the bands is probably not related to variations in iron content but may reflect the presence of inclusion-rich zones. The sphalerite banding has a consistent pattern which may be correlated for over 2.7 kilometers across the district. Fluid inclusion geothermometry on sphalerites from the later periods of mineralization indicate that the ores formed in the temperature range of at least 100° to 160°C.* Galenas from the three generations have progressively higher Pb^{208}/Pb^{204}, Pb^{207}/Pb^{204}, and Pb^{206}/Pb^{204} ratios. Furthermore, smaller ore bodies have a wider range in lead ratios and seem to be more radiogenic than larger bodies. (Author's abstract)

*Pers. comm. from author: these are Th values; pressure correction would probably be small.

FOLEY, N.K. and CRAIG, J.R., 1980, Ore and gangue mineralization of the Austinville-Ivanhoe deposit, Wythe County, Virginia (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 177.

Fluid inclusion and lead isotope studies presently underway are aiding in an understanding of the ore formation by indicating low temperatures of crystallization and a slightly anomalous character of the lead. The combination of mineral assemblages, fluid inclusion studies and major and minor element data permit the construction of a model of ore genesis. (From the authors' abstract)

FONTEILLES, M., GUY, B. and SOLER, P., 1980, Study of the processes of formation of the skarn ores of Salau and Costabonne, pp. 259-282 in Johan, Z., ed., Mineralization in granitoids, Memoire du BRGM no. 99 (in French).

FORESTER, R.W. and TAYLOR, H.P., Jr., 1980, Oxygen, hydrogen, and carbon isotope studies of the Stony Mountain complex, western San Juan mountains, Colorado: Econ. Geol., v. 75, p. 362-383.

The mid-Tertiary Stony Mountain ring-dike complex, approximately 1.3 km in diameter, is composed of an outer diorite, a main mass of biotite gabbro, and an inner diorite. This composite stock and most of the surrounding country rocks of the San Juan volcanic field in the vicinity of the Silverton caldera have experienced various degrees of ^{18}O depletion (up to 10 per mil) due to interaction with heated meteoric ground waters. Most of the isotopic effects are a result of exchange between H_2O and solidified igneous rocks, but the inner diorite may have been intruded as an inhomogeneous, low ^{18}O magma. The $\delta^{18}O$ values of the rocks decrease with decreasing grain size, compatible with subsolidus exchange. Quartz typically has $\delta^{18}O = 6$ to 8 and is more resistant to exchange than any other mineral studied. The order of increasing resistance to hydrothermal ^{18}O exchange is feldspar-pyroxene-biotite-magnetite-quartz. Hydrogen isotope analyses of sericites, chlorites, biotites, and amphiboles range from -117 to -150 (SMOW) and exhibit the same order of D/H enrichment as do normal igneous hydrous phases, except that each phase is drastically depleted in deuterium. The δD in biotites varies inversely with Fe/Fe+Mg and positively with elevation in the intrusion over a range of 600 m. The calculated δD of the Tertiary meteoric waters is -100. Carbonate $\delta^{13}C$ values average -5.5 (PDB), within the generally accepted range for deep-seated carbon. Based on numerical simulation of thermally driven convective fluid flow of plutons in similar geologic environments, the average integrated fluid flux that persisted for most of the cooling history of the Stony Mountain complex is estimated to be 10^{-7} g cm^{-2} s^{-1}, equivalent to an overall water/rock ratio of 0.2 (weight units). It is likely that the time-temperature circulation history of the meteoric-hydrothermal fluids associated with the Stony Mountain complex, and with gabbroic complexes in general, was such that any ore metals in solution were dispersed into the surrounding country rocks. (Authors' abstract)

FOSTER, R.P., 1980, The controls of gold precipitation in Archaean gold deposits: Mining and Engineering (Zimbabwe), June, 1980, p. 21-23, 25; (see also August, 1980, p. 31, for missing paragraphs).

Includes a review of temperature of formation of a large number of gold deposits (mainly from inclusions). (E.R.)

FOURNIER, R.O., THOMPSON, J.M. and AUSTIN, C.F., 1980, Interpretation of chemical analyses of waters collected from two geothermal wells at Coso, California: J. Geophys. Res., v. 85, no. B5, p. 2405-2410. First author at U.S. Geol. Survey, Menlo Park, CA 94025.

Wellhead and downhole water samples were collected and analyzed from a 114.3-m well at Coso Hot Srpings, (Coso No. 1) and a 1477-m well (CGEH No. 1) 3.2 km to the west. The same chloride concentration is present in hot waters entering both wells (about 2350 mg/kg), indicating that a hot-water-dominated geothermal system is present. The maximum measured temperatures are 142°C in the Coso No. 1 well and 195°C in the CGEH No. 1 well. Cation and sulfate isotope geothermometers indicate that the reservoir feeding water to the Coso Hot Spring well has a temperature of about 240°-250°C, and the reservoir feeding the CGEH well has a temperature of about 205°C. The variation in the chemical composition of water from the two wells suggests a model in which water-rock chemical equilibrium is maintained as a convecting solution cools from about 245°C to 205°C by conductive heat loss. (Authors' abstract)

FRANTZ, J.D. and POPP, R.K., 1979, Mineral-solution equilibria-I. An experimental study of complexing and thermodynamic properties of aqueous $MgCl_2$ in the system $MgO-SiO_2-H_2O-HCl$: Geochim. Cosmo. Acta, v. 43, p. 1223-1239. Authors at Geophy. Lab., Carnegie Inst. Wash., Wash., DC 20008.

Speciation of aqueous magnesium in the system $MgO-SiO_2-H_2O-HCl$ in supercritical aqueous fluids has been investigated using standard rapid-quench hydrothermal techniques and a modification of the Ag + AgCl buffer method (Frantz and Eugster, 1973, Am. J. Sci., 267, 268-286). A concentric double-capsule charge was utilized. The outer gold capsule contained the assemblage talc + quartz + Ag + AgCl + H_2O-$MgCl_2$ fluid; the inner platinum capsule, Ag + AgCl + H_2O-HCl fluid. During the experiments, fH_2 and thus fHCl equilibrated between the two capsules. After quenching, measurement of the chloride concentration in the fluid in the inner capsule and total magnesium in the fluid in the outer capsule defines the concentrations of HCl and Mg that coexist with talc + quartz in the outer capsule. Changes in the measured molality of HCl as a function of the total magnesium concentration at constant P and T were used to identify the predominant species of magnesium in the hydrothermal fluid. Experimental results showed that at 2000 bar, $MgCl_2^\circ$ is the predominant species above 500°C and Mg^{2+}, below 400°C. Data at intermediate temperatures when combined with the dissociation constant for HCl were used to obtain the dissociation constant for $MgCl_2^\circ$. The results of these experiments were combined with results from experiments using Ag + AgCl in conjunction with the oxygen buffer, hematite-magnetite, to obtain the equilibrium constant for the reaction

$$1/3\text{Talc} + 2\text{HCl}^\circ \rightleftarrows MgCl_2^\circ + 4/3\text{Quartz} + 4/3H_2O$$

from which the difference in Gibbs free energy of $MgCl_2^\circ$ and HCl° was obtained as a function of temperature at 1000, 1500 and 2000 bar pressure. Solubility constants for brucite, forsterite, chrysotile, and talc were calculated. (Authors' abstract)

FRANTZ, J.D., POPP, R.K. and BOCTOR, N.Z., 1980, Solubility constants of rock-forming minerals: Carnegie Inst. of Washington Yearbook 79, for 1979-80, p. 340-345.

FREESTONE, I.C. and HAMILTON, D.L., 1980, The role of liquid immiscibility in the genesis of carbonatites-an experimental study: Contrib. Min. & Petrol., v. 73, no. 2, p. 105-118.

FRENZEL, Gerhard, 1980, Sodium chloride as a component in Tafoni-granite: Chem. Erde, v. 39, p. 158-169.

Includes crystallography of hydrohalite, $NaCl\cdot 2H_2O$. (E.R.)

FREUND, F., KNOBEL, R., WENGELER, H. and KATHREIN, H., 1980, Carbon solubility in minerals of the mantle, carbon dioxide and hydrocarbon degassing, and the role of O (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 45.

Under high pressures and at high temperatures the solubility of silicates for CO_2 and H_2O is high, but the physical and chemical state of the dissolved gaseous species still remains uncertain. From studies on MgO and latest results on mantle-derived olivines, we have now firmly established the fact that carbon can dissolve as atomic carbon and yet be evolved as CO_2 upon heating.

The atomic carbon in solid solution exhibits peculiarities: it is highly mobile (which points at interstitial site occupancy), it strongly affects many physical properties (electrical conductivity, thermal expansion, etc.), and is highly reactive.

Also H_2O is, at least partially, dissolved as hydrogen. We now start to understand the equilibrium reaction by which hydrogen molecules and O ions are formed from pairs of OH^- ions compensating cation vacancies: $[OH^- \; V''_{Mg} \; HO^-] \rightleftharpoons [O^- \; H\text{-}H \; O^-]$.

The carbon atoms react with lattice oxygen, probably with O^-, to give CO_2. They also react with co-dissolved hydrogen to give hydrocarbons. A rich variety of hydrocarbons, both saturated and unsaturated (including aromatics), has been obtained by the direct reaction C + H in carbonaceous MgO and olivines.

The formation of O^- ions appears to be outmost important consequence of all relevant reaction schemes. On the basis of molar volume arguments we predict that, when CO_2 and H_2O dissolve in oxide lattices and/or magmas, high pressure should favor the O^- formation leading to an overall densification due to the smaller size of O^- as compared to O^{2-}. At the same time high temperatures should favor lower oxidation states. Extrapolation of this concept to very high pressures and temperatures leads to the conclusion that $Fe^{2+} + 2\,O^{2-}$ will reduce to $Fe^0 + 2\,O^-$ and that, eventually, also $Si^{4+} + 4\,O^{2-}$ will reduce to $Si^0 + 4\,O^-$. If such reactions occur under the conditions of the lower mantle, the distinction between oxide and silicate phases and metallic phases will vanish and complete miscibility will be established between iron, oxygen, silicon, carbon and hydrogen. (Authors' abstract)

FREY, Martin, BUCHER, Kurt, FRANK, Erik and MULLIS, Josef, 1980, Alpine metamorphism along the Geotraverse Basel-Chiasso - a review: Eclogae geol. Helv., v. 73, p. 527-546. First author at Mineral.-Petrog. Inst. der Univ., CH-4056 Basel, Switzerland.

The mineralogical zonation, the geothermometry and geobarometry as well as some aspects of the timing of the Alpine metamoprhism along the Swiss Geotraverse are reviewed. In addition, a new zonation of metamorphism based on fluid inclusions from fissure quartz crystals is presented. (Authors' abstract)

FREY, Martin, TEICHMÜLLER, Marlies, TEICHMÜLLER, Rolf, MULLIS, Josef, KÜNZI, Beat, BREITSCHMID, Alfred, GRUNER, Ueli and SCHWIZER, Benno, 1980, Very low-grade metamorphism in external parts of the central Alps: illite crystallinity, coal rank and fluid inclusion data: Eclogae geol. Helv., v. 73, no. 1, p. 173-203. First author at Mineral.-Petrograph. Inst. Univ., Bernoullistrasse 30, CH-4056, Basel, Switzerland.

Very low-grade regional Alpine metamorphism has been studied along three cross sections of the Helvetic Alps (Kien valley, Lake Lucerne-Reuss valley and Glarus Alps) and in the Pennine Falknis nappe. Illite crystallinity (IC) and coal rank by means of the reflectivity (R_m and R_{max}) were determined for 107 samples. In addition, the fluid inclusions from fissure quartz at 50 localities were studied and yielded information about the fluid composition during metamorphism and, in some cases, minimum temperatures and pressures of formation.

In general, IC and R_m increase from tectonically higher to lower units and from external to internal parts within the same tectonic unit. Deep diagenetic conditions occur in the Border chain, the northern part of the Wildhorn nappe, the Drusberg nappe and the northern part of the Axen nappe. Anchizonal conditions are reached in the Gellihorn nappe and the middle to southern part of the Axen nappe while anchi- to epimetamorphic conditions are found in the Doldenhorn nappe and in the autochthonous cover of the Aar massif.

The fluid composition in fluid inclusion from fissure quartz crystals shows a general evolution related to metamorphic grade as determined by IC and R_m data. In the deep diagenetic zone, fluids with >1 mole-% of higher hydrocarbons were found with homogenization temperatures of less than 200°C. The low- and medium-grade anchizone is dominated by methane-bearing fluids with minimum formation temperatures between 200° and 270°C. In the higher-grade anchizone and the epizone, water-bearing fluids were encountered.

The following examples of inverted metamorphism have been found, i.e. cases where higher-grade units have been thrusted on lower-grade units: a) The high-grade anchimetamorphic Pennine Niesen nappe is lying on Helvetic units belonging to the deep diagenetic zone. b) The southern part of the Axen nappe with medium to high anchizonal grade is thrust on the North Helvetic Flysch zone with deep diagenetic to anchimetamorphic conditions. Post-metamorphic thrusting, therefore, is an important phenomenon in external parts of the Central Alps.

Good but different correlations between IC, R_m (or R_{max}) and fluid inclusion data were found for the Kien valley and Lake Lucerne-Reuss valley sections. No generally valid relationship between these three parameters seems to exist.

Divergent relations between IC, R_m and fluid inclusion data were found in the Pennine Falknis nappe. According to the IC data this nappe either belongs to the diagenetic or medium-grade anchimetamorphic zone. However, the R_m data indicate deep diagenetic to anchizonal conditions during a prekinematic stage with some additional syn- to postkinematic coalification under anchizonal conditions. Fluid inclusion data indicate medium-grade anchizonal conditions for the upper- and higher-grade anchizonal conditions for the lower part of the Falknis nappe. (Authors' abstract)

FRITZ, P. and FONTES, J.Ch., eds., 1980, Handbook of Environmental Isotope Geochemistry, Vol. 1, The Terrestrial Environment, A.: Amsterdam, Elsevier, 546 pp.

Includes much on the behavior of isotopes at the surface of the earth that is pertinent to isotope studies in fluid inclusions. (E.R.)

FROMBERG, E.D., 1980a, Origin of ultrapotassic rhyolite: Dokl. Akad. Nauk SSSR, v. 253, no. 3, p. 684-687 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 125-128 (1982). Author at Moscow Geol. Prospecting Instit.

Author believes ultrapotassic rhyolites were formed by continuous fractional crystallization, but show evidence of liquid immiscibility. (E.R.)

FROMBERG, E.D., 1980b, Petrology of subvolcanic complexes of the eastern part of the Rudny Altai: Sov. Geol., v. 9, p. 98-100 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

FUJII, Toshitsugu, KUSHIRO, Ikuo, NAKAMURA, Yasuo and KOYAGUCHI, Takehiro, 1980, A note on silicate liquid immiscibility in Japanese volcanic rocks: J. Geol. Soc. of Japan, v. 86, no. 6, p. 409-412 (in English).

FUZIKAWA, K., 1980, Preliminary fluid inclusion study in albite from Logoa Real project albitites, Caetité, Brazil: Anais do XXXI Congresso Brasileiro de Geologia. V. 4, p. 2038-2049 (in Portuguese. English abstract).

The uranium mineralization in albitite of the Caetite-Lagoa Real area, Bahia State, Brazil and that occurring in Russia seem very much alike. Preliminary fluid inclusion studies in metasomatic albite grains from the Lagoa Real uranium deposit indicated mixing of strong brines (23 wt% NaCl equivalent) with low salinity fluids (2.3 wt% NaCl equiv.). Microthermometry and crushing tests indicated elevated pressures and the presence of hydrocarbons in larger amount than CO_2. The remobilization of uranium as uranyl carbonate complexes and its precipitation, reduction of U^{6+} to U^{4+} by CH_4, is considered as a possibility. (Author's abstract)

GALY, S.A. and KURILO, M.V., 1980, Thermobarometrical investigations of sphalerites of the Nagolny Mountain Range (Donets Basin): Dopovidi Akad. Nauk Ukr. Rsr, Ser. B. Geol., Khim., Biol., 1980, no. 5, p. 8-12 (in Ukrainian).

GARCIA, Michael O., MUENOW, David W. and LIU, Norman W.K., 1980, Volatiles in Ti-rich amphibole megacrysts, southwest U.S.A. : Am. Mineral., v. 65, p. 306-312. First author at Hawaii Inst. Geophy., Un. of Hawaii.

Ferro-kaersutite and kaersutite megacrysts (3.8 to 5.8 wt.% TiO_2) from peridotite-bearing alkalic basalt lavas and tuffs from near Hoover Dam, Peridot Mesa, Soda Springs, and Vulcan's Throne in Arizona, Salt Lake Crater in Hawaii, and Lunar Craters in Nevada were analyzed by electron microprobe and high-temperature mass spectrometry. During heating at 5°C/min all volatiles (H_2O, CO_2, F, Cl, S) were released between 950° and 1050°C under a vacuum of 1×10^{-8} torr. Total volatile loss ranged from 0.9 wt.% for high F-content amphiboles (0.225 wt.% F) to 1.9 wt.% for low F-content amphiboles (0.070 wt.% F). H_2O is the predominant volatile constituent of all amphiboles, varying inversely with F content, and ranges from 0.487 to 1.578 wt.%. S and Cl contents are low and show no apparent correlation in abundance with either H_2O or F. S ranges from 0.001 to 0.052 wt.%; Cl varies from 0.001 to 0.012 wt.%. F content varies proportionally with TiO_2 content. No other correlation between volatile and nonvolatile amphibole constituent was observed. CO_2 contents range from 0.095 to 0.337 wt.%. Rapid heating and quenching of amphibole in the mass spectrometer produced CO_2^+-ion spikes, which indicates that CO_2 is trapped in the amphibole as minute gas inclusions. The relatively low F/H_2O contents of Ti-rich amphiboles examined in this study indicate that F does not play a major role in extending their thermal stability. (Authors' abstract)

GARRARD, P., 1980, Problems of mineralization associated with acid magmatism: Inst. Mining and Metallurgy Trans., v. 89, Sect. B, p. B192-197.

A discussion of the MAWAM (Mineralization associated with acid magmatism) meeting held at Univ. Exeter, England, Dec. 1979. The bulk of the paper consists of abstracts of the 30 papers presented. Most dealt with Sn-W mineralization F and B in granitic melts, and the related hydrothermal processes; those that are stated to involve fluid inclusion studies are given in this volume. (E.R.)

GEHRIG, M., 1980, Phase equilibria and pVT-data of ternary mixtures from water, carbon dioxide and sodium chloride up to 3 kbar and 550°C - Diss. rer. nat. Karlsruhe 1980, Hochschulsammlung Naturwissenschaft: Chemie; Bd. 1, 109 p. (in German).

GEHRIG, M. and LENTZ, H., 1980, Phase equilibria and pVT of binary and ternary mixtures of water, carbon dioxide and sodium chloride up to 3 kb and 550°C (abst.): Mineralog. Soc. Bull. (London), 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 inclusions 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)

GERLACH, T.M., 1980a, Evaluation of volcanic gas analyses from Kilauea volcano: J. Volcano. Geotherm. Res., v. 7, p. 295-317.

The common presence of hydrocarbons and anomalously low atomic S/C in several Kilauea gas analyses is due to contamination of erupting lavas with organic materials. A similar origin also applies to above background levels of environmentally hazardous organohalogens in volcanic gases. Thermodynamic calculations indicate these compounds would be virtually absent in gases erupted from lavas at temperatures above 500-600°C. (From the author's abstract)

GERLACH, T.M., 1980b, Chemical characteristics of the volcanic gases from Nyiragongo lava lake and the generation of CH_4-rich fluid inclusions in alkaline rocks: J. Volcano. Geotherm. Res., v. 8, p. 177-189.

At temperatures above 800°C and pressures of 1-1.5 kbar, the Nyiragongo gas compositions resemble those observed in primary fluid inclusions believed to have formed at similar temperatures and pressures in nephelines of intrusive alkaline rocks. Cooling to 300°C, with fO_2, buffered by the rock, results in gas compositions very rich in CH_4 (50-70%) and resembling secondary fluid inclusions formed at 200-500°C in alkaline rocks. Below 600°C the gases become supersaturated in carbon as graphite. These inferences are corroborated by several reports of hydrocarbons in plutonic alkaline rocks, and by the presence of CH_4-rich waters in Lake Kivu - a lake on the flanks of Nyiragongo volcano. (From the author's abstract)

GERLACH, T.M., 1980c, Evaluation of volcanic gas analyses from Surtsey volcano, Iceland, 1964-1967: J. Volcano. Geotherm. Res., v. 8, p. 191-198.

GERLACH, T.M., 1980d, Investigation of volcanic gas analyses and magma outgassing from Erta'Ale lava lake, Afar, Ethiopia: J. Volcano. Geotherm. Res., v. 7, p. 415-441.

GERLACH, T.M., 1980e, Generation of CH_4-rich fluid inclusions in alkaline rocks (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 394.

The Canadian and Soviet geochemical literature contains several reports of CH_4-rich fluid inclusions in alkaline intrusives. Nepheline grains commonly host these inclusions, which give formation pressures and temperatures of 100-150 MPa (1-1.5 kbar) and 475-775 K (Sobolev et al., 1974). The inclusions contain 70-90% CH_4, 10-30% CO_2, and condensed hydrocarbons or "bituminous compounds" with $\Delta^{13}C$ indicating an inorganic origin (Petersilie and Sorensen, 1971). Gold has recently suggested an origin by mantle-outgassing of CH_4 along deep seismic and rift zones often associated with alkaline complexes.

Recent studies of volcanic gas data (Gerlach, 1980) from Nyiragongo volcano indicate gases from nephelinite magma are CO_2-rich (35-50%) with fO_2 between QMF and MW. Calculated equilibrium compositions for the cooling of Nyiragongo-like gases at 100 MPa yield little CH_4 ($\leq$.3%). CH_4 concentrations of 45-80% are calculated, however, for fO_2 buffering of the gases at or slightly below QMF during cooling; CH_4 increases abruptly and the gases become supersaturated in C below 850 K.

These results suggest that anomalous CH_4 and bituminous matter form in alkaline intrusives by subsolidus CO_2/H_2O fluid-rock interactions associated with fracture and recrystallization events during cooling, provided that rock-buffering of fO_2 is maintained at or below QMF. They also support an earlier proposal for the volcanic origin of the CH_4-rich waters of Lake Kivu on the southern flank of Nyiragongo (Burke, 1963). (Author's abstract)

GERLACH, T.M., 1980f, The gas phase of tholeiitic and alkaline magmas (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 66.

GERONSIN, R.L., 1980, Chemical relationship of the Mississippi-Valley type ore deposits in Missouri, Oklahoma, and Kansas: M.S. thesis, Univ. Missouri-Rolla, 158 pp.

The lead, zinc, and barite deposits of Missouri, Oklahoma, and Kansas have long been the subject of debate and controversy over their origin and the genetic relationship which they might have toward one another. This thesis is an attempt to determine if any chemical relationship exists in the ore fluids of the Tri-State district, the Central Missouri district, the Viburnum Trend, the Southeast Missouri Barite district, and the Old Lead Belt.

Thirty-six galena samples collected from these districts were analyzed for sodium, potassium, magnesium, and calcium. These elements are expected to occur within the fluid inclusions and thus represent an analysis of the included ore fluids. The final data points were ratioed into Na/K, K/Na, Ca/Na, and Ca/Mg ratios. These ratios were then statistically compared to determine if any similarities could be discovered between the districts. The statistics showed that the Tri-State district and the Viburnum Trend samples were similar and also that the Southeast Missouri Barite district was similar to these two districts. By statistical comparison none of the other districts showed any similarity to another. These similarities suggest that the ore fluids responsible for these deposits were chemically alike in regards the elements and ratios considered. (Author's abstract)

GIBSHER, N.A., KARGAL'TSEV, S.V., TYCHINSKIY, A.A. and BAULINA, M.V., 1980, Thermobarogeochemical studies of ores of stratiform zinc-lead (with fluorite) deposits in carbonate rocks (Western Pribaykal'ye), in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 170-177 (in Russian).

Formation of ores and solution composition have certain peculiarities: relatively high (for this type of deposit) maximum Th (190-250°C), presence of bituminous substance in inclusions (plus hydrocarbons), low Tm (-10 to -20°C) and Te (to -46°C) typical of the Mississippi-type ores, proving high total salt concentration of ore-forming fluid. The important role of organic substance in the deposit formation is postulated. (Authors' abstract translated by A.K.)

GIGGENBACH, Werner F., 1980, Geothermal gas equilibria : Geoch. Cosmo. Acta, v. 44, p. 2021-2032. Author at Chem. Div., DSIR, Private Bag, Petone, New Zealand.

Comparison of theoretical and analytical equilibrium constants based on the reactions $CH_4 + 2H_2O = CO_2 + 4H_2$, $2NH_3 = N_2 + 3H_2$, and iron(II)-aluminium-silicate + $2H_2S = FeS_2 + H_2$ + aluminium-silicate, shows that the composition of fluids discharged from geothermal areas in New Zealand (Wairakei, Kawerau, Broadlands) reflects close to complete attainment of chemical equilibrium within the system H_2O, CO_2, H_2S, NH_3, H_2, N_2 and CH_4. Under conditions prevailing in exploded geothermal systems in New Zealand, the minerals graphite (elemental carbon), anhydrite, pyrrhotite, magnetite do not appear to take part in the overall equilibrium system. The three physical parameters required to evaluate geothermal gas reactions are temperature, pressure and vapor-liquid ratios within the gas equilibration zone. (Author's abstract)

GIZE, A.P. and HOERING, T.C., 1980, The organic matter in Mississippi Valley-type deposits: Carneg. Inst. Wash. Yearbook 79, for 1979-1980, p. 384-388.

GLASSLEY, William and WINTER, John K., 1980, C-O-H fluid species and abundances in deep crustal environments (Abst.): EOS, v. 61, p. 384.

The Isortoq Complex of Central West Greenland contains upper amphibolite and granulite facies rocks, some of which satisfy either or both of the equilibria (A)C + O2 = CO2 and (B)Annite = Kspar + Magnetite + H2. Detailed studies of individual samples demonstrate that (1) fH2O/fCO2 and fH2/fCO ratios will be >1.0 for assemblages which satisfy (A) and will be <1.0 for assemblages which satisfy (B), (2) both assemblages will have log fCH4 >3.8, (3) fugacity values for individual fluid species may vary by several orders of magnitude over distances of <10 cm, and may correlate with compositional banding in gneisses.

Likely evolutionary schemes for fluid species imply that graphite will precipitate only at very high grades from the fluid during prograde metamorphism. At that point a major recrystallization should be recorded as the fluid and solid phases reequilibrate with graphite. Many deep crustal metamorphic events may reflect only this reequilibration. The sensitivity of the fluid composition to fH2 implies that major recrystallization may also occur if fH2 is modified (by mantle degassing?). (Authors' abstract)

GLEASON, Richard J., 1980, Wall-rock alteration around the Panteon vein system; Limon mining district, Nicaragua (Abst.): Geol. Soc. Amer. Abstracts and Programs, v. 12, p. 434.

The Panteon vein system is a classic epithermal gold-quartz deposit in the Limon mining district of northwestern Nicaragua. This vein system is a paired quartz vein structure of 0.2 to 6 meters width emplaced in an andesite flow unit of the mid-Miocene Lower Coyol group. Altered wall-rock samples from 90, 40, and 5 cm on either side of the veins were collected at ten subsurface locations for specific gravity and major element chemical analyses. Country rock samples considered to be unaltered were collected approximately 25 meters from the veins for comparison. Assuming alteration was isovolumetric, SiO_2, K_2O, and volatiles were added to the wall-rock, and CaO, FeO, Na_2O, MgO, TiO_2, MnO, and Al_2O_3 were depleted in amounts inversely proportional to distance from the veins. Alternatively, if Al_2O_3, often considered to be immobile during hydrothermal alteration, is assumed to have remained constant, the other components would have behaved as above but volume increases of 35%, 20%, and 14% would have occurred at 5, 40, and 90 cm, respectively, from the veins. These increases are greater than is evident in the wall-rock, and along with the general preservation of microscopic textures, suggest that alteration was nearly isovolumetric and Al_2O_3 was not immobile.

The original labradorite-augite andesite has the present assemblage chlorite + illite + montmorillonite + quartz + calcite + adularia ± analcite ± prehnite ± epidote. Filling temperatures obtained from 79 fluid inclusions range from 160-275°C, clustering about 216-220°C, indicative of zeolite-facies alteration. (Author's abstract)

GLIUK, D.S., see GLYUK

GLYUK, D.S. and KHLEBNIKOVA, A.A., 1980, Solubility of gold in water, solutions of HCl, HF, sodium and potassium chlorides, fluorides, carbonates and bicarbonates under pressure of 1000 kg/cm^3: Dokl. Akad. Nauk SSSR, v. 254, no. 2, p. 472-474 (in Russian).

GLYUK, D.S., TRUFANOVA, L.G. and BAZAROVA, S.B., 1980, Phase relations in the system granite-H_2O-LiF under pressure 1000 kg/cm^2: Geokhimiya, no. 9, p. 1327-1343 (in Russian, English abst.). Authors at Geochem. Inst. of Siberian Branch of Acad. Sci. of USSR, Irkutsk, USSR.

Pertinent to melt inclusion studies including immiscibility phenomena. (A.K.)

GOGISHVILI, V.G., 1980, Metasomatic zoning in the sulfide-polymetallic deposits of the Little Caucasus: Sov. Geologiya, no. 4, p. 86-98 (in Russian). Author at the Caucasian Inst. of Mineral Raw Mat., Tbilisi, Georgian SSR.

The author studied pyrite, chalcopyrite, Cu-Zn, Pb-Zn, barite-Pb-Zn and barite deposits: Alaverdi, Kedabek, Akhtala, Madneuli and David-garedzhi occurring in Bajocian and Turomian beds. Metasomatites underlying ores yielded Td and Th 350-420°C, metasomatites of ore level (pre-ore stage) >400°C, (ore stage) 200-250°C; hydrothermal argillites 200-300°C, silica-manganese and agate bodies, Ca-Na zeolites with prehnite and silica-rich zeolites and bentonites 120-200°C. (Abstract by A.K.)

GOLDEN, K.M. and ACKLEY, S.F., 1980, Modeling of anisotropic electromagnetic reflection from sea ice: CRREL Report 80-23, 21 p.

The contribution of brine layers to observed reflective anisotropy of sea ice at 100 MHz is quantitatively assessed. The sea ice is considered to be a stratified, inhomogeneous, anisotropic dielectric consisting of pure ice containing ordered arrays of conducting inclusions (brine layers). Below the transition zone, the ice is assumed to have constant azimuthal c-axis orientation within the horizontal plane, so that the orientation of brine layers is uniform. The brine layers are also assumed to become increasingly well-defined with depth, since adjacent brine inclusions tend to fuse together with increasing temperature. (From the authors' abstract)

GOLDING, S.D. and WILSON, A.F., 1980, The application of oxygen isotope studies to the occurrence of gold mineralization in eastern Australia: The Aust. I.M.M. Conference, New Zealand, May 1980.

The use of stable isotopic measurements as a technique for elucidating the origin and history of the water in hydrothermal fluids is relatively new. Recent studies have emphasized the importance of meteoric water in the formation of many hydrothermal ore deposits including many epithermal gold-base metal deposits which occur in faulted volcanic terrane. Other vein-type gold ores are believed to have formed from fluids of magmatic or metamorphic origin and exhibit characteristic $\delta^{18}O$ values. These values also give information regarding temperatures and the degree of equilibrium. Preliminary oxygen data for some important gold deposits of eastern Australia are evaluated in the context of styles of mineralization. (Authors' abstract)

GOLOVCHENKO, N.G., MYAZ', N.I. and SIMKIV, Zh.A., 1978, Thermobarogeochemical characteristics of mercury deposits (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 124-125 (in Russian). Authors at L'vov State Univ., L'vov, USSR.

The range typical of Hg and As-Hg deposits is 320-50°C with ore stage from 230 to 50°C, and the best T for cinnabar crystallization 180-70°C. Vertical T gradient is about 5° per 100 m. Water leachates from cinnabar yielded fluid composition essentially of HCO_3-Ca type, pH of water leachate was 5.36 to 7.05. T data help to evaluate the depth of erosion of deposits presently at the Earth's surface. (A.K.)

GOLOVCHENKO, N.G., MYAZ', N.I. and SIMKIV, Zh.A., 1980, Certain conditions of formation of the mercury deposits, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 188-192 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980. (A.K.) See previous item.

GOMELAURI, A.I. and AMBOKADZE, A.N., 1980 Temperature conditions of the formation of barite deposits in the Caucasus: Soobshch. Akad. Nauk. Gruz. SSR, v. 100, no. 2, p. 353-356 (in Russian).

The fluid inclusions in quartz and sphalerite from the barite deposits showed Th at 250-280°; inclusions in witherite and calcite 110-120° and

90-120°, resp. Quartz-2, corresponding to early barite, had Th = 180-220. Td inclusions in sulfides associated with the barite were: galena 240-280°, early-generation pyrite 340-360°, and marcasite 240-260°. Barite in deposits with a quartz-galena-sphalerite association formed at 220-280°. Veins in which the barite occurs together with calcite, witherite, fluorite, and cinnabar had the lowest temperature (90-140°) of the barite deposit formation. (CA 94:195197r) (Authors' abstract)

GONCHAROV, V.I., NAYBORODIN, V.I., SAFRONOV, D.N. and SIDOROV, A.A., 1978, Physico-chemical conditions of formation of a certain gold ore deposit, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 179 (in Russian). Authors at North-East Complex Sci.-Res. Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Magadan, USSR.

The deposit (name not given) is of the sulfide-low gold-quartz type. Ore bodies form veinlets in sands, clays and tuffs. Inclusions are essentially G/L, sometimes pure LCO_2, sometimes with 50% of dm chlorides, Th 340-280 and 240-180°C; the second interval corresponds to native gold crystallization. P was ≥480-560 atm. (From the authors' abstract translated by A.K.)

GONCHAROV, V.I. and SIDOROV, A.A., 1978, Thermobarogeochemistry of gold volcanic-plutonic ore mineralization of North-Eastern USSR, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 177-178 (in Russian). Authors at North-East Complex Sci.-Res. Inst. of Far East Sci. Center of Acad. Sci. USSR, Magadan, USSR.

The deposits occurring in the Mesozoic sandstone-shale beds in the periphery of the Okhotsk-Chukotka volcanic belt formed in two stages: a) rare metal and b) gold-arsenic-antimony. The first stage of mineralization (wolframite, cassiterite, bismuthinite, arsenopyrite, quartz) yielded Th 380-180°C, P 1410-180 atm, and the second one (arsenopyrite, pyrite, galena, sphalerite, chalcopyrite, gold, arsenic, quartz, gypsum, kaolinite) - 380-100°C, P 800-80 atm. Solution composition changed greatly, from early highly concentrated solutions of NaCl and KCl (40-50 wt%), through dilute CO_2-rich solutions, and back again to concentrated ones. Gases consist of N_2, CO_2, rarely with admixture of O_2 and CO. (From the authors' abstract translated by A.K.)

GONCHAROV, V.I. and SIDOROV, A.A., 1980, Peculiarities of ore formation at the gold volcanic-plutonic deposit in the Arctic part of the Far East, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 121-125 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980. (A.K.) See previous item.

GORBACHEV, N.S. and OSADCHIY, Ye.G., 1980, Immiscibility in melts as a factor in early differentiation of meteorites and planets: Dokl. Akad. Nauk SSSR, v. 255, no. 3, p. 693-697 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 255, 1980, p. 137-141 (1982). Authors at Instit. Experi. Mineral., USSR Acad. Sci., Chernogolovka (Moscow Oblast), USSR.

Experiments were run at 1250-1350°C and 1 atm, under controlled O_2 fugacity of mixtures of peridotite, spinel, and sulfides. (E.R.)

GOROVOY, A.F., MANUCHARYANTS, B.O. and KHITAROV, D.N., 1978, Physicochemical conditions of formation of mercury deposits of the Nikitovskoe ore field (abst.): Abstracts of the Sixth All-Union Meeting Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 125-126 (in Russian). First author at "KGM," Kommunarsk, USSR.

Th of inclusions in quartz from Nikitovskoe ore field are in two intervals: 170-290 and 90-190°C, but only quartz of the first T interval occurs with cinnabar. Gangue quartz yielded Th 120-180°C and 125-180°C for different sampling areas. Th of inclusions in cinnabar was 90-170°C. Ankerite and quartzite gave Th about 145°C. Water leachates from quartz suggest presence of following ions in fluids: Ca>K>Na and HCO_3; from ankerite - Mg>Ca>Na>K and HCO_3. High contents of Na and F are typical of antimonite ores. Value of pH varied as follows: quartz 7.6, ankerite 8.0, antimonite 6.1, cinnabar 7.1 (the method of measurement not specified). (A.K.)

GOROVOY, A.F., MANUCHARYANTS, B.O. and KHITAROV, D.N., 1980, Thermobarogeochemical peculiarities of formation of mercury ores of the Nikitovskoe ore field, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 193-199 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980. (A.K.) See previous item.

GORYAINOV, I.N. and APLONOV, V.S., 1980, Regional hydrothermal activity in the northwest of the Siberian platform: Geologiya i Geofizika, v. 21, no. 7, p. 35-42 (in Russian; translated in Sov. Geol. and Geophys., v. 21, no. 7, p. 30-36).

A decrepitational analysis of Cambrian and Ordovician carbonates and of Devonian dolomites and anhydrites showed that their decrepitation peaks occur in the 160°-450°C interval. The regional character in combination with other facts suggest that occurrence of a regional hydrothermal process that was combined with traprock magmatism in the northwest of the Siberian platform. The series of hydrothermally altered and neogenic rocks constitute a region of dispersion of the fluids and solutions that ascended from infracrustal depths along the throats of paleovolcanoes and the stems of ore-magmatic clusters, or ore fields. (Authors' abstract)

GOURGAUD, Alain, BOURDIER, J.-L. and VINCENT, P.M., 1980, Mixing of over- and under-saturated lavas from the volcano Sancy (Dore Mountains, french Massif Central): C.R. Acad. Sc. Paris, v. 291, Ser. D, p. 175-178 (in French).

Physical magma mixing is corroborated by emulsified lavas with a trachytic lava host and K-mugearite rounded inclusions. Oversaturated and undersaturated magmas have been ejected together (type locality: Grande Cascade, Sancy Massif, France). (Authors' abstract)

GRAHAM, C.M., SHEPPARD, S.M. and HEATON, T.H., 1980, Experimental hydrogen isotope studies - I. Systematics of hydrogen isotope fractionation in the systems epidote-H_2O, zoisite-H_2O and AlO(OH)-H_2O: Geochim. Cosmo. Acta., v. 44, p. 353-364.

GRANOVSKIY, A.G. and CHISTOV, N.N., 1978, Thermobarogeochemical peculiarities of occurrence of commercial ores in the Sadon ore region (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 112-113 (in Russian). Authors at Rostov Univ., Rostov-on-Don, USSR.

The Sadon polymetal deposits formed at 320-180°C and 450-300 atm (>400 determinations of commercial ores). Water leachates from ore quartz bear mainly Ca, K, Na and minor amounts of Cl and SO_4. Cryometric determinations gave values 8-12 wt % of total salts in inclusion fluids. (A.K.)

GRANT, J.N., HALLS, Christopher, SHEPPARD, S.M. and AVILA, Waldo, 1980, Evolution of the porphyry tin deposits of Bolivia: Mining Geol. (Japan) Spec. Issue, no. 8, p. 151-173. First author at Billiton Intern. Metals, Louis Couperusplein 19, The Hague, The Netherlands.

Most of the tin production from the central and southern parts of the Bolivian tin belt has come from vein-type deposits associated with acid igneous eruptive complexes of Tertiary age. At some of these there is also potentially important low-grade porphyry-type mineralization, consisting of disseminated, veinlet, and breccia-controlled cassiterite and sulphides. The mineralization is developed within or peripheral to stock-like bodies of rhyodacite porphyry and breccia which fill volcanic vents. The igneous rocks are pervasively altered; the characteristic alteration minerals are tourmaline, sericite and clays, and lateral and vertical zonation of alteration and ore-mineral assemblages are well developed in some cases. In most, though not all of the porphyry type deposits, the early dispersed mineralization is cross-cut by a system of veins which carry high-grade ore.

Geologic, fluid inclusion and stable isotope studies suggest a genetic model involving an initial supply of heat, fluid and ore components associated with the emplacement of porphyry magma at shallow depth (1-2 km) in the vents. Earliest hydrothermal activity produced widespread explosive brecciation, and this was followed by intense rock alteration, beginning at temperatures above 500°C. Patterns of pervasive alteration and dispersed ore-mineral deposition were controlled partly by fluid boiling, partly by mixing of the high-temperature saline magmatic fluid with cool dilute water of probable meteoric origin. Most porphyry-style cassiterite and sulphide deposition was associated with sericitic alteration of moderate temperature and fluid salinity. Later, due to structural adjustments probably related to the cooling of large underlying plutons, major fracture systems formed, and tapped the deeper magmatic sources. Hydrothermal circulation and ore deposition were then confined to major fractures, resulting in high-grade vein ores which cross-cut the earlier pervasive alteration and mineralization. (Authors' abstract)

GRATIER, J.-P. and VIALON, Pierre, 1980, Deformation pattern in a heterogeneous material: folded and cleaved sedimentary cover immediately overlying a crystalline basement (Oisans, French Alps): Tectonophysics, v.

65, p. 151-179. Authors at Inst. de Recherches Interdisc. de Geologie et de Mecanique, Univ. I de Grenoble, B.P. 53X-F-38041, Grenoble Cedex, France.

Particularly well exposed structures in folded and cleaved sedimentary cover immediately overlying a crystalline basement have been studied. Chemical analysis (XRF and microprobe) reveal a pressure solution process and make possible the measurement of mass transfer. Study of fluid inclusion in veins has determined the temperature pressure conditions: thermal effect of the basement and decrease of temperature and pressure with the age of various synkinematic veins.

Characteristic examples of the behavior of a heterogeneous material during coaxial and non-coaxial deformation are shown:

(1) Successive different asymmetrical folds, various cleavages and fractures appear in a shear zone parallel to the main fabric with variations of thickness and rock behavior.

(2) Evolution of cleavage in such a shear zone (with or without slipping) is linked to the relations between the rotation of contraction direction and the rate of the cleavage process.

(3) Fold axes changed from the horizontal Y direction to the vertical (or E-W transversal to the crystalline massif) X direction, with increase of the (X/Z) and (X/Y) ratios (obtained by fossils and reconstructed fold shape). This strain is always heterogeneous and the most deformed zone frequently evolves to discontinuities with slip.

(4) Indentation exists on all scale: from hard objects (100 μm, with parenthesis form of pressure solution cleavage apparent on map distribution of various elements) to basement block (with variation of strain value in the indented cover).

A model of the evolution of the deformation of sedimentary cover immediately overlying a crystalline basement is given in conclusion. (Authors' abstract)

GRAZIANI, G., SCANDALE, E. and ZARKA, A., 1980, Development and genetic medium of a beryl single crystal (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 12.

The aim of this paper concerns the correlation between the growth defects and the thermodynamic data on the genetic medium of a natural Brasilian beryl, studied by means of X-ray topography, optical microscopy and electron microprobe. Our observations on the inclusions permit us to estimate the temperature range (710-730°C) and the pressure range (5.5-10 kbar): these results correspond to pegmatitic growth conditions. On the other hand the results of the X-ray topographs indicate that the crystal has been created by subsequent aggregation of more or less disoriented grains. This points to a quite different type of growth from that of the good quality minerals, generally grown in hydrothermal solutions at low temperature. In this case our observations are in good agreement with the model reported by Grigoriev, leading to a "horseshoe" or scarred polyedral forms. It seems, therefore, that the method of X-ray topography not only gives information about the crystal growth, but more generally useful solutions to geological and mineralogical problems, when it is used in correlation with other techniques. (Authors' abstract)

GREBENCHIKOV, A.M., KHETCHIKOV, L.N., ZVEREVA, Y.A., BARKHUDARYAN, N.B. and VALYASHKO, L.M., 1980, Some characteristics of quartz from disseminated-vein ores of the Baikal region: In: A study of minerals with research on zoning and genesis of non-ferrous and precious metal deposits, L.N. Khetchikov and B.Ernshteyn, eds.: Trudy-Tsentral'nyy Nauchno-Issledovatel'skiy Geologorazvedochnyy Institut Tsvetnyk I Blagorodnykh Metallov ("Tsnigri"), 1980, no. 150, p. 32-38 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

GREEN, G.R., OHMOTO, H., DATE, J., and TAKAHASHI, T., 1980, Oxygen isotope and alteration zonation in volcanic rocks from around the Fukazawa Kuroko deposit, Japan, and its implication for mineral exploration (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 436-437.

Whole rock oxygen isotope data of felsic volcanic rock samples within a 9 km radius of the Fukazawa Mine in the Hokuroku district show a consistent relationship to alteration assemblages. The lowest grade alteration is zeolite facies, with $\delta^{18}O$ values ranging from +15 to +21‰. Below the ore horizon, within 1 to 2 km of the orebody, there is a sericite-Mg chlorite alteration zone with rocks having $\delta^{18}O$ values from +5 to +9‰. This zone is fringed by a montmorillonite zone with a minimum width of 0.7 km and with rocks of $\delta^{18}O$ values from +9 to +15‰. In rocks up to at least 500 m above the ore horizon this pattern of alteration is repeated but the sericite-chlorite and montmorillonite zones contract towards the orebody and there is an additional Na-montmorillonite zone lying within the sericite-chlorite zone directly above the orebody. $\delta^{18}O$ whole rock values generally increase upward throughout the sequence in any drill hole. These data indicate that the Fukazawa Mine area remained a locus of discharge of relatively high temperature (>200°C) fluids with a $\delta^{18}O$ of 0‰ (Pisutha-Arnond and Ohmoto, this volume) after ore deposition. The high $\delta^{18}O$ values of rocks from the zeolite zone (>15‰) are probably caused by interaction with fluids with $\delta^{18}O$ values of about 0‰ at lower temperatures (<200°C). The results suggest oxygen isotope zonation may provide a useful exploration guide for volcanogenic massive sulfide deposits in other areas, particularly where low grade regional metamorphism has destroyed preexisting clay mineral alteration patterns. (Authors' abstract)

GREGORIO, F., LATTANZI, P. and TANELLI, G., 1980, A contribution to the understanding of the genetic environment of the Tuscan deposits of Niccioleta, Gavorrano, Boccheggiano and Campiano: studies on sphalerite: Rendiconti Soc. Ital. Mineral. Petrol., v. 36, p. 279-294. Authors at Instit. di Mineral., Petro. e Geochimica, Univ. di Firenze, Italy. (in Italian with English abstract).

Sphalerite from the pyrite deposits of Niccioleta, Gavorrano and Boccheggiano, the pyrite-Cu-Pb-Zn deposit of Campiano, and the Cu-Pb-Zn mineralizations of Niccioleta-Pozzo Serpieri (Southern Tuscany) was studied by optical and electron probe methods. Some fluid inclusion homogenization temperatures and sulphur isotope temperatures are also reported.

For all deposits, electron probe analysis reveals a large spread of values for Fe contents in sphalerite. At the single specimen scale Fe distribution may be either fairly homogeneous or quite irregular. Zoning of Fe content is seldom observed; in some instances it may correspond to a marked color banding in sphalerite as observed in doubly-polished thin section.

Sphalerite from Niccioleta etched with 57% HI reveals it has been deformed both in a brittle and in a plastic mode. Fluid inclusion homogenization temperatures range from 225±1° to 270.0±0.5°C; sulphur isotope temperature for sphalerite-galena pairs range from 180±30° to 394±20°C.

For Gavorrano samples (sphalerite-galena pairs) sulphur isotope temperatures are between 279±20°C and 366±20°C; for Boccheggiano ones (pyrite-sphalerite pairs) between 238±40°C and 289±40°C.

In a sample from Campiano, sphalerite (FeS content 19.8 mole %), pyrite, monoclinic and hexagonal pyrrhotite appear to coexist; a temperature of ~260°C and a pressure of 0.6±0.5 Kb have been deduced.

Comparison of results of this study with previously acquired data on Cu-Pb-Zn deposits from Tuscany (Valle del Temperino and Fenice Capanne) allows the following conclusions:

- Fe content of sphalerite always indicates a log fS_2-T field in agreement with associated phases in the Fe-S system. Namely, in pyrite deposits where pyrrhotite is never found in equilibrium with sphalerite, Fe content in sphalerite is limited in the range 1-10 mole % FeS. In the Cu-Pb-Zn-(pyrite) deposits the appearance of the sphalerite-pyrite-pyrrhotite assemblage corresponds to FeS contents in sphalerite up to 21 mole %;
- Mn, Cd and Cu contents in sphalerite are quite similar for both types of deposits; they never exceed 0.5 wt %;
- available thermometric data indicate a temperature range between ~200° and ~400°C. (Authors' abstract)

GRIBANOV, A.P. and SHEVKALENKO, V.L., 1978, Conditions of formation of gold-bearing quartz veins in the Ipatinskaya complex of Precambrian beds (Priamur'ye), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 192 (in Russian). Authors at Far-East Inst. of Mineral Raw Materials, Khabarovsk, USSR.

The gold-quartz veins occur in quartz-albite-muscovite paraschists. Pre-ore albitization developed at Th>370°C; ores formed at Th<370°C together with sericite, quartz, chlorite, arsenopyrite and carbonates; main ore stage had Th 366°C (marginal parts of veins) to 142°C (central parts of veins). (Abstract by A.K.)

GRIBANOV, A.P. and SHEVKALENKO, V.L., 1980, Conditions of formation of gold ore quartz veins in the Ipatinskaya beds of Precambrian (Priamur'ye), in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 126-129 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980. (A.K.) See previous item.

GRIGORCHUK, G.Yu., 1980, Criteria of stages of hydrothermal mineral formation: Zapiski Vses. Min. Obshch., v. 109, no. 4, p. 396-411 (in Russian). Author at L'vov Univ., L'vov, Ukrainian SSR.

In the paper the geological, mineralogical-geochemical and physicochemical criteria were discussed, applied for stages of mineral formation in ore fields Krasnoyarovo-Zolin (Transbaikalia), Aprel'kovskoe and others as examples of mineralized areas tectonically divided into several blocks. The compared factors include also Th in individual blocks of scheelite-Au-sulfide-quartz ore field Aprel'kovskoe, equal 390-235°C for early stages and 330-70°C for late ores. (Abstract by A.K.)

GRIGORCHUK, L.A., GRIGORCHUK, G.Yu. and MARTYNOVA, S.S., 1978, Dependence of certain geochemical peculiarities of pyrite on physico-chemical conditions of its formation (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 209-211 (in Russian). Authors at L'vov State Univ., Ukrainian SSR.

Kluchevskoe gold ore field (E. Transbaikalia) formed during complex polystage process, resulting in nine mineral parageneses each of which contains pyrite. Pyrite formed at 430-210°C (Th in paragenetic quartz and carbonate). Isomorphic admixtures of Co, Ni, Cu, Zn and Sb were determined in each pyrite variety. (A.K.)

GRIGORYAN, S.S., SUSHCHEVSKAYA, T.M., ALEKSANDROVA, E.S., KOZERENKO, S.V. and DOLPAKOVA, N.N., 1978, Contribution to understanding of the genesis of certain gold ore deposits* in Armenia (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 216-217 (in Russian). Authors at GEOKHI, Moscow, USSR.

The deposits belong to subvolcanic gold-polymetallic, gold-tellurium and gold-silver types. Initially in quartz veins crystallized pyrite, arsenopyrite, magnetite and chalcopyrite, and next polymetallic association formed (galena, sphalerite, tetrahedrite) and strictly connected gold-tellurium one. Sometimes a gold-antimonite association, later than the polymetallic one, may be distinguished. The process was finished by formation of post-ore quartz-carbonate veins. From Th and Td the general T range of the deposit formation was 380-140°C, essential commercial associations formed at 350-280°C. In solutions main ion Na>K, important also were Ca and Mg; main anions were HCO_2>Cl. S^{2-} concentrations by water leachate method and sulfide-silver electrode with inclusions opened under inert atmosphere was 10^{-3}-10^{-4} moles/l of ore-forming solution. Gases, by G chromatography, consist of CO_2, CH_4, CO_2 (sic., probably misprint for CO, A.K.), H_2 and N_2; CO_2 prevails. During gold precipitation CO_2 concentration and CO_2/CH_4 ratio increases regularly. (From the authors' abstract, translated by A.K.)

*Deposit names not specified, A.K.

GRINENKO, L.N., ZAIRI, N.M., PONOMAREV, V.G., RUCHKIN, G.V. and TYCHINSKIY, A.A., 1978, Sulfur- and carbon-isotope composition of the ores and rocks of the lead-zinc deposits of the Sardana ore node (Southeastern Yakutia): Geolog. Rudnykh Mestor., v. 20, no. 2, p. 57-73 (in Russian; translated in Internat. Geol. Rev., v. 22, no. 10, p. 1210-1224, 1980). First author at Moscow State Univ., Moscow, USSR.

We examined variations in sulfur isotopes from the sulfides of ores and rocks, and also carbon isotopes of the carbonate rocks of the Sardana ore node. The deposition of the ores probably took place from solutions (brines or subsurface waters), heated in the thermal field of dikes and rising along fault zones. During the reduction of the oxidized forms of sulfur and transportation of the ore-forming elements, carbon dioxide gases, associated with petroleum occurrences, played a probable role. (Authors' abstract)

GRISHINA, S.N., 1979, Microanalysis of gas phase of inclusions in minerals: Zapiski Vses. Mineral. Obsh., v. 108, no. 5, p. 617-621 (in Russian). (See translations.)

GROMES, N., 1980, Geological and microthermometrical investigations on the mineralization of the Bavarian "Pfahl": Dipl. Arb., Göttingen 1980, 119 p. (in German).

Fluid inclusion investigations on quartz. (E.Horn)

GROMOV, A.V., 1978, Genesis of stratiform deposits on the basis of thermobarogeochemical data (iron ore and polymetal deposits of Northern Algeria) (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 95-96 (in Russian). Author at MGRI, Moscow, USSR.

Liassic and Aptian iron and polymetallic ore deposits in carbonate rocks of N. Algeria yielded T (not specified whether Th or Td) for Fe-bearing parageneses 320-200°C, polymetal ores 250-150°C, fluorite-barite mineralization - 180-50°C. P changed from few hundreds atm to lithostatic values. (A.K.)

GUNOW, A.J., LUDINGTON, Steve and MUNOZ, J.L., 1980, Fluorine in micas from the Henderson molybdenite deposit, Colorado: Econ. Geology, v. 75, no. 8, p. 1127-1137. First author at Dept. Geol. Sci., Univ. Colo., Boulder, CO 80309.

Anamalously high fluorine values have been found in biotite, sericite, and spessartine garnet associated with the various intrusive and alteration sequences at the Henderson molybdenite deposit in Clear Creek County, Colorado. Twelve-element microprobe analyses of these minerals throughout this Tertiary rhyolite complex indicate that the highest fluorine values are found in vein-related, magnesium-rich biotite (up to 7.5 wt% F) and that the lowest fluorine values are found in sericite from the outer zone of pervasive sericitic alteration (<1.7 wt% F).

Application of previously calibrated F-OH exchange relations (Munoz and Ludington, 1974; Ludington, 1974; Gunow, 1978) indicate equilibration of biotite-sericite pairs, high initial relative activity of fluorine, and substantial decreases in fluorine activity during evolution of the hydrothermal fluid. Log (fH_2O/fHF) values have been calculated at an assumed final temperature of exchange of 350°C, and they indicate that, within the orebody, the fugacity ratio averages about 3.9 for all varieties of mica. There is a progressive increase in the fugacity ratio with distance from the mineralization center, and values are >4.5 at a distance of 500 m from the 0.1 percent MoS_2 zone. These results provide evidence that fluorine was an essential component of the hydrothermal fluid at Henderson, that significant fluorine gradients are found within the sericitic alteration zone, and that the highest activity of fluorine was spatially associated with molybdenite mineralization. (Authors' abstract)

GURNEY, J.J., 1979, Inclusions in diamonds from southern Africa: Geokongres 79, 18th Congress of the Geol. Soc. of S.A., Abstracts, Part 1, p. 164-176.

On the basis of mineral inclusions in diamonds from most of the producing mines, southern African diamonds have two parageneses: peridotitic and eclogitic.

Both are always present at each kimberlite locality, but the relative proportions show wide variations. Overall, periodotitic inclusions are more abundant but there are exceptions of which the most notable are Orapa and Premier Mines. (Author's abstract)

(Note - Author believes peridotitic suite formed from a melt "saturated with respect to water and CO_2" (p. 166).) (E.R.)

GUTMANN, J.T., 1977, Textures and genesis of phenocrysts and megacrysts in basaltic lavas from the Pinacate volcanic field: Am. J. Sci., v. 277, p. 833-861. Author at Dept. Earth & Environ. Sci., Wesleyan Univ., Middletown, CT 06457.

The Pinacate volcanic field, Sonora, Mexico, contains alkali basalts and hawaiites of Pleistocene age. These rocks are characterized by the presence of phenocrysts and megacrysts of labradorite, olivine, and, in much lesser abundance, calcic augite and magnetite. In contrast to many other suites of megacrysts described from mafic, alkaline lavas elsewhere, subhedral to euhedral crystals of plagioclase dominate both phenocryst and megacryst assemblages volumetrically, and the plagioclase megacrysts are among the most calcic feldspars, or nearly so, in their host units. The labradorite megacrysts, which are as much as 10 cm long in some units, grade continuously downward in size into phenocrysts and microphenocrysts. Many of these smaller crystals are as calcic as the associated megacrysts, although others exhibit resorbed cores ranging downward in anorthite content to calcic andesinc.

The compositions of the lavas cannot be derived from one another by addition and subtraction of olivine and plagioclase. The groundmasses of rocks rich in coarse labradorite crystals are correspondingly depleted in plagioclase. The gem-quality labradorite megacrysts, which are in fact megaphenocrysts, contain primary tubular fluid inclusions of large size and probably grew within the upper crust concomitant with evolution of fluid from adjacent silicate melt. Many of the phenocrysts and megacrysts exhibit skeletal crystal forms typical of rapid growth from melts moderately to strongly supersaturated with crystalline phases.

A petrogenetic model for near-surface crystallization in rising magmas is proposed. This model involves evolution of water from the melts, perhaps initially by partitioning into a separate, CO_2-rich, fluid phase. Supersaturation promoted by this exsolution of water may be nil or only slight at first but evidently induced formation of numerous skeletal crystals, some more than 1 cm long, at depths within or not far below the Pinacate volcanic pile. Caution is indicated in interpreting the textures and paragenesis of coarse crystals in volcanic rocks. (Author's abstract)

GUTSALO, L.K., 1980a,Discharge of mantle methane in waters of thermal sources of Kamchatka: Geokhimiya, no. 3, p. 351-358 (in Russian, English abstract). Author at Inst. Geol. and Geochem. of Mineral Fuels of Acad. Sci. of Ukr. SSR, L'vov, Naukova 3A Street, Ukrainian SSR.

Pertinent to gas composition studies in fluid inclusions. (A.K.)

GUTSALO, L.K., 1980b, On principles and factors determining variation of isotopic composition of brines in the process of evaporation (in connection with criteria of genesis of underground brines): Geokhimiya, 1980, no. 11, p. 1734-1746 (in Russian).

HAAPALA, Ilmari, 1980, Fluid inclusions in the apatite of the Sokli carbonatite, Finland - a preliminary report: Geologi, v. 32, no. 7, p. 83-87.

Apatite from the Sokli carbonatite contains many large primary inclusions of two types, both with small bubbles. Type I has 60-80 vol.% dms, and Type II has only a few minute dms. When Type I is opened in glycerol + HCl, most dms dissolve rapidly with effervescence. Th V-L occurs at 250-350°C; dm dissolution starts well below 500°C and most are gone by 550°C; all inclusions leaked in slow runs (≤24 hrs.) at 550-620°C, before Th. Very little dm was present at that time. Type II Th L-V is 168-239°C, Tm (ice?) = -15.4 to -21.4°C. Tm CO_2 hydrate(?) at -6 to +8°C. LCO_2 was rare. Another sample showed NaCl dms, with Th L-V ~200 and Tm NaCl ~240°C. Others contain nahcolite dm.

The occurrence of Types I and II together suggests immiscibility, but other explanations are possible. (E.R.)

HAAPALA, I. and KINNUNEN, K., 1980, Fluid-inclusion evidence on the genesis of tin deposits (abst.): Papers presented at MAWAM Conference, Univ. Exeter, Dec. 1979, Inst. Mining and Metallurgy Trans., v. 89, Sect. B, p. B194.

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

HAGNI, R.D., 1980, Ore microscopy and fluid inclusion geothermometry of the Precambrian Ag-W-Sn deposits in the Silver Mines District Southeast Missouri, USA (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 942.

The Precambrian Ag-W-Sn deposits of the Silver Mines District in Southeast Missouri occur as erratically distributed pods, lenses, and irregularly shaped bodies in quartz veins and contiguous greisen. The quartz veins have moderate dips, are several feet thick, and occur within a Precambrian glomeroporphyritic granodiorite. A light greenish gray, medium-grained, quartz-topaz-sericite greisen occurs in granodiorite adjacent to the quartz veins and has developed more pervasively in a brecciated and banded tuff. Ore microscopic examination of 150 polished sections prepared from specimens from nine mines and prospects in the district has shown that the primary ores consist of sixteen minerals deposited during two stages. An early vein stage involved the crystallization of quartz, topaz, sericite, cassiterite, wolframite, zinnwaldite, arsenopyrite, hematite, and magnetite. A subsequent stage of base metal deposition consisted of pyrite, fluorite, sphalerite, chalcopyrite, pyrrhotite, freibergite, argentiferous galena, and additional quartz. The tungsten ore mineral, wolframite exhibits marked compositional zoning and is veined by the base metal sulfides. Pyrite, the most abundant sulfide mineral, exhibits patchy replacements by sphalerite, chalcopyrite, and galena. Sphalerite is characterized by abundant blebs of chalcopyrite and pyrrhotite. Measurements of fluid inclusion filling temperatures for minerals belonging to the base metal stage give 132-114°C for fluorite and 121-105°C for sphalerite. The mineralogy, texture, fluid inclusions, and geologic setting indicate that the ore deposits of this district are markedly different from those in the southeast Missouri Lead district, and that they are deposited over a wide range of temperature and at shallow depths under low pressure conditions characteristic of xenothermal ore deposits. (Author's abstract)

HAHN-MEITNER-INSTITUT für Kernforschung, Berlin (1976-1980), C-5 GEOCHEMIE, Bericht über den Zeitraum 1976-1980, pp. 70-75, Fluid inclusions in fissure minerals of penninic rocks of the western Tauern window (in German).

Fluid inclusions in the range of ore occurrences. (E.Horn)

HALL, W.E. and BATCHELDER, J.W., 1980, [Light-stable isotopes and fluid inclusion study of the Thompson Creek and Little Boulder Creek deposits, Idaho] (abst.): U.S. Geol. Survey Prof. Paper 1175, Geological Survey Research, 1980, p. 205.

A light-stable isotope and fluid inclusion investigation is being conducted on the Little Boulder Creek and Thompson Creek molybdenum deposits, Custer County, Idaho. Homogenization and freezing temperature measurements of fluid inclusions indicate deposition temperatures of 371° to 377°±3°C and salinities of approximately 5 to 10 equivalent wt-percent NaCl. The $\delta^{18}O$ values for quartz range from ±10.7 to +11.2 per mil with calculated $\delta^{18}O$ H_2O value ranging from +4.7 to +5.3 per mil. The δD values of fluid inclusion water from quartz range from -121 to -83 per mil. Sulfide minerals have $\delta^{34}S$ values ranging from +9.6 to 11.4 per mil. These preliminary data indicate that the ore fluids of both deposits probably were composed of both meteoric and magmatic waters. The Thompson Creek ore fluids had as much as 35 percent magmatic water. Sulfur in both deposits probably was derived from the surrounding Paleozoic sedimentary rocks. (Authors' abstract)

HALLBAUER, D.K., 1980, The palaeo environment and thermal history of the Witwatersrand fossil placers (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 2, p. 774.

Sedimentological evidence, the frequent occurrence of ventifacts and baked mud deposits as well as thin coal or kerogene seams with relict algal structures point to a Precambrian depositional environment for the gold and uranium placers characterized by alternating shallow water and arid environment for distal parts, and a system of braided channels of ephemeral streams for the proximal part of the fluvial fans.

The trace element content and composition of many detrital heavy minerals indicate an oxygen deficient atmosphere. In particular the presence of detrital sphalerite, cobaltite and gersdorffite as well as the trace element content of gold particles strongly supports the assumption of a low oxygen level in the Precambrian atmosphere. Local areas of oxygen enrichment, however, appear to have existed in the biological environment of algal/bacterial mats preserved as bituminous coal-like seams as evidenced by the different geochemical behavior of gold, uranium and other elements within these bioherms.

The post depositional thermal history of the Witwatersrand sediments is apparent from the homogenization temperatures of secondary fluid inclusions in quartz pebbles which point to temperatures not exceeding 250°C. This is supported by geochemical evidence in the form of a high volatile content in the kerogene, the presence of volatile trace elements in gold and the presence of detrital gersdorffite which is not stable at higher temperatures. (Author's abstract)

HALLBAUER, D.K. and KABLE, E.J.D., 1979, Geochemical and fluid inclusion studies of quartz pebbles in Witwatersrand conglomerates and their relationship to gold mineralization: Geokongres 79, 18th Congress of the Geol. Soc. of S.A., Abstracts, Part 1, p. 176-186.

A series of quartz pebbles from this gold-bearing conglomerate were studied by various methods. Neutron activation analysis of pebble interiors showed a good positive correlation of high Au and high La content. Th of inclusions ranged generally from 120-180°C and none >500°C, suggesting a low-temperature hydrothermal source. SEM studies of dms exposed in opened inclusions on broken surfaces* included common orthoclase and muscovite, as well as hematite, rutile, apatite, calcite, corundum, anhydrite, NaAl silicates and various mixed chlorides (e.g., CaAlNaFe, and CaFeMnMgKNa). Evaporation deposits had Fe, Ni, Cu, K, Na and Mg, or FeZnCu, Na and K (Ca not mentioned). Leachates from one crushed sample showed major Cl, Ca, K and Na, and Cu (900 ppm) Ni (700 ppm), Co (20 ppm), Mn (90 ppm) and Au (0.7 ppm). (E.R.)

*Editor's note: In correspondence with Dr. Hallbauer, it is apparent that some of these apparent daughter minerals could be solid inclusions to which a liquid inclusion was attached.

HALLBAUER, D.K. and KABLE, E.J., 1980, The metallogeny of the Witwatersrand gold-uranium deposits in the light of recent geochemical research (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 943.

A large number of single grains of heavy minerals from Witwatersrand conglomerates obtained by hydrofluoric acid treatment of rock samples as well as single quartz pebbles were analyzed for major elements and trace elements.

Significant differences in the K, La and total REE content as well as in the Na:K ratio allow the prediction that several geochemical different source areas for the Witwatersrand existed. The geographical delineation and identification of these sources is at present an object of active research.

The concept of different sources is supported by systematic regional changes in the silver and trace element content of gold particles. Information on the type of the primary deposits is obtained from the study of detrital heavy minerals and their intergrowths. Detrital gold, for example, is primarily intergrown with sphalerite, chalcopyrite, gersdorffite and bravoite. Detrital pyrite from various localities contains inclusions of molybdenite, chalcopyrite, spessartine, biotite and other minerals.

Leaching and analysis of fluid inclusions in quartz pebbles is employed as an additional source of information on the type of the primary deposits for the Witwatersrand conglomerates. (Authors' abstract)

HAND, J.H., KATZ, D.L. and VERMA, V.K., 1974, Review of gas hydrates with implication for ocean sediments: In Natural gas in marine sediments, I.R. Kaplan, ed.: New York, Plenum Press, p. 179-194. Authors at Dept. of Chem. Engrg., The Univ. of Michigan, Ann Arbor, Michigan 48104.

This paper presents a general review of gas hydrate knowledge, the utilization of such knowledge in the natural gas industry, some contemplated uses of gas hydrates in sea water desalinization, and discusses the existence of natural gas hydrates under the permafrost of the Northern Hemisphere. The theory of how gases enter the water phase and cause premature crystallization of water into an ice-like hydrate structure is presented. With this background, hydrate formation in ocean sediments is considered. (Authors' abstract)

HANOR, J.S., 1980, Dissolved methane in sedimentary brines: potential effect on the PVT properties of fluid inclusions: Econ. Geol., v. 75, p. 603-609.

An important paper, reviewing the problems that methane may cause in interpreting the behavior of fluid inclusions, particularly the pressure correction and the estimation of salinities. (E.R.)

HARDY, Michel, ILDEFONSE, J.-P., FORTUNE, J.-P., TOURAY, J.-C. and GARCIA-IGLESIAS, Jésus, 1980, Talc genesis by simultaneous diffusion of magnesium and silica, as exemplified by Puebla de Lillo deposits (Bonar, Leon, Spain). Guidelines for prospecting: C.R. Acad. Sci. Paris, Series D, v. 290, p. 731-734 (in French).

At Lillo, talcitites are pseudomorphosed magnesian or siliceous rocks. The talc originates from local redistribution of silica and magnesia by diffusion through solutions. Guidelines for prospecting are proposed for diffusion-generated talc deposits. (Authors' abstract)

HARMON, R.S. and ATKINSON, T.C., 1980, Interpretation of past climates from D/H and $^{18}O/^{16}O$ ratios of speleothem calcite and fluid inclusions (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 2, p. 658.

The climatic significance of isotopic variations in U-Th dated speleothem calcite is reviewed. $\delta^{18}O_c$ of calcite is of limited use alone, but if $\delta^{18}O_w$ of the parent water can be established, fractionation of ^{18}O between calcite and water provides a measure of depositional temperature in the cave. Cave temperature is close to mean annual temperature in most cases. $\delta^{18}O_w$ cannot yet be measured directly but δD_w of fluid inclusion water in the speleothem can. This is presumed to be ancient recharge water. $\delta^{18}O_w$ can be estimated from δD_w by assuming that the same relationship between them applied in the past as in modern meteoric waters. In this way estimates of cave temperature to ±1°C are possible. Speleothems from N. America indicate a 12°C depression of mean annual temperature during glacial periods. A Holocene stalagmite from Britain shows δD variations attributable to changes in seasonal distribution of precipitation. (Authors' abstract)

HARMON, R.S. and SCHWARCZ, H.P., 1980, Oxygen-hydrogen isotope relationship in meteoric water: evidence for change during glacial periods (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 442.

The modern relationship between δD and $\delta^{18}O$ for meteoric waters at continental and many maritime sites has been observed to the $\delta D = 8\,\delta^{18}O + \delta o$ where $\delta o = 10‰$. Speleothems deposited at oxygen isotope equilibrium in North America, Mexico and Bermuda, contain fluid inclusions of pure water. Using the above δD-$\delta^{18}O$ relationship, paleotemperatures were calculated from δD of fluid inclusion and $\delta^{18}O$ of the host calcite of these inclusions. Glacial and interglacial periods of deposition were identified from Io/U dates and correlation with marine isotopic record. Paleotemperatures for interglacial periods are comparable to those observed at the sites at present. However, glacial-age paleotemperatures are too low, falling below 0°C at some sites. Speleothem deposition cannot occur when cave is below 0°C because carbonate-bearing waters would be frozen. Antarctic ice cores from glacial periods, analyzed by Epstein et al., give $\delta o = 0$. Using this intercept in the paleotemperature calculations leads to non-negative, glacial-age temperatures at almost all sites, suggesting that the δD-$\delta^{18}O$ relationship may have been globally different during the Pleistocene ice ages. This is confirmed by some analyses of Pleistocene groundwaters. Calculations by Merlivat and Jouzel have related shift in δo to changes in humidity of air masses formed above the ocean surface. (Authors' abstract)

HARRIS, D.M., 1980, The concentration of CO_2 in submarine basalts (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 66.

Previous studies have demonstrated that the average size and volume fraction of vesicles in submarine basalts decrease with increasing depth. Vesicles in H_2O-poor submarine basalts are rich in CO_2, implying that seafloor basalts are commonly CO_2-saturated. The presence of vesicles in samples precludes accurate determination of the CO_2 concentration in the glass unless steps are taken to analyze only uncontaminated, vesicle-free glass. A new microanalytical technique has been developed for determination of H_2O and CO_2 in glass. The technique has been applied to 5 mid-ocean ridge (East Pacific Rise, FAMOUS area, Reykjanes Ridge) and 2 Kilauea East Rift Zone submarine basalts collected at depths from 970 to 4680 m. The vesicle-free glasses contain 0.10 to 0.34 wt.% H_2O. Except for two samples from the flanks of seamounts, CO_2 concentrations increase linearly with quenching pressure. Although sample depths are well-known, there are uncertainties in quenching pressure due to movement of lava during eruption, eustatic sea level variations, and post-eruption vertical motion of the seafloor. The maximum vertical distance traveled by a lava flow is difficult to evaluate unless local seafloor topography is known. Sea level variations introduce an uncertainty of (+6, -16) bars. Non-tectonic uncertainties of quenching pressure have been estimated. The inferred solubility of CO_2 in the liquids is 0.056 wt.% CO_2/kilobar. This value is 2 - 6 times smaller than values reported by Kadik and others; their run products contained 1% vesicles. The two samples from flanks of seamounts have excess CO_2 compared to the solubility limit defined by the other samples. Further research is needed to explain the anomalous samples. (Author's abstract)

HARRIS, M., 1980, Hydrothermal alteration at Salave gold prospect, northwest Spain: Inst. Min. and Met., Trans., Sect. B, v. 89, p. B5-B15.

"Hongorock," an auriferous ($\geq$ 1 ppm Au) alteration facies, consisting of sericite-carbonate-albite-± quartz-sulfide cataclasite, contains S fluid inclusions containing H_2O and CO_2. The ratios of H_2O/CO_2 and CO_2V/CO_2L vary widely. The author suggests boiling but does not mention necking down. (ER)

HARVIE, C.E. and WEARE, J.H., 1980, The prediction of mineral solubilities in natural waters: the Na-K-Mg-Ca-Cl-SO_4-H_2O system from zero to high concentration at 25°C. Geochim. Cosmo. Acta, v. 44, p. 981-997.

HATTORI, Keiko and SAKAI, Hitoshi, 1980, Implications of D/H and $^{18}O/^{16}O$ ratios of ore fluids for the Neogene vein-type and Kuroko mineralization of Japan; Proceedings of the Fifth Quadrennial IAGOD Symposium, Vol. 1, J.D. Ridge, ed: Stuttgart, E. Schweizerbart Verlag, p. 297-307. First author at Dept. Geol., Univ. Alberta, Edmonton, Alberta, Canada T6G 2E3.

Neogene vein-type mineralization generally is found in Tertiary submarine volcanics and pyroclastics that also are the host rocks for the Kuroko mineralization. Coupled with this, geological, mineralogical, and chemical similarities led to the currently most widely accepted view that the vein-type mineralization took place contemporaneously and under the similar submarine environments to the Kuroko ore deposits. To test this view, fluid inclusions were extracted from quartz, chalcopyrite, sphalerite, and calcite of these ore deposits and their O/H ratios were measured. The $^{18}O/^{16}O$ ratios of ore fluid were estimated from those of quartz, the filling temperature, and the fractionation factor between quartz and water. Major ore deposits of Japan (7 Au-Ag vein-type, 9 Cu-Pb-Zn vein-type, and 6 Kuroko ore deposits) were studied, the localities of which cover a full range of the north-south span of the Japanese Islands.

The D/H ratios of fluid inclusions from the vein-type ore deposits range from -40 to -70‰ relative to SMOW. A strong parallelism exists between the D/H ratios of fluid inclusions from the Au-Ag vein-type deposits and their respective meteoric waters. A similar, though weaker, correlation also is found between late stage mineralization of the Cu-Pb-Zn vein-type deposits and local meteoric waters. These results and a model calculation based on a rock-water interaction model that takes into account the hydration reaction of the original rocks, strongly indicate that the ore fluids for the vein-type mineralization were essentially meteoric in origin. On the other hand, the D/H ratios of the Kuroko ore deposits from northeast Honshu are confined within -10 to -30‰ and can be interpreted as mixtures of sea water and local meteoric waters.

Major implications of the present results are, among others, that the vein-type mineralization occurred under terrestrial environment and thus, their ages of mineralization must be younger than the Kuroko mineralization, probably in the upper Miocene to the lower Pliocene, and that the ore constituents of the vein-type deposits must have come from the Tertiary country rocks. Many similiarities in the isotopic compositions of sulfur and lead and chemistry between the Kuroko, and the vein-type deposits can be explained on the basis of this present view. (Authors' abstract)

HAVETTE, Andrée and CLOCCHIATTI, Robert, 1979, Ionic analyses of para-genetically concentrated Ba and Sr in a scoriaceous lava from Vesuvius (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France, p. 248 (in French).

HAYNES, F.M. and TITLEY, S.R., 1980, The evolution of fracture-related permeability within the Ruby Star granodiorite, Sierrita porphyry copper deposit, Pima County, Arizona: Econ. Geol., v. 74, p. 673-683. First author at Fischer-Watt Mining Co., 114 Tucker, Suite 2, Kingman, AZ 86401.

Quantitative data from the margins of the Sierrita porphyry copper deposit were derived by direct measurements of fractures in the field and fluid temperatures in the laboratory. These data constrain interpretations of the nature and extent of fracture permeability at different stages of cooling of the quartz monzonite porphyry which invaded the Ruby Star Granodiorite.

Fracturing coeval with formation of the orebody extends into the granodiorite some 4.5 km from the center of the hydrothermal system. Integrated fracture densities decrease from values of 0.2 to 0.3 cm^{-1} near the system's center to a background value of 0.03 cm^{-1} or less outside of the system. Four mineralogically different vein types with a distinct paragenetic sequence are present. Early veins, characterized by a quartz-orthoclase assemblage, are crosscut by two distinct types of sulfide-bearing quartz veins. The bulk of the copper mineralization is associated with the later of these two events. The final vein set present consists of an orthoclase-epidote assemblage. Distribution of the vein types in the granodiorite indicates that the areal extent of fracturing associated with each type diminishes with time.

Vein filling temperatures determined from fluid inclusions at two localities reveal a general decrease in the temperature of deposition of vein quartz in each vein type as the system evolved. Homogenization temperatures in excess of 350°C were observed in the quartz-orthoclase vein set. Temperatures in the quartz-sulfide vein assemblages were considerably lower, never exceeding 320°C, and those in the final orthoclase-epidote vein set were lower still, never exceeding 260°C. Sulfide-bearing quartz veins collected at sites 1.8 and 2.9 km from the system's center showed similar temperatures of formation; however, secondary inclusions representing later events, present at the 1.8-km site, were absent at the 2.9-km site, suggesting that the later, lower temperature event related to their formation was less widespread. (Authors' abstract)

HEINRICH, E.W., 1980 (reprinting date), The geology of carbonatites: New York, Robt. Krieger Pub. Co., 585 pp plus indices. Author at the Univ. of Michigan.

A thorough review of the petrology and geology of carbonatites, but the book contains only a brief mention of immiscibility, and fluid inclusions (indexed only under vacuole, but also termed vesicles in text) are also mentioned only briefly, with a few references to old work, mainly on CO_2 inclusions. (E.R.) After the above review was written, it was discovered that there actually were a number of references to fluid inclusion work on two pages each in Appendices 1 and 2, but these Appendices have their own reference lists and are not indexed in either the subject or locality indices, so the material is essentially lost to many readers. (E.R.)

HELGESON, H.C., 1980, Reaction rates and mass transfer in geochemical processes (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 49.

Correlation of thermodynamic and kinetic constraints on mass transfer among silicates and aqueous solutions permits calculation of the extent to which minerals are produced and destroyed as a function of time and surface area in geochemical processes. Calculations of this kind suggest that the bulk of the chemical and mineralogic changes observed in hydrothermal systems occur over relatively short periods of time and that the rate of change is controlled by the pH of the aqueous phase, either directly through formation of activated complexes on the surface of the reactant minerals, or indirectly through the dependence on pH of the chemical affinity of the overall reaction. Early incongruent reaction products form more rapidly in geochemical processes than those produced or destroyed in later stages of reaction progress. As a consequence, equilibrium among reactant minerals and aqueous solutions is achieved faster in open systems than in closed, where chemical affinity commonly controls reaction rates and quasi-equilibrium stated lead to significant differences in fluid composition corresponding to different degrees of progress toward complete equilibirum. In general, the greater the number of local equilibrium constraints, the slower the rate of overall equilibration. In certain cases the relative abundance and zonal association of minerals can be used to assess participation rates and directions of fluid flow. Correlation of these observations with computer experiments affords estimates of temperature and concentration gradients, diffusion rates, flow velocities, and fluid to rock ratios in hydrothermal systems. Data currently available permit such calculations to be carried out for pressures and temperatures to 5kb and 600°C. (Author's abstract)

HEMLEY, J.J., MONTOYA, J.W., MARINENKO, J.W. and LUCE, R.W., 1980, Equilibria in the system Al_2O_3-SiO_2-H_2O and some general implications for alteration/mineralization processes: Econ. Geol., v. 75, p. 210-228.

HENRY, D.J., CHAN, I., and NAVROTSKY A., 1980, Evidence for immiscibility in glasses along the albite-diopside binary join (Abst.): EOS, v. 61, p. 1147.

HERRMANN, A.G., 1980, Bromide distribution between halite and NaCl-saturated seawater: Chem. Geol., v. 28, p. 171-177. Author at Geochem. Inst., Univ. Göttingen, D-3400 Göttingen (Fed. Rep. Germany).

Bromide partition coefficients for the first halite crystallized under natural conditions from evaporated modern seawater in the marine salt works at Secovlje (Yugoslavia) are presented. The bromide content of halite corresponds to an average of wt.% $Br_{(halite)}$/wt.% $Br_{(solution)}$ = 0.14 ± 0.02 at 25°C. (Author's abstract)

HERZBERG, P.J., 1980, Geology of lode gold occurrences, Timberline Creek area, central Alaska: M.S. thesis, Univ. of Alaska, Fairbanks, AK, USA.

Indexed under Fluid Inclusions. (E.R.)

HESSE, Reinhard and HARRISON, William E., 1980, Abnormally low pore-water salinities in deep marine sections of the continental margins related to gas-hydrate (clathrate) occurrence (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 446.

During leg 67 of the Deep Sea Drilling Project gas-hydrates (methane clathrates) were for the first time recovered from two deep drill holes on the lower and middle trench slope of the Middle America continental margin off Guatemala. The clathrates occur in organic matter-rich Pleistocene to Miocene terrigenous sediments. In holes 496 to 497 drilled in water depths of 2064 and 2358 m respectively, a spectacular decrease in interstitial water salinities was observed starting at about 80 to 100 m subbottom depth. At the bottom of the holes (near 400 m subbottom) the pore-waters have salinities less than half of that of sea-water. A similar but less pronounced downward decrease in salinity was observed during previous legs of the DSDP (e.g., leg 11) in other clathrate-prone regions, e.g. on the Blake Outer Ridge, where recharge of fresh water from the continent can be excluded. The crystallization of gas-hydrates, like ice, excludes salt ions from the lattice structure. It is, therefore, proposed that dissolved salts are ejected upward from the clathrate bearing sections. This is in line with the high salinity (above 35%) observed in the upper 50 to 80 m of the holes where clathrate formation has probably not yet started. The fact that salinities do not decrease to values near zero in the clathrate zone suggests that only a portion of the pore waters is tied up in clathrate formation. The thawing of clathrates at depth is a possible cause for abnormally high fluid pressures. (Authors' abstract)

HIBBARD, M.J., 1980, Indigenous source of late-stage dikes and veins in granitic plutons: Econ. Geol., v. 75, p. 410-423.

Microveins within granitic igneous bodies can form at all stages of crystallization from early magmatic to late post-magmatic and can be described as either inter- or intragranular. The indigenous character of such veins is evident when they begin and end within the scale of the thin section, but for larger dikes and veins an indigenous origin with respect to a parent pluton may or may not be apparent. The microveins result from mechanical activity, such as fracturing, affecting the system at the various stages of crystallization. The mineralogical character of the microveins is dependent on the timing of "mechanical release" with respect to the stage of consolidation of a specific portion of the water-bearing magmatic system. Overlapping relationships of dikes and veins characterizing the various stages are to be expected: in a specific portion of a pluton repeatedly affected by incomplete mechanical release of fluid as crystallization of that portion of the pluton proceeds or as the result of the simultaneous release of fluids from one portion of a pluton and the relocation in another in which release is occurring at a different stage of consolidation.

The mineralogy of dikes and veins reflects the timing of separation of fluid from the crystallizing parent system, but it is somewhat variable depending on whether or not further release occurs from the crystallizing of newly separated fluid. Intergranular fluids of crystallizing H_2O-bearing granitic magmas are classified as: main magmatic, late magmatic, early post-magmatic, and late post-magmatic. Main magmatic stage microveins contain minerals in equilibrium with fractionated intergranular melt existing at this stage of release from the crystal-melt parent system. The assemblage typically will be quartz, K-feldspar, plagioclase, and biotite, but it may include lesser amounts of late crystallizing K-feldspar, sodic plagioclase, quartz, and myrmekite if the system remains closed. If fluids of the main magmatic stage are accumulated and concentrated beyond the microscopic scale, for example, in dilational joints forming in an interlocking crystal framework, they form dikes comagmatic with the parent pluton.

Late magmatic indigenous microveins typically contain quartz, K-feldspar, sodic plagioclase, and relatively large amounts of myrmekite, all of which crystallize from melt saturated in H_2O. They originate from the parent pluton or by release from already separated, main magmatic-stage veins or dikes. Larger scale equivalents are leucogranites or alaskites; if internal segregation takes place, they become aplite-pegmatite complexes. Post-magmatic indigenous microveins and their larger scale vein equivalents are characterized by secondary K-feldspar and quartz (± ore minerals) and represent growth in an H_2O-rich environment into which growth materials are entering from coexisting magma. In a closed aplite-pegmatite system the early post-magmatic stage is represented by the coarse-grained pegmatite fraction. Late post-magmatic indigenous microveins and their mesoscopic equivalents may contain ore minerals, quartz, and many other minerals, all of which crystallize from the very latest stage, H_2O-rich fluids, either issuing directly from a specific portion of a pluton in which release takes place only very late, or from crystallizing systems already released from the parent pluton at an earlier stage. (Author's abstract)

HIGGINS, M.D., 1980, Evidence concerning the possible effects of liquid immiscibility during the differentiation of the Sept-Iles anorthosite complex, (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Program with Abstracts, v. 5, p. 60.

HIGGINS, N.C., 1980a. The genesis of the Grey River tungsten prospect: a fluid inclusion, geochemical and isotopic study: Ph.D. thesis, Memorial Univ. of Newfoundland, St. Johns, Newfoundland, Canada, 550 pp.

Mineralization in the Grey River tungsten prospect, Newfoundland, is contained within a swarm of quartz veins and fractures which traverse the contact between a sheared Devonian (405 ±10 Ma) K-feldspar megacrystic granite and metamorphic rocks which are typical of the gneissic terrain of the Gander Zone. The mineralization is genetically related to a suite of post-tectonic, highly differentiated, alkali-rich leucogranite dykes.

The tungsten-bearing hydrothermal veins, dated at 330 Ma, range from tensional fractures and veinlets to lodes containing several injections of quartz. The mineralization is divided into four stages; the Early Stage characterized by quartz-feldspar-molybdenite veins; the Composite Stage, consisting of five vein types (in paragenetic order), quartz-bismuthinite, quartz-wolframite (Fe-rich), greisen, quartz-sulfide, and quartz-wolframite (Mn-rich) veins; the Sulphide Stage, characterized by silver-bearing quartz-galena-sphalerite veins; and the Late Stage, composed of zoned fluorite-calcite-barite veins. A spatial mineral zonation from south to north matches the temporal sequence outlined above, with the exception of the Late Stage veins which crosscut Composite Stage veins.

Fluid inclusion data indicate a complex evolutionary history for the hydrothermal fluid. Initially a homogeneous supercritical fluid (XCO_2 = 0.4) with a density of 0.65 g/cc deposited quartz-feldspar-molybdenite veins at temperatures of 450-500°C and fluid pressures of 1200-1400 bars (120-140 MPa). The simultaneous trapping of CO_2-rich and H_2O-rich fluid inclusions, as well as solid inclusions of calcite in quartz of the quartz-bismuthinite vein type is evidence for the existence of an immiscible heterogeneous fluid during this stage of mineralization. Fluid phase equilibria indicate immiscibility occurred at temperatures of 390-430°C and fluid pressures of 1000-1200 bars (100-120 MPa). Oxygen isotope data indicate that greisen alteration halos of the composite lodes were formed at temperatures between 350-400°C.

In these lodes quartz-sulphide and quartz-wolframite veins were deposited in open spaces created by normal faulting. These movements prompted rapid decreases in fluid pressure and temperature and caused retrograde boiling of the hydrothermal fluid (at 350 bars and 300-390°C) during deposition of quartz-sulphide veins. Deposition of wolframite in quartz-wolframite veins occurred at 270-330°C and fluid pressures less than 350 bars, from an aqueous fluid of low salinity (<0.5 wt% NaCl) and CO_2 content (<10 bars PCO_2), and after separation of a CO_2 vapor phase by retrograde boiling.

Calculated $\delta^{18}O$ values for H_2O indicate a progressive depletion in ^{18}O isotopic composition of the hydrothermal fluid with time (7.3‰ to 0.5‰). The depletion is due to the loss of 40 mol% CO_2 from the hydrothermal fluid by immiscibility and retrograde boiling, and subsequent fractionation effects. The oxygen isotope data suggest that the hydrothermal fluid was dominantly of magmatic origin.

Heavy REE enrichment and light REE depletion during greisenization indicate extensive REE mobility, and imply both that CO_3^{2-} was the dominant anionic species in the hydrothermal fluid and that mobilization of

REE occurred by REE carbonate complexing. A positive correlation between heavy REE enrichment and high tungsten concentration suggests that REE mobility is related to tungsten transport. Together with the fluid inclusion evidence these data suggest that the transport of tungsten in hydrothermal fluids might be due to carbonate/bicarbonate complexing.

The fluid inclusion and isotopic data from the Grey River tungsten prospect serve to illustrate the previously unrecognized role of CO_2 in the transport and deposition of tungsten in the hydrothermal environment. (Author's abstract)

HIGGINS, N.C., 1980b, Fluid inclusion evidence for the transport of tungsten by carbonate complexes in hydrothermal solutions: Canadian J. Earth Sci., v. 17, no. 7, p. 823-830. Author at Dept. Geol., Memorial Univ. Newfoundland, St. John's, Nfld., Canada A1B3X5.

Fluid inclusion evidence from the Grey River Tungsten Prospect, Newfoundland, and other tungsten deposits indicates that CO_2 is an important component of the hydrothermal fluid. Carbon dioxide is enriched in fluids evolved from granitic melts under high fluid pressure, while lower pressure fluids are chloride-rich. The association of tungsten deposits with these carbon dioxide-rich hydrothermal fluids suggests that carbonate/bicarbonate complexes may be important in tungsten transport at very high pressures. (Author's abstract)

HITCHON, Brian, 1974, Occurrence of natural gas hydrates in sedimentary basins: In Natural gases in marine sediments, J.R. Kaplan, ed.: New York, Plenum Press, p. 195-225. Author at Alberta Research, Edmonton, Alberta, Canada.

Clathrates are a special variety of inclusion compound in which the guest molecules fit into separate spherical or nearly spherical chambers within the host molecule, and when the host molecule is water and the guest molecules are largely gases or liquids with low boiling points found in natural gas, the clathrates are termed natural gas hydrates. They are solid compounds, resembling ice or wet snow in appearance, and form both below and above the freezing point of water under specific PT conditions. The water molecules form pentagonal dodecahedra, which can be arranged into two different structures, leaving interstitial space in the form of either tetrakaidecahedra or hexakaidecahedra. Methane and hydrogen sulfide can be accommodated in all the spaces, ethane and carbon dioxide can fit in both the tetrakaidecahedra and the hexakaidecahedra, but propane and isobutane fit only in the hexakaidecahedra. Normal butane, pentane, and hexane are not known to form hydrates. PT diagrams describing the initial conditions for hydrate formation indicate that, relative to methane, all common components of natural gas (except nitrogen and the rare gases) raise the hydrate formation temperature, propane and ethane being the most effective. The presence of dissolved salts in the water, or nitrogen and rare gases in the natural gas, depresses the temperature of initial hydrate formation. (Author's abstract)

HITCHON, Brian, BILLINGS, G.K. and KLOVAN, J.E., 1971, Geochemistry and origin of formation waters in the western Canada sedimentary basin - III. Factors controlling chemical composition. Geochim. Cosmo. Acta, v. 35, p. 567-598. First author at Res. Council of Alberta, Edmonton, Canada.

Twenty major and minor chemical components are reported for 78 formation waters from oil fields and gas fields in Alberta, Canada. Using published pore volume and chlorinity distribution data, a volume-weighted mean composition of formation waters in the western Canada sedimentary basin is presented. The results of Q-mode, R-mode, and second-order R-mode factor analyses are tabulated and interpreted. The volume-weighted mean composition is similar to that of present day sea water and is compelling evidence for an ultimate origin from sea water of the major portion of the dissovled salts in the formation waters. Dilution by fresh water recharge and concentration by membrane filtration are the major factors controlling chemical composition. Together, they produce a chemical population ranging from freshwater to brines which is confirmed by the Q-mode analysis. Compared to sea water, the volume-weighted mean formation water has gained NaCl, which occurs as a separate factor in the R-mode analysis, and quantitative calculations demonstrate that sufficient halite has been dissolved from Middle Devonian evaporite beds to account for the observed gain in NaCl, and that the balance of halite dissolved from bedded evaporites in the basin has been, and is being, lost to the surface. The presence of Mg and Ca in separate factors, together with quantitative calculations, indicate that the ionically balanced loss of Mg and gain of Ca in the volume-weighted mean formation water cannot be attributed to dolomitization. Similarly, the total loss of SO_4 is not due to conversion of H_2S. Chlorite formation could account for the loss of Mg. Other factors controlling chemical composition and suggested by the factor study include cation exchange on clays, a probable contribution of Br and I by desorption from the clay fraction of argillaceous rocks, as well as from organic matter, and solubility control of $Ca-CO_3$ and $Sr-SO_4$ concentrations. (Authors' abstract)

HOEVE, J., SIBBALD, T.I., RAMAEKERS, P. and LEWRY, J.F., 1980, Athabasca Basin unconformity-type uranium deposits; a special class of sandstone-type deposits? In Uranium in the Pine Creek Geosyncline; Proceedings of the international uranium symposium on the Pine Creek Geosyncline, Ferguson, J. and Goleby, A.B. eds.: I.A.E.A., Proc. Ser. STI/PUB/555, p. 575-594.

Indexed under Fluid Inclusions. (E.R.)

HOLLAND, A.E., 1980, A petrographic and fluid inclusion study of the Julia deposit, Mineral, Virginia: M.S. thesis, Univ. of North Carolina, Chapel Hill, NC, USA.

Indexed under Fluid Inclusions. (E.R.)

HOLLISTER, Lincoln and SHERWOOD, Michael, 1980, Metamorphic evidence for rapid uplift, Coast Ranges, British Columbia, Canada (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 51.

The Eocene granulite facies metamorphic terrane in the central Coast Ranges of British Columbia was apparently uplifted and eroded at an unusually rapid rate. Reactions showing the transition from high pressure to low pressure assemblages are the best evidence for this interpretation. These include garnet → hypersthene + plagioclase, almandine/pyrope + sillimanite → cordierite; sillimanite + grossular → plagioclase; biotite + sillimanite → hercynite + cordierite, and kyanite → sillimanite. The occurrences of abundant low density $CO_2 + H_2O$ fluid inclusions and of andalusite in late discordant pegmatites imply that the rocks were still at moderate temperature when relatively near the surface, which is consistent with a model of rapid uplift. Mineral and rock ages published by Armstrong and co-workers, combined with the metamorphic data, constrain the rate of uplift to be 2-3 mm/yr as the rocks presently exposed at the surface rose from a depth of 15 km to 5 km. Calculations similar to those of Albarède, fitted to the metamorphic and age constraints, show that the initial uplift rate was about 10 mm/yr beginning at a depth of about 30 km. The average rate for the total uplift was between 5 and 8 mm/yr. (Authors' abstract)

HORN, E.E., 1980, Carbon contents in cassiterite: Neues Jahrbuch für Mineral., Abh., v. 139, no. 2, p. 128-130 (in English).

Cassiterite from Viloco/Araca, Bolivia, showed Th 370-425°C and evidence of boiling. Solid opaque carbon inclusions were also described. (E.R.)

HUANG, C.-I., ROSE, A.W. and DEINES, P., 1979, Fluid inclusions and isotopic gradients as a guide to ore at Ely, Nevada, USA (abst.): in Watterson, J.R. and Theobald, P.K., eds., Int. Geochem. Explor. Symp., Proc., v. 7, p. 499. First author at Houston Oil and Min. Corp., Suite 408, 222 Milwaukee, Denver, CO 80206.

At Ely, Nevada, U.S.A., the predominantly limestone country rocks intruded by mid-Cretaceous quartz monzonite show the effects of contact metamorphism and metasomatism collectively called the tactite stage. The minerals of the tactite stage, including garnet, pyroxene, wollastonite and recrystallized calcite were subsequently affected by hydrothermal activities, the clay-sulfide stage, during which chalcopyrite, pyrite, magnetite, actinolite, epidote, clay and calcite were deposited. Five concentric zones of alteration in the country rocks were recognized by James (1976). They are, from the contact outward, the garnet-rich tactite, the pyroxene-rich tactite, the silica-pyrite, the wollastonite, and the peripheral zones.

Heating of fluid inclusions allows estimates of the salinity and temperatures of ore-forming fluids. Most inclusions in garnet, pyroxene, and quartz of the tactite stage are of moderate to high density with one or no daughter mineral, and give homogenization temperatures of 450° to 600°C. Inclusions in quartz of the clay-sulfide stage contain up to 42 weight percent NaCl equivalent and have wide range of densities. Some homogenize as a vapor, suggesting boiling, although most of them homogenize as a liquid at temperatures between 250° and 500°C. The minimum fluid pressure during the clay-sulfide stage was estimated at 200 atm based on the fluid inclusion study. Jasperoids derived from oxidation and leaching of silicified mineralized rocks contain highly saline inclusions similar to those of the clay-sulfide stage. Inclusions in this quartz have been protected from supergene effects.

$^{18}O/^{16}O$ ratios of hydrothermal calcite and marble increase systematically from the contact to the peripheral zone, but are mostly higher than the coexisting quartz, suggesting isotopic disequilibrium. Excluding calcite, minerals of different stages have ^{18}O values corresponding to the tendency to concentrate ^{18}O under equilibrium conditions. ^{18}O values of quartz are 9.1 to 12.8 per mil (‰) (vs. SMOW); of pyroxene, 8.3 to 12.4‰; of garnet, 5.3 to 8.5‰; of two actinolites, 7.2 and 7.8‰; of magnetite, 3.7 to -0.3‰. Quartz-magnetite pairs give isotopic temperature estimates between 663° and 355°C for the clay-sulfide stage (using the calculated fractionations of Becker, 1971).

The calculated oxygen isotopic composition of waters associated with quartz of the clay-sulfide stage in the tactite zone within the Veteran pit shows a regular outward decrease from 10.5 to 7‰. Mixing of the ore-forming fluid with groundwater may be responsible for this zonal pattern.

The preservation of hypogene fluid inclusions in leached outcrop can be used for recognizing deep-seated mineralization. The zonal pattern of calculated ^{18}O values of water found in this porphyry copper deposit may aid in the exploration of similar ore deposits, especially during a detailed study. (Authors' abstract)

HUC, A.Y. and HUNT, J.M., 1980, Generation and migration of hydrocarbons in offshore South Texas Gulf Coast sediments: Geochim. Cosmo. Acta., v. 44, p. 1081-1089. First author at C.N.R.S. Lab. Geol. Appliquee, ERA 601, 45046 Orleans, France.

Includes a section on gas chromatographic techniques. (E.R.)

HUTCHINSON, R.W., FYFE, W.S. and KERRICH, R., 1980, Deep fluid penetration and ore deposition : Minerals Sci. Engng., v. 12, no. 3, p. 107-120. Authors at Dept. Geol., Un. Western Ontario, London, Canada N6A 5B7.

Direct observations on continental geothermal areas and sea-floor hydrothermal systems leave no room for doubt that many ore deposits are products of thermally driven fluid convection. Heat-flow studies show the types of patterns of such systems that may be looked for in mineral exploration. The flow velocity and discharge characteristics of a system may be related to the form of a deposit ranging from a massive orebody to a chemically enriched sediment or to a wide dispersion of values. It now is considered that more than one quarter of the Earth's present surface is involved in geothermal convective systems, which represent a major cooling mechanism for the Earth. It is also becoming apparent that in addition to the abundant and mobile base metals, elements such as tin, chromium, lead, nickel, tungsten, platinum, and palladium are transported through fracture systems and vented into the ocean-floor environment by high temperature brines under conditions of low redox potential. (Authors' abstract)

IAGC (International Association of Geochemistry and Cosmochemistry) and Alberta Research Council, 1980, Proceedings 3rd International Symposium on Water-Rock Interaction, Edmonton, Canada, July 14-24, 1980 (214 pp.).

Contains many short papers from sessions on formation waters, mineral stability in the presence of water, reaction rates, applications to mineral deposits, active geothermal systems, environmental and engineering aspects, and experimental studies. (E.R.)

IGNAT'YEVA, I.B., MIRONOVA, O.F. and PASHKOV, Yu.N., 1980, Methods of studies of gas phase of inclusions of mineral-forming media: p. 118-135 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

Composition of gases evolved from inclusion may change due to P decrease at room T on crushing and even more at decrepitation at elevated T. Analysis of G should be made under carefully controlled conditions and recalculated in view of the mineral-formation conditions. The mechanical and thermal methods of inclusion opening described in the literature are discussed, and authors find that no universal method exists, but the method used must depend on the problem studied. Analytical methods for gases are also evaluated critically. Analysis of individual inclusions (volumetric) needs high accuracy of the bubble measurements and provides no possibility of a H_2O determination. Analysis of individual inclusions by mass spectrometry needs large inclusions, and practically excludes parallel (control) determinations. Analysis of total gases from any sample may be obtained by volumetric, G chromatographic or mass spectrometry. Each method is specific and may be used for special investigation problems, which are discussed mostly on the basis of the earlier published data. (Abstract by A.K.)

IGONIN, I.P. and IVANOV, V.V., 1978, Temperature regime of mineral formation of commercial associations of certain Early Paleogene ore mineralized points of the Lower Priamur'ye, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 191 (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Vladivostok.

Two ore mineralized points* in volcanic rocks yielded Th 170-420 and 175-350°C for inclusions (LH_2O and LH_2O+LCO_2) in quartz and adularia. The metal of interest is not specified for those deposits but the abstract is placed in the part of book devoted to gold deposits. (A.K.) (*Names not given, A.K..)

IMAI, Hideki, and numerous others, 1978, Geological studies of the mineral deposits in Japan and East Asia: Tokyo, Univ. Tokyo Press, 392 pp.

A thorough review of the work of H. Imai and many of his students on a wide variety of ore deposit types in Japan. It consists mainly of a summary of previously published work, but is extensive, and covers much fluid inclusion work previously reported only in Japanese. Part II = vein-type deposits; Part III = pyrometasomatic deposits; Part IV = strata bound deposits; Part V = porphyry copper deposits; Part VI = sedimentary deposits, and a special 12-page report on inclusion studies by Takenouchi (See this volume). (E.R.)

INNORTA, G., RABBI, E. and TOMADIN, L., 1980, The gypsum-anhydrite equilibrium by solubility measurements. Geochim. Cosmo. Acta, v. 44, p. 1931-1936. First author at Instituto Chim. Ciamician, Univ. Bologna, via Selmi 2, 40127 Bologna, Italy.

Solubility measurements have been used to establish the gypsum-anhydrite equilibrium in the $CaSO_4$-H_2O system at atmospheric pressure. The saturation equilibrium has been approached both from undersaturated and supersaturated solutions. The invariant point temperature has been found to be 49.5 ± 2.5°C. (Authors' abstract)

IRWIN, W.P. and BARNES, Ivan, 1980, Tectonic relations of carbon dioxide discharges and earthquakes: J. Geophy. Res., v. 85, no. B6, p. 3115-

3121. Authors at U.S. Geol. Survey, Menlo Park, CA 94025.

CO_2-rich springs occur worldwide along major zones of seismicity. They are mostly in young orogenic belts, but some are in areas of rifting continental platforms. Analyses of ^{13}C content indicate that much of the CO_2 is derived from the mantle and that other important sources are the metamorphism of marine carbonate-bearing sedimentary rocks and the degradation of organic material. The presence of calc-silicate minerals, such as pumpellyite in metagraywacke, is evidence of former conversion of carbonate-bearing rocks into calc-silicate minerals and release of CO_2. The CO_2 pressure in fractured rocks of a fault zone reduces the effective normal stress and, if it is sufficiently great, allows the fault to slip. If the pressure were maintained at a sufficiently high level, the fault behavior might be characterized by frequent small earthquakes and a seismic creep such as occur along active segments of the San Andreas system. The presence of CO_2-rich springs may indicate a potentially hazardous seismic region. Monitoring of CO_2 discharges could be useful in earthquake prediction. (Authors' abstract)

ISHIKAWA, K.-I., KANISAWA, Satoshi and AOKI, K.-I., 1980, Content and behavior of fluorine in Japanese quaternary volcanic rocks and petrogenetic application: J. Volcanol. Geotherm. Res., v. 8, p. 161-175.

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). Authors at Geol. Inst. of Buryatian Div. of Siberian Branch of Acad. Sci. of the USSR, Ulan-Ude, USSR.

Commercial laser microanalyzer LMA-1 may be successfully applied for determination in L phase of individual inclusions of a number of elements in amounts nx10^{-12} (Be), nx10^{-11} (B, Cu), nx10^{-10} (Fe, Mn, Zn, Al). On the basis of above absolute sensitivity, the detection in L phase of inclusions of average volume 10^{-8} ml such elements as Fe, Mn, Zn, B proves the relatively high (in order tens grams per liter) concentrations of metals in ore-forming hydrothermal solutions. By calculating the volume of analyzed liquid exactly, a real possibility exists for determination of numerous elements in L phase of individual inclusions. (A.K.)

IVANOV, V.G., SAMOYLOV, V.S., SAPOZHNIKOV, A.N., KASHAEV, A.A. and VINOGRADOV, A.P., 1980, Mineralogy of the lazurite deposite of the USSR, in: Gem minerals-Proceedings of the XI General Meeting of IMA: "Nauka," Leningrad, p. 97-104, price 70 kopecks, 9100 copies printed (in Russian, English abst.).

Temperature conditions of formation of rocks of the lazurite deposits were studied by the homogenization method. In the deposits of S. Pribaykal'ye, the post-magmatic stage of mineral formation developed in a wide T interval - from 635 to 100°C. Lazurite rocks formed at 600-545°C, phlogopite metasomatites - 580-535°C, afghanite rocks 565-520°C, wollastonite rocks - 605-565°C, but late phlogopite rocks formed at Th 505-465°C. (A.K.)

IVANOV, V.V., 1978, Physico-chemical conditions of ore precipitation in Late Paleogene ore mineralized points of the Lower Priamur'ye, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 190 (in Russian). Author at Far-East Geol. Inst. of Far-East

Sci. Center of Acad. Sci. of USSR, Vladivostok.

The subsurface ores occur in extrusive-effusive complexes in two types of tectonic structure: a) calderas and b) volcanic depressions of block structure. The minerals in the deposits are: quartz, chalcedony, opal, adularia, clay minerals, carbonates, zeolites, pyrite, marcasite, melnikovite (the author does not write what metal is of interest in the ores but the abstract is in the part of book concerning gold mineralization, A.K.). Th fall into two ranges: 140-355°C and 150-370°C. (Abstract by A.K.)

IVANTISHINA, O.M. and SHUMLYANSKY, V.A., 1980. Temperatures of bitumen formation in hydrothermal process: Dopovidi Akad. Nauk Ukr. Rsr, Ser. B. Geol., Khim., Biol., 1980. no. 6, p. 20-23 (in Ukrainian).

JACKSON, N.L., HALLIDAY, A.N., SHEPPARD, S.M. and MITCHELL, J.G., 1980, Isotopic and fluid-inclusion evidence bearing on the polyphase metallogenic evolution of the St. Just district, Cornwall (abst.): Papers presented at MAWAM Conference, Univ. Exeter, Dec. 1979, Inst. Mining and Metallurgy Trans., v. 89, Sect. B, p. B194.

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 m.y. ago.

(2) Metasomatic skarns developed at 274±8 m.y.; meteoric fluids entered system.

(3) Barren pegmatites, dominantly from meteoric fluids, formed in joints.

(4) Sheeted steep northwest-trending greisen-bordered cassiterite-bearing vein swarms developed in pluton roof at 270±5 m.y. from moderately saline meteoric fluids yielding Th = 400-450°C.

(5) Main-stage, polymetallic, northwest- or WNW-trending fracture-controlled vein and replacement mineralization from meteoric fluids about 270 m.y. ago that is comprised of (i) cassiterite without sulphides with Th = 310-380°C and moderately saline fluids; (ii) cassiterite with sulphides, Th = 280-320°C, and more variably saline fluids; and (iii) sulphide without cassiterite, with Th = 200-270°C and low saline fluids.

(6) Hydrothermal rejuvenation of event 5 fracture systems 215-225 m.y. ago, 160-170 m.y. ago and in Tertiary times, probably at progressively lower temperatures and from meteoric fluids; development of north-trending lead-zinc-iron-uranium-bearing veins.

(7) Deep kaolinization in pluton roof during weathering by low-temperature meteoric fluids. (Authors' abstract)

JAIRETH, S.K. and DRUZHININ, A.V., 1980, Copper deposits Madhan-Kudhan and Kolihan of the Khetri belt (India): Izvestiya AN SSSR, ser. geol., no. 11, p. 109-123 (in Russian). Authors at the Lumumba University of the Friendship of Nations, Moscow, USSR.

The 80-km-long Khetri belt occurs in the NW part of the Indian Shield, in Precambrian banded gneisses and miogeosynclinal meta sediments. The ores form a band almost 3 km long, divided into two zones. Quartz and calcite from ore bodies were studied by homogenization method, pyrrhotite, chalcopyrite and pyrite - by decrepitation. Early quartz bears either only G (5-30 vol.%) + L (95-70 vol.%) inclusions sometimes with two dms, Th 230-460°C in L, or these inclusions plus inclusions of "dry" gases and essentially G inclusions homogenizing in G phase at 560-580°C. Td of pyrite is 290-330°C, chalcopyrite 250°C, pyrrhotite 240°C. Calcite from carbonate stage yields Th 240-260°C in L phase. The deposit formed in three stages with the main T thresholds: I) 560 to 580 - 290 to 330°C; II) 200 to 400°C and III) 240 to 260 - 100to 120°C. (Abstract by A.K.)

JAMISON, A.A., 1979, Silicate immiscibility in Proterozoic basaltic lavas and feeder dykes near Carletonville Goldfield, South Africa (abst.): Geokongres 79, 18th Congress of the Geol. Soc. of S.A., Abstracts, Part 1

JASIŃSKI, Andrzej and WITEK, Barbara, 1980, Rare earth elements (TR) in vein quartz from Oleszna Podgorska: Bull. Acad. Polonaise des Sci., v. 28, no. 4, p. 257-262 (in English).

Preliminary results of spectral studies of vein quartz from Oleszna Podgorska and quartz from streaks and grains in leucogranite were used to determine the contents and composition of rare earth elements (TR) in these samples by conventional chemical analysis and the atomic absorption method. TR in a quartz vein were found to range in quantity from 0 to $1.25 \times 10^{-1}\%$ and in quartz from veins in leucogranite from 0 to $1.24 \times 10^{-1}\%$, whereas these elements consist of 55% Ce, 31% La, 4% Pr, 9% Nd. The decrepitation point of samples from veins and streaks was estimated approximately by the thermogravimetric method to be about 620 K. X-ray studies of those samples showed that we deal with a low-temperature silica modification and that TR do not form their own minerals. The conjecture of the hydrothermal origin of quartz from the mentioned vein formation filling tensionally open crevices at the contact between leucogranite and Kaczawa schists was thus supported. (Authors' abstract)

JENKINS, W.J., RONA, P.A. and EDMOND, J.M., 1980, Excess ^{3}He in the deep water over the Mid-Atlantic Ridge at 26°N: evidence of hydrothermal activity. Earth & Planet. Sci. Lett., v. 49, p. 39-44. First author at Woods Hole Ocean. Inst., Woods Hole, MA 02543.

We have observed distinct and significant patterns of excess ^{3}He in bottom waters over the Mid-Atlantic Ridge in the "TAG hydrothermal field." The lateral regional gradients are comparable in magnitude to gradients observed in the Galapagos rift, an area of confirmed hydrothermal activity. Together with this, the ^{3}He patterns, magnitudes and vertical gradients all indicate on-going and continuous hydrothermal activity. (Authors' abstract)

JIANG, Peimo, 1980, The calculation of equilibrium temperatures of the ore-bearing rocks of the Fe-P ore deposits in Fanshan, Hebei, and its geological significance: Acta Geol. Sinica, v. 54, p. 273-283 (in Chinese with English abstract). Author at Dept. Geol., Beijing Univ.

The equilibrium temperatures of diopside-clinoenstatite and diopside-magnetite in the different igneous rock zones of Fe-P deposits in Fan-Shan, Hopei have been calculated by thermodynamic methods. The calculated temperatures coincide with the decrepitative temperatures of apatite, which are determined by decrepitation of fluid inclusions. Although the calculated temperatures of the rock zones show a small divergence in a few cases, the results of these studies indicate, on the whole, that the equilibrium temperature of apatite rock is the lowest, while that of the overlying and underlying zones increase gradually. (Author's abstract)

JOHAN, Z., ed., 1980, Porphyry copper deposits and their magmatic environment, in Johan, Z., ed., Mineralization in Granitoids: Memorie du BRGM no. 99 (in French with English summary).

JOHAN, Z. and Le BEL, L., 1978, Origin of chromitite layers in rocks of ophiolitic suite: Internat. Min. Assoc. XI General Meeting, Novosibirsk, 1978, Abstracts, v. 1, p. 51-52.

Several hypothesis of origin for chromite layers and podiform chromite have been proposed: contamination of basic magma with melted acid roof rocks (Irvine, 1975), magmatic cumulation along the accreting plate boundaries (Dickey, 1975), and mixing of two mafic liquids of different compositions (Irvine, 1977).

The study of chromitite layers in dunites occurring near the bottom of the ophiolitic complex of Al Ays (Saudi Arabia), composed mainly of olivine and clinopyroxene cumulates and emplaced in the Precambrian of the Arabic shield, showed the following features:

Chemical composition of massive chromite is distinctly different from disseminated chrome-spinel in dunites and other rocks.

Chromite layers always contain inclusions of olivine (subhedral crystals), amphibole and occasionally of clinopyroxene, never observed in disseminated chromite.

Fluid inclusions have been found only in massive chromite; they are lacking in other minerals, including disseminated chromite.

It should be noted that olivines occurring as inclusions in chromite are extremely magnesium-rich (Fo: 94.0 - 97.7 mol %), and show high chromium (up to 0.6 wt % Cr_2O_3) and nickel (up to 1.0 wt % NiO) contents, but they are manganese-poor (0.0 - 0.2 wt % MnO). In contrast, olivines in dunites surrounding chromitite layers have Fo: 83.9 - 90.7 mol %, are enriched in MnO (0.3 - 1.6 wt %). The included amphibole is a chromium-rich pargasite (up to 3.4 wt % Cr_2O_3). Rare clinopyroxene inclusions have a composition of chrome diopside En 46.7 - 50.2; Fs 2.1-2.3; Wo 51.2 - 47.6, with 1.0 - 1.2 wt % Cr_2O_3. Equilibrium temperatures calculated for coexisting olivine-massive chromite range from 970° to 1050°C; the projection of the clinopyroxene composition on the pyroxene solvus gave 900° - 1000°C. These temperatures are significantly lower than those obtained for olivine-chromite pair in dunites; 1250 - 1350°C. Most fluid inclusions fill negative crystal cavities. The fluid is an aqueous solution with 5 equiv. wt % NaCl, containing minor CO_2, CH_4 and heavier hydrocarbons, and having a density of 0.68 g/cm^3. Th ranges from 337.5° to 357.5°C. Taking into account the equilibrium temperatures for the mineral assemblage in the chromitite layers and the isochore of the fluids, one obtains a pressure of 6-7 kbars. It is concluded that the origin of the chromitite layers could be explained by incongruent melting of highly chromium-rich pargasite, following the reaction: Pa $\rightarrow$ Chr + Ol + Liq + Fl. (Authors' abstract)

JOHAN, Z. and LE BEL, L., 1980, Genesis of chromite beds and pods in ophiolitic complexes: Int. Geol. Congr., 26th, Abstracts, v. 3, p. 950 (in French).

Chemical analyses for CO_2, CH_4, C_2H_4, and C_2H_6 and $\delta^{13}C$, plus some data on Na, K, Ca, Cl, and S, in inclusions in chromite. (E.R.)

JOHANSSON, A., 1980, Fluid inclusion thermometry on calcite, sphalerite and fluorite from the Akerlandet vein, Västerbotten county: Annual Report of the Ore Research Group, Stockholm Univ., David Rickard (ed.), p. 188-200.

Thermometric measurements have been made on fluid inclusions in calcite, sphalerite, and fluorite from the Akerlandet calcite-sphalerite-fluorite vein in the Precambrian of Västerbotten. Most freezing temperatures fall within two distinct groups, one between -10 and -15°C, and one around -40°C, while the homogenization temperatures range between +74 and +166°C. For the T_H-values greater than about +120°C, the two T_F-groups appear to be distinctly separate, whereas for lower T_H-values T_F shows a continuum between -10 and -45°C, probably due to mixing of the two original fluids. It is suggested that the inclusions measured are of primary and pseudo-secondary type, and that both T_F-maxima represent fluids active in the formation of the Akerlandet deposit. (Author's abstract)

KADIK, A.A. and FRENKEL', M.Ya., 1980a, Thermodynamics of decompression of water-bearing magmatic melt (the system albite-water) and role of pressure decrease in the mechanism of magma formation: Geokhimiya, no. 3, p. 307-334 (in Russian, English abstract). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Pertinent to melt inclusion studies. (A.K.)

KADIK, A.A. and FRENKEL', M.Ya., 1980b, Magma formation connected with decompression of the crust and mantle rocks at the presence of volatile components: Geokhimiya, no. 4, p. 467-495 (in Russian, English abstract). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Pertinent to melt inclusion studies. (A.K.)

KALININ, A.S. and REVERDATTO, V.V., 1980, Model of evolution of fluid during crystallization of an intrusive magma: Dokl. Akad. Nauk SSSR, v. 250, no. 4, p. 956-959 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 250, 1980, p. 203-205 (1982).

KALININ, A.S., SOTNIKOV, V.S. and BERZINA, A.P., 1980, A hydrodynamic and thermal model of a magmatogenic hydrothermal system in molybdenum deposits (computer simulation): Dokl. Akad. Nauk SSSR, v. 252, no. 5, p. 1230-1234 (in Russian; translated in Doklady Acad. Sci. USSR,. Earth Sci. Sect., v. 252, 1980, p. 176-178 (1982).

KALITA, Ye.D., MEL'NIKOV, F.P., KANDINOV, M.N., KHRAPOV, A.A. and KORYTOV, F.Ya., 1978, Conditions of formation of fluorite deposits of the Eastern Transbaikalia and Mongolia, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 165-167 (in Russian). Authors at Sci.-Research Lab. "Zarubezhgeologiya," Moscow, USSR.

In the E. Transbaikalian-Mongolian fluorite province four types of fluorite deposits occur: magmatic, pegmatite, greisen and hydrothermal; the second and fourth type are important sources of optical fluorite. Hydrothermal deposits consist of quartz-fluorite veins up to 1500 m long with maximum thickness 7-9 m or rarely 60 m. Hydrothermal fluorite had

Td max. 300-380°C, beginning of decrepitation was 250-260°C; Th = 120-240, rarely 265-320°C. (From the authors' abstract translated by A.K.)

KALYUZHNYI, V.A., 1979. Dynamics of mineral genesis on the basis of studies of mineral-forming fluids (granite "zanorysh" pegmatites and ore-bearing hydrothermal bodies of Ukraine), 48 pp., 150 copies printed, free copies, publ. by Inst. Geochem. and Physics of Minerals, Kiev (in Russian). Author at Inst. Geol. and Geochem. of Mineral Fuels of Ukrainian Acad. Sci., L'vov, Naukova street 3A, Ukraine.

The booklet is the author's summary of his doctoral dissertation consisting of 303 p. of the text, 45 plates, 160 drawings and 417 references, available in the library of Inst. of Geochem. and Physics of Minerals of Acad. Sci. of Ukr. SSR, 252068 Kiev-68, Palladina st., 34, Ukraine. The summary contains general characteristics of the dissertation and a review of its text. The first part - theoretical and practical basis of the studies of mineral-forming fluids - discusses problems of relation between the host crystal and inclusion, including classification and refilling of inclusions, and methods of reconstruction of parameters of mineral genesis (fluid composition, T and P). The second part characterizes inclusions of fluids and dynamics of mineral genesis of post-magmatic deposits like the Volhynian pegmatites and hydrothermal bodies from certain parts of Ukraine: Donbass, Transcarpathians and Volhynian-Podolian area. The results presented include determinations of Th, phase relations, pH, ion composition of individual inclusions and gas composition in inclusions. The essential conclusions are as follows: 1) inclusions are valid source of information about the parameters of mineral origin, 2) obtaining of this information and its correct interpretation depends on the knowledge of general properties of inclusion formation and the system crystal-inclusion, features of the inclusion and proper use of basic knowledge (physics, etc.) for inclusion studies, 3) redistribution of volatiles in the magmatic chamber is the first reason of zoning and formation of various bodies in granites, and pegmatites; this redistribution is characterized in the summary, 4) regular sequence of changes of acid-alkaline properties of solutions plus general T decrease are the main factors of crystallization and recrystallization of mineral parageneses, 5) the studied hydrothermal bodies are typical products of crysjallization from CO_2-H_2O, CH_4-H_2O and hydrocarbon-oil-H_2O fluids, with frequent heterogenization, boiling and P changes. A total of 83 previously published papers (i.e., before 1979) is pertinent to various aspects of the dissertation. (Abstract by A.K.)

KAMILLI, R.J., OHMOTO, Hiroshi, PETERSEN, Ulrich and DIAZ, Noel, 1979, Geochemistry of the Finlandia vein and the origin of bonanza-type silver and gold deposits: Annals of the Fourth Peruvian Geologial Congress, Valdivia Ampuero, H., et al., eds., Soc. Geol. Peru Bol., v. 60, p. 73-105 (in Spanish; abstract translation courtesy D.E. Teggin).

The Finlandia vein cuts Tertiary volcanic rocks, principally of andesitic composition. The vein produces Pb, Zn, Ag and Au and is extraordinary in that the silver and gold mineralization is earlier and of a higher temperature than the lead and zinc mineralization. The hypogene mineralization can be divided into seven stages: (1) quartz, (2) quartz + muscovite + tetrahedrite + silver sulphosalts + electrum + sphalerite + galena + pyrite + siderite, (3) quartz, (4) sphalerite + galena, (5) quartz, (6) sphalerite + galena, (7) yellow-green sphalerite + galena + barite. Muscovite from stage (2) gives a K-Ar age 10.3 ± 0.5 m.y., which corresponds to the late Tertiary volcanism of the Central Andes.

The homogenization temperatures of the fluid inclusions are 270°C ±20°C for stages 1, 2 and 3, 260°C ±20°C for the 4th, 240°C ±20°C for the 5th, 180°C ±20°C for the 6th and 200°C to 140°C for the 7th.

The distribution and nature of the stage 2 mineralization is strongly controlled by its elevation. The bonanzas of stage 2 are limited to a vertical interval of 130 meters in the vein, where the minerals are very fine and contain at least 13 phases. (From the authors' abstract)

KANISAWA, Satoshi and AOKI, Ken-ichiro, 1980, Behavior of fluorine in rocks and its petrological application: J. Japan. Assoc. Min. Petrol., Econ. Geol., Special Vol. 2, p. 325-333 (in Japanese with English abstract).

KAPUSTIN, Yu.L., 1980, Graphite find in typical carbonatite: Dokl. Akad. Nauk SSSR, v. 252, no. 4, p. 956-959 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 120-122 (1982). Author at Moscow Geol. Prospecting Instit., USSR.

Graphite was found to be an early crystallizing mineral in the Novopoltavskiy carbonatite pluton in the Ukraine. (E.R.)

KARAYEVA, Z.G., VORONINA, L.B., GAYDUKOVA, V.S., and KHARLAMOV, Ye.S., 1978, Near-surface greisen deposits of tin: Sovetskaya Geologiya, 1978, no. 3, p. 81-92 (in Russian; translated in Internat. Geol. Rev., v. 21, no. 9, p. 1033-1042, 1979). Authors at All-Union Inst. Min. Raw-Materials (VIMS).

Dm halite found; Th 645-185°C, in part with critical behavior. Salinities up to 40%. (E.R.)

KARSKIY, B.Ye., FORTUNATOV, S.P. and ZORIN, B.I., 1980, Temperature zoning of the mica-bearing pegmatitic veins of the Karelia-Kola and Mama-Chuy regions: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 4, p. 57-61 (in Russian). Authors at Moscow Geol.-Prosp. Inst., Moscow, USSR.

Quartz, tourmaline and other minerals from mica pegmatites were studied by decrepitation. The authors found that various types of pegmatites have typical decrepitation curves, especially typical intensities of peaks at various T and they attributed Td intervals to various stages of pegmatite formation. (Abstract by A.K.)

KARSTEN, J.L. and DELANEY, J.R., 1980, Ion microprobe study of water diffusion in rhyolite glass (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 66.

KARWOWSKI, L. and WLODYKA, R., 1980, Thermobarogeochemical methods of study and their use, p. 3-5 in: The first field school of the workers of the Geoscience Faculty, Silesian University, Abstracts of the lectures, Sosnowiec (in Polish). Authors at the Geoscience Faculty, Siberian Univ., Sosnowiec, Mielckarskiego Str., Poland.

The paper presents the basic methods of inclusion studies: homogenization, decrepitation, pressure determinations, cryometry, and interpretation of the obtained data. (A.K.)

KASSANDROV, E.G., 1980, Orbicular and laminar felsites in Devonian iron-ore-bearing beds of the Western Altai : Theoretical and genetic mineralogy (Transactions of the W. Siberian Division of the All-Union Mineralogical Society), v. 8, p. 53-59, "Nauka" Pub. House, Novosibirsk (in Russian).

In the junction of Variscan Rudnyi Altai and Caledonian Gornyi Altai (marginal deep-seated fault) acid volcanites occur commonly with fluidal-laminar and orbicular textures. Thickness of flows range from 10 to 15 m, thickness of complex 70-90 m. Orbicular forms are from few mm to 5-6 cm in dia., laminae have thickness from <1 mm to 5-6 mm. Orbicules consist of quartz and K-spar with boundary rims of hematite, magnetite and titanomagnetite, matrix - of 60-65% of K-spar, 15-20% of quartz, up to 15% of albite and ore minerals up to 5%. Rocks have composition of alkali-rich liparites, komendites, pantellerites and trachites. Author supposes that the melt split into three immiscible melts: SiO_2-rich, SiO_2-K-rich and SiO_2-K-Fe-rich ones, under action of volatiles (F, P and B), i.e., textures of rocks formed due to acid melt immiscibility. (Abstract by A.K.)

KATOVA, L.M. and KHETAGUROV, G.V., 1980, Peculiarities of phase composition of pyrrhotite and regularities of its distribution in ores in the deposit Kizil-Dere (Mountainous Dagestan): Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 6, p. 60-65 (in Russian). Authors at the North-Caucasian Mining-Metallurgic Inst., USSR.

Ferromagnetic pyrrhotite from Cu-pyrrhotite ores yielded the most intensive decrepitation at 90-100°C, the authors suppose that one-phase water inclusions in this pyrrhotite decrepitate at T close to water boiling point. (sic). (A.K.)

KENDALL, A.C. and BROUGHTON, P.L., 1978, Origin of fabrics in speleothems composed of columnar calcite crystals: J. Sed. Petrol., v. 48, p. 519-538. First author at Sask. Geol. Survey, 201 Dewdney Avenue East, Regina, Saskatchewan, Canada, S4N 4G3.

Most calcite in speleothems is composed of columnar crystals (palisade calcite) and exhibits fabrics similar to those in some porefilling calcites interpreted to be replacive after acicular carbonate cements. The columnar crystals do not interfere with each other's growth (suggesting that they are secondary features) and this, together with the occurrence of layers of acicular calcite in some speleothems, leads to a conclusion that columnar crystals have replaced acicular carbonate. The evidence, however, is misleading. The same crystal fabrics can be explained by normal, but somewhat complex, growth processes.

Inclusions (and patterns made by them) constitute the most important clues to the origin of the columnar crystals. Most inclusions are fluid-filled cavities and six types of growth layering are distinguished on the basis of variations in inclusion abundance, size and pattern. Growth layers defined by parallel, linear inclusions are interpreted to have formed during the incomplete lateral coalescence of numerous syntaxial overgrowth crystallites which grow upon the speleothem surface. The linear inclusions represent remnants of the former inter-crystallite spaces. Complete crystallite coalescence generates inclusion-free calcite, whereas inhibition of the lateral coalescence of the overgrowth crystallites generates layers of acicular calcite. During episodes of cave-flooding, however, the crystallites merge and overgrow each other and precipitation eventually occurs upon large, planar crystal faces.

It is believed that the distinctive fabrics of palisade calcite are formed because precipitation usually occurs from thin water films that flow over the growing speleothem surfaces. Large crystal terminations do not form on the speleothem surface because they form projections that disturb the water flow away from the projections which, as a consequence, are gradually eliminated. Small crystal terminations (crystallites), on the other hand, do not disturb the water-flow and thus come to dominate the growth surfaces.

Petrographic distinction of columnar calcite crystals in speleothems (and other vadose calcites with similar fabrics) and mosaics of columnar crystals that have replaced earlier, acicular-carbonate cements is commonly difficult. Such distinctions are attempts to distinguish between calcite crystals that have grown penecontemporaneously from numerous syntaxial overgrowths (calcites in speleothems) and other calcites in which replacement occurs at a much later date, possibly accompanied by replacement of a metastable phase (replacement of acicular cements). (Authors' abstract)

KENDRICK, G.C. and EDMOND, C.L., 1980, Large-scale magma immiscibility in the Shonkin Sag and Square Butte laccoliths (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 276.

KERRICH, Robert, ALLISON, Iain, BARNETT, R.L., MOSS, Stephen and STARKEY, John, 1980, Microstructural and chemical transformations accompanying deformation of granite in a shear zone at Miéville, Switzerland; with implications for stress corrosion cracking and superplastic flow: Contrib. Mineral. Petrol., v. 73, p. 221-242. First author at Dept. Geol., The Univ. Western Ontario, London, Ontario, Canada N6A 5B7.

Granitic rocks of the basement are deformed into mylonites within a major subvertical shear zone. The ambient temperature during translation is estimated at 250°C±30°C from fluid inclusion filling temperatures in syntectonic microveins, from $\Delta^{18}O$ quartz-ilmenite of +15‰, and from mineralogical criteria.

Two-way mass balance calculations utilizing major and selected trace element data, reveal that deformation of the granite was essentially isochemical, involving average additions of <1% H_2O+CO_2, at approximately constant specific gravity. (From the authors' 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 $K/Na \approx 1$. 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, R., GORMAN, B.E. and FYFE, W.S., 1980, Geochemistry and field relations of lode gold deposits in felsic igneous intrusions: Ontario Geol. Surv. Misc. Paper 93, p. 136-143. Authors at Dept. Geol., Univ. Western Ontario.

Numerous lode gold deposits are associated with felsic igneous intrusions (porphyries) in greenstone belts. This study investigates the geochemistry, field relations, and structural control of gold deposits in felsic stocks from the Timmins and Kirkland Lake areas, in order to propose guidelines for exploration strategies.

It is concluded that the mineralized felsic porphyry as a whole exhibits anomalous enrichments of Na_2O, volatiles, and $\delta^{18}O$ compared to the barren porphyry. These patterns reflect pervasive albitization and hydration, coupled with oxidation and deposition of carbonate + sulphate, which are characteristic of large-scale spilitization by thermally driven seawater convection in proximity to the hydrosphere at temperatures between <200°C-350°C.

Gold-bearing quartz veins were precipitated from hot (420°C-480°C) acidic, reducing fluids of metamorphic origin, whose access was controlled primarily by hydraulic fracturing.

The initial results demonstrate that it is possible to formulate field and geochemical parameters to discriminate between those felsic intrusions which are favorable hosts for gold mineralization, and those which are not. The methods are suitable for rapid, large-scale areal surveys. It is emphasized that although large volumes of favorable intrusions are characterized by a low degree of gold enrichment that is subeconomic, each one examined did contain ore-grade lodes. Thus, the large-scale geochemical anomalies of these intrusions provide a much larger exploration target than the presence of the lodes alone, by a factor of ca. 100. (Authors abstract)

KHAIBULLIN, I.Kh., NOVIKOV, B.Ye., COPELIOVICH, A.M. and BESEDIN, A.M., 1980, Phase diagrams for steam solutions and caloric properties of two- and three-component systems: H_2O-NaCl, H_2O-Na_2SO_4 and H_2O-NaCl-Na_2SO_4. In J. Straub and K. Scheffler, eds., Water and steam: Oxford, Pergamon Press, p. 641-647. Authors at The Krzhizhanovsky Power Eng. Inst., Moscow, USSR.

The data presented for NaCl-H_2O indicate lower pressures and lower temperatures than Sourirajan and Kennedy (1962) reported for the same compositions. (E.R.)

KHAKIMOV, A.K. and PATSKEVICH, G.P., 1980, Formation characteristics of the Kedon amethyst deposit: Gems and Precious Stones, V.P. Petrov, ed., Izd. Nauka, Moscow, p. 247-253 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

KHAR'KIV, A.D., AFANAS'YEV, V.P., KVASNITSA, V.N., SHTURMAN, V.L., KULAKOVA, I.I., RUDENKO, A.P., SMIRNOV, G.I. and SOKOLOV, V.N., 1980, Catalytic oxidation of diamond by contact with high-temperature kimberlite melt: Dokl. Akad. Nauk SSSR, v. 250, no. 4, p. 949-952 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 250, 1980, p. 179-182 (1982).

KHARLAMOV, Ye.S., 1978, Inclusions of melt in minerals from iron ores and carbonatites of the Kovdor pluton: Dokl. Akad. Nauk SSSR, v. 239, no. 1, p. 169-172 (in Russian; translated in Dokl. Acad. Sci. USSR Earth Sci. Sect., v. 239, p. 25-28, 1980).

Abstracted in Fluid Inclusion Research--Proc. of COFFI, v. 11, p. 101, 1978. (E.R.)

KHARLAMOV, Ye.S., KUDRYAVTSEVA, G.P., GARANIN, V.K., KORENNOVA, N.G., MOSKALYUK, A.A., SANDOMIRSKAYA, S.M. and SHUGUROVA, N.A., 1980, Origin of carbonatites of the deposit Kovdor: Geol. Rudn. Mest., v. 22, no. 4, p. 3-20 (in Russian). First author at Inst. Mineral and Geochem. of Rare Elements of Geol. Ministry, Moscow, USSR.

The Kovdor massif occurs in Karelia-Kola carbonatite province, in the NE wing of the En-Loukh synclinorium among intensively fenitized gneisses of the Belomorie Archean series. Formation of massif was in several stages: hyperbasite, alkaline, carbonatite, postcarbonatite and exogene. Massif consists of olivinites, pyroxenites, jacupirangites, ijolite-melteigites, turjaites and alkaline metasomatites, plus a complex of various dykes. Apatite-magnetite deposit Kovdor formed in carbonatite stage and it occurs in the SE part of the massif in the junction of jacupirangites, ijolites and olivinites. The deposit consists of closely linked lenses of apatite, magnetite and carbonatite. Rocks of pre-ore substage consist of nepheline, pyroxene, calcite, apatite, etc. Contact zones of calcite-bearing rocks with ijolites sometimes are rich in wollastonite. Minerals of these rocks contain inclusions with 5-70 vol. % of silicate dms, 5-85 vol. % of carbonate dms plus 0-15 vol. % of trapped magnetite, 0-10 vol. % of LCO_2, 0-85 vol. % G and 0-15% of LH_2O (see Figure 3). Th in melt 690-930°C (41 measurements). Early ore substage resulted in rocks consisting of forsterite-magnetite, apatite-forsterite, calcite-forsterite-phlogopite-magnetite, etc. Melt inclusions in forsterite, apatite, calcite, diopside and phlogopite consist of (vol. %):

silicate dms 10-65, carbonate dms 20-80, trapped magnetite 0-20, LCO_2 0-15, G 0-60, LH_2O 0-15, Th 670-900°C (185 measurements); at 790 and 890°C immiscibility in inclusions was observed. Late ore stage (humite-apatite-calcite-magnetite-forsterite, tetraferriphlogoprite-forsterite-calcite and amphibole-tetraferriphlogopite-calcite rocks) minerals bear inclusions with silicate dms 10-30, carbonate dms 55-70, G 0-10, LH_2O 0-10, Th 660-880°C (39 measurements). Two post-ore substages resulted in dolomite-forsterite-magnetite or dolomite rocks, where in dolomite, calcite and zircon melt inclusions consisted of 75-100% dms, 0-15 G, 0-10 LH_2O, Th 640-755°C (53 measurements) with occasional immiscibility at 720°C. By analysis of G in individual inclusions, N_2, rare gases, H_2S+sulfur oxides, HCl, HF and CO_2 (usually prevailing) were found. By electron microprobe and laser emission analysis of dms following elements were determined: Si, Al, Mg, Ca, Fe, P, Na, K, Ti. By laser microspectrographical emission analysis Ti, V, Cr, Mn, Ni and CO in magnetite from the inclusions and the ore were determined. This proved the complete identity of the two varieties of magnetite. Water leachates from apatite (inclusions with Th 500-50°C) yielded solution composition (in mg-equiv.) at 500-250°C: Na 0.097-0.079, Mg 0.060-0.048, K 0.011, HCO_3 0.060, Cl 0.050, SO_4 0.025, and at T <250°C: Mg 0.036-0.048, Na 0.019, K 0.009, HCO_3 0.150-0.060, F 0.001. By cryometry of inclusions in apatite, nepheline, calcite, diopside, dolomite and gypsum with Th 50-520°C, the following prevailing salts were found: $NaCl \cdot 2H_2O$, Na_2CO_3, $MgCl_2$, NaCl, and total salt concentrations ranged from 1 to 50 wt%; P at Th ranged from 250 to 1600 kg/cm^2 (determined by the Lemmlein-Klevtsov method). Also presence of hydrocarbons in inclusions was found. (Abstract by A.K.)

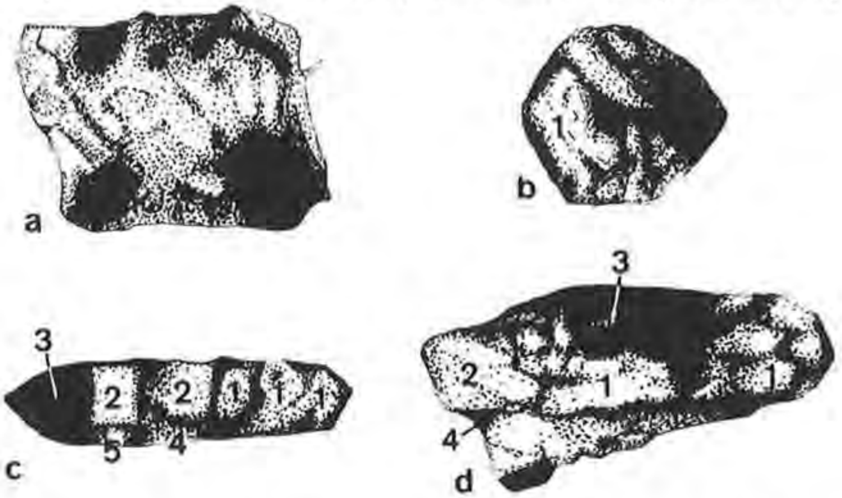

Figure 3 of original paper. Primary melt inclusions in minerals of iron-ore-carbonatite deposit Kovdor: a - in forsterite from calcite-forsterite-phlogopite-magnetite ores from ore substage, filled mostly by calcite and magnetite, Th 890°C, X 800; b - in forsterite from forsterite-calcite carbonatites from ore substage, Th 880°C, X 1000; c - in apatite from amphibole-tetraferriphlogopite-calcite carbonatite of late ore substage, Th 780°C, X 420, d - in dolomite from dolomite carbonatites of post-ore substage, Th >635°C, X 120; drawings by A.K. from the authors' photos. 1 - carbonates, 2 - soluble salts, 3 - gas, 4 - LH_2O, 5 - LCO_2.

KHEISKANEN, K.I., 1980, On the thermobarometry of igneous complexes: Dokl. Akad. Nauk SSSR, v. 254, no. 5, p. 1213-1216 (in Russian).

KHETCHIKOV, L.N., 1980, Temperatures of homogenization of minerals synthetized from melts: p. 40-50 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The author gives short characteristics of the homogenization method and its validity, and reviews the types of magmatic inclusions. Sometimes one crystal bears melt inclusions differing in Th and sometimes in composition of silicate and ore components, e.g., inclusions in feldspar from Tolbachik volcano: silicate Si, Ca, Al, K, Na + Fe ore, Th 1200-1250°C, and silicate Si, Fe, Mg + Fe, Ti ore, Th 1320-1340°C; feldspar and olivine from xenoliths in deep-formed rocks: silicate Fe, Si, Ti, Ca + Fe ore, Th 1405-1410°C - silicate Si, Fe, Mg + Fe, Ti ore, Th 1320-1340°C (composition by electron microprobe). In experiments intending to elucidate origin of such inclusions, runs were made using melt-solutions (synthetic Ca and Mg tungstates) and melts (minerals of type of eulytine $Bi_4(GeO_4)_3$, sillerite Bi_2GeO_{20}*, yttrium-aluminum garnet $(Y, Er)_3Al_5O_{12}$ and crystals $K_3Nd(MoO_4)_4$ without mineralizers, of stoichiometric composition. Ca and Mg tungstates bear melt inclusions of the parent melt composition and Th very close to T of crystallization (e.g., 605-610 vs 600-610°C, 450 vs 450-460°C, 690 vs 690-700°C, respectively). Garnet and sillenite bear melt inclusions of the host mineral composition, eulytine - of composition of the host mineral and the ones rich in Bi_2O_3 (92.67% vs 74.61% in mineral) and poor in GeO_2 (7.59% vs 26.45% in mineral); Th in both inclusion types very similar to T of crystallization. In the $K_3Nd(MoO_4)_4$ inclusion composition always differs from the mineral composition: Mo content is almost the same but inclusions bears more K (30-33%) than mineral (22-23%) and Nd much less (3-5%). Author supposes that the differences are caused by "change of parent melt in time." Synthetic fluorophlogopite grown from melt of stoichiometric composition plus excess of K_2SiF_6, $MgFe_2$ (probably a misprint for MgF_2, A.K.) etc. The possible immiscibility during the melt cooling may occur, as well as the mineral sequence of crystallization was stated: forsterite I → spinel → forsterite II + phlogoprite. Forsterite I, II and spinel bear only melt + G inclusions with composition of the parent melt and Th ≈ maximum T of melt. Fluorophlogopite bears 2-phase G + glass inclusions and polyphase ones, bearing glass of varying composition (refractive indices from 1.510 to 1.526±0.003), globules also of a glassy, white isotropic substance with refractive index 1.360-1.371, chemically determined after separation as $NaMgF_3$, and fine-crystalline phlogopite clusters; Th is also variable. Late polyphase inclusions are supposed to be of immiscibility origin. Similar results were obtained during synthesis of spinel $ZnAl_2O_4$ and garnet $Y_3(Al_2Ga)_5O_{12}$. The author concludes that Th of melt inclusions are not always close to T of crystallization of host minerals; good agreement should be anticipated when minerals formed from melt of simple composition. In complicated systems Th may differ from T_{cr} and composition of inclusions may vary widely. (Abstract by A.K.)

*Fleischer (1980) lists only eulytite, as $Bi_4(SiO_4)_3$ and sillenite, as Bi_2O_3. Ed.

KHETCHIKOV, L.N., BARKHUDARYAN, N.B., ANDREYEVA, M.G., BOCHEK, L.I., VALYASHKO, L.M., MEL'NIKOV, F.P., RUSINOV, V.L. and SHISHAKOVA, L.N., 1980, The contents of water and carbon dioxide in quartz near the surface of gold ore deposits in the eastern USSR: In: A study of minerals with research on zoning and genesis of non-ferrous and precious metal deposits,

L.N. Khetchikov and P.S. Bernshteyn, eds., Trudy - Tsentral'nyy Nauchno-Issledovatel'skiy Geologorazvedochnyy Institut Tsvetnyk I Blagorodnykh Metallov ("TSNIGRI"), no. 150, p. 28-32.
Indexed under Fluid Inclusions. (E.R.)

KHITAROV, D.N., SHMARIOVICH, Ye.M. and REUTIN, Yu.V., 1980, Physico-chemical peculiarities of solutions that formed hydrothermal deposits of uranium: Sov. Geologiya, no. 5, p. 90-100 (in Russian). Authors at Mingeo USSR, Moscow.

Samples from various uranium deposits were analyzed by fluid inclusion methods: homogenization (16 samples), triple water leachate (70 determinations) gas chromatography (28 determinations), decrepitation (26 samples). Deposits of sulfide-U, fluorite-U, Mo-U and titanate-U formations yielded T 170-250°C, average T of pitchblende formation - ~200°C, uranylvanadate formation in limestones - Th 170°C, U-bitumen in sandstones - Th 180°C. Carbonates are important components of uranium ore-forming deposits: total CO_2 in solutions of post-ore stages of U-Mo deposits averaged 1.7 mole/l (ranges 0.29-3.06), sample of pitchblende ore stage 0.7 mole/l; $CO_3 + HCO_3$ are the main anions in solutions in 22 U deposits of the 29 studied ones, as well as in solutions concerning the pre-ore Na metasomatism. Chlorine concentration varies from analytically indeterminable to 3 mole/l (av. 0.8), sometimes (rarely) CL $>\Sigma CO_2$ (or $CO_3 + HCO_3$). Leachates from 80% of samples bear F with maximum concentrations in post-ore stage 0.3-0.4 mole/l (av. 0.09). Na is present in concentrations in ore and post-ore stage from 0.0n to 3.5 mole/l (av. 0.67); K<Na, usually from indeterminable concentrations to 0.48 mole/l (av. 0.17). Ca usually >Mg so that Ca/Mg ranges from 2 to 10; variations of both elements are significant. Sulfur was found in 77% of the studied samples, usually in 0.0n to 0.n mole/l, up to 0.69 mole/l in ore stage. Modal value of $\Sigma S/\Sigma CO_2$ is in range 0.07-0.7. Concentration of NH_4 in leachates was in range 0.24 to 0.90 mole per mole of $H_2CO_3 + HCO_3$ (av. 0.46). About 50% of samples bear determinable amounts of CH_4, always with molar concentration of $CH_4 < CO_2$. Total salt concentrations (calculated) were from tens to few hundreds g/l, approximate value of ionic strength of those solutions was 0.3-4.0, av. ~1.0. The calculated pH values of ore-forming solutions are presented in Fig. 2.

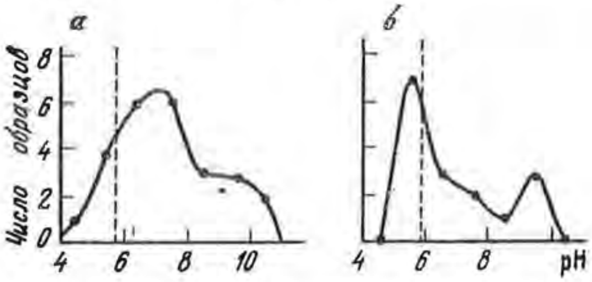

Fig. 2. Variation curves of the calculated values of pH of hydrothermal solutions of U-ore deposits trapped in minerals of ore (a) and post-ore (b) stages; dashed lines-neutral points of water at 200°C (a) and 150°C (b), vertical axis - number of samples.

Analyses proved that various stages of process of formation of U-ore deposits did not vary in ion composition but did vary in pH and T. However, other metal deposits formed from solutions distinctly different than U deposits (Fig. 4). (Abstract by A.K.) Continued next page.

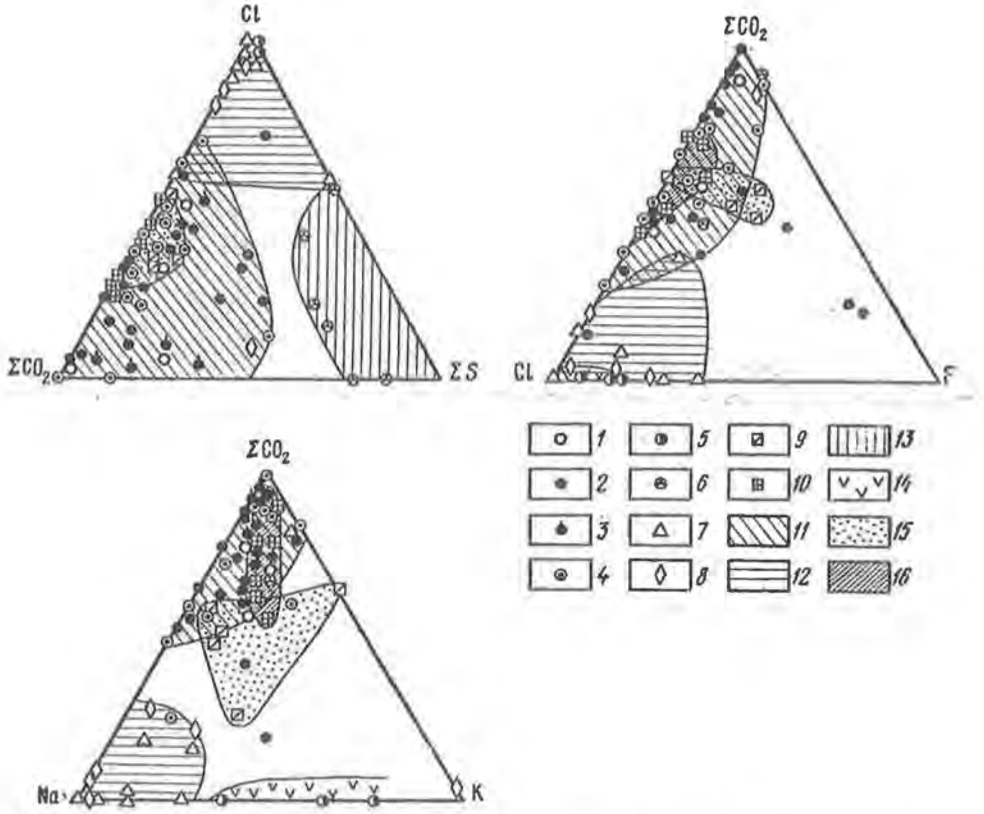

Fig. 4. Plots of molar concentrations of total CO_2, total S, Cl, F, Na and K in inclusion solutions in minerals; hydrothermal U deposits: 1-pre-ore stage, 2-ore (pitchblende) stage, 3-same, literature data, 4-post-ore stage; other deposits: 5-Au, 6-Pb-Zn, 7-fluorite, 8-young calcite veins of Tyan'-Shan', 9-high-T quartz-feldspar veins, 10-granites, aplites, pegmatites; geochemical fields of solutions in inclusions: 11-hydrothermal deposits of U, 12-fluorite deposits, 13-Pb-Zn deposits, 14-Au deposits, 15-high-T quartz-feldspar veins, 16-granites, aplites, pegmatites.

KHITAROV, D.N. and SUSHCHEVSKAYA, T.M., 1980, Analysis of composition of the liquid phase of inclusions in minerals of hydrothermal genesis: p. 80-109 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The authors discuss the possibility of studies of a geological object via fluid inclusion composition studies and they conclude that such studies are valid if the final aim is distinctly defined, minerals suitable for such studies are present, and microscopic studies confirm the features of minerals and inclusions appropriate for inclusion fluid studies. Two methods of inclusion opening are presented: decrepitation (usually results in too low values), and grinding, which is accepted as the better procedure, but with greater possibility of the host mineral dissolving in the leaching water and sorption of inclusion salts on mineral powder. First source of errors may be minimized by triple leaching of each sample: the first one contains essentially the ions from the inclusions and from dissolving host mineral, the second one is a wash, containing ions adsorbed on the mineral powder, the remaining first leachate wetting the mineral powder, and ions from dissolving host mineral, and the third one, a control leachate, containing ions from dissolving host mineral. For final calculation one should take the first results minus the third results (the second leachate is only for washing the mineral powder). Sorption depends on many factors like T and concentration of solution, ion charge and ion size, etc. Sorption was studied on the washed mineral powders and on the inclusion-free synthetic and natural optical-grade crystals. The powders were placed in three standard solutions under the same conditions and time as during leachate preparation. For washed natural quartz powder the sorption is 10-30% Na, 8-30% K, 0-8% Ca, 0-7% Cl; for synthetic quartz powder - Na and K 0%, Ca 2-20%; for natural washed calcite - Na 16-37%, K 2-28%, Ca 2-28%, Mg 0-42%, Cl 2-5%; for natural optic-grade non-washed calcite - Na 0-33%, K 0-57%, Ca 0%, Mg 84-92%, Cl 0%; for washed natural fluorite - Na 12-21%, K 0-8%, Ca 0-5%, Mg 24-100%, Cl 0-7%; for non-washed artificially grown fluorite - Na 0-12%, K 0-20%, Ca 0%, Mg 44-100%, Cl 0%. The recommended analytical methods are as follows: Na, K, Ca, Mg - atomic absorption, Cl and F - ion-selective electrodes, HCO_3 and SO_4 - titration, S^2 - sulfide-silver electrode, B-colorimetric method with acetate-chinalizarine, NH_3 - colorimetric with Nessler reagent, Cu and Pb by polarography, Au and Ag - inversion voltamperometry. The authors discuss also the ionic species for the elements in hydrothermal solutions and method of calculation of pH and Eh of mineral-forming solutions from water leachate analytical results. (Abstract by A.K.)

KHOLMOGOROV, A.I., STEPANOV, Ye.R. and YAKOVLEV, Ya.V., 1980, Discontinuity and temperature of formation of a deposit of tin-bearing greisens (zwitters) in the North-East Yakutia, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 103-104 (in Russian).

The deposit of tin-ore greisens (zwitters) is genetically connected with a stock of Li-F granite porphyries. Post-magmatic mineral formation consists of three stages: pre-ore greisenization (topaz-siderophyllite-quartz), ore stage (cassiterite-fluorite-quartz) and post-ore stage (hematite-goethite). Mineral formation developed in a background of general decrease in T (from 550 to 115°C) and total salinity of post-magmatic solutions. Mineral parageneses of pre-ore stage crystallized at 540-205°C, ore stage 550-115°C and post-ore stage 240-130°C. Cassiterite precipitation occurred at T 400-225°C with maximum at 304-240°C. (Authors' abstract translated by A.K.; note - this paper was not abstracted in the Abstract volume of the Vladivostok Meeting, 1978.)

KHOTEEV, A.D., 1980, Contribution to the problems of standarization of conditions of the decrepitation analysis: p. 31-40 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The paper characterizes briefly the two currently most widely applied varieties of decrepitation method: acoustic and baric, and next discusses specific problems of the thermoacoustic method. The interlaboratory studies of decrepitation of sample "Quartz-74" proved that even for the commercially produced devices "D-1" the total impulse number differs seriously for runs made in various laboratories and even more for non-standard devices, i.e., by a factor of over 3000 (from 16,300 to 296 for "D-1" and from 1492 to 5 for the others in the T interval up to 600°C, using the same sample weight). Next the author discusses the possible reasons resulting in differences in decrepitograms: grain class of sample, weight of sample, T increase rate, sensitivity of the measuring set, as well as details of construction of the electronic block of the decrepitometer. (Abstract by A.K.)

KHRUSHCHEV, D.P. and PETRINCHENKO, O.I., 1980, Central Paratethys halogen formations and conditions of their development: Litol. Geokhim. Solenosnykh Tolshch, V.I. Kityk, ed., 1980, p. 31-48 (in Russian).
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KIHIEN, A., 1980, Fluid inclusions from the porphyry copper at Quyellaveco, Peru: Int. Geol. Congr., 26th, Abstracts, v. 3, p. 952 (in French).
Salinities of ~40% NaCl, Th ~800°C are reported, along with many lower salinity and Th fluids. (E.R.)

KIM, K.H. and NAKAI, Nobuyuki, 1980, Carbon and oxygen isotope studies of the carbonate rocks from the Shinyemi zinc-lead ore deposits western Taebaegsan metallogenic belt, Korea: J. Earth. Sci. Nagoya Univ., v. 28, p. 57-74 (in English).

KIRKER, Jill and NAHNYBIDA, Cynthia, 1980, Diagenesis of part of the Lower Nisku Formation (Upper Devonian) near Edson, Alberta, (abst.): Geol. Assoc. Canada-Min. Assoc. Canada Program with Abstracts, v. 5, p. 66. Authors at Dept. Geol. & Geophy., Univ. Calgary, Calgary, Alberta, T2N 1N4.

Petrographic examination of dolostones from approximately 100 m of the Lower Nisku Formation reveals a sequence of stromatoporoid/coral floatstones and mudstones with a wackestone to packstone matrix. The matrix was subjected to early dolomitization. Early formed dissolution cavities, related to depositional breaks, are lined with large (0.5-4 mm) euhedral zoned dolomite rhombs with cloudy interiors and clear ferroan overgrowths. Stylolites cut the dolomitized framework of the rock, indicating substantial pressure solution in this part of the section, but do not cross-cut cavity filling blocky calcite cements or anhydrite fracture fillings. Anhydrite appears as large crystals (1-10 mm) filling cross-cutting fractures and as felted fine-grained masses filling cavities. The diagenetic sequence is interpreted to be: selective dissolution of fossils, dolomitization, extensive stylolitization, precipitation of blocky calcite cements, and anhydrite emplacement.

The blocky calcite cements contain abundant primary two-phase fluid inclusions upon which homogenization temperature determinations were made. These fluid inclusions homogenized in the liquid phase between 130° and 185°C. Estimating a geothermal gradient of 26°C/km in this area, the lower temperatures indicate approximately 5 km of burial at the time of calcite cementation. Study of the equilibrium between gypsum and anhydrite indictes that at fluid pressures corresponding to the total burial depth (5 km) anhydrite would be the stable phase above 50°C. These calculations agree with the fluid inclusion data and indicate that large scale migration of fluids into carbonates has taken place during late diagenesis. (Authors' abstract)

KIRSANOV, I.T. and MARKOV, I.A., 1979, Evolution of basalts in the process of formation of the Kluchevskiy volcano, in: Problems of deep magmatism: "Nauka," Moscow, p. 80-96, price 3 rbls 20 kopecks, 900 copies printed (in Russian).

Th of melt inclusions in clinopyroxene changes during eruption from 1060 to 1290°C and in plagioclase from 1090 to 1250°C, i.e., T increases. (A.K.)

KITLYK, V.I., GALABUDA, N.I., PETRICHENKO O.I. and SHAIDETSKAYA, V.S., 1980, Study of Late Devonian salt accumulation in the Pripyat Depression and the Dnieper-Donets Basin: Litol. Geokhim. Solenosnykh Tolshch, V.I. Kityk, ed., 1980, p. 77-95 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

KLEMM, W. and BLANKENBURG, H.-J., 1980, On the fluorine content in quartz: Zeitschrift für angewandte Geologie, v. 26, 1980, pt. 1, p. 24-26 (in German).

The fluorine content of 41 samples of quartz of various genesis were measured and interpreted. Three groups are distinguished, of which fluorine contents >1000 ppm in quartz probably can be explained by mineral and liquid inclusions. (Authors' abstract)

KLINKHAMMER, G.P., 1980, Early diagenesis in sediments from the eastern equatorial Pacific, II. pore water metal results. Earth & Planet. Sci. Lett., v. 49, p. 81-101.

KNAUTH, L.P., 1980, Trace water content of salt in Gulf Coast salt domes (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 464.

The trace water content of salt from Gulf Coast salt domes has been measured by volatilizing 1-4 gm samples under high vacuum and reducing the outgassed water by reaction with uranium at 700°C. Hydrogen liberated from this reaction is collected and measured in a calibrated glass toepler pump.

Water contents in wt% for mine samples range from .01-.09 for Weeks Island, .0024-.52 for Belle Isle, .0007-.0162 for Jefferson Island, and .0036-.005 for Avery Island. Core samples from the Vacherie dome range from .005-.023 wt%. A halite crystal from the Rayburn dome had only .0004 wt% water.

Loose granular mine samples have 10-100 times the water of coherent hand samples indicating that significant quantities of water can be adsorbed by salt exposed to atmospheric moisture. In Weeks Island, salt associated with sandstone inclusions has a water content 3 times greater than that of the main salt stock suggesting that the trace water content is greater near these anomalous zones.

Using a value of .005 wt% as an average water content, the amount of water in liters (W) that will collect around a radioactive waste depository is given as $W = .461 r^3$, where r is the radius in meters of the sphere in which water will be thermally activated to migrate completely to the repository. Since much of the trace water probably does not occur as droplets, but as hydroxyl and oxonium (H_3O^+) substitutions and along grain boundaries, W is probably a maximum value. The trace water content of domal salt appears to be the lowest of any terrestrial rock type. (Author's abstract)

KNIGHT, C.A., 1980, Icicles as crystallization phenomena: J. Crystal

Growth, v. 49, p. 193-198. Author at Nat. Ctr. Atmosph. Res., Boulder, CO 80307.

Icicles grow by dissipating the heat of fusion through the exterior liquid film. Their growth is therefore partly analogous to hailstone growth, and it is also partly analogous to stalactite growth. Like hailstones, they may grow as virtually solid ice or as a mixture of ice and water. Some aspects of the crystallinity, shape, and air bubble structure of icicles are described and discussed. Icicles are an interesting and instructive phenomenon for observation or for organized study. (Author's abstract)

KNYSH, S.K., 1978, Physico-chemical conditions of formation of gold ores in the Urik-Kitoy zone (East Sayan) (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 206-207 (in Russian). Author at Tomsk Polytechnical Inst., Tomsk, USSR.

Gold ores formed during pulsating process. Two stages were distinguished: A) pre-ore (contact-metasomatic, pneumatolytic-hydrothermal), substage I - calcareous skarns Td 380-310°C, substage II - quartz molybdenite Th 430-340°C, substage III - tourmaline-quartz Th 430-315°C, substage IV - quartz-albite Td 360-300°C, substage V - chlorite-carbonate-quartz Th 320-300°C, substage VI - epidote-quartz Th 215°C; B) ore stage (hydrothermal), substage VII - dark gray gangue quartz (Th 430-360°C, substage VIII - pyrite-quartz poor in gold Th 340-280°C, substage IX - gold-quartz-polymetal Th 320-180°C, substage X - quartz-carbonate Th 250-80°C. Solutions changed from HCO_3-Mg-Na (I) through Cl-Na (II), SO_4-HCO_3-Ca (III), HCO_2-Na (IV), HCO_3-SO_4-Ca-Mg-Na (V), SO_4-Ca (VI), HCO_3-Cl-Ca-Na (VII), HCO_3-SO_4-Ca-Na (VIII + IX) to HCO_3-Cl-Ca-Na (X). During stage A total salt concentration increased from 11 mg per l to 115 mg per l, Na>K, solutions were alkaline; during stage B concentration increases from 54 to 114 mg per l and again decreases in substage X, solutions were alkaline → neutral → alkaline, Na:K = 2:1, G consisted of N_2-CO_2 with subordinate H_2 hydrocarbons. (From the author's abstract, translated by A.K.)

KOCH, K. and VOGEL, J., 1980, Relationship between tectonics, formation of sylvinite and basalt intrusions in the Werra potash region; German Democratic Republic: Freiberg. Forschungsh., Reihe C, no. 347, p. 104-xyz.

Indexed under Fluid Inclusions. (E.R.)

KOGARKO, L.N., RAMENDIK, G.I., ROMANCHEV, B.P. and TROFIMOV, V.A., 1980, Trace-element fractionation by minerals of alkalic basalt: Dokl. Akad. Nauk SSSR, v. 254, no. 5, p. 1224-1227 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 254, 1980, p. 213-215 (1982). Authors at Instit. Geochem. & Analy. Chem., USSR Acad. Sci., Moscow, USSR.

Incidental to the studies, crystallization temperatures were determined by an (unstated) combination of Th determinations and the nickel, cobalt and magnesium geothermometers. Olivine and augite in ankaramites Saint Helena = 1300°C, and from alkali olivine basalts, 1240°C. (E.R.)

KOGARKO, L.N., ROMANCHEV, B.P. and MOSCOU, U.R., 1980, Chemical evolution of alkaline-basalt magmas, evidenced by microinclusions (abst.): Internat.

Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 130.

Chemical composition of homogenized inclusions in olivine and clinopyroxenes was studied by microprobe analysis from ankaramites, ankaramite-basalts, and alkaline-basalts of South Atlantic islands - Gran Canaria, Saint Helena and Tristan-da-Cunha.

Inclusions with MgO contents up to 21.12% were found in olivine of Gran Canaria ankaramite. They are considered to be the primary mantle melt, which gave rise to the differentiated alkaline rock series.

Inclusions with MgO contents from 10.1 to 13.8% represent trapped differentiated liquids. The groundmass composition is more differentiated, as a rule, as compared to that of the incluisons. (Authors' abstract)

KOIVULA, J.I., 1980a, Fluid inclusions; hidden trouble for the jeweler and lapidary: Gems and Gemology, v. 16, no. 8, p. 273-276.

KOIVULA, J.I., 1980b, The three-phase inclusion; a product of environment: Gems and Gemology, v. 16, no. 11, p. 338-342.

KOIVULA, J.I., 1980c, Carbon dioxide as a fluid inclusion: Gems and Gemol., v. 16, no. 12, p. 386-390.

KOKIN, A.V., ANDRYANOV, N.G. and PROKOPOV, N.S., 1978, Vacuum decrepitometry of gold and its genesis, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 195 (in Russian). First author at Yakutian Teritorial Geol. Office, Yakutsk, USSR.

Td of two nuggets were as follows: "Varlamov" - surface 285±7°C (5 analyses), I layer 303±5°C(5), II layer 390±8°C(3), central part 390°C(2); "Ogonyok" - surface 298±7°C(4), I layer 319±6°C(6), II layer 414±8°C(6), central part 415±6°C(5). Td of gold from quartz veins 500-600 m distant from contact with batholith was 300-320°C but all inclusions in gold within 250 m leaked under action of thermal field of the batholith. (Abstract by A.K.)

KOKORIN, A.M. and KOKORINA, D.K., 1976, Temperature peculiarities of mineralization of the Deputatskoe tin ore deposit, p. 138-162 in: Metallogeny of the East of the USSR, Publ. House of Far-East Sci. Inst., Vladivostok, 168 pp., 600 copies printed, price 85 kopecks (in Russian). Authors at Far-East Geol. Inst. of the Far-East Sci. Center, Vladivostok, USSR.

Occurrence of greisens, tin-bearing quartz-tourmaline veins, quartz-chlorite zones and Pb-Zn mineralization in relatively small area is the main peculiarity of the Deputatskiy ore area in Yakutia. On the basis of fluid inclusion studies in main minerals (quartz, tourmaline, cassiterite, fluorite and siderite) the following Th were established: greisens 480-200°C, cassiterite-tourmaline veins 450-100°C, quartz-cassiterite-chlorite zones 420-100°C. (Part of the authors' abstract translated by A.K.)

KOKORIN, A.M. and KOKORINA, D.K., 1978, Substance composition and certain peculiarities of formation of the classic tin-tungsten deposits (Krusne Hory in Czechoslovakia), in: Ores in the Far East, p. 136-146 (in

Russian), Vladivostok, Publ. House of Far-East Sci. Center, 600 copies printed, price 1 rbl. 20 kopecks. Authors at the Far-East Geol. Inst. of the Far-East Sci. Center, Vladivostok, USSR.

The Cinovec deposit occurs in the apical part of the Krusne Hory granite stockwork as vein and greisen ore bodies. Inclusions in quartz from the zinnwaldite-K-feldspar greisens have Th 440-185°C, homogenization in G at high T, next in L. Greisens replacing quartz porphyry yielded Th > 500°C (crystal-fluid inclusions) 425-400°C (G inclusions) and 415-145°C (L inclusions). Similar Th were obtained for minerals of the quartz-zinnvaldite-topaz greisens. Quartz from veins bears G/L inclusions with LCO_2 (up to 30 vol.%), Th in L or G 470-360°C, or G/LH_2O, Th 410-130°C. Fluorite from veins yielded Th 360-290°C. Late quartz-barite-fluorite mineralization formed at 325-290°C (Th for barite) and 215-85°C (Th for fluorite). Ores formed at 430-350°C. The deposit Krasno (15 km SW of Karlovy Vary) of tin-tungsten ores yielded Th 440-380°C (in G) and 428-135°C (in L) for greisens and similar ones for veins, 400-385°C for greisen cassiterite and 395-375°C for vein cassiterite. Sphalerite crystallized at $T < 360$°C. Quartz associated with molybdenite has Th 410-120°C; for fluorite in greisens Th are 310-120°C. (Abstract by A.K.)

KOKORIN, A.M. and KOROSTELYOV, P.G., 1978, Problem of local prognosis of the tin ore bodies on the example of the Komsomol'skiy ore region, p. 102-110 in: Genesis of endogene mineralization of the Far East, 168 pp., 600 copies printed, price 2 rbls., Publ. House of the Far-East Sci. Center, Vladivostok (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

Komsomol'skiy ore region bears numerous tin ore deposits of the quartz-tourmaline type of the cassiterite-silicate-sulfide formation. Generally, in the S part of the region ores of Sn and Mo formed at 450-550°C, in the central part ores of Sn, W, As and Cu - at 350-400°C, in the northern part - ores of Sn and polymetals at 250-300°C and Sb-Hg ores at 100-150°C. (A.K.)

KOKORIN, A.M. and KOROSTEL'YOV, P.G., 1980, Problem of genesis of tin ore deposit Val'kumey (Western Chukotka), p. 51-61 in: Structure, composition and genesis of tin-ore deposits of the Far East, publ. by Far-East Sci. Center, Vladivostok, 136 pp., 500 copies printed, price 1 rbl. 25 kopecks (in Russian).

The deposit Val'kumey (Pevek ore region) belongs to tourmaline type of cassiterite-silicate formation and it consists of veins and metasomatic zones in granodiorites. Quartz in metasomatites bears inclusions with Th 395-105°C, carbonate 300-240°C; in vein quartz Th 420-180°C (G/L plus rare inclusions with halite - 330°C), vein quartz with arsenopyrite 340-100°C; in quartz-tourmaline rocks 450-370°C (in L or in G) and 340-190°C (in L), in cassiterite at 400-340°C (in L); quartz from greisens 440-400°C (in G) and 440-135°C (in L). (Abstract by A.K.)

KOKORINA, D.K., KUNAKIN, S.V. and TKACHENKO, G.A., 1980, Conditions of localization and genesis of the rare metal mineralization of the Sofiya ore region (Priamur'ye), p. 47-50 in: Structure, composition and genesis of tin-ore deposits of the Far East, publ. by Far-East Sci. Center, Vladivostok, 136 pp., 500 copies printed, price 1 rbl. 25 kopecks (in Russian).

Continued next page.

Sofiya ore region (Ezop Mts., Nilanskoe anticlinorium) occurs in Proterozoic and Paleozoic metamorphic rocks cut by Cretaceous intrusions. Ores of Sn, W and Mo occur in greisenized granites and in veins. Generally, minerals formed from pneumatolytic (Th 460-355°C) and hydrothermal (Th 425-140°C). (A.K.)

KOLKER, Allan, 1980, Petrology, geochemistry and occurrence of iron-titanium oxide and apatite (nelsonite) rocks: M.S. thesis, Univ. of Mass., 157 pp.

Nine melt inclusions in apatite of oxide-apatite ore from Hesnes, Norway, were analyzed for ten constituents by electron microprobe (p. 91-93). Some are high-silica (~78%), others are low-silica (33-45%). (E.R.)

KOLONIN, G.R., 1978, On technique of determination of oxidation reduction conditions of hydrothermal ore formation (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 153-154 (in Russian). Author at Instit. Geol. Geophys. of the SB AS USSR.

1. Lately gas-liquid inclusions have become an important source of information about oxidation reduction conditions of mineral formation. Techniques of analysis of gas phase in inclusions allows determinations of such components as CO_2, CH_4 and other hydrocarbons, H_2, O_2, H_2S, etc.; that makes possible calculations of oxidation-reduction potential of the solutions from the gas relations. At the same time such published data sometimes appear to be incompatible with the results obtained by other methods. A very large amount of oxygen (tens of percents) in gas phase of inclusions, often connected with nitrogen content (in the same ratio) as in air, is given in a number of works mainly on the study of volcanogenic gold-silver deposits. As these data refer to the conditions of mineral formation during the main productive stages when crystallization of sulphide minerals occurred, they are completely incompatible with the results of experimental study and thermodynamic calculations which show oxygen must be absent. Hence, one must test the technique of gas analysis and be careful as to the significance of the composition of gas-liquid inclusions of near-surface deposits.

2. In geochemical and thermobarometric investigations, one must take into account that oxidation rates in ore-forming solutions of most of metals of variable valence are firmly established by experimental and thermodynamic techniques. If sulphide sulphur is present, all iron is in the state of Fe(II), gold - Au(I), arsenic - As(III) and almost all copper - Cu(I). One must also bear in mind that in many cases it is impossible to judge the metal oxidation state in the solution from the composition of minerals crystallizing from it. This comes from parageneses of sulphide minerals with magnetite and even hematite, the existence of sulphosalt of 5 valent As and Sb, barite and anhydrite formation in reducing conditions, etc.

3. We assume that one must distinguish two limiting cases of regulation of oxidation-reduction conditions in ore formation process. In open systems they are set by the sum of all solutions of oxidized and reduced components. In many cases it is worth singling out the so-called "potential determining" reactions; ratios SO_4^{2-}/H_2S, CH_4/CO_2, H_2O/H_2 play the main role in ore formation. O_2/H_2O is of no real significance because regardless of quantitative water prevalence, its second component (free oxygen) is practically absent in the solution. This is expressed

in terms of tiny magnitudes of its fugacity, which are below 10^{-20} atm under hydrothermal conditions at temperature up to 300°C.

4. Under the conditions of mainly closed systems, which are likely the basic ones in ore formation, oxidation-reduction potential is determined by mineral buffered pairs in the system and quantitatively prevailing in it. The buffering role of such associations as fayalite+magnetite+quartz, and hematite+magnetite, is well-known and used for a long time. For sulphide deposits, the associations pyrrhotite+pyrite, magnetite+pyrite, pyrite+barite, chalcopyrite+bornite+pyrite, etc. are of most significance. Unfortunately, accurate magnitudes of oxygen fugacity for these associations are a function of the solution composition (its pH), sulphide sulphur, iron, barium, and copper activity. To calculate them, it is necessary to solve a system of equations connecting the given components and to use some additional magnitudes. Examples of such calculations are given. (Translation courtesy Dr. A.P. Berzina)

KOLTUN, L.I., 1978, Conditions of formation of some polymetallic deposits of the Eastern Transbaikalia on the basis fo data derived from inclusions of mineral-forming solutions (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 119-120 (in Russian). Author at the L'vov State Univ., L'vov, Ukrainian SSR.

Polymetallic deposits in E. Transbaikalia occur mostly in Lower Paleozoic limestones and only occasionally in sandstones, granites and effusive rocks. The upper T range of ore formation was 380 to 400°C, often in a pneumatolytic process, especially during early axinite stage. Commercial ores formed at 230-140°C in T interval over 20-55°C for individual deposits. High-temperature stages developed abundant arsenopyrite-pyrite-pyrrhotite ores, low-temperature ones-galena-sphalerite-quartz-carbonate ores sometimes with chalcopyrite or pyrite, or even with Hg and As minerals. Commercial ores formed from HCO_3-Ca type solutions with subordinate amounts of Na, K, Cl, F and $HSiO_3$. (A.K.)

KOMATSU, Hiroshi, 1980, Genetic relation between line defects and inclusions in crystal growth: J. Mineral. Soc. of Japan, v. 14, Spec. Issue 2, p. 142-152 (in Japanese).

KONEV, A.A. and BEKMAN, I.K., 1980, Discussion: contribution to the problem of correct interpretation of chromatographic analyses: Geokhimiya, no. 1, p. 157-160 (in Russian). Authors at Inst. of the Earth's Crust of Siberian Branch of Acad. Sci. of the USSR, Irkutsk, USSR.

The paper is the reply to the discussion (see entry Letnikov, F.A., this volume), evaluating as invalid for petrological considerations the analyses of total G (volatiles) released from rocks on calcination up to elevated T (even >800°C) as mixture of G from fluid inclusions, tiny structure defects, structural components like OH or CO_3^{3-} etc., using as one example the high (10 wt.%) CO_2 content in basalt, attributed by Letnikov to the fluid. The authors discuss also some practical problems of G chromatography. (A.K.)

KONNERUP-MADSEN, Jens, 1980. Fluid inclusions in minerals from igneous rocks belonging to the Precambrian continental Gardar Rift Province, South Greenland: The alkaline Ilímaussaq intrusion and the alkali acidic igneous complexes: Ph.D. dissertation, Univ. of Copenhagen, 140 pp.

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 fluid inclusions were found to vary in composition from CO_2-CH_4 through CO_2-CH_4-H_2O mixtures to entirely aqueous, saline fluids. The inclusions represent solidus and/or sub-solidus fluid phases.

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 from the Ilímaussaq intrusion are dominated by hydrocarbons (especially CH_4) and contain only insignificant amounts of CO_2. These differences in the composition of the carbon-bearing fluids reflect the lower oxygen fugacities (values below QFM) prevailing during crystallization of the Ilímaussaq nepheline syenites than for the granites and quartz syenites. Based in part on δ^{13}C-values a juvenile origin for the carbon in the carbon-bearing fluids is considered likely.

Early CO_2-CH_4 inclusions in granites and quartz syenites contain less than 5 mole % CH_4 and have densities from 0.75 to 1.0 g/cc. The most dense of these inclusions suggest conditions of final solidification for most of the granitic and quartz syenitic magmas at 3.5 to 5 Kb and 600 to 700°C. The H_2O inclusions have salinities between 1 and 64 weight %; the majority contain less than 40 equivalent weight % NaCl and have densities from 1.15 to 0.9 g/cc. Microthermometry indicates that other cations such as K^+, Ca^{2+}, Mg^{2+} and/or Fe^{3+} are present in these aqueous fluids. The H_2O inclusions are thought to primarily represent fluids from post-magmatic stages involving repeated episodes of microfracturing and progressive introduction of water during uplift and cooling of these rocks. The CO_2-CH_4-H_2O inclusions are closely related to late aqueous inclusions and show a wide compositional range. These inclusions may indicate the existence at a late stage of locally developed heterogeneous mixtures of CO_2-CH_4 and H_2O.

Minerals from the Si-undersaturated agpaitic nepheline syenites and associated hydrothermal veins from Ilímaussaq dominantly contain hydrocarbon-rich fluid inclusions. These fluids are thought to have been trapped as immiscible droplets of hydrocarbon-rich fluids in highly saline (30 to 46 equivalent weight % NaCl) aqueous solutions at temperatures from 800 to 500°C and pressures from 1.5 to 1.0 Kb. The hydrocarbon gases are thought to be of inorganic origin and reflect very low oxygen fugacities during crystallization of the Ilímaussaq intrusion.

The results of analysis of δ^{18}O and δD on minerals and whole rocks from the Ilímaussaq intrusion indicate contamination of the Ilímaussaq magmas by high-^{18}O crustal rocks. Meteoric water seems only to have influenced the magmatic/hydrothermal system to a limited extent.

Comparisons of the gases in the nepheline syenites from Ilímaussaq with those in similar rock types from other Si-undersaturated complexes reveal a high degree of similarity and suggest the existence of a characteristic vapor phase associated with Si-undersaturated, peralkaline magmatic activity. (Author's abstract)

KONNIKOV, E.G., 1979, Stratification mechanism in the China gabbroid intrusion, East Siberia: Moskov. Obshch. Ispytateley Priorody Byull., otdel. geol., v. 54, no. 3, p. 47-53 (in Russian; translated in Internat. Geol. Rev., v. 22, no. 9, p. 1103-1107, 1980).

Gravitational differentiation is inapplicable to the origin of the stratified China batholith; the mineral compositions of the gabbroids in this intrusion indicate cyclic banding due to liquation of a basalt magma which gives two immiscible liquids differing in fluid content. (Author's abstract)

KONONOV, V.I., 1979, Thermal brines of Reykjanes in the rift zone of Iceland: Akad. Nauk SSSR Izvest., ser. geol., 1979, no. 6, p. 138-151 (in Russian; translated in Internat. Geol. Rev., v. 22, no. 7, p. 815-825, 1980). Author at Geol. Inst. USSR Acad. Sci., Moscow.

The thermal brines of Cape Reykjanes are discharged in the Middle neovolcanic zone of Iceland, regarded as the terrestrial continuation of the Mid-Atlantic Ridge. In contrast to the other hydrothermal systems of Iceland, characterized by low mineralization of subsurface waters and the predominance of SO_4^{2-}, HCO_4^{1-}, and CO_3^{2-} in their anion composition, the steam hydrotherms of Reykjanes have a high mineralization (32-52 g/liter) and a chloride sodic composition. Their temperature at a depth of 1-2.6 km is 250-300°C. The formation of these therms involves seawater, which flows into the coastal zone along faults and joints as a result of filtration convection, and steam-lift phenomena, which develop in the sphere of activity of a heat focus. An estimate of the heat intensity of the discharge of these therms, reaching $4.45 \cdot 10^6$ cal/sec, and also the specific isotope composition of hydrogen, helium, and sulfur, indicate the presence in this brine, besides marine (57%) and infiltration waters (18%) of magmatic and juvenile waters (25%). The chemical aspect of the thermal brines of Cape Reykjanes has been determined by infiltration mass transfer, leading to the displacement of these waters, by their metamorphic transformations during interaction with the rocks under high-temperature conditions, and, finally, by concentration of the brines during evaporation in the near-surface zone. (Author's abstract)

KONOVALOV, I.V., 1980, Types of metamorphic-hydrothermal mineralization of gold ores at the Bodaybo synclinorium, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 141-146 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 11, 1978, p. 109-110. (A.K.)

KOPLUS, A.V. and KOROTAEV, V.V., 1978, Relation between formation temperatures of fluorite ores and mercury content, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 139-141 (in Russian). Authors at VIMS, Moscow, USSR.

Analysis of 180 samples of fluorite from 12 deposits from E. and W. Transbaikalia revealed mercury concentrations from 0.1 to 34 ppb (sensitivity of Hg determination method was 0.1 ppb). Th ranged from 90 to 255°C. It was found that Hg concentration in fluorite is higher in low temperature samples. Statistical characteristics calculated for relation Hg content versus Th (average) confirmed this conclusion. (A.K.)

KOPLUS, A.V., KOROTAEV, V.V. and KANDINOV, M.N., 1978, Temperature regime of fluorite formation in ore bodies of the Naran deposit (W. Transbaikalia), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 139 (in Russian). Authors at VIMS, Moscow, USSR.

On the basis of about 1000 Th measurements the T range of the deposit Naran formation was determined to be 190-100°C, and P ranged from 300 to 200 atm. (A.K.)

KORCHEMAGIN, V.A., PANOV, B.S., KUPENKO, V.I., BUTURLINOV, N.V. and PILOT, I., 1980, Genesis of hydrothermal mineralization in Donbass from the geochemistry of isotopes: Geokhimiya, no. 3, p. 408-415 (in Russian). First author at the Donetsk Polytechnical Inst., Donetsk, USSR.

Ankerite from Esaul polymetallic deposit yielded Th 110-150°C, E. Dolomitnyi Mine, dolomite 135-140°C, calcite 80-120°C, Yuzhnyi Mine, calcite 115-140°C, Amvrosiyevka, calcite 60-65°C, Petrovo-Gnutovo, calcite 220-260°C, parisite 200-250°C, Donetsk, Mine No. 1 "Chelyuskintsev," calcite 90-100°C, quartz from various points of Donbass 115-170°C. (A.K.)

KORNILOV, V.F., 1978, Mineralized cavities of stable thermobaric regime at mercury-antimony deposits, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 129-130 (in Russian). Author at L'vov State Univ., L'vov, Ukrainian SSR.

Ore breccias in Hg-Sb jasperiod type deposits in S. Kirgizia often bear cavities up to 0.8 m^3 by volume with large crystals of fluorite, quartz, cinnabar and calcite (deposits Chauvay, Tolubay-Kyshtau, Zor-Dange), with Th 170-130°C. The author connects origin of the cavities with hydrothermal karst of siliceous rocks. (A.K.)

KOROBEYNIKOV, A.F., 1980, Peculiarities of gold distribution in rocks and minerals of the Eastern slope of the Kuznetskiy Alatau: Geokhimiya, no. 7, p. 999-1017 (in Russian; English abstr.). Author at Polytechnical Inst., Tomsk, USSR.

High gold concentration was found only in silicified, listvenitized and sulfidized skarns, i.e., altered in hydrothermal ore stage at Th 420-130°C, and in metasomatic magnetites - 500-450°C; albitization of wall rocks was at 480-260°C. (A.K.)

KOROBEYNIKOV, A.F. and CHERNYAEV, Ye.V., 1980, Application of methods of thermobarogeochemistry for prospecting and evaluation of gold ore bodies in zones of metasomatites, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 147-157 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 11, 1978, p. 110. (A.K.)

KORONOVSKIY, N.V. and FROMBERG, E.D., 1979, Possible signs of liquation in acid volcanic rocks: Moskov. Obshch. Ispytateley Prirody Byull., otdel. geol., v. 54, no. 5 p. 47-54 (in Russian; translated in Internat. Geol. Rev., v. 22, no. 12, p. 1437-1442, 1980).

We discuss immiscibility in acid volcanic rocks at different levels (macro-, micro-, and micro). The relationships of the layered phases, their sharp discontinuities, and compositional differences suggest the liquation nature of their origin. (Authors' abstract)

KOROSTELYOV, P.G., KOKORIN, A.M., SUCHKOV, V.I., GONEVCHUK, V.G., KOKORINA, D.K. and SEMENYAK, B.I., 1978, Mineralogy and genetic peculiarities of molybdenum mineralization in the Komsomol'skiy region, in: Ores of the Far East, p. 108-114 (in Russian), Vladivostok, Publ. House of Far-East Sci. Center, 600 copies printed, price 1 rbl. 20 kopecks. Authors at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

The molybdenum mineralization occurs in a NNW veinlet zone (quartz-tourmaline and quartz-feldspar veinlets up to 25 cm thick, with molybdenite). Quartz bears G/L and polyphase inclusions. The G/L ones have Th from 418 to 160°C, polyphase ones (with dms: halite, sylvite and soluble prismatic mineral) should homogenize at T > 515-525°C (T of inclusion decrepitation), those with dms halite and sylvite yielded Th 440-450°C. Apatite bears G/L inclusions without dms, their Th = 365-100°C, fluorite - 280-240 and 140-120°C, ankerite 265-130°C, calcite 165-145°C. (Abstract by A.K.)

KORYTOV, F.Ya. and SHILIN, N.L., 1978, Relation between gold content in fluorite [ore] and temperature of formation (example from Transbaikalia), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 143 (in Russian). First author at "Nilzarubezhgeologiya," Moscow, USSR.

Highest gold content was found in fluorite with Th 250-450°C (Nizhnechikoyskoe deposit); the lowest one - in fluorite with Th 120-140°C (Usuglin deposit). Usually Au content is higher in high T fluorites. (A.K.)

KORZHINSKIY, A.F., MAMCHUR, G.P. and YARYNYCH, O.A., 1978, Isotope composition of carbon in the carbonates of the Gumbeykan scheelite deposits in the southern Urals: Vses. Mineralog. Obshch. Zapiski, v. 57, no. 5, p. 554-561 (in Russian; translated in Internat. Geol. Rev., v. 22, no. 10, p. 1234-1240, 1980). Authors at Inst. Geol. & Geochem. Combustible Fuels, AN UkrSSR, L'vov.

Through investigations of the isotope composition of carbon of various generations and carbonates from marbles, skarns, and nested and vein scheelite orebodies, the probable source of carbon of these carbonates has been established as a mixture of sedimentary carbonates, plus carbon dioxide formed by oxidation of the organic matter from sedimentary terrane (δC^{13} -0.05 to 0.62%).

In the calcite and dolomite phenocrysts of marble and the coarse-grained dolostone, containing scheelite, the carbon was lighter (δC^{13} from -0.60 to -0.87%). For the dolomite and ankerite from scheelite pockets of the Balkan deposit and quartz veins of the Buranovo, (δC^{13} varied from -0.44 to -0.87%.

The lightest carbon was found in strontianite (δC^{13} = -1.32%), located near a coating of organic matter (δC^{13} = 1.25%) in fractures in a quartz vein of the Buranovo deposit.

In the section through the orebodies and near-ore-diffusion-metasomatic zones of the Balkan deposit, a decrease in the carbon in the carbonates was observed, with increasing distance away from the fracture. δC^{13} in the altered granitoids ranged from -0.44 to -1.03%; while in the diopside-wollastonite hornfels, from -0.89 to -1.13%. The lessening in weight of the carbon is explained by diffusional fractionation of the isotopes caused apparently by the differential movement of volatile mixtures of carbon during ore-forming processes and the formation of their diffusion-metasomatic zones (table 3). (Authors' abstract)

KORZHINSKIY, A.F., MAMCHUR, G.P. and YARYNYCH, O.A., 1980, Isotopic composition of carbon from carbonates of hydrothermal rare-earth deposits in Eastern Siberia: Geologiya i Geofizika, no. 2, p. 60-65 (in Russian, English abstract). Authors at Inst. Geol. and Geochem. of Mineral Fuels of Acad. Sci. of Ukr. SSR, L'vov, Ukrainian SSR.

The authors noted the presence of LCO_2 high-T inclusions in minerals of the Pervomayskoe deposit. (A.K.)

KOSALS, Ya.A., 1980, Behavior of rare elements and fluorine during the formation of the Kunaley volcanic-plutonic association (Western Transbaikalia): Geokhimiya, no. 1, p. 40-52 (in Russian, English abstract). Author at Inst. Geol. Geoph. of Siberian Branch of Acad. Sci. USSR, Novosibirsk.

Melt P inclusions in quartz from alkaline granites of subvolcanic and apical parts of the hypabyssal intrusions homogenized at 890-880°C, crystal-fluid P inclusions in the same sample - at 890-670°C, S crystal-fluid inclusions - at 650-350°C, P of fluid phase was 2250-4750 atm. Alkaline syenites poor in volatiles have only melt inclusions of Th 1020-900°C; all this proves the presence of volatiles in the upper part of the magmatic column, which separated by retrograde boiling on crystallization of magmatic melt. The separated fluid caused albitization of granites at 670-420°C and next fluorite and rare-metal-quartz-fluorite mineralization at 250-140°C. The high fluorine content in magmatic melt that caused crystallization of subalkaline leucocratic granites caused low Th of melt inclusions in quartz and fluorite (890-740°). Presence of P crystal-fluid inclusions (Th 880-670°C) proves the presence of concentrated fluid phase coeval with melt. P of fluid phase varied from 4000 atm to 1000-500 atm. Those fluids formed next rare-metal-feldspar and rare-metal-fluorite metasomatites at 400-140°C. (Abstract by A.K.)

KOSUKHIN, O.N., 1980, Peculiarities of genesis of granitoids of the Sherlovaya Gora-Adun Chelon region: Geologiya i Geofizika, no. 4, p. 18-26 (in Russian, English abstract). Author at Inst. Geol. and Geophys., Novosibirsk, USSR.

The studied specimens were taken in the massifs: Sherlovaya Gora, Adun Chelon, Bolshaya Mt. and Vysokaya Mt. Melt inclusions in magmatic quartz are usually <5 μm, very rarely ~20-30 μm. They bear silicate and fluid (G+L) components; Th of G+L→L = 320-300°C, hence water concentration in parent magmas was high. Th of silicate+fluid are rather low: Sherlovaya Gora, porphyric granite and quartz porphyry - 640-690°C, miarolytic aplite - 670-650°C, Bol'shaya and Vysokaya Mts., quartz porphyry in the massif - 700-900°C, in dikes - 720-1100, in explosive breccias, blocks 730-1090°C, cement - 730-960°C, Adun Chelon, granite porphyry 630-690°C, graphic zones in chamber pegmatites 620-640°C. The water-rich magmas formed volatile-saturated pegmatitic melts (or with excess of volatiles). Greisens of Sherlovaya Gora yielded Th (in L or G) 580-570°C (in quartz, topaz, beryl); the inclusions bear G, L, cubic soluble dm, anisotropic dms (silicates?) and ore minerals. Water fluid in melt inclusions bears ~10%

of NaCl equivalent solution; fluid P in "boiling" melt was ~0.8-0.9 kbar. (Abstract by A.K.)

KOVACHEV, V. and STRASHIMIROV, S., 1979, Mineral thermometry studies and temperature zoning in the Zidarovo ore field: Review of the Bulgarian Geol. Soc., v. 40, pt. 1, p. 101-108 (in Russian).

The paper presents a study of the temperatures of formation of the various types of mineralizations in the Zidarovo deposit and in the Zidarovo ore field. The temperature determinations are based on homogenization of primary fluid inclusions in certain minerals. Observations on the shape and origin of the fluid inclusions, some of them illustrated with photographs, are made. Inclusions in the following minerals have been homogenized: chlorapatite (magnesioferrite-chlorapatite association), quartz (quartz-pyrite, and quartz-chalcopyrite, and quartz-sphalerite association), sphalerite (quartz-sphalerite association) and calcite (galena-gold association). Until now such studies have never been made in the Zidarovo ore field.

The minerals of the magnesioferrite-chlorapatite association show the highest temperature of formation (650°C). The temperature of formation of quartz, used as the main indicator of temperature, varies from 390°C to 210°C (quartz-pyrite-association - 390°C, quartz-chalcopyrite association - 305-290°C, quartz-sphalerite association - 295-210°C). Sphalerite (quartz-sphalerite association) shows a temperature of formation of 230-110°C, and calcite (galena-gold association) 170-180°C.

A horizontal temperature zoning is found in the deposit, the higher temperatures of mineral formation being recorded near the Zidarovo intrusive body, and the lower ones in ore zones occurring at greater distances from it.

Two temperature centers are distinguished in the Zidarovo deposit on the basis of the observations made. They coincide with the main structures in the ore zones 13 and 55, which identifies them as mineralizing structures. The temperature centers mark the place of two currents of hydrothermal solutions separated in time and space, which formed the chalcopyrite-bismuthinite and the chalcopyrite-galena-sphalerite-gold types of mineralization, respectively.

Although less studied, three temperature centers, coinciding with the ore manifestations near the villages of Krusevec, Zidarovo and Hurdere, have been distinguished in the area of the Zidarovo ore field. (Authors' abstract)

KOVAL', V.B., 1980, A geochemical model for the accumulation of uranium in alkali-carbonate metasomatic rocks of the Precambrian: Izd. Nauk. Dumka, Kiev, Ukrainian SSR, 148 pp. (in Ukrainian).

Indexed under Fluid Inclusions. (E.R.)

KOVALEVICH, V.M., 1980, On genetic implications of inclusions in halite: Litol. Plezn. Iskop. (Moscow), v. 1, p. 147-151 (in Russian).

KOVALISHIN, Z.I. and PLATONOVA, E.L., 1980, Fluorite mineralization in the Beregovskoe deposit: Mineralog. Sborn., v. 34, no. 1, p. 85-86 (in Russian, English abstract). Authors at Inst. Geol. and Geochem. of Mineral Fuels of Acad. Sci. of Ukr. SSR, L'vov, Naukova 3A street, Ukrainian SSR.

In drilling cores from the Beregovskoe Hg-polymetallic deposits fluorite mineralization was found by the authors in a) diabases and their tuffs, argillites and aleurolites of the pre-Neogene basement and in b) rhyolite tuffs and tuffites of the Upper Tortomian age. Mineralization (a) forms veinlets of calcite, violet fluorite and quartz plus dispersed chalcopyrite. Th of inclusions are in quartz 235-230°C, in calcite 220-214°C, in fluorite 210-205°C, all in L; G in inclusions in fluorite consists of 89.57 vol.% of N_2 and 10.43 vol.% of CH_4. Mineralization (b) forms veinlets of quartz, green fluorite and sulfides, Th for quartz and fluorite are 205-200°C. (Abstract by A.K.)

KOVALISHIN, Z.I., PLATONOVA, E.L. and SASIN, G.G., 1978, Conditions of formation of gold ore mineralization in Transcarpathians (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 213-215 (in Russian). Authors at Inst. Geol. Geochem. of Mineral Fuels of Acad. Sci. of Ukr. SSR, L'vov, Ukrainian SSR.

Gold ore mineralization is connected with Miocene volcanism widely developed at the Beregovskoe Highland: there are three levels of rhyolite tuffs separated by two levels of sediments. Quartz-adularia gold ores formed from K-rich (up to 30%) solutions of SO_4 type with subordinate Ca and Mg. CO_2 makes up to 65.3 vol. % of total G, CH_4 - up to 66.6 vol. %. Gold-polymetal ores formed down to Th 250-260°C from Ca- and Mg-rich solutions of SO_4 type, G were N_2 (56-94 vol.%), CO_2 rarely reaches 40 vol. %. Sometimes heterogenization of solutions was detected. Gold-barite-kaolinite ores yielded Th in barite 120-125°C, CO_2 makes up 67 vol. %, N_2 up to 22 vol. %, H_2 up to 44 vol. %, moreover small amounts of CH_4, C_2H_6 and C_3H_8. Water leachates bear Na up to 24%, K up to 14%, Ca up to 7%, Mg up to 3%, Cl up to 62% and SO_4 up to 60% (of total salts? A.K.). By cryometry salt concentration was 3-4 wt. % NaCl equivalent. (From the authors' abstract, translated by A.K.)

KOVALISHIN, Z.I., PLATONOVA, E.L. and SASIN, G.G., 1980, Physico-chemical conditions of formation of gold ore mineralization at the Beregovskoe Hills, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 135-140 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980. (A.K.) See previous item.

KOZLOWSKI, Andrzej, KARWOWSKI, Lukasz and ROEDDER, Edwin, 1980, Parent fluids of the zinc and lead ores from the Silesia-Cracow region: Acta Geologica Polonica, v. 30, no. 2, p. 147-152.

Fluid inclusions in sulfide minerals (sphalerite, wurtzite) of the zinc and lead ores from the Silesia-Cracow region, Southern Poland, bear water solution (brine) and liquid and gaseous hydrocarbons, probably extracted from wall rocks of ores. These ores have formed at temperature close to homogenization temperature of inclusions, ranging from 92 to 138°C. (Authors' abstract)

KRAFFT, M. and CHAIGNEAU, M., 1980, Gas inclusions in volcanic bombs from the activity of Piton de la Fournaise in 1975-1976, Reunion Island: In: A collection of papers on the geochemistry of volcanic gases, M. Chaigneau, ed., Bull. Volcanol., v. 43, no. 1, p. 225-232 (in French).

KRASOV, Nikolai and CLOCCHIATTI, Robert, 1979, Modes of crystallization and the formation of residual immiscible liquids in plagioclase phenocrysts from calc-alkaline lavas of Karimski Volcano (Kamtchatka, USSR) (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France p. 269 (in French).

KRASOV, N.F., OSORGIN, N.Yu., CHUPINA, L.Yu. and SHESHEGOV, F.N., 1978, High-temperature installation for the investigation of inclusions in mafic minerals (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 215-216 (in Russian). Authors at Instit. Geol. and Geophy. of the SB AS USSR.

The installation consists of: 1) microthermochamber, placed on the microscope stage, 2) gas line and 3) water cooling line.

The heating chamber is made of stainless steel. There are two windows in the chamber case: the lower, hermetically sealed by alumina glass (sapphire?), and the upper, into which a microscope objective lens is introduced. Between the upper hole and the objective lens there is a mushroom-like seal. The body of an ordinary objective x 20 lens has been specially changed by a new one of the author's design to make the mushroom-like seal. The absence of partitions between the objective lens and the preparation does not require the use of long-focus optics and improves the object visibility. The mushroom-like connection of the chamber and microscope objective lens permits changing the preparation in the course of the work.

The gas line of the installation consists of 1) gas balloon (bottle?) with high pressure gauge, reduction gear and low pressure gauge, 2) gas purification systems, which include a tube with activated copper fillings and a tube with moisture-absorber.

The water-cooling line has two branches. One of them connects to the chamber case, in which there are special channels for water circulation, the other - on the objective lens body. With the installation inclusions in mafic minerals are investigated up to 1250°C, the whole course of the homogenization process may be observed (the beginning of glass softening, sequence of phase fusion in inclusions, etc.), and undoubtedly gives additional information about mineral-forming process.

With this installation A.A. Tomilenko has made successful experiments of inclusion homogenization in garnet and hypersthene from metamorphic rocks of granulitic facies. The minerals studied are characterized by high iron content (from 40 to 80% in garnet and 60% in hypersthene).

On heating minerals in ordinary thermochambers in air up to 700°C, they darken sharply and become unsuitable for further investigation. However, on heating in the installation mentioned above, good visibility of the objects under study (hardened inclusions of 20-30 microns, the composition is liquid phase, several solid anisotropic phases) is preserved up to 1200°C in spite of numerous holds (up to 6 hours each) at temperatures of 800, 900, 1000, 1100 and 1200°C. (Translation courtesy Dr. A.P. Berzina)

KRASOV, N.F. and POPOVA, N.M., 1978, Comparison of viscosity of Kamchatka andesite lavas based on the study of inclusions in minerals: Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 94-95 (in Russian). Authors at Instit. Geol. and Geophy. of the SB AS

USSR. Authors at Instit. Geol. Geophys. of the SB AS USSR.

Proceeding from the conviction that the speed of phase transformations in melts is to a great extent dependent on their viscosity, the authors have made a number of experiments comparing melt viscosities in inclusions in rock-forming basalts, andesites and dacites from some volcanoes of Kamchatka.

Th was initially determined for each group of inclusions in one preparation. The inclusions were stablized at temperature 50° lower than Th after cooling and heterogenization. The temperature in the chamber was then sharply increased (in 2 sec.) up to Th and phase equilibrium time in inclusions (i.e. time of repeated homogenization) was noted. It was established that in basaltic, andesitic and dacitic melts, pyroxenes and plagioclases were trapped accordingly at 1245-1305°C, 1300-1340°C and 1285-1330°C, equilibrium came accordingly in 5-15 sec., 25-50 sec. and 85-100 sec. The figure obtained on lavas, creating block flows, once again prove the evidence that the melts' viscosity increases with the decrease of their basicity.

For inclusions in plagioclases from pumice-like dacites phase equilibrium time is 25-60 sec. (at trapping temperature 925-1115°C), and that undoubtedly evidences that pumice-like dacite lavas are of less viscosity and greater gas saturation than blocky ones.

For andesite melts in inclusions in plagioclases, with homogenizing in the range 1340-1250°C, it is established that phase equilibrium time increases from 25 to 95 sec., and at trapping temperature 1230-1160°C it decreases up to 25-35 sec. Such two-stage differently directed alteration of melt viscosity may be due to their deoxidation during crystallization at the first stage and sharp enrichment in volatiles at the second one.

A number of experiments with melt inclusions of different temperature was carried out with different heating and cooling rates (from 2°/min to 40°/min), and the alteration of trapping temperature of the inclusions was recorded. It was established that under similar experimental conditions, inclusions of basic melts show less increase in Th than acid melt inclusions. These data provide an indirect confirmation of melt viscosity and prove the regularities mentioned. (Translation courtesy Dr. A.P. Berzina)

KRAVCHUK, I.F., CHERNYSHEVA, I.V. and URUSOV, V.S., 1980, Partitioning of some elements between plagioclase phenocrysts and matrix as an indicator of crystallization conditions of basalts from the Southern Eruption of Tolbachik: Geokhimiya, no. 7, p. 966-973 (in Russian; English abst.). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. USSR, Moscow, USSR.

The paper bears some literature values for Th (1135-1200°C), of melt inclusions in plagioclase and an evaluation of PH_2O in magmatic melt for 0-0.5 kbars. (A.K.)

KRAVTSOV, A.I., KROPOTOVA, O.I., BOBROV, V.A., KIRIKILITSA, S.I. and POLKANOV, Yu.A., 1980, New data on $\delta^{13}C$ in diamonds from fine-grained placers in the Russian platform: Geokhimiya 1980, no. 1, p. 143-147 (in Russian; translated in Geochem. Internat., v. 17, no. 1, p. 71-74, 1980 (pub. 1981)).

KREMENETSKIY, A.A., LAPIDUS, I.V. and YUSHKO, N.A., 1980, Temperature conditions of formation of fluorine-rare metal ore mineralization in volcanic-sedimentary rocks, <u>in</u> Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 31-34 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 97, Kremenetskiy et al. (A.K.)

KREULEN, R., 1980, CO_2-rich fluids during regional metamorphism on Naxos (Greece): carbon isotopes and fluid inclusions: Am. J. Sci., v. 280, p. 745-771. Author at Vening Meinesz Lab., Dept. Geochem., Univ. Utrecht, P.O.B. 80021 Utrecht, The Netherlands.

The regional-metamorphic complex of Naxos consists of a central migmatite dome surrounded by schists and marbles of decreasing metamorphic grade. Sillimanite, kyanite, biotite, and chlorite-sericite schists occur at successively greater distances from the migmatite dome. Fluid inclusions in quartz and other minerals indicate that fluids containing more than 50 mol percent CO_2 were predominant during metamorphism. The compositions of fluid inclusions are largely independent of metamorphic grade and lithology, suggesting that most of the fluid was pervasive. $\delta^{13}C$ values of CO_2 from fluid inclusions in syn-metamorphic quartz segregations cover the range from -16 to +5‰. Many of these $\delta^{13}C$ values are between -1 and -5‰ and indicate that a large part of the CO_2 cannot have originated by decarbonation of the marbles but probably came from a deep-seated source. CO_2 with $\delta^{13}C$ values of +1 to +5‰ is locally present in siliceous dolomites. These positive $\delta^{13}C$ values represent CO_2 formed in situ by decarbonation of the dolomites. CO_2 with low $\delta^{13}C$ values (-6 to -16‰) is restricted to quartz segregations within a narrow zone containing graphite quartzites and probably results from oxidation of organic carbon. Samples taken in traverses across the schists adjacent to the graphite quartzites show low $\delta^{13}C$ values over distances of 50 to 100 m. (Author's abstract)

KRIVOSHLYK, I.N., 1980, Autoliths and some corollaries of the hypothesis of their genesis from immiscible phases: Dokl. Akad. Nauk SSSR, v. 252, no. 1, p. 190-192 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 81-82 (1982).

KROPOTKIN, P.N., VALYAYEV, B.M., VOYTOV, G.I. and POLYAK, B.G., 1980. Degasification of the Earth and geotectonics: Moscow, Izd. Nauka (in Russian).

KRUTII, V.M., PETROV, P.R. and RUCHKIN, G.V., 1980, Carbon and hydrocarbons in ore-enclosing sediments of lead-zinc deposits of the Sardansky ore region (South-East Yakutia): Dokl. Akad. Nauk SSSR, v. 252, no. 2, p. 423-426 (in Russian).

KULIKOV, I.V., 1980, New commercial scheelite-fluorite formation and fluorite from Tyrnyauz deposit: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 1, p. 67-73 (in Russian). Author at Moscow Geol.-Prosp. Inst., Moscow, USSR.

Colorless or pale-bluish fluorite forms veins and nests, sometimes also with white fluorite. It bears fluid inclusions with numerous dms (up to 10-15), Th >800°C. Calcite associated with fluorite bears fluid inclusions with up to 6 dms, Th 550-600°C. (Abstract by A.K.)

KURRUS, A.W., III, 1980, Geochemistry, geothermometry, and mineralogy of quartz and base metal vein deposits, Montgomery County, Arkansas: M.S. thesis, Univ. Arkansas, Fayetteville, AR, USA.
Indexed under Fluid Inclusions. (E.R.)

KUSHNIR, Jacob, 1980, The coprecipitation of strontium, magnesium, sodium, potassium and chloride ions with gypsum. An experimental study. Geochim. Cosmo. Acta, v. 44, p. 1471-1482.

KUZNETSOV, Yu.A. and KULIK, Zh.V., 1978, Fluid regime of formation of polymetal ore mineralization in the Donets Basin (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 118 (in Russian). Authors at Inst. Geochem. and Physics of Minerals of Acad. Sci. of Ukr. SSR, Kiev, Ukrainian SSR.

Over 20 analyses of water leachates from quartz of ore parageneses (ankerite, pyrite, arsenopyrite, galena, sphalerite, tetrahedrite, bournonite, boulangerite, etc.) revealed that early solutions were of Na-HCO_3 type but late ones of Ca-Cl type. Gases commonly consist of CO_2 (50%), N_2 + rare G (40%), and "acid" gases (10%). (A.K.)

KUZNETSOVA, S.V., 1980, Thermobarogeochemical characteristics of quartz veins as prospecting criteria for alkaline metasomatic zones with rare-metal mineralization, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemisty: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 35-36 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 11, 1978, p. 119, Kuznetsova. (A.K.)

KVENVOLDEN, K.A. and CLAYPOOL, G.E., 1980, Origin of gasoline-range hydrocarbons and their migration by solution in carbon dioxide in Norton Basin, Alaska: The Am. Assoc. of Petrol. Geol. Bull., v. 64, no. 7, July, 1980, p. 1078-1086.

KVENVOLDEN, K.A. and McMENAMIN, M.A., 1980, Hydrates of natural gas: a review of their geologic occurrence: U.S. Geol. Survey Circ. 825, 11 pp.

The world occurrence of gas hydrates, particularly in off-shore sediments, is reviewed, plus a discussion of the available P-T-X data. (E.R.)

LAMBERT, S.J., 1980, Mineralogical aspects of fluid migration in the "Salt Block II" experiment: Sandia Nat'l. Laboratories Report SAND 79-2423, 24 pp.

A block of evaporite rock containing the mineral assemblage halite (88%) - polyhalite (8%) - sylvite (4%) was machined into a cylinder one meter in diameter and one meter high, and was fitted with an axial heater, thermocouples and an off-gas collection system. After about 100 days of heating, identification of mineral efflorescences at the heater hole (carnallite and bischofite) showed that a significant portion of the 111 grams of water recovered (out of around 8500 grams available in the rock) migrated as a liquid, not as a vapor. A microscopic examination of rock slices from within 15 cm of the heater hole (where the temperature was 100 to 200°C, and the gradient was 3 to 15°C/cm) revealed that (1) fluid inclusions had migrated, but rarely across grain boundaries, (2) fluid inclusions had not been mobilized at distances greater than about 15 cm from the heater hole, and (3) intergranular liquid had been conspicuously mobilized within 15 cm of the heater hole. (Author's abstract)

(See also Roedder and Belkin, 1980b, this volume.)

LAMBERT, S.J. and EPSTEIN, Samuel, 1980, Stable isotope investigations of an active geothermal system in Valles Caldera, Jemez Mountains, New Mexico: J. Volcanol. and Geotherm. Res., v. 8, p. 111-129. Authors at Div. of Geol. and Planet. Sci., Calif. Inst. of Tech., Pasadena, CA 91125.

$^{18}O/^{16}O$, $^{13}C/^{12}C$ and D/H measurements have been made on rocks and minerals from drill cuttings (0 to 1700 m depth) from Valles Caldera, New Mexico, a post-Pliocene collapsed volcano containing an active hydrothermal system. $\delta^{18}O$ values of calcite reflect isotopic equilibrium with large amounts of a meteoric-hydrothermal fluid ($\delta^{18}O$ = -12‰) at temperatures between 60 and 280°C. Calcites appear to have retained their original $^{13}C^{12}C$ ratios, typical of either marine or fresh-water origin. The mineralogical changes which have accompanied the hydrothermal activity resulted in decreases in whole-rock $\delta^{18}O$ values of as much as 7‰ as compared to the original $\delta^{18}O$ of the volcanically-derived rocks. The isotopic composition of hydrothermal quartz in altered rocks is entirely unrelated to the most recent episode of alteration. D/H ratios of kaolinite formed in equilibrium with the meteoric-hydrothermal fluid have allowed the determination of approximate kaolinite-water hydrogen isotope fractionation factors between 60 and 280°C. These data are compatible with previous determinations at 400 and 300°C. The $\ln \alpha^D$ (kao-H_2O) relationship with $1/T^2$ is not linear over the temperature range 400-25°C. (Authors' abstract)

LANE, C.A., 1976, Geology, mineralogy, and fluid inclusion geothermometry of the El Paso gold mine, Cripple Creek, Colorado: M.S. thesis, Univ. Missouri, Rolla, MO.

LANG, Barbu, COLVINE, R.J., GOLDBERG, Moshe, BUCHBINDER, L.G. and ZILBERFARB, Aryeh, 1981, Fluid inclusion studies on mineralization from Israel and Sinai: Current Res., 1980, p. 25-26 (Ministry of Energy and Infrastructure, Israel).

Two types of mineralization containing abundant fluid inclusions were examined. The Ashdod area is located at the centre of the Israeli Mediterranean coastal plain, some 30 km south of Tel Aviv. Mineralization consisting of dolomite-fluorite-calcite-quartz-clays was penetrated in a highly porous dolomite sequence of Jurassic age which is a target for oil exploration. Th fell in two groups 90-100°, and 200-300°C; the reason is unknown.

The Wadi Samra area of southeastern Sinai, some 50 km north of Sharm-e-Sheikh, contains copper mineralization in a vein/fault system mainly within metamorphic Precambrian greywackes. The inclusions determined in quartz had Th 245-439°C. (E.R.)

LARHIDI, N., CLOCCHIATTI, R., HAVETTE, A., METRICH, N. and WEISS, J., 1980, Chemical and thermometric study of hyperalkaline lavas (pantellerites and comendites) of St. Pietro Island (southern Sardinia, Italy) (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 131-132 (in French; translation courtesy R. Clocchiatti).

Various authors have studied the acidic lavas of San Pietro by long established petrographical and chemical means (Arana and others, 1974; Arno, 1978); but as the rocks are highly altered by hydrothermal processes, these methods did not permit an appropriate petrographic definition. And neither is it possible, with the usual geothermometers, to determine the thermal interval of crystallization of the parageneses found, nor to define the geothermal interest of this type of rocks.

For better understanding of their genesis, a chemical study of glass inclusions in various minerals were carried on by electron microprobe, so that the composition of the melt at the time of crystallization of these minerals could be established: an hyperalkaline composition was found, which is in agreement with the mineralogy of these rocks.

Furthermore, a combined study by ion probe and electron microprobe revealed that alteration by late fluids resulted in glass depleted in sodium and, to a lesser extent, in potassium near certain cracks; the mobility of these ions depended on the hydration stage of the glass. Such phenomena, evidenced by ion imagery, remain invisible under classic microscope observations.

This convergence of information shows that these rocks with hyperalkaline mineralogy show only an apparent subalkaline composition, due to the alteration of K and mostly Na along fissures. This bulk chemical composition would set them far from the thermal minima A and B of the Ab-Cr-Q-Ac-Ns-H_2O system (Carmichael and Mackenzie); A: thermal minimum Q-Ab-Or; B: mini Q-Ab-Or + 4.5 Ac + 4.5 Ns.

On another level, thermo-optical studies were carried on on glassy inclusions of different lavas which showed a bimodal Th distribution: one group of lavas is characterized by intra-mineral inclusions giving Th between 780 and 800°C ± 10°C, another by $T \geqslant 1200°C \pm 20°C$. Only the former ones, which are in agreement with other geochemical data obtained on rocks of similar nature (Benhamou and Clocchiatti, 1976; Metrich and Clocchiatti, 1979), seem to bear a petrogenetic significance.

Actually, the higher temperatures were obtained on inclusions in which a host mineral grew from the included melts, after the closure of the vacuoles, during the slow cooling of the lava. This growth is well shown by the chemical evolution of residual melts and occurs together with a loss of the volatiles formerly trapped in the inclusion, either through the crystalline net or thanks to microfissures (hardly visible or cemented).

In conclusion, the study of melt inclusions appears to be a very efficient tool for petrogenetic studies of volcanic products, even though their primary nature were deeply modified by alteration. (Authors' abstract)

LAZARENKO, E.A., 1980, Magmatic formation and its metallogenetic significance: Geol. Zh., v. 40, no. 6, p. 110-122 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

LAZARENKO, E.E., 1980, Physicochemical characteristic of mineralogenesis in rocks of the Belaya Tserkov block of the Ukrainian Shield (by the data of mineralogenetic medium inclusions): Mineral. Zhurn., 1980, v. 2, no. 2, p. 32-41 (in Russian).

Continued next page.

Physicochemical conditions of the processes of amphibolite facies metamorphism are established on the basis of studies performed for minerals of the Belaya Tserkov block rocks by the methods of thermobarogeochemistry. The lower temperature limit of metamorphizing solutions did not exceed 300°C, and the minimum pressure was 600-800 atm.

The chemical composition of postmagmatic solutions for granite and pegmatite minerals is chiefly chloride-hydrocarbonate-sulphate-sodium-potassium, and for gneisses - chloride-sodium-potassium-magnesium. Solution concentration does not exceed 20%.

Enrichment of the inclusion postmagmatic solutions by acid gases (CO_2, F_2) is observed in their gas component. (Author's abstract)

LAZARENKO, E.E. and KUZNETSOVA, S.V., 1980, Hydrogen sulfide inclusions in quartz from granitic rocks: Dopov. Akad. Nauk Ukr. RSR, Ser. B, Geol., Khim. Biol. Nauki, 1980, no. 12, p. 9-12 (in Ukrainian).

LEACH, D.L., 1980, Nature of mineralizing fluids in the barite deposits of central and southeast Missouri: Econ. Geol., v. 75, p. 1168-1180. Author at U.S. Geol. Survey, Br. of Explor. Res., 5946 McIntyre St., Golden, CO 80401.

In central Missouri, many small high-grade barite deposits occur as open-space fillings in solution collapse structures in carbonate rocks. In southeast Missouri, extensive low-grade residual deposits have been derived from the weathering and dissolution of carbonate host rocks. Fluid inclusion studies show that the barite in both districts was precipitated from solutions having salinities in the range of 4 to 10 weight percent salts and at temperatures less than 40° to 50°C. The salinities of different primary and sets of pseudosecondary inclusions may vary within a single barite crystal - showing that the salinity of the mineralizing fluids changed during crystal growth.

Electron microprobe analysis shows calcium and strontium to be the only trace elements detected in barite. Most barite shows an increase in strontium concentration toward the younger parts of the crystal. Some barite crystals have small-scale, strontium compositional banding which suggests that the crystals responded to regular fluctuations in physio-chemical conditions during mineralization. This systematic compositional banding suggests that the depositional sites were influenced by near-surface processes, specifically seasonal changes.

Paragenetic relationships indicate that the period of barite mineralization was distinctly later than that of the lead-zinc mineralization in the central and southeast Missouri barite districts. Fluid inclusion data show that sphalerite was deposited by brines, generally greater than 22 weight percent salts, at temperatures ranging from 80° to 110°C. The lack of any mineral deposition in the barite deposits in the temperature range from 80° to 40°C and salinity range of 21 to 10 weight percent salts suggests the possibility of two distinct and perhaps completely unrelated episodes of mineralization. The most geologically plausible model for the large amount of barite deposited requires the mixing of a barium-rich fluid with a sulfate-bearing surface fluid. (Author's abstract)

LEBEDEV, L.M., ZOTOV, A.V., NIKITINA, I.B., DUNICHEV, V.M. and SHURMANOV, L.P., 1980, Present processes of mineral formation in the Volcano Mendeleev (Island Kunashir): "Nauka," Moscow, 176 p., price 1 rbl 90 kopecks, 650 copies printed (in Russian).

Continued next page.

The book describes formation of minerals in thermal waters: acid sulfate, acid sulfate-chloride of shallow and deep circulation, neutral chloride-sodium, and in solfatara field (sulfide deposit). Pertinent to fluid inclusion studies on such environments. (A.K.)

LE BEL, L., 1980a, The cupriferous porphyry of Cerro Verde-Santa Rosa (southern Peru); plutonic interpretation: Int. Geol. Congr., 26th, Abstracts, v. 3, p. 957 (in French).

Le BEL, L., 1980b, Characteristics of the fluid phase associated with the mineralization of Cerro Verde-Santa Rosa, pp. 283-292 in Johan, Z., ed., Mineralization in granitoids, Memoire du BRGM no. 99 (in French).

LEE, C.A. and SHARPE, M.R., 1980, Further examples of silicate liquid immiscibility and spherical aggregation in the Bushveld Complex: Earth and Planet. Sci. Letts., v. 48, p. 131-147. First author at Johannesburg Consol. Invest. Co., Fundamental Res. Unit, P.O. Box 976, Randfontein 1760 (Rep. S. Africa).

The Boulder Bed and the Merensky Reef occur in the upper portions of the critical zone of the Bushveld Complex. Their origin has been the subject of much debate and so a general review of the more significant literature is presented.

An investigation of these occurrences in the Rustenburg area has drawn parallels between their geological settings and geochemistry. Both phenomena display similar features, including aggregates of orthopyroxene, marginal layers of chromitite and coincident bulk chemical and mineralogical trends. The Boulder Bed and the Merensky Reef may be equated on this basis with the spherical orthopyroxenite aggregates previously reported by us from the main zone of the Bushveld Complex in the eastern Transvaal.

The formation of these phenomena in the critical zone may be related to the process of spherical agglomeration, whereby orthopyroxene grains were accreted by means of an immiscible bridging liquid which formed in the volatile-rich magma trapped beneath an anorthosite layer. (Authors' abstract)

Le GUERN, F., NOHL, A., BICOCCHI, P. and TAZIEFF, H., 1979, Field analyses of volcanic gases (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France, p. 289 (in French).

LETNIKOV, F.A., 1980, Discussion: contribution to the problem of the correct application of chromatographic analyses in geochemical studies: Geokhimiya, no. 1, p. 154-157 (in Russian). Author at Inst. of the Earth's Crust of Siberian Branch of Acad. Sci., Irkutsk, USSR.

The author discusses the paper by Konev and Bekman, Geokhimiya, no. 3, 1978, p. 390-397, and evaluates his method of determination of total G released from rocks by calcination at elevated T (even >800°C) as the best, since G is released under conditions of rock formation and volatiles fixed in mineral structure like OH, CO_2 or F are also components of the primitive fluid. See also entry Konev, A.A. and Bekman, I.K., in this volume. (A.K.)

LETNIKOV, F.A., FEOKTISTOV, G.D., OSTAFIYCHUK, I.M., KISELEV, A.I., KHARIN, G.S., GRUDININ, M.I., MOLYAVKO, V.G. and TOLSTOY, M.I., 1980, Fluid regime of formation of the mantle rocks: "Nauka" Publ. House, Novisibirsk, 144 pp., 1000 copies printed, price 2 rbls. 10 kopecks (in Russian).

Studies of the volatile components of the supposed mantle-generated rocks were performed by high-temperature gas chromatography, where not only G components of fluid inclusions are analyzed, but also all volatiles present in the rock as mineral constituents, etc., released by sufficiently extensive and high-T calcination. The book presents over 400 such analyses for H_2O, CO_2, CO, CH_4, H_2, and N_2, and a similar number of determinations of chemical composition of the studied rocks and numerous determinations of trace elements. After presentation of theoretical considerations and experimental results concerning fluids in mantle rocks, the authors describe distribution of fluid components in volcanic mantle rocks, namely in andesite series of the young intracontinental belts (Carpatho-Dynarides, Armenia, and Great Caucasus), in Cenozoic volcanites of Central Asia in connection with mantle degassing (Baikal rift) and in basalts of the Atlantic Ocean floor and Norwegian-Greenland basin. Similar studies are presented for evaluation of fluid components in intrusive mantle rocks; the studied complex as a trap formation of the Siberian platform, also the role of fluids during formation of basite-hyperbasite rocks is discussed. (Abstract by A.K.)

LETNIKOV, F.A., GLEBOVITSKIY, V.A., SEDOVA, I.S., VILOR, N.V., YAROSHCHUK, M.A., KASTRYKINA, V.M., MAKRYGINA, V.A., DRUGOVA, G.M. and SEMYONOV, A.P., 1980, Fluid regime of metamorphism: "Nauka" Publ. House, Novosibirsk, 192 pp., 1000 copies printed, price 2 rbls. 70 kopecks (in Russian).

Because formation of fluid inclusions in growing crystals is a relatively rare phenomenon, the prevailing amount of fluid components is fixed in defects of crystal lattice: vacancies and dislocations of submicroscopic size. The total fluid was analyzed by high-T gas chromatography with fluid release at T and P roughly similar to those occurring during rock formation. The determined fluid components were as follows: H_2O, CO_2, CO, CH_4, H_2, N_2; a total of over 500 samples were analyzed. Also few Th measurements for ultrametamorphic granites from Byelomorie complex were made: crystallized melt inclusions in granite minerals 820-980°C, P from CO_2 inclusions 7-9 kbar, same in hypersthene diorites 880-1080°C. The book discusses the general concept of the fluid regime of metamorphism and the detailed characteristics and discussion of the fluid regime (according to Letnikov) of formation of granulite and granulite-amphibolite complexes (Sutama, Larbin, the oldest metamorphism and ultrametamorphism of Byelomorie, and Sharyzhalgay), as well as amphibolite and greenschist facies rocks. The latter includes thermodynamic conditions and fluid regime of formation of the Muzkol' and Yazgulem complexes in the Central Pamirs, zonal metamorphic complexes of Khamar-Daban and metamorphic vein series of the Patom Highland, Krivoy Rog iron ore formation, zonal shallow-metamorphism rocks in the Takhtalyk Ridge (Middle Tyan'-Shan'), and metamorphic rocks from the Kokchetavskiy massif. (Abstract by A.K.)

LEVITSKIY, V.V., DEMIN, B.G.and POPIVNYAK, I.V., 1978, Physicochemical conditions of formation of ores in the Muy region (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1979, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 200-201 (in Russian). Authors at East Siberian Sci.-Res. Inst. of Geol., Geophysics and Mineral Raw Materials, Irkutsk, USSR.

Most of the ore bodies belongs to sulfide-low quartz-ore formation. Five stages of mineralization were distinguished - the first three stages formed from pneumatolytic-hydrothermal solutions, the last two stages from hydrothermal solutions: 1) dark quartz 450-350°C, 2) tourmaline-quartz >500-350°C, >1000-1100 atm, 3) pyrite-quartz >460-310°C, 600-700 atm, 4) ore sphalerite-galena 330-170°C, 950-820 atm, 5) quartz-carbonate 160-50°C. CO_2 displays important role in the commercial ore stage, when boiling was common. Other gases are H_2, CH_4 and N_2. (From the authors' abstract translated by A.K.)

LEVITSKIY, V.V., DEMIN, B.G., POPIVNYAK, I.V. and BABURIN, L.M., 1980, Gas phase of ore-magma systems: Dokl. Akad. Nauk SSSR, v. 254, no. 3, p. 712-714 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 254, 1980, p. 89-91 (1982). First author at East Siberian Res. Instit. Geol., Geophys. and Mineral Products, Irkutsk, USSR.

Various rocks were crushed under vacuum. Gas analyses obtained are stated in terms of H:C:N:O (and in part, CO_2). Samples used included kimberlites, granites, pegmatites, gold ores, and samples from the Kola ultradeep hole. (E.R.)

LEVITSKIY, V.V., VIKULOVA, L.P., DEMIN, B.G. and POPIVNYAK, I.V., 1980, Comparative analysis of gold-carbon sulfide-quartz ores and organometallic compounds: Dokl. Akad. Nauk SSSR, v. 255, no. 6, p. 1471-1476 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 255, 1980, p. 240-243 (1982). Authors at East Siberian Res. Instit. Geol., Geophy. & Econ. Minerals, Irkutsk, USSR.

LI, Binglun, XIE, Yihan, WANG, Yinglan and JIANG, Wenyu, 1980, Fast gas microanalysis for gas-liquid inclusions in mineral (abst.): Scientia Geologica Sinica, 1980, no. 1, p. 96 (in Chinese).

LI, Yingqing, RUI, Zongyao and CHEN, Laixian, 1980, Fluid inclusion and mineralization study of the Yu Long porphyry copper (molybdenum) deposit, eastern Tibet autonomous region (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 133-134.

By means of micro-heat stage, freeze stage, trace chemical analysis and general microscopy, the authors have studied type, frequency, size, temperature, pressure, salty, daughter minerals, ratio of gas to liquid, revivable boiling and composition of fluid inclusions in the Yu Long porphyry copper (molybdenum) deposit, Eastern Tibet autonomous region. From the data acquired, a series of very interesting problems such as the character of thermal fluid, physical-chemical condition, alteration, mineralization and its possible mechanism have been suggested.

In Yu Long porphyry copper (molybdenum) deposit, various minerals within the mineralized ores are rich in fluid inclusions. Inclusions of different types as gaseous, liquidous and poly-phase are usually associated together in the same sample or even the same mineral. In the monzonitic granite porphyry of the biotite-potash feldspar alteration the inclusions are dominantly gaseous and poly-phase; while in those porphyry with quartz-potash feldspar and quartz-sericitization alteration mainly poly-phase and a little gaseous and liquidous. In the monzonitic granite porphyry host rock of argillaceous alteration and the country rock of propylitic alteration periphery to the host body, the inclusions are principally liquidous and minor gaseous and poly-phase. But gaseous inclusions appear to be more dominant in the same country-rock while it overlies upon the intrusive body. The temperatures of homogenization of the inclusions mentioned above range from 180 to 600°C; the temperatures of deposition of Cu-Mo sulphides range from 250 to 420°C. From the center of the porphyry body to the wall-rocks the temperature of the mineralization decreases gradually. The salty of the fluid inclusions ranges from 6 to 56 wt%, but the high-salty poly-phase inclusions are concentrated only in the region of economic mineralization. The Cu-Mo sulphides deposited under the condition of the high salty fluid. The calculated pressures during homogenization range from 240 to 1800 atm. The revivable boiling of the fluids at the top of the porphyry body is manifested by an intimate coexistence of gaseous and polyphase inclusions.

The fluids in the inclusions belong to NaCl-KCl ($CaCl_2$, $MgCl_2$) -- $CaSO_4$ -- H_2O type. As indicated by our analysis the thermal fluids of the mineralization were rich in halogen, alkaline metals, but poor in base metals, sulphur, phosphorus and so on, with very high temperature (600°C) during initial stage. Such thermal fluids could have easily extracted the metals out from country rocks around the tunnel through which they rose. When they rose up and gathered into the top of the porphyry intrusive and its neighbouring wall-rocks, with the decrease of temperature, the alkali and hydrogen metasomatism took place inevitably, meanwhile brought about the deposition of metal sulphides. (Authors' abstract)

(Ed. note - the above is quoted verbatim rather than edited to avoid introduction of errors.)

LI, Zhaolin, ZHAO, Meifang, JIANG, Haishen and WU, Qi-Zhi, 1980, H_2O and CO_2 contents of fluid inclusions of granites and related ore deposits in South China: Geological Review, v. 26, no. 6, p. 538-540 (in Chinese).

The H_2O and CO_2 gases evolved on heating >400 samples of 14 granites and 5 ore deposits (including 2 of Nb and Ta, one of Ag, one of W, and one of Be) in South China were analyzed by using CXL-101 inorganic gas chromatograph. The H_2O content of fluid inclusions in different age granites ranges from 0.04 to 0.61%. The content of H_2O of fluid inclusions in pre-Caledonian age granites is higher than that in younger granites. The CO_2 contents of fluid inclusions in granites range from a trace to 0.2%. The content of CO_2 of fluid inclusions in 5 mineral deposits range from a trace to 0.31%. The CO_2 contents of fluid inclusions in rich ore is higher than that in others. (Abstract courtesy of Dr. Huanzhang Lu)

LI, Zhitong, 1980, Formative conditions of Tuanjieguo gold deposit and its type of genesis: Bull. of the Chinese Acad. Geol. Sci., Series V, v. 1, no. 1, p. 1-17 (in Chinese with English abstract).

Multi-stage hydrothermal activity, shown by different mineral assemblages and different grain sizes as well, is a notable characteristic of this important ore deposit. The temperature range of mineralization as determined by inclusion decrepitation method, is 315°C. The wall rock alteration is represented by silicification, K-feldspathisation, kaolinization and propylitisation. The alteration zoning is not well defined and telescoped alteration zoning is another notable feature of this ore deposit. The microscopic study of many ore specimens verifies clearly that the main gold mineralization took place at the low temperature and the gold precipitated together with chalcedony, adularia and colloid pyrite.

From the formative conditions of main mineralizing features of the deposit outline above, the genetic type of the Tuanjieguo gold deposit may be referred to be volcano-hydrothermal. (From the author's abstract)

LISTER, C.J., 1980, A fluid inclusion study of tourmalinization on Dartmoor (abst.): Min. Soc. Bull. (London), no. 46, p. 4.

The occurrence of a "luxullianite"-type tourmalinized rock in central Dartmoor may be attributed to in situ replacement of the original granite along a vertical vein-like structure. Fluid inclusion data indicate that the process of tourmalinization may have been associated with high temperature fluids (possible boiling) and salinities in the region of 50 wt.% NaCl. Comparison may be made between this example and other occurrences of tourmalinized rocks for which fluid inclusion data are available. (Author's abstract)

LITVINOVSKIY, B.A. and LETNIKOV, F.A., 1980, Evidence of participation of mantle fluids in granitoid magma generation, as inferred from gas analysis: Dokl. Acad. Nauk SSSR, v. 253, no. 2, p. 440-445 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 101-104 (1982). Authors at Geol. Instit., Buryat Br., Siberian Div., USSR Acad. Sci., Ulan Ude, USSR.

Gas chromatography was used to determine H_2O, CO_2, CO, CH_4 and N_2 (presumably released by heating) on a series of granitic and mafic rocks. (E.R.)

LOFGREN, G., 1980, Experimental studies on the dynamic crystallization of silicate melts: Chapt. 11 in Physics of Magmatic Processes, R.P. Hargreaves, ed.: Princeton, N.J., Princeton Univ. Press. p. 487-557.

Includes much on texture that is pertinent to silicate melt inclusion formation. (E.R.)

LONSDALE, P.F., BISCHOFF, J.L., BURNS, V.M., KASTNER, M. and SWEENEY, R.E., 1980, A high-temperature hydrothermal deposit on the seabed at a Gulf of California spreading center. Earth & Planet. Sci. Lett., v. 49, p. 8-20. First author at Marine Phys. Lab., Scripps Inst. Ocean., La Jolla, CA 92093.

A submersible dive on a turbidite-covered spreading axis in Guaymas Basin photographed and sampled extensive terraces and ledges of talc. The rock contains siliceous microfossils, smectite, and euhedral pyrrhotite as well as rather pure iron-rich talc. Sulfur and oxygen isotopes indicate precipitation around a hydrothermal vent, at about 280°C. (Authors' abstract)

LOUP, H., WILHELM, S. and SAGON, J.P., 1979, Rhythmic, epitaxial crystallization of alkali feldspars with entrapment of silicate liquid which recrystallized along growth planes in megacrystals from the Rostrenen

Granite (Brittany) (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France, p. 299 (in French).

LU, Huanzhang, 1980, A study on the inclusions in some rocks from Xizang (abst.): Symposium on Qinghai-Xizang (Tibet) Plateau, Academia Sinica, Beijing, China, May 25-June 1, 1980, Proceedings of Symposium on Qinghai-Xizang (Tibet) Plateau Abstracts, p. 33-35 (in English). Published by Scientific Pub. House, Peking. Author at Inst. Geochem., Academia Sinica.

Xizang (Tibet) volcanic and intrusive rocks contain a large number of glass and melt inclusions, as well as fluid inclusions. All these inclusions are representatives of magmas and silicate melts, and later hydrothermal fluids respectively, from which the rocks were derived. Glass inclusions mainly occur in volcanic rocks whereas melt inclusions are only found in intrusive rocks, such as granites, diorites, olivinfels, etc. In this work, the author has found for the first time liquid ring-bearing glass inclusions in acid volcanic rocks(sic.), which provide strong evidence of the development from magma to hydrothermal solution, and made an investigation into the cooling history of these rocks with reference to magmatic inclusions.

The results obtained by the homogenization and the quenching method are given in a table. The homogenization temperatures are in the range of 750-1250°C. The homogenization temperatures of volcanic rocks or hypabyssal rocks are higher than those of intrusive rocks, while those of intermediate-basic rocks are much higher than those of acid rocks. Heating experiments show that the temperatures of appearance and disappearance of daughter minerals can be used as indicators of the upper and lower limits of crystallization temperatures of rocks.

Based upon the foregoing discussion and compared with Nanling granites and Suzhow granites, it is concluded that Xizang rocks under consideration are of magmatic origin. (Author's abstract)

LU, Huanzhang, JIANG, Bangjie and SUN, Xinyi, 1980, Application of inorganic gas-chromatography to research on fluid inclusion composition: Geochimica, 1980, no. 1, p. 106-110 (in Chinese with English abstract).

Inorganic gas chromatography using the CXL-101 apparatus is characterized by high sensitivity, high speed, small quantity of sample required, less adsorption, and reliability of the results. It is especially suitable for the determination of H_2O and CO_2 in fluid inclusions. H_2O and CO_2 contents in fluid inclusions of 41 samples were measured by this instrument from a number of types of tungsten and quartz deposits. Regular variation has been found in the content of H_2O, i.e., it decreases with decreasing distance from the parent rock, or with increasing temperature, and vice versa. This regularity may be ascribed to the origin of fluid, distance between parent rock and ore deposit, temperature of formation, changes in the way of fluid movement, and the nature of country rocks. (Authors' abstract)

LUCIDO, G., NUCCIO, P.M., LEONE, G. and LONGINELLI, A., 1980, Amygdaloidal basalts: isotopic and petrographic evidence for non-diagenetic crustal source of carbonate inclusions: Tschermaks Min. Petr. Mitt., v. 27, p. 113-128. First author at Istit. Min., Pet. Geochim., Univ. Palermo, Italy.

Even though carbonate amygdules in volcanics are generally assumed to be diagenetic in origin, the authors are of the opinion that almost all carbonate inclusions in the investigated amygdaloidal volcanic rocks from Sicily (Italy), Pindos (Greece) and Bohemia (Czechoslovakia), have a different origin. On the basis of a mineralogical, petrological and geochemical study these "amygdules" are interpreted as being remains of magmatic incorporation of carbonate. Therefore, the identification of carbonate globules in volcanics purely on field observations, is inadequate to distinguish true amygdules from carbonate assimilation remnants.

A nomenclature of the various types of inclusions is proposed.

The isotopic data suggest that the incorporation of carbonatic material by magma could have taken place without any significant modification of the isotopic composition of the carbonate. This study suggests that limited amounts of carbonate could be dissolved in alkali basalt magma; the further addition of moderate amounts of carbonate develops liquid immiscibility.

Our inclusions, in agreement with the experimental evidence (Wyllie, 1974), are contrary to the limestone syntexis hypothesis for the generation of feldspathoidal magmas from subalkaline magmas. A possible model of interaction between magma and carbonate is also suggested. (Authors' abstract)

LUCKSCHEITER, B. and MORTEANI, G., 1980a, The fluid phase in eclogites, glaucophane-bearing rocks and amphibolites from the central Tauern Window as deduced from fluid inclusion studies: Tschermaks Min. Petr. Mitt., v. 27, p. 99-111.

Fluid inclusions in rock-forming quartz and in quartz from veins and Alpine fissures from eclogites and glaucophane bearing rocks of the southern Grossvenediger area as well as from amphibolitized eclogites and calcareous mica schists from the Grossglockner area (Austria) have been studied by microthermometry. The oldest fluid inclusions in the eclogites contain only CO_2 and are characterized by a very high density up to 1.15 g/cm^3. From eclogite forming temperatures in the range of 500 to 550°C a trapping pressure of about 8 kb results for these inclusions. This pressure is in good agreement with that derived from the eclogite-forming mineral reactions. The amphibolites formed by retrogressive metamorphism from the eclogites show fluid inclusions containing H_2O and CO_2, the densities of the CO_2 being much lower compared to those of the fluid inclusions form the unaltered eclogites. (Authors' abstract)

LUCKSCHEITER, B. and MORTEANI, G., 1980b, Microthermometrical and chemical studies of fluid inclusions in minerals from Alpine veins from the penninic rocks of the central and western Tauern Window (Austria/Italy): Lithos, v. 13, p. 61-77. First author at Hahn-Meitner-Inst. für Kernforschung Berlin GmbH, Bereich Kernchemie und Reaktor, Glienicker Str. 100, 1000 Berlin 39.

The fluid inclusions in samples of quartz, apatite, epidote, diopside, beryl and phenakite from Alpine veins in gneisses, amphibolites and mica schists from the western Tauern Window were analyzed by microthermometrical, chemical and neutron activation methods. The inclusions of the eclogites contain a high density CO_2 phase without optically detectable H_2. In the Greiner Schieferserie the fluid inclusions show high CO_2/H_2O ratios and low salt contents. In the Zentralgneis area inclusions with low CO_2/H_2O ratios and high salt contents are typical. In the calcareous mica schists of the lower Schieferhülle, in the eastern part of the investigated area, generally no CO_2 could be detected in the inclusions. These inclusions contain aqueous solutions showing a low salt content. The only CO_2-bearing inclusions observed here were in the graphite-rich rocks of the so-called Habachzungen and in the eclogites from south of the Grossvenediger. Trapping pressures estimated from the fluid inclusions are up to 7.5 kbar in the eclogites, but in general the pressures are between 2 and 4 kbar. These pressure data are in good agreement with the pressure data of mineral equilibria. The chemically analyzed elements in the fluid inclusions are Na, K, Cs, Mg, Ca, Mn, As, Cl and Br. From the K/Na ratios temperatures between 435 and 490°C can be deduced. The very low Cl/Br ratios (<110) suggest that the dissolved elements came from the country rocks. The alkali/chlorine ratios (~1) indicate tht the positive loadings of the cations are balanced by Cl. (Authors' abstract)

LUDINGTON, Steve and DESBOROUGH, George, 1980, Unique low-pressure hydrothermal alteration at Big Southern Butte, Snake River Plain, Idaho (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 279.

Big Southern Butte is a Quaternary rhyolite dome in the central Snake River Plain, Idaho. K-Ar ages reported by M.A. Kuntz (1978, USGS Open-File Report 78-302) suggest an emplacement age of 300,000 years B.P. This young age, coupled with geomorphic evidence, suggests minimal erosion and, thus, very low pressures (<10 bars?) of emplacement.

Several areas of altered rhyolite on the butte exhibit the assemblage quartz + albite + zircon ± halite ± specular hematite ± aluminum hydroxy-fluoride $[Al(OH,F)_3 \cdot nH_2O]$, hereafter termed AHF, which has a crystal structure very similar to that of ralstonite.

Both obsidian and fresh lithoidal rhyolite are characterized by high concentrations of Rb (250-270 ppm), Y (100-160 ppm), and Nb (270-280 ppm), all of which are elements enriched in the upper parts of large magma chambers by diffusion differentiation (Smith and MacDonald, 1979, GSA Abstr. with Prog., v. 11, p. 520). Altered rhyolite may contain more than 1000 ppm Rb and Nb, as much as 300 ppm Sn, and several percent Cl and F.

The presence of AHF instead of topaz or any phyllosilicates indicates extremely high activity ratios of HF to H_2O. This interpretation is supported by the presence of significant amounts of halite, which is highly soluble in aqueous fluids. High activity of HF also apparently facilitated vapor-phase transport of Zr, as shown by zircon in vugs in the lithoidal rhyolite.

The alteration assemblages formed in a fumarole-like environment as a result of the release of very fluorine-rich fluids, either from crystallizing maga, or from obsidian undergoing devitrification. (Authors' abstract)

LYAKHOV, Yu.V., 1980, Paleotemperature zoning of ore fields, <u>in</u> Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 20-30 (in Russian).

Heat fields present during formation of post-magmatic deposits, as appears from thermobarogeochemical data, had significant T gradients occurring when the whole ore-formation process developed. Variation of T gradients is the most significant in the shallow deposits (6-10°C per 100 m vertically and 1-10°C horizontally) and less for the moderate depths (7-20°C but most frequently 12-16°C per 100 m vertically and 1-5°C horizontally). This phenomenon is explained by thermostatic properties of overlying rocks for the hydrothermal systems. (Author's abstract translated by A.K.; note: the lecture was not abstracted in the Abstract volumes of the Vladivostok Meeting 1978.)

LYON, G.L., 1974, Geothermal gases: In Natural gases in sediments, I.R. Kaplan, ed.: New York, Plenum Press, p. 141-150. Author at Inst. Nuclear Sciences, Dept. Scientific and Industrial Research, Lower Hutt, New Zealand.

The major components of geothermal gases are steam and carbon dioxide. At high temperatures, chemical and isotopic equilibrium will be established, but as the gases cool, equilibrium conditions are not maintained. Interaction of gases with wet sediments will result in a gas mixture consisting of methane, hydrogen, nitrogen and rare gases. (Author's abstract)

LYUBINETSKAYA, A.V., 1980, Conditions of formation of organic carbon-bearing mineral and substances at the Slavyanskoe mercury ore mineralization, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 200-203 (in Russian).

See Zatsikha and Lyubinetskaya, Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980. (A.K.)

LYUBINETSKAYA, A.V., ZATSIKHA, B.V., SHABO, Z.V. and MAMCHUR, G.P., 1980, Nature and genetic peculiarities of organic minerals and substances of the Slavyanskoe mercury mineralized area: Mineralog. Sborn., v. 34, no. 1, p. 32-39 (in Russian, English abstract). First author at Inst. of Oil and Gas, Ivano-Frankovsk, Ukrainian SSR.

The Slavyanskoe deposit occurs in the NW part of Donbass, in sandstones and in brecciated rocks of a salt stock. Calcite of the deposit yielded Th 200-130°C (cement of the breccia) and 130-120 and 100-70°C for various habit crystals associated with cinnabar. Quartz forms two generations: prismatic milky and dark (black) crystals (Th 260-290°C) and colorless crystals (Th 155-100°C), the latter paragenetic with cubic habit fluorite. Earliest octahedral fluorite yielded Th 410-415°C, P $440 \cdot 10^5$ to $560 \cdot 10^5$ Pa, and the intermediate cubooctahedral - Th 240-225°C. Main mass of cinnabar occurs with calcite of Th 130-120°C, but also trapped cinnabar crystals occur in G/L inclusions in quartz (Th 205-245°C) and in pyrite. Paragenetic ties occur also between cinnabar and sphalerite plus organic substance. Organic substance was found in solid, L and G state, also in aqueous G/L inclusions in minerals; the inclusions frequently contain halite dms. Water leachates from fluorite, quartz and calcite yielded composition of mineral-forming solutions (in G/L): Cl 240-260, SO_4 nil to 5, Ca 50-150, Na 150-200 or not determined(?), K not found to 5, Mg not found to 36; gases, vol. %: CO_2 44.5-54.0, N_2 10-20, O_2 not listed to 5.2, H_2 2.6-17.4 or not listed, H_2S 0.3 or not listed, CH_4 9.8 to 55.5, C_2H_5 0.1 or not listed, C_3H_8 0.05 or not listed. The deposit bears also whewellite, Th of inclusions 60°C. (Abstract by A.K.)

McCARTHY, T.S. and JACOBSEN, J.B.E., 1980, Additional geochemical data on the Messina copper deposits, Transvaal, South Africa - A discussion: Econ. Geol., v. 75, p. 478-481.

A criticism of a paper by Sawkins and Rye (1979, abstract in Fluid Inclusion Research -- Proceedings of COFFI, v. 12, p. 169). See Sawkins and Rye, 1980 (this volume) for rebuttal. (E.R.)

MACDONALD, K.C., BECKER, Keir, SPIESS, F.N. and BALLARD, R.D., 1980, Hydrothermal heat flux of the "black smoker" vents on the East Pacific Rise: Earth & Planet. Sci. Letters, v. 48, p. 1-7. First author at Dept. Geol. Sci. & Marine Sci. Inst., Univ. Calif., Santa Barbara, CA 93106.

Active hydrothermal vents have been discovered on the East Pacific Rise at 21°N. The most spectacular of the vents jets out 350°C water at flow rates of several meters per second. The heat loss associated with a single vent of this type is three to six times the total theoretical heat loss for a 1-km segment of ridge out to 1 m.y. age. This underscores the importance of hydrothermal circulation in the heat budget of mid-ocean ridges. It also requires that vent activity of this type be highly episodic rather than steady state. (Authors' abstract)

MACKEVETT, E.M., Jr., ARMSTRONG, A.K., POTTER, R.W., II, and SILBERMAN, M.L., 1980, Kennecott-type copper deposits, Wrangell Mountains, Alaska--an update and summary (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 117.

Kennecott-type deposits are stratabound, massive, copper-sulfide-rich lodes confined to the partly dolomitic intertidal, supratidal and sabhka facies of the lower 130 m of the Late Triassic Chitistone Limestone, which disconformably overlies Nikolai Greenstone and is paraconformably overlain by open-marine carbonate rocks. The Nikolai consists of altered tholeiitic basalt with an intrinsic copper content of 155 ppm. Both units are part of the allochthonous Wrangellia terrane. Ore bodies at Kennecott are localized along the fault-wedges. Solution collapse breccias occur near many deposits. Sulfide ore phases of the CuS-Cu_2S system generally exceed oxide ore 3 to 1. High copper and sulfur, low iron content, important by-product silver, minor gangue, and generally sharp wall-rock contacts characterize ore. Malachite and azurite are widely distributed throughout all known deposits, and extend to the deepest workings. Fluid inclusion and mineralogic studies, corroborated by oxygen isotope measurements, suggest that ore formed at temperatures of 90° ± 10°C. The deposits probably reflect filling of voids and caverns subsequent to karstification, with copper derived from the Nikolai. Limited sulfur isotope data permit derivation of sulfur from algal mat decay or evaporite sulfate alteration. Whether ore formed during the interval marked by the paraconformity in the lower Chitistone or during later alteration and weak metamorphism of the Nikolai, concomitant with accretion of Wrangellia, is not known. (Authors' abstract)

McLIMANS, R.K., BARNES, H.L. and OHMOTO, H., 1980, Sphalerite stratigraphy of the upper Mississippi Valley zinc-lead district, southwest Wisconsin: Econ. Geol., v. 74, no. 3, p. 351-361.

Sphalerites in the ore of the upper Mississippi Valley zinc-lead district exhibit color banding. This banding is uniform across the district and a sphalerite stratigraphy can be described. The stratigraphy can be divided into three stages: A (early), B (middle), and C (late). It is possible to correlate individual bands over a few hundred meters in an orebody, and certain bands may be correlated many kilometers across the ore district.

The color of the sphalerite bands is related to the FeS content. Light colors correspond to a low FeS content and dark colors to a high FeS content. The variability of the FeS content within any single band is small, suggesting the existence of uniform chemical conditions during deposition of any band across the district.

Ore textures and the uniformity of the sphalerite stratigraphy across the district during any ore deposition interval are more compatible with ore formation from a fluid carrying both metals and sulfur than from mixing of metal-rich and sulfur-rich fluids of different origin. (Authors' abstract)

MAHON, W.A., McDOWELL, G.D. and FINLAYSON, J.B., 1980, Carbon dioxide: its role in geothermal systems: New Zealand J. Sci., v. 23, p. 133-148. Authors at Chem. Div., Dept. Sci. and Ind. Res., Wairakei, New Zealand.

Carbon dioxide is probably the most important constituent, apart from hot water, present in geothermal systems. It influences to a major extent the chemical and physical characteristics and properties of a system. The chemical composition and pH of hot water together with hydrothermal rock alteration and deposition of secondary minerals are strongly influenced by the concentrations of carbon dioxide. Sodium bicarbonate sulphate waters, which are frequently present in large volumes in geothermal systems, are produced by the movement of carbon dioxide and hydrogen sulphide through cold meteoric waters.

The density of fluids and the fluid content of rocks in a geothermal system are influenced by the presence and concentration of carbon dioxide. Gassing and degassing of a system can have a marked effect on the bulk hydrology of the system and the movement of fluids within the system. The thermal gradients and the depths to given temperatures are influenced by carbon dioxide concentrations. Free carbon dioxide gas can effectively decrease the porosity of rocks available to water and allow complete evaporation of water in a very porous medium, when thermal equilibrium between all phases exists.

Carbon dioxide can control the discharge behavior of wells and is considered by the authors to be a critical component in determining whether a system produces steam or a steam/water mixture. It explains how "vapor dominated systems" could be formed and the apparent similarity of temperature and pressures within these systems in the early stages of exploitation. It is notable that the well known "vapor dominated systems" all contain relatively high concentrations of carbon dioxide per unit mass discharge. It is considered that some geothermal systems are controlled more by the presence of carbon dioxide than they are by the presence of free steam.

The thermal contribution from carbon dioxide to a geothermal system is probably considerable. Similarly, the movement of a carbon dioxide rich vapor phase can have a marked influence on shallow fluid temperatures and the formation of temperature inversions within the system. (Authors' abstract)

MAKAGON, V.M., TAUSON, L.S. and KUZ'MINA, T.M., 1980, Physico-chemical conditions of pegmatite formation with different ore specialization in E. Siberia, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 37-40 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 11, 1978, p. 130-131, Makagon et al. (A.K.)

MAKAGON, V.M., VAKHRUSHEV, V.A. and SINITSKAYA, Ye.G., 1978, Temperature regime of crystallization of amethyst in Angaro-Kat iron ore deposits

(Siberian Platform), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 158-159 (in Russian). Authors at Geochem. Inst. of Siberian Branch of Acad. Sci. USSR, Irkutsk, USSR.

Amethyst mineralization in the Angaro-Kat magnetite deposit is connected with quartz-calcite veins. Th for amethyst from the base to the top of the crystal varied over the intervals 400-380, 415, 385-375, 420-400 and 310°C. Most quartz formed at 390-330°C. (A.K.)

MAKHOV, S.F., 1980, Methods for the sampling of water from gas-liquid inclusions for the isotopic analysis of oxygen and hydrogen: 80-i Vses. Simpoz. po Stabil'n. Izotopam v Geokhimii, Moskva, 1980, p. 267-268 (in Russian).

MAKIYEVSKIY, V.P., 1978, Mineral-formation parameters at the skarn Pb-Zn deposits of the Dal'negorsk* region (Primorie) (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2. Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 115-116 (in Russian). Author at Far East Geol. Inst. of Far East Sci. Center of Acad. Sci. of USSR, Vladivostok.

Numerous studies gave Th in sphalerite 370-50°C (80% of deposits at 300-150°C) and Th pertinent to galena crystallization 330-40°C (80% of deposits at 280-140°C). For the Nikolaevskoe deposit ore solutions were of $Ca-HCO_3-CO_2$ type, gas content up to 178 mole/l, inclusions in sphalerite contain also NH_3. At the Sadovoe deposit inclusions contain the same ions as at Nikolaevskoe plus F, and gases are mostly CO_2-N_2. (A.K.)

*Kal'negorsk-formerly famous Tietiukhe ore region. (A.K.)

MAKIYEVSKIY, V.P., 1979, Thermobaric conditions of formation of gold ore deposit, p. 190-191 in: Geology of the continent margins, Publ. House of Far-East Sci. Center, Vladivostok, 208 pp., 800 copies printed, price 1 rbl. 90 kopecks (in Russian). Author at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

Inclusions in quartz and calcite from the unnamed Au deposit were studied by homogenization technique (±5°C) and P determinations were made by the Naumov-Malinin and Lemmlein-Klevtsov methods. Three stages of deposit formation were distinguished: 1) hydrothermal-metasomatic with origin of Au-quartz and Au-adularia-quartz veins, Th 380-145°C, carbonate veins, Th 320-155°C, P in this stage varied from 800 to 200 atm; 2) skarn-hydrothermal stage with magnetite-quartz, Th 390-95°C and sulfide quartz veins, Th 340-105°C, P 900-180 atm; 3) hydrothermal stage with formation of tourmaline-feldspar-quartz veins, Th 290-105°C, P 800-250 atm, and tourmaline-quartz veins, Th 315-125°C. (Abstract by A.K.)

MALYSHEV, A.G. and SKOBEL', L.S., 1978, Relation between certain features of fluoroapatites from rock-crystal cavities and their temperature of formation, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 147 (in Russian). Aurthors at VNIISIMS, Alexandrov, USSR.

Th for fluoroapatite from quartz veins of Pripolyarnyi Ural was 150-200°C; from pegmatites of Kazakhstan - 285-290°C; from E. Africa - 355 and 215°C. Mn content in apatite increases with Th increase (from 0.05 in the

Ural to 1-2% in the E. Africa) and its color changes simultaneously from pale blue to deep blue and cherry-smoky. Lattice parameters do not change with Th. (Authors' abstract translated by A.K.)

MAMCHUR, G.P., 1980, Abiogenic hydrocarbon synthesis in kimberlite pipes, as revealed by isotope distribution in carbon: Dokl. Akad. Nauk SSSR, v. 252, no. 4, p. 974-977 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 163-165 (1982).

MAMETOV, V.M. and GALABURDA, Yu.A., 1980, Conditions of formation of quartz-sulfide mineralization of the upper sedimentary complex of the Beregovskoe deposit (Transcarpathia): Mineralog. Sborn., v. 34, no. 2, p. 91-94 (in Russian, English abstract). First author at Inst. Geol. and Physics of Minerals, Kiev, Ukrainian SSR.

Quartz-sulfide veinlets in sedimentary-pyroclastic beds consist of galena, sphalerite, and subordinate chalcopyrite, pyrite, covellite, anglesite, cerussite chalcocite, adularia and kaolinite in quartz matrix. Quartz bears P and S inclusions; P ones occur a) in crystals or b) between induction faces of two neighboring quartz crystals. Inclusions (a) are essentially G, no phase changes down to T -195°C, inclusions (b) are two-phase, as well as some inclusions inside crystals, Th = 236-248°C in L, S inclusions yielded Th 152-198°C in L. Inclusions in sphalerite (P) have Th 230-235°C in L. Parent solutions of quartz and sphalerite were heterogeneous. (Abstract by A.K.)

MANN, A.W. and DEUTSCHER, R.L., 1980, Solution geochemistry of lead and zinc in water containing carbonate, sulphate and chloride ions: Chem. Geol., v. 29, p. 293-311.

MANUCHARYANTS, B.O., KNYAZYEVA, S.N. and PRUSHINSKAYA, E.Ya., 1978, Genesis of gold-antimony ore occurrences in North-Eastern Yakutia (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 199-200 (in Russian). First author at Inst. of Mineralogy and Geochem. of Rare Elements, Moscow, USSR.

The ore occurrences have tectonic control. Main minerals are following - quartz, antimonite and berthierite; antimonite/berthierite ratio varies strongly. T range of formation determined by Th is 350-145°C, P - 1600-600 atm, the main gold-antimonite association formed at 250-170°C, native antimony - at 280-350°C. Minerals crystallized from weakly acid solutions. Gas chromatography of inclusions in quartz, antimonite and berthierite showed that CO_2 was the main gas in solution (2-15 moles/liter); CH_4 content ranges from 0.05 to 0.9 moles per liter, moreover N_2, CO and very rarely H_2 were found. (Abstract by A.K.)

MARAKUSHEV, A.A., 1980, Genesis of chromite ores and wall-rock ultrabasites: Geol. Rudn. Mest., v. 22, no. 1, p. 3-23 (in Russian). Author at Moscow State Univ., USSR.

The paper contains discussion of immiscibility of chromite ores. Pertinent to melt inclusion studies. (A.K.)

MARKOVA, E.A., CHERNITSOVA, N.M., BORODAEV, Yu.S., DUBAKINA, L.S. and YUSHKO-ZAKHAROVA, O.Ye., 1980, New mineral kolymite (Cu_7Hg_6): Zapiski

Vses. Min. Obshch., v. 109, no. 2, p. 206-211 (in Russian).

The mineral was found in the deposit Krokhalinoe (Magadan region, Kolyma River basin), in quartz porphyry with sulfide mineralization. Kolymite crystallized in quartz-antimonite association (Th in quartz 240-140°C), most probably at ~140°C. (A.K.)

MARSHALL, Brian and TAYLOR, B.E., 1980, Origin of hydrothermal fluids responsible for gold deposition, Alleghany district, Sierra County, California (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 118. Authors at Dept. Geol., Un. California, Davis, Calif. 95616.

The Alleghany district is characterized by steep to shallow dipping quartz veins up to 40 feet thick which are associated with large serpentine bodies. The wall rocks are altered schist, granite, gabbro, and amphibolite. Alteration minerals present are quartz, dolomite, mariposite, serpentine, talc, ankerite, and calcite. Sulfides include pyrite, arsenopyrite, jamesonite, and galena; gold is usually associated with arsenopyrite or galena.

Vein quartz varies in its oxygen isotope composition ($\delta^{18}O_{SMOW}$ values) from +16 to 22‰. Quartz-carbonate pairs yield isotopic temperatures of 320 to 350°C, and serpentine-magnetite pairs 328°C (antigorite) and 282°C (antigorite plus lizardite). Calculated $\delta^{18}O$ values for a fluid in isotopic equilibrium with the quartz at 320°C range from +11.5 to +15.8‰.

Fluid inclusions in quartz can be divided visually and isotopically into primary and secondary types; hydrogen isotope compositions (δD_{SMOW} values) range from -84 to -47‰, and primary inclusions yield the less negative values. A meteoric component was added to the fluid in places, and appears to be associated with high grade gold deposits and with lizardite in serpentinites. CO_2 in fluid inclusions ($\delta^{13}C_{PDB}$ = -4.3 to -1.9‰) was probably derived from the mantle and contaminated by CO_2 from decarbonation reactions.

Gold in the deposits may have originated in the serpentinized ultramafic rocks. Antigorite and quartz crystallized in the same hydrothermal system at temperatures on the order of 320°C. The hydrothermal fluid was deep-circulating, exchanged its oxygen with chert (or other biogenic silica), and contained mantle-derived (CO_2), metamorphic (H_2O, CO_2), and meteoric (H_2O) components. (Authors' abstract)

MARSHALL, W.L., 1980, Amorphous silica solubilities - I. Behavior in aqueous sodium nitrate solutions; 25-300°C, 0-6 molal. Geochim. Cosmo. Acta, v. 44, p. 907-913.

MARTINEZ, J.D. and KUMAR, M.B., 1980, Thermal migration of formation waters in salt domes: EOS, Trans. Am. Geophys. Union, v. 61, no. 47, p. 1177-1178.

Includes a discussion of the possibility of natural migration of fluid inclusions into domal salt as a result of thermal gradients. (E.R.)

MASI, U., FERRINI, V., O'NEIL, J.R. and BATCHELDER, J.N., 1980, Stable isotope and fluid inclusion studies of carbonate deposits from the Tolfa Mountains mining district (Latium, Central Italy): Mineral. Deposita, v. 15, p. 351-359. First author at Instit. di Geochimica, Univ. di Roma, Italy.

Continued next page.

Carbon and oxygen isotope analyses were made of representative samples of calcite and quartz from the carbonate deposits in the Tolfa Mountains mining district. Measurements were also made of hydrogen isotope compositions, filling temperatures and salinites of fluid inclusions in these minerals. There are three stages of mineralization at Tolfa. In stage I, characterized by calc-silicate hornfels, the carbonates have relatively high $\delta^{18}O$ values of 14.5 to 21.6 suggesting a rather low water/rock ratio. $\delta^{13}C$ values of -0.3 to 2.1 indicate that appreciable decarbonation or introduction of deep-seated carbon did not occur. Stage II is marked by phanerocrystalline carbonates; $\delta^{18}O$ values of 13.1 to 20.0 and $\delta^{13}C$ values of 0.7 to 5.0 identify them as hydrothermal veins rather than marbles. δD values of -56 to -50 for inclusion fluids suggest a possible magmatic component to the hydrothermal fluid. Filling temperatures of coarse-grained samples of Calcite II are 309° to 362°C with a salinity range of 5.3 to 7.1 weight percent NaCl. Calculated $\delta^{18}O$ values of 11-12 for these fluids are again indicative of low water/rock ratios. The sparry calcites of stage III have $\delta^{18}O$ and $\delta^{13}C$ values of 8.1 to 12.9 and -1.7 to 3.2, respectively. δD values of inclusion fluids are -40 to -33, clearly heavier than in earlier stages and similar to values of modern local ground waters. A salinity measurement of <0.1 weight percent NaCl in a sample of Calcite III is compatible with a relatively unaltered ground water origin for this fluid. Precipitation of the sparry calcite took place at much lower temperatures, around 160°C. For quartz, $\delta^{18}O$ values of 9.3 to 12.4 and δD values for inclusions of -53 to -28 are consistent with its late occurrence and paragenetic link with associated carbonates. (Authors' abstract)

MASI, U. and O'NEIL, J.R., 1980, Stable isotope variations in the Quaternary epithermal calcite-fluorite deposit at Monte delle Fate near Cerveteri (Latium, Central Italy). Mineral. Deposita, v. 15, p. 41-45. First author at Instit. di Geochimica, Univ. di Roma, Italy.

Carbon, oxygen and hydrogen isotope variations have been measured in samples from the epithermal fluorite vein deposit at Monte delle Fate, Latium. The ranges in $\delta^{13}C$ and $\delta^{18}O$ of calcite are -1.3 to 3.4 and 9.5 to 17.3, respectively. δD values of water extracted from fluid inclusions are -49 to -39 for calcite and -41 to -34 for fluorite. Fluid inclusion filling temperatures (225°-240°C) and salinities (3.75) are nearly the same for both fluorite and sparry calcite. An elongated form of calcite, of minor abundance, precipitated at lower temperatures. The data indicate that (1) the CO_2 involved in the mineralization was provided by the local marine limestones, (2) the waters were meteoric in origin and underwent an ^{18}O shift of ~10 permil by exchange with marine country rocks, and (3) all geochemical features can be explained by the action of two hydrothermal fluids. Hot brines recently discovered in the Cesano geothermal area, 30 km to the east, have temperatures and some chemical characteristics similar to the hydrothermal fluids at Monte delle Fate. (Authors' abstract)

MATASUHISA, Yukihiro, SATO, Noritaka and TAKENOUCHI, Sukune, 1980, Oxygen isotopic composition of vein quartz from the Akenobe mine, southwest Japan and the origin of the ore solution: A preliminary report: Mining Geol., v. 30, no. 4, p. 251-254 (in Japanese).

$^{18}O/^{16}O$ ratios and homogenization temperatures of fluid inclusions were determined for five quartz samples collected from veins in the Akenobe polymetallic deposits, southwest Japan. The $\delta^{18}O$ values (relative to SMOW) of quartz range from +0.4 to +1.8‰. The homogenization temperatures of fluid inclusions, which are estimated to be primary, are in a range of 260 to 320°C. $\delta^{18}O$ values of -8.0 to -4.5‰ are calculated for thermal waters equilibrated with the quartz by utilizing the above data and quartz-water isotopic fractionation. The low $\delta^{18}O$ values of thermal waters indicate that the waters are primarily of meteoric origin.

A positive correlation between oxygen isotopic composition of thermal waters and homogenization temperatures of fluid inclusions is observed. This correlation suggests mixing of ^{18}O-poor, low-temperature meteoric water with ^{18}O-rich, high-temperature magmatic water. If a simple mixing model is assumed, the proportion of meteoric waters in the thermal waters is as high as 80 to 100%. Some modification of isotopic composition of waters may also have been produced by reaction with hot rocks. (Authors' abstract)

MATHEZ, E.A. and DELANEY, J.R., 1980, The distribution of primary carbon in submarine basalt glass (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 405.

Fresh submarine basalt glasses from the FAMOUS area and from near the Bouvet Islands contain a reduced form of carbon concentrated (1) in bubbles and microcracks in glass (melt) inclusions in phenocrysts, (2) on walls of vesicles in matrix glass, and (3) along cracks in phenocrysts and matrix glass. The carbon distribution was studied using specialized microprobe techniques on Al-coated mounts prepared in a non-carbon bearing medium.

Many carbon bearing melt inclusions contain bubbles and quench-produced microcracks which do not penetrate host crystals. These inclusions appear to have remained completely isolated from the outside environment since entrapment, indicating that the inclusion carbon is primary and suggesting, by analogy, a primary origin for carbon in matrix cracks and vesicles as well.

In cooling cracks in matrix glass, carbon appears as semicontinuous dendritic masses. In vesicles it forms an irregular coating on walls and on sulfide globules protruding from these walls. The carbon possesses optical properties of graphite, and x-ray signals corresponding to >50 wt.% carbon can be generated from crack and vesicle surfaces. However, neither detailed study of characteristic x-ray spectra nor SEM examination of surface morphologies haved allowed specific identification of this phase. It is probably an intimate mixture of graphite and amorphous material.

The presence of a reduced form of carbon explains the self-reducing phenomenon observed in many intrinsic fO_2 measurements. However, because carbon deposition occurred during quenching, its presence does not provide direct information on magmatic redox conditions. (Authors' abstract)

MATHEZ, E.A. and DELANEY, J.R., 1980b, On the distribution and concentration of carbon in melt inclusions in submarine basalts (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 135-136.

See preceding item. (E.R.)

MATKOVSKIY, O.I. and STEPANOV, V.B., 1978, Temperatures of formation of gold ore mineralization in metamorphic complexes of Eastern Carpathians (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 215-216 (in Russian). Authors at L'vov State Univ., L'vov, Ukrainian SSR.

Gold is connected with sulfide-poor quartz and quartz-carbonate lenses in metamorphic rocks of the Delovets complex formed under conditions of greenschist facies metamorphism. Native gold occurs with quartz, pyrite, pyrrhotite, chalcopyrite, sphalerite and galena, and layer silicates (muscovite, sericite, chlorite). Gold ore quartz is distinctly granular (granoblastic); S G/L inclusions connected with fractures homogenize at 200-190°C. PS inclusions in wedge-shaped fractures (sic) homogenize at 265-220°C. Individual single inclusions have Th 380-315°C. Td are very similar to Th. Above data are the basis for distinguishing gold-quartz and overlapping gold-quartz-sulfide and gold-quartz-mica stages of mineralization. (Authors' abstract, translated by A.K.)

MATROSOV, I.I., 1980, Problem of stage formation of rare-metal pegmatites. I. Junction of formation of metasomatic complexes and stages of the process: Geologiya i Geofizika, no. 6, p. 44-55 (in Russian, English abstract). Author at Tomsk State Univ., Tomsk, USSR.

The paper bears some literature data on fluid inclusions. (A.K.)

MATSUBAYA, Osamu, SAKAI, Hitoshi, TORII, Tetsuya, BURTON, Harry and KERRY, Knowles, 1979, Antarctic saline lakes-stable isotopic ratios, chemical compositions and evolution: Geochim. Cosmo. Acta, v. 43, p. 7-25.

MATYASH, I.V., KALINICHENKO, A.M. and PASAL'SKAYA, L.F., 1980, Gas constituents in mantle rocks of the Ukraine: Geokhim. Rudoobraz., v. 8, p. 98-102 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

MAUGH, T.H., II, 1980, Separations by MS speed up, simplify analysis: Science, v. 209, p. 675-677.

This new method, known as tandem mass spectrometry and by a variety of names including MS/MS and MIKES, uses one mass spectrometer to ionize and separate the components of a mixture, and a second produces a mass spectrum of each component. It has great potential, even in the sub-picogram range. (E.R.)

MAXIMOV, S.P., PANKINA, R.G., GURIEVA, S.M. and ZAPIVALOV, N.P., 1980, Carbon isotopy of CO_2 of gases of the Western Siberia in relation to its genesis: Geokhimiya, 1980, no. 7, p. 992-998 (in Russian).

MAZUROV, M.P., 1980a, Parageneses and conditions of formation of garnets in skarn-magnetite deposits of folded areas : Theoretical and genetic mineralogy (Transactions of the W. Siberian Division of the All-Union Mineralogical Society), v. 8, p. 63-69, "Nauka" Pub. House, Novosibirsk (in Russian).

Garnets, collected mostly in the skarn-magnetite deposits of the Altae-Sayan area, bear polyphase fluid inclusions with solid mineral inclusions: wollastonite, pyroxenes, amphiboles, magnetite, plagioclases, and dms: salts dissolving at 320-440°C; sometimes LCO_2 is present. Inclusions in the dark-green inner core have Th 630-580°C, next zone, yellow, bears inclusions with Th 630-450°C, next one, brown, - 430-380°C, and outer core, red-brownish - 400-270°C. This Th interval covers almost all studied deposits. (Abstract by A.K.)

MAZUROV, M.P., 1980b, Temperature of ore formation in skarn-magnetite deposits of the folded areas, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 204-209 (in Russian).

Temperatures of formation of iron-bearing magnesium skarns were 860-750°C, calcium skarns 740-480°C, pyroxene-feldspar rocks 710-540°C, pyroxene-scapolite rocks 680-480°C, pyroxene skarns of pegmatoid type 670-550°C, pyroxene-dashkesanite rocks 580-540°C. Ore-bearing parageneses formed at T 560-430°C, post-ore associations epidote+actinolite+quartz at 450-350°C, babingtonite+epidote 480-450°C, babingtonite+epidote+prehinite 450-460°C, ilvaite+quartz 420-360°C, epidote+quartz 460-420°C, epidote+chlorite+calcite 300-240°C, anhydrite+calcite 180-120°C and barite+fluorite+calcite 150-75°C. (Author's abstract translated by A.K.)

MEDINA, J.A., MORANTE, M. and LEGUEY, S., 1980, Pyramidal inclusions in beryl related with corrosion processes (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 181.

The morphology and the genesis of pyramidal inclusions that rarely appear in some crystals of beryl are studied.

The form of the inclusions varies between the perfect hexagonal pyramid, which c axis is parallel to the [0001] direction in the crystal, and others, with rhombic base normal to the (0110) face. There are intermediate terms between both forms, the base of which are deformed, depending on the orientation followed by the corrosion. The detailed analysis of the inclusions with optic and scanning electron microscopy reveals that there are etch pits, totally or partially refilled later by potassium silicoaluminates or manganese and iron oxides. The more important etch pits follow the [0001] direction; many of them are connected with negative crystals, and often the contact channel is obstructed by the material overlapping the walls of the etched phase. (Authors' abstract)(sic).

MEKHTIYEVA, V.L., 1980, $\delta^{34}S$ in sediments and brines of the current and former Kara Bogaz Gol: Geokhimiya 1980, no. 5, p. 745-753 (in Russian; translated in Geochem. Internat., v. 17, no. 3, p. 72-79, 1980 (pub. 1981)). Author at All-Union Petro. Geol. Prospecting Inst., Moscow.

Measurements of $\delta^{34}S$ have been made for sulfate sulfur in brine and salt deposits of the existing and former Kara Bogaz Gol, which is a classical example of an undrained salt-deposition basin. The sulfate in the Kara Bogaz Gol brine is enriched in ^{32}S by about 4‰ relative to sulfate in the water of the southwestern Caspian, due to the ongoing deposition of salts in the gulf. The brine between the crystals has a constant $\delta^{34}S$ of +11.4‰, due to the salt karst effect. The $\delta^{34}S$ of the sulfate sulfur in this brine has no effect on the $\delta^{34}S$ for the enclosing salts.

There is a regular fall in $\delta^{34}S$ for sulfate sulfur from gypsum to glauberite and halite, which is as much as 3.4‰. The $\delta^{34}S$ for ancient Kara Bogaz Gol salts and for the shells of mollusks in the former Caspian show that the $\delta^{34}S$ for sulfate sulfur in evaporites gives some information on the hydrochemical features of the former Caspian. However, definition of any exact relationship to the dissolved sulfate of any particular geological time requires a knowledge of the deposition conditions. (Author's abstract)

MEL'NIKOV, F.P., 1980, Cryometric studies of gas-liquid inclusions in minerals: p. 70-79 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The author recommends liquid nitrogen as the cooling agent for freezing microscope stages; the stage used in Moscow University is described. Some other freezing stages from the literature are briefly characterized. The recommended freezing stage should cover the T interval -180°C to +20°C, freezing rate 14°/min., accuracy of T stabilization ±0.3°C. The procedure for T measurement and calibration (on freezing points of NaCl and $CaCl_2$ solutions) is presented. The study of inclusions in calcite from various Siberian deposits made by the leachate method and by cryometry showed similar change of salt concentration in inclusion solutions. The author also presents a diagram of change of phase ratios in inclusions not only during heating but also for freezing procedure. Problems of metastability are also discussed. (Abstract by A.K.)

MEL'NIKOV, I.V., TIMOFEEV, A.V., KOTOV, Ye.I., SHTEYNSHNEYDER, T.L. and GORBUNOV, V.Yu., 1980, Thermobarogeochemical peculiarities of hydrothermal uranium deposits in Phanerozoic folded areas, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 210-217 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 11, 1978, p. 138. (A.K.)

MELTON, C.E. and GIARDINI, A.A., 1980, The isotopic composition of argon included in an Arkansas diamond and its significance: Geophys. Res. Letters, v. 7, no. 6, p. 461-464. First author at Dept. Chem., Univ. Georgia, Athens, GA 30602.

The isotopic composition of argon entrapped in a 6.3 carat, Type I, Arkansas, U.S.A. diamond (emplacement date 106 ± 3 m.y. ago) has been determined by mass spectrometric techniques. This was done by crushing the stone in a diamond crusher attached to the high vacuum inlet system of a high-sensitivity research mass sepctrometer. The results show an $^{40}Ar/^{36}Ar$ value of 189 compared to a ratio of 294 for atmospheric argon, and an $^{38}Ar/^{36}Ar$ value of 0.18 almost identical to that for atmospheric argon (0.19). The isotopic data have been applied to a model of the outer Earth to test the crystallization age of the diamond. The results may be interpreted in terms of diamond crystallization about 3.1 billion years ago.

The existence of primordial ^{36}Ar and ^{38}Ar (nonradiogenic isotopes) shows that the Earth had not completely degassed at the time of diamond crystallization. In fact, if the diamond is assumed to be a representative sample of the upper mantle with respect to fluid content, the mass of primordial ^{36}Ar in this region of the Earth is calculated to be 1 x 10^{10} tons at the time of diamond crystallization, or 2.5 x 10^{-5} ppm by weight. (Authors' abstract)

MENARD, J.-J., CLOCHIATTI, R., MAURY, R.C. and BROUSSE, R., 1980, Origin of rhyolite pumice of Mont Dore (Massif Central, France): Petrological arguments: C.R. Acad. Sc. Paris, v. 290, Ser. D, p. 559-563 (in French). First author at Lab. Pétrographie, Univ. Paris Sud, Bat. 504, 91405 Orsay Cedex, France.

The study of the phenocrysts from the rhyolitic pumice flows of Mont-Dore and of their glassy inclusions shows that these units represent differentiated liquids belonging to the alkaline series of this volcano. They do not result from crustal anatexis, as proposed by most authors. (Authors' abstract)

MENYAILOV, I.A. and NIKITINA, L.P., 1980, Chemistry and metal contents of magmatic gases: the New Tolbachik Volcanoes Case (Kamchatka): Bull. Volcanol., v. 43-1, p. 197-205. Authors at Inst. Volcanol., Petropavlovsk-Kamchatsky, USSR.

The gaseous products of new Tolbachik volcanoes were studied during 1975 to 1977 throughout all eruptive stages and during the post-eruptive activity. In investigations the northern break-out gases emitted during the eruption from the moving and consolidated lava flows there have been detected H_2O (the main component), H_2, HF, HCl, SO_2 and H_2S, CO_2, CO, NH_3, CH_4 and other hydrocarbons. NH_4Cl predominated in compositions of condensates and sublimates on lava flows and the most characteristic microcomponents were Zn, Cu, Pb, Sn, Ag and others. Sampling of gases and condensates at the southern break-out was conducted immediately from the flowing melt. In gases there have been detected H_2O (98 mol. %), HCl and H_2 (0.9 mol. % each) as well as HF, SO_2, H_2S, CO_2 and in small quantities O_2 and N_2. Gases reached the equilibrium state at T and P sampling and were characteristic of gas composition of the southern break-out magma. HCl, HF and H_2SO_4 were predominant during condensate and sublimate mineralization. The major microcomponents were represented by Pt, Sb, As, Zn, Cu, Pb, Ni, Co and others. Comparison of compositions of gases and of products of their reactions at the northern and at the southern break-outs allows us to assume the presence of the deeper magma source at the northern break-out and of shallow magma source at the southern break-out. (Authors' abstract)

MERGENOV, B.M., 1980, On the melted inclusions and geochemical features of volcanogenic facies in the Verkhubin ore field (Rudnyi Altai): Izv. Akad. Nauk Kaz. SSR Ser., Geol. (Alma-Ata), v. 2, p. 66-70 (in Russian).

MERTSALOV, I.M., 1980, Water as a factor in primary hydrocarbon migration and accumulation: Dodk. Akad. Nauk SSSR, v. 253, no. 3, p. 682-684 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 123-124 (1982). Author at All-Union Aerogeol. Trust, Moscow, USSR.

A new theory involving oil migration and accumulation is based on the assumption of dissolution, diffusion, and reprecipitation of mineral matter in thermal gradients, resulting in development or elimination of porosity. (E.R.)

METRICH, N. and CLOCHIATTI, R., 1979, A contribution toward understanding the crystallization history and the emplacement of a pantellerite flow from the Ethiopian Rift: a study of silicate-melt inclusions: C.R. Acad. Sc. Paris, v. 289, Série D, p. 57-60 (in French). Authors at Lab. Pétrographie, Bat. 50 Univ. Paris Sud, 91405 Orsay Cedex, France.

Quartz, anorthoclase, hedenbergite and aenigmatite phenocrysts in a pantellerite from the Ethiopian Rift contain 2-phase melt inclusions. Leucocratic minerals have crystallized between 740 and 830°C and the lava was emplaced below 900°C. The composition of the glass trapped in phenocrysts is very similar to that of the bulk rock and of the groundmass. Volatile content is <3%. The low temperature of crystallization can partly be explained by the fluorine and chlorine content in the initial melt. (Authors' abstract, modified by J. Touret)

METRICH, Nicole, CLOCCHIATTI, Robert and BIZOUARD, Hélène, 1979, Thermometric and chemical study of intercrystalline liquids of olivine, pyroxene and leucite from a scoriaceous lava of Vesuvius: a comparison with the residual parent liquids of the Avellino pumice (abst.): 7th Annual Meeting on the Earth Sciences, April 23-25, 1979, Lyon, France, p. 326 (in French).

MIKHAILOV, M.Yu. and SHATSKY, V.S., 1978, Redeposition of the matter in gas-liquid inclusions in beryls (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 207 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

At present time gas-liquid inclusions with solid phases in the form of fringes occur in many minerals of variable composition. Partial dissolution of the fringe matter is possible only at temperatures higher than those of disappearance of the gas bubble. In most cases it is impossible to dissolve the fringe completely as the inclusions decrepitate.

The fringes of matter around the inclusions of mineral-forming media in natural and synthetic beryls have been studied. The observation of the fringes is possible due to minor differences in index of refraction of the fringe matter and host rock (side illumination and phase-contrast adapters are used).

Considerable changes in the solution volume in the inclusion and matter volume in the fringe are established. Possible mechanisms of fringe formation (precipitation from the solution in isolated inclusion; precipitation in a partly isolated inclusion, etc.) are discussed. It has been shown that the formation of such fringes is the consequence of an equilibrium form of "negative" crystal. Besides, apparent nonconformity of isometric, with a well manifested cut, outside outlines of the fringe and irregular form of the inclusions itself, is explained(sic). (Translation courtesy Dr. A.P. Berzina)

MILLER, K.R., 1980, Petrology, hydrothermal mineralogy, stable isotope geochemistry and fluid inclusion geothermometry of Borehole Mesa 31-1, East Mesa geothermal field, Imperial Valley, California: M.S. thesis, Univ. of California, Riverside, CA.

MILLER, S.L., 1974, The nature and occurrence of clathrate hydrates: In: Natural gases in marine sediments, I.R. Kaplan, ed.: New York, Plenum

Press, p. 151-177. Author at Dept. Chem., Univ. California at San Diego, LaJolla, California 92037.

Clathrate hydrates are crystalline compounds in which an expanded ice lattice forms cages that contain gas molecules. There are two principal gas hydrate structures. Structure I, with a 12 Å cubic unit cell, contains 46 water molecules and 8 cages of two types, giving an ideal formula (for CH_4) of $CH_4 \cdot 5\text{-}3/4H_2O$. The actual formula contains somewhat more water as the cages are not completely filled. Examples of gases that form Structure I hydrates are ethane, N_2, O_2, Ar, Xe, CH_3Cl, H_2S. Structure II, with a 17 Å cubic unit cell, contains 136 water molecules, and 8 large cages and 16 small cages. This gives an ideal formula of, for example, $CHCl_3 \cdot 17H_2O$. Other molecules that form a Structure II hydrate include propane, ethyl chloride, acetone, and tetrahydrofuran. The conditions of pressure and temperature for hydrate formation are discussed. The statistical-mechanical treatment of hydrate stabilities shows that the cages are not completely occupied; thus the clathrate hydrates are non-stoichiometric compounds. (Author's abstract)

MISHINA, N.B., KHITAROV, D.N. and VASIL'KOVA, 1978, Physico-chemical conditions of formation of fluorite deposits in the Southern Branch of the Forebalkhash-Iliy volcanic belt, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 144-145 (in Russian). Authors at VIMS, Moscow, USSR.

Essentially commercial ores of the deposits E. Taskaynar, Kyzyl-Bel'deu, and Zhangiz-Agach formed under subsurface conditions from weakly acid hydrothermal solutions at T 160-70°C; main ions were Na-F and $Ca\text{-}HCO_3$. (A.K.)

MITCHELL, P.A., SILBERMAN, M.L. and O'NEIL, J.R., 1980, Gold vein mineralization, north-central Kenai Peninsula, Alaska (abst.): Geol. Soc. Am. Prog. Abstracts, v. 12, p. 142. First author at Exxon Min. Co., Missoula, MT 59806, USA.

The Valdez Group, a late Cretaceous volcaniclastic sandstone and interbedded siltstone, is the host for epithermal gold lode mineralization in north-central Kenai Peninsula, Alaska. The lode occurrences are primarily fissure vein fillings of quartz ± calcite with native gold; disseminated wall-rock alteration and mineralization are uncommon. Vein emplacement was controlled by joint and fault planes; the more productive veins parallel structures along with recurrent movement occurred.

The presence of arsenopyrite-pyrite ± chalcopyrite in all of the mineral assemblages indicates that sulfur fugacity is restricted to a relatively narrow range. Fluid inclusion filling temperatures suggest that early quartz ± sulfide precipitation was initiated at ≈200°C and that late mineral assemblages, dominated by calcite ± sulfides, formed at ≈125°C. An absence of visible daughter minerals indicates a dilute ore fluid. δD of fluid inclusion waters from quartz averages $-106 \pm 7‰$, which is similar to values of present-day meteoric water in this area. A dominant meteoric water source for the ore fluid is implied. Hydrothermal muscovite from an altered trondhjemite dike cut by mineralized quartz veins gave a K-Ar age of 52 ± 2 m.y., from which we infer that mineralization occurred late in the Paleocene. Accretion of the Chugach terrane to the North American continent occurred during the Late Cretaceous and early Tertiary. We suggest that hydrothermal vein mineralization in the Valdez

Group of north-central Kenai Peninsula occurred during or shortly after the later stages of this process. (Authors' abstract)

MITIN, S.N. and MEL'NIKOV, F.P., 1978, New data on Upper Jurassic evaporites of northern Ciscaucasia, as revealed by study of gas-filled inclusions in halite: Dokl. Akad. Nauk SSSR, v. 241, no. 2, p. 463-466 (in Russian; translated in Dokl. Acad. Sci. USSR Earth Sci. Sect. (Washington), v. 241, no. 1-6, p. 139-142, 1980).

Abstracted in Fluid Inclusion Research--Proc. of COFFI, v. 11, p. 141 (1978). (E.R.)

MITSYUK, B.M. and GOROGOTSKAYA, L.I., 1980, Physico-chemical alterations of silica under conditions of metamorphism: "Naukova Dumka" Publ. House, Kiev, 236 p., price 2 rbls 10 kopecks, 750 copies printed (in Russian, English summary). Authors at Inst. Geochem. and Physics of Minerals of Acad. Sci. of Ukrainian SSR, Kiev, Ukrainian SSR.

The book discusses transformations of silica gel to quartz and intermediate phases during this process, and the process of crystallization of quartz from hydrothermal solutions. Reference Th values for various vein and pegmatitic quartz are presented on p. 187-204. (A.K.)

MIYAZAWA, Shintaro, 1980, Fluid-flow effect on gas-bubble entrapment in Czochralski-grown oxide crystals: J. of Crystal Growth, v. 49, p. 515-521. Author at Musashino Electrical Commun. Lab., Nippon Telegraph and Telephone Public Corp., Musashino-shi, Tokyo 180, Japan.

Gas-bubble entrapment in Czochralski-grown $Pb_5Ge_3O_{11}$ and TeO_2 single crystals was analyzed from the viewpoint of fluid-flow convection in the melt. The entrapment was found to be closely related to the shape of the growing solid-liquid interface. Rh-doped $LiNbO_3$ and $LiTaO_3$ single crystals were examined to aid in recognizing the effects of crystal rotation rate and crystal diameter on the interface shape. It was established that the interface shape is attributable to fluid-flow convection modes, both natural and forced. Taking into account the relation between fluid-flow modes and the gas-surplus liquid layer adjacent to the interface where gases rejected from the growing interface supersaturate to some extent, gas-bubble entrapment was qualitatively explained by the interface shape. (Author's abstract)

MOGAROVSKIY, V.V. and MOROZOV, S.A., 1978, Genesis of celestite deposits of the southern part of Middle Asia and the problem of their classification, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 172-173 (in Russian). Authors at Inst. Geol. of Acad. Sci. of Tadzhik SSR, Dushanbe.

The deposits Gulisay, Chaltash, Daudyr, Ayzikent, Obi-Ziya and Payryagatau occur in argillites and limestones. The ore bodies are lenses, veins, and nests. G/L inclusions in quartz, celestite and calcite yielded Th attributable to 2 stages: a) marcasite-calcite 260-240°C and b) celestite-quartz 240-140°C. In the Southern Turkmenian deposit Arikskoe Th and Td of celestite and quartz were 250-100°C. The parent solutions were of the type $Cl > SO_4$ or $SO_4 \gg Cl$. (From the authors' abstract translated by A.K.)

MOISEENKO, V.G. and FAT'YANOV, I.I., 1978, Evolution of hydrothermal paleosystems of the Pacific belt, p. 122-129 <u>in</u>: Genesis of endogene mineralization of the Far East, 168 pp., 600 copies printed, price 2 rbls., Publ. House of the Far-East Sci. Center, Vladivostok (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

During studies of hydrothermal paleosystems which formed endogene deposits of the Pacific belt commercial associations of minerals precipitated from hydrotherms each typical of a genetically connected group of the deposits: Pb-Zn - from alkaline earth - HCO_3 solutions, W - from alkaline-alkaline earth - HCO_3 solutions, Au - from alkaline-HCO_3 solutions and Sn - from alkaline-Cl -HCO_3 solutions. T ranges of the deposit formation also are given. (Authors' abstract translated by A.K.)

MOISEENKO, V.G., ZALISHCHAK, B.L., PISKUNOV, Yu.G., PETRACHENKO, BYEDA, V.D. and PAKHOMOVA, V.A., 1979, Peculiarities of physico-chemical conditions of formation of one of the deposits in Priamur'ie, p. 184-185, <u>in</u>: Geology of the continent margins, Publ. House of Far-East Sci. Center, Vladivostok, 208 pp., 800 copies printed, price 1 rbl. 90 kopecks (in Russian). Authors at the Far-East Geol. Inst. of the Far-East Sci. Center, Vladivostok, USSR.

The Au-Ag low-sulfide deposit (name not given) occurs in a volcanic-plutonic structure. Gold content in ores depends on the concentration of reduced gases (H_2, $\frac{CO+CH_4}{CO_2}$) in parent fluids. Metamorphism of rocks of ore field was long and multistage, with general T interval from 800 to 100-50°C, pH of mineral-forming solutions varied from 4 to 8. Pre-ore metasomatism was under conditions of weak acid dissolving and alkaline activity with considerable Ca, Fe, Mg and then K at 400-250°C. Next stage of rock dissolving developed due to acid K-$HSiO_3$ solutions at 300-150°C. Commercial ores formed together with $HSiO_3$ dissolving of rocks. Mineral associations of commercial stage formed at 500-140°C, post-ore stage yielded Th 700-135°C(sic.) and less. Major part of the native gold formed at 250-150°C from alkaline-alkaline earth-HCO_3 solutions +H_2S, the second, quartz-gold stage is characterized by high contents of H_2, CO, CH_4, and Cl ions, the third, gold-carbonate - by NH_3, Mg, S and CO_2. Post-ore (skarn) stage differs by high Cl low N_2 contents. (Abstract by A.K.)

MOLCHANOV, V.P. and SILICHEV, M.K., 1978, Thermobarogeochemical criteria of formation of gold ores of a deposit in Yakutia, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 196 (in Russian). First author at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Vladivostok.

The deposit* formed at 430-120°C, but gold-quartz stage developed at 310-180°C, including pyrite-arsenopyrite association (Th 310-290°C), gold-sphalerite association (Th 250-220°C) and gold-sulfoantimonite association (Th 210-180°C). Early solutions are rich in S and NH_4, late ones in CO_2. Gold-rich stage has abundant Na and K in solutions. (Abstract by A.K.)
(*Name not given, A.K.)

MONAKHOV, V.S., GALIY, S.A., GALABURDA, Y.A., STESHIN, V.I., GEVORK'YAN, S.V. and PASAL'SKAYA, L.F., 1980, Typomorphic characteristics of quartz from gold-bearing vein formations in the Precambrian Ukrainian Shield:

Mineral. Zh., v. 2, no. 4, p. 43-50 (in Russian).
Indexed under Fluid Inclusions. (E.R.)

MONROE, S., 1980, Gold solubilities and transport mechanisms near Sheep Mountain, Beaverhead county, Montana: M.S. thesis, Western Washington Univ., Bellingham, WA, USA.
Indexed under Fluid Inclusions. (E.R.)

MOON, K.J., 1980, Genesis of the Sandong scheelite deposit, Korea (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 971.

Scheelite is mined from quartz-mica-amphibole zones and quartz veins lying within pyroxene-garnet skarns formed by alteration of Cambrian limestones interbedded with shales. The sediments dip at 35°C. Wollastonite is common between the skarn and limestone.

In two of the three main ore horizons Mo-bearing scheelite is concentrated in a quartz-biotite ± muscovite ± K-feldspar core which occurs at the base of altered limestone beds. The core is mantled by quartz-hornblende ± chlorite rock of lower WO_3 grade, and both zones are elongate down dip. Apatite, pyrite, pyrrhotite, bismuth and bismuthinite are important minor minerals. Scheelite-bearing veins are composed of quartz ± molybdenite ± wolframite ± chalcopyrite ± bismuthinite.

Two-phase fluid inclusions in pyroxenes of the skarn homogenize between 380 and 570°C (average 420°C) and show evidence of boiling; a pluton is inferred immediately below the mine. Inclusions in scheelite from the mica core homogenize between 200 and 380°C (average 282°C), the highest temperatures coinciding with the richest ore. Scheelite inclusions in quartz veins homogenize between 200 and 400°C; some at 400° show near-critical behavior, indicating a pressure near 280 bars. Scheelite inclusions in the mica core have salinities near 5 wt % equivalent NaCl, those in quartz veins slightly higher.

Fluid inclusion data and mineral assemblages allow preliminary estimates of the chemical characteristics of the ore solutions. (Author's abstract)

MOORE, Diane, MORROW, Carolyn, and BYERLEE, James D., 1980, Fluid flow through granite in a temperature gradient: II. Fluid chemistry (Abst.): EOS, v. 61, p. 1112.

MOORE, G.R., 1980, Study of chemical and isotopic composition of fluid inclusions, in gangue minerals, from the north Pennine orefield (abst.): I.M.M. Trans., B, v. 89, p. B136.

Fluid inclusions are thought to represent the original ore fluid of specific phases of mineralization. Thus, their isotopic and chemical compositions may indicate possible sources of elements in relation to one another.

Decrepitation of thermal fracturing (sic) was used on fluorite and quartz from Dunham's fluorspar zone to obtain the inclusion fluids and gases.

Deuterium/hydrogen isotopic analysis of the fluids yielded fairly reproducible results, which are being interpreted with respect to other chemical parameters. Chemical compositions were obtained from leaching decrepitated material of known fluid inclusion content. (Author's abstract)

MORSE, J.W., MUCCI, Alfonso and MILLERO, F.J., 1980, The solubility of calcite and aragonite in seawater of 35% salinity at 25°C and atmospheric pressure: Geochim. Cosmo. Acta, v. 44, p. 85-94.

MOTORINA, I.V., 1978, Crystallization temperatures of quartz-pyroxene trachybasalt porphyrites and liparite-dacite porphyries (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 99-100 (in Russian). Author at Instit. Geol. Geophys. of the SB AS USSR.

The Post Ordovician rocks of a subvolcanic complex in the Bayanaulskii region of Central Kazakhstan: quartz-pyroxene trachybasalt porphyrites, and closely related (both spatially and chronologically) pyroxene quartz-plagioclase liparite-dacite porphyries, have been investigated mineralothermometrically. Crystallized inclusions in silicate melts occur in pyroxenes of trachybasalt porphyrites and in quartz of both types. By homogenization it was established that trachybasalt porphyrites formation, plagioclase and quartz phenocrysts crystallized at several temperatures accordingly: 1250-1300°C and 980-970°C. In liparite-dacite porphyries quartz phenocrysts formed at 1000-900°C. (Translation courtesy Dr. A.P. Berzina)

MOYSEENKO, V.G. and KHOMICH, V.G., 1978, Peculiarities of composition of gas-liquid inclusions in minerals of deposits associated with volcanic rocks of various formations, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 187-188 (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Vladivostok.

The authors' abstract is an analysis of volcanic wall rock types and sequence of Au-Ag deposits from the Pacific, Mongolian-Okhotsk and Mediterranean belts. The deposits formed in rocks of liparite formation rather than with andesite formation. Water leachates had high Na/K and Mg/Ca ratios, main anion was Cl, Te was important and minor F, HCO_3 and sulfur compounds. Gases in deposits of andesite formation bear rather reduced forms of carbon that (later) oxidized. (A.K.)

MOZZHERIN, Yu.V., 1980, Problem of structure of water, *in*: Mineralogical studies of hydrothermal deposits of the Urals, p. 103-107: The Ural Sci. Center of Acad. Sci. USSR Publ. House, Sverdlovsk, price 95 kopeck, 700 copies printed (in Russian).

The discontinuities in changes of water density were found by calculation for four temperature intervals. The possible reason is formation of four complex water molecules: $H_2O-(H_2O)_2$, $(H_2O)_2-(H_2O)_4$, $(H_2O)_4-(H_2O)_8$, $(H_2O)_8-(H_2O)_{16}-(H_2O)_{24}$ at 374-320, 320-260, 260-165, 165-0°C, respectively. Appearing of unstable and short-lived intermediate molecule $(H_2O)_{16}$ in the last interval causes a minimum in the specific heat capacity of water about +40°C. Increase of water density due to decrease of kinetic energy is compensated below 3.98°C by density decrease due to great amount of "loose" molecules $(H_2O)_{24}$, which at 0°C begin to move from the mixture with $(H_2O)_8$ and $(H_2O)_{16}$ into ice lattice and, opening, they transform their "vacuoles" in hexagonal channels. High concentration of molecules $(H_2O)_{24}$ in supercooled water caused decrease of melting heat of ice at $T<0°C$. Melting point of monomeric water at -94°C was confirmed experimentally. (Author's abstract, translated by A.K.)

MUECKE, G.K., ed., 1980, Short course in neutron activation analysis in the geosciences: Mineral. Assoc. Canada Short Course Handbook, v. 5, 279 pp.

Nine papers cover the many applications. (E.R.)

MUNOZ, J.L., 1980, Determination of relative HCl and HF activities in hydrothermal systems from biotite analyses (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 489.

A combination of laboratory studies using synthetic iron biotites, thermodynamic modelling, 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-Cl) = 5151/T(kelvins) - 5.01 - 1.93 XMg. Standard states for the equilibrium constant as written are pure ideal gas H_2O and HCl at 1 bar and T, pure hydroxyl-biotite and (hypothetical) chlor-biotite at P and T; XMg represents the mole fraction of octahedral Mg in biotite.

The equation can be used to extract relative HCl fugacities in hydrothermal fluid from analyses of natural biotites. Moreover, when combined with analagous data for F=OH exchange, the equilibrium constant for the halogen exchange reaction Bi-Cl + HF = Bi-F +HCl is: log K(F-Cl) = 3051/T - 5.34 + 3.13XMg. This equation is used to compare biotites from the porphyry molybdenum deposit at Henderson, CO. These two biotite suites are strongly separated on a log (XF/XCl) - XMg 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. (Author's abstract).

MYENYAYLOV, I.A., NIKITINA, L.P. and SHAPAR', V.N., 1980, Geochemical peculiarities of exhalations of the great fracture eruption of the Tolbachik volcano: "Nauka," Moscow, 235 p., 700 copies printed, price 2 rbls 30 Kopecks (in Russian).

The authors characterized exhalations of the northern and southern parts of the Tolbachik fracture eruption. The subject of investigation were gases from cones, lava flows, fumaroles, water leachates from volcanic ash, atmospheric gases, rains and aerosols in the eruption region. Pertinent to G phase composition in melt inclusions of volcanic rocks. (A.K.)

MYSEN, B.O. and VIRGO, David, 1980a, Solubility mechanisms of carbon dioxide in silicate melts: a Raman spectroscopic study: Am. Mineralogist, v. 65, p. 885-899.

MYSEN, B.O. and VIRGO, David, 1980b, The solubility behavior of CO_2 in melts on the join $NaAlSi_3O_8$-$CaAl_2Si_2O_8$-CO_2 at high pressures and temperatures: a Raman spectroscopic study: Am. Mineralogist, v. 65, p. 1166-1175.

MYSEN, B.O., VIRGO, David, HARRISON, W.J. and SCARFE, C.M., 1980, Solubility mechanisms of H_2O in silicate melts at high pressures and temperatures: a Raman spectroscopic study: Am. Mineralogist, v. 65, p. 900-914.

NADLER, Arie, MAGARITZ, Mordeckai and MAZOR, Emanuel, 1980, Chemical reactions of seawater with rocks and freshwater: experimental and field observations on brackish waters in Israel: Geochim. Cosmo. Acta, v. 44, p. 879-886.

NAMBU, Masateru, 1980, The analysis of fluid inclusion in microgram range with an ion microanalyzer (abst.): Int'l. Geol. Cong., 26th, Abstracts,

v. 1, p. 67.

It has been desired to realize the analysis of specified fluid inclusions of less than 100μm, because almost all inclusions are smaller than 100μm which gives us valuable informations of mineralizing conditions. This paper deals with the development of a method of microanalysis of inclusions by means of the ion microanalyzer. Some analytical results on samples of hydrothermal deposits in Japan are also reported. In this method, the ion beam works not only to analyze the inclusion fluid, but also to spatter the host mineral which encloses an inclusion. Fluid inclusions were kept frozen to avoid rapid evaporation into vacuum. The ionization properties of aqueous solution in frozen state were investigated, since such a study had never been done: It was promised that semi-quantitative analysis was possible, using relative ion intensities and depression of freezing temperature.

It was found that compositions of mineralizing fluid especially Mg and Al varied with mineralizing period, even in the same deposit. An example of application to the prospecting of a new Cu deposit was found under the so called barren zone of Pb-Zn vein type deposit as expected from this study. (Author's abstract)

NAMBU, M. and TANIDA, K., 1980, Cryptomelane-manjiroite-hollandite series minerals: Mineral. Soc. Jap., J., v. 14, no. 3, p. 62-85 (in Japanese).

Indexed under Fluid Inclusions. (E.R.)

NASEDKIN, V.V. and BOYARSKAYA, R.V., 1980, Minerals in pores of volcanic glass: Izvestiya AN SSSR, ser. geol., no. 11, p. 90-97 (in Russian). Authors at Inst. Geol. Ore Deposits, Petrogr., Mineral. and Geochem. of Acad. Sci. USSR, Moscow.

Two samples of volcanic glass (massif Arteni, 75 km W of Erevan) were studied by optical and electron microscopy, the first from the extrusive dome, the second from the side part of the flow. In closed pores minerals crystallized from condensing mineralized fluid. High-T minerals are oldhamite CaS, native iron, Mn- and Zn-spinels, magnetite; low-T ones are amphibole and silica gel. High-T fluid bears Ca, Fe, Zn, Mn, Ti, Cl, S, Low-T fluid - petrogenic elements, mostly Si and alkali. (Abstract by A.K.)

NAUMOV, G.B. and NAUMOV, V.B., 1980, Inclusions in minerals as source of information in studies of geologic process: p. 178-195 <u>in</u> Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

Review of results of fluid inclusion studies made mostly on the basis of the Soviet papers and books (37 of the total 41 items cited). (A.K.)

NAUMOV, V.B., 1980, Methods of determination of concentration of volatile components in magmatic melts on the basis of inclusions in minerals: p. 60-69 <u>in</u> Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

Quartz from biotite granites from Central Buryatiya bears melt inclusions (Reyf 1973, 1976) containing G 10 vol.%, + high-silica muscovite 41 vol.%, + quartz 49 vol.% (= muscovite 48 wt.% + quartz 52 wt.%); calculated H_2O content in melt = 2.4 wt.%. Similar inclusions occur in quartz from F-rare metal granites of the W. Transbaikalia: muscovite weight content in those inclusions is 53%, i.e., water content in melt was ~3 wt.%. Water-bearing melt inclusions were also found in pegmatites. Generally, mass of melt (M_m) = mass of fluid (M_f) + mass of the other components, mostly silicates (M_s). Fluid density a_f may be calculated in inclusion consisting of G + L from the formula $a_f = Fa_L$ (F-filling degree, a_L-L phase density at room T), F may be evaluated from Th when total salt concentration is known. From the shape of inclusions with silicate melt, G and L phases, the inclusion volume and mass of each component may be calculated. Such calculations gave water content in granitic melts of various Soviet and Mongolian granites from 0.5 to 6.9 wt.%, and CO_2 from 1.9 to 2.3 wt.%. (Abstract by A.K.)

NAUMOV, V.B. and IVANOVA, G.F., 1980, Connection between rare metal ores and acid volcanism on the basis of studies of inclusions in minerals: Geol. Rudn. Mest., v. 22, no. 3, p. 95-103 (in Russian). Authors at Inst. Geochem. and Anal. Chem. of Acad. Sci. of USSR, Moscow.

On the basis of 65 samples or deposits, mostly from literature and several of the authors own studies, it is concluded that high pressures typical of tungsten-tin deposits are connected with volatile content, usually high, in parent acid magmas. Also T gradients at those deposits are induced by specific magmatic chambers of acid magmas. (A.K.)

NAUMOV, V.B., KOVALENKO, V.I., GOREGLYAD, A.V. and YARMOLYUK, V.V., 1980, Crystallization of alkalic granites and comendite of the South Gobi belt, Mongolian People's Republic, as shown by study of melt inclusions: Dokl. Akad. Nauk SSSR, v. 255, no. 5, p. 1244-1247 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 255, 1980, p. 149-152 (1982). First author at Instit. Geochem. & Analy. Chem., USSR Acad. Sci., Moscow, USSR.

Melt inclusions in quartz of ekerite porphyry had dms - feldspar, amphibole, and aegirine. Quenching runs were made (3-30 hours at temperature) to determine onset of melting (580-720°C) and Th (700-1080°C) for 11 rocks. Most inclusions decrepitated before homogenization; in some samples, only ≤5 μm inclusions did not leak. Th L-V for aqueous phases in some of these inclusions (up to 13.9 wt.%) ranged from 196-346°C; pressures were calculated from these data. (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, English abst.). Authors at Vernadsky Inst. Geochem., Moscow.

On the basis of the authors' and reference data from over 4700 publications it was found that 88% of post-magmatic minerals crystallized from L solutions, 10% from heterogenized G+L solutions and 2% from G solutions. The data are pertinent to 32 mineral species. Among 1015 determinations of density of inclusion fluids (Th 200-700°C) ranging from 0.4 to 1.8 g/cm^3, the interval 0.4-0.6 (here and later in g/cm^3) is occupied by 0.8% of determinations, 0.6-0.8 - 15.6%, 0.8-1.0 - 41.3%, 1.0-1.2 - 33.4%, 1.2-1.4 - 6.8%, 1.4-1.6 - 1.8% and 1.6-1.8 - 0.3%. Only five determinations yielded density lower than density of pure water on the saturation line liquid/vapor - these inclusions contained also L CO_2 at room T. Determinations (1124) of concentration (% of NaCl equiv.) are distributed as follows: 0-10% - 45.7% of det., 10-20% - 11.1% of det., 20-30% - 9.7% of det., 30-40% - 15.7% of det., 40-50% - 9.3% of det., 50-60% - 4.9% of det., 60-70% - 3.6% of det. Intervals of Th most common for ten selected minerals ("most promoting T for crystallization") are also given in the paper. A total of 880 determinations of P (in bars) may be characterized as follows: 0-500 - 19.5%, 500-1000 - 29.4%, 1000-1500 - 25.8%, 1500-2000 - 10.9%, 2000-3000 - 7.4%, 3000-4000 - 4.1%, 4000-5000 - 2.9%. Also other properties of mineral-forming fluids (pH, activities of S^{2-} vs SO_4, CO_2 content) are discussed in the paper. (Abstract by A.K.)

NAUMOV, V.B. and SHAPENKO, V.V., 1980a, Evidence from fluid inclusions on the iron concentrations in high-temperature chloride solutions: Geokhimiya 1980, no. 2, p. 231-238 (in Russian; translated in Geochem. Internat., v. 17, no. 1, p. 125-131, 1980). Authors at Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. of the USSR, Moscow.

Results are presented on the iron levels in fluid inclusions containing an iron-bearing solid phase. The following parameters have been determined for the fluid during the crystallization of fluorite from skarns in the Tyrnyauz deposit in the North Caucasus: minimum temperature 625-655°, density of solution 1.5 ±0.2 g/kg of solution. It is concluded that the iron concentration increases with temperature and with the chloride concentration. (Authors' abstract)

NAUMOV, V.B. and SHAPENKO, V.V., 1980b, Concentration of iron in high-temperature chloride solutions, data from fluid inclusion studies: Geokhimiya, no. 2, p. 231-238 (in Russian, English abstract). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The paper presents list of 31 dms presumably containing iron described in literature: hematite, magnetite, pyrite, chalcopyrite, aqueous chloride of bivalent iron, and Th of the respective inclusions. The authors' studies of polyphase inclusions in fluorite from the W-Mo deposit Tyrnyauz (Caucasus) revealed that 14 inclusions bear magnetite occupying from 2.5 to 4.6 vol.% of inclusion vacuole, average given by the authors 3.0±0.6 vol.%(sic. A.K.). These inclusions bear other phases (in vol.%): G 20±1, L 27-39 (i.e., 32±4, sic.), solids, mostly halite and sylvite 45±5. Average concentration of NaCl was 38 wt.% and KCl - 24 wt.%, Cl 340 g per 1000 g of solution, fluid density 1.5±0.2 g per cm^3, Fe concentration 73±21 g per 1000 g of solution. Phases in inclusions on heating dissolved at T, °C: sylvite 180-200, anisotropic salt 260-295, halite 435-455, G 615-655, magnetite 625-655; on cooling one or several magnetite grains formed. Magnetite in inclusions has magnetic properties up to 450-490°C. Also calculations of Fe content in inclusion fluids were made for data from literature. Hence, Fe concentration increases with T and Cl concentration increments. (Abstract by A.K.)

NAYBORODIN, V.I., 1980, Anomalous mineral associations in certain volcanic gold-silver deposits: Geol. Rud. Mestorozhd., v. 22, p. 103-112 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

NEDACHI, Munetomo, 1980, Chlorine and fluorine contents of rock-forming minerals of the Neogene granitic rocks in Kyushu, Japan: Mining Geol. (Japan) Spec. Issue, no. 8, p. 39-48. Author at Dept. Geol., College of Liberal Arts, Kagoshima Univ., Korimoto, Kagoshima, Japan.

Many stocks and cupolas of Neogene granitic rocks are located in

Kyushu, Japan. Some of them are genetically related to ore deposits. Chlorine and fluorine contents were measured by X-ray microanalyzer for apatite and biotite in granitic rocks related and unrelated to ore deposits. Although enrichment of chlorine has sometimes been observed in the altered rims of biotite grains in the Suzuyama and Taishuy granitic bodies, almost all fresh biotites have homogeneous compositions. Each granitic body has a distinct character. Apatites and fresh biotites of granitic bodies related to lead-zinc deposits have high halogen contents and high Cl:OH ratios, whereas those from bodies related to tin deposits have also high halogen contents but low Cl:OH ratios.

The distribution coefficient of chlorine and hydroxyl between coexisting apatite and fresh biotite has widely scattered values. Correlation of the distribution coefficient with biotite compositions suggests that it may be extremely sensitive to the composition of biotite. The correlation of the fluorine-hydroxyl distribution coefficient with biotite composition is similar to that estimated by Ludington (1978). The trends are for the fluorine contents of these minerals to increase and the chlorine contents to decrease slightly, with increase in silica content of the host rocks. These results may support the possibility that apatite and fresh biotite retain their original compositions, and that the chlorine and fluorine contents are correlated with kind of ore metals. (Author's abstract)

NEKRASOV, I.Ya., EPEL'BAUM, M.B. and SOBOLEV, V.P., 1980, Partition of tin between melt and chloride fluid in the granite-SnO-SnO_2-fluid system: Dokl. Akad. Nauk SSSR, v. 252, no. 4, p. 977-981 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 165-168 (1982).

NERONSKIY, G.I., LEVITSKIY, Yu.T., OSTAPENKO, N.S. and BELOUSOV, V.I., 1978, Decrepitation temperatures of gold from certain deposits of the Far East, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 193-194 (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Vladivostok.

Special highly sensitive device of vacuum thermobaric type was constructed for measurement of Td of gold. Essentially Td is similar to T range of formation of commercial mineralization, but the most intense peaks do not always fall in this range. Low T range of Td for all types of gold deposits are the same (60-120°C), but various types of deposits have different upper Td range: 1) 410, 180-80; 2) 500-420, 100-80; 3) 620, 570-460, 380-250, 120-90; 4) 565, 390-340, 120-100°C. (Abstract by A.K.)

NESTERENKO, G.V., BANNIKOVA, L.A., MEDVEDEVA, L.S. and NAUMOV, V.B., 1980, Conditions of formation of carbonate veins in basalts of the Philippine Sea floor: Geokhimiya, no. 8, p. 1250-1253 (in Russian). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Drilling cores obtained during cruise No. 58 of "Glomar Challenger" (Shikoku depression and Dayto submarine chain) bear basalts cut by carbonate and quartz-carbonate veinlets with pyrite and native copper. Inclusions in calcite are one-phase L, sometimes with trapped pyrite or zeolites. (A.K.)

NEWTON, R.C., SMITH J.V. and WINDLEY, B.F., 1980, Carbonic metamorphism, granulites and crustal growth: Nature (London), v. 288, no. 5786, p. 45-49.

Indexed under Fluid Inclusions. (E.R.)

NEYKUR, T.L. and DEMINA, N.Ye., 1978, Differences in the acidity-alkalinity evolution of hydrothermal solutions during formation of rock-crystal-bearing and ore quartz veins, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 155-157 (in Russian). Authors at Inst. Geol. Geophysics of Siberian Branch of Acad. Sci. USSR, Novosibirsk, USSR.

Water leachates were made from 32 samples of rock crystal, barren and Mo-W-ore-bearing quartz veins surrounding one of large granite intrusions in the Urals. All quartz-forming solutions bear Na as main cation, and Na/K ratio is the highest for rock-crystal-bearing veins (about 8); this ratio varies moderately in individual generations of quartz types. The ratio (Na+K)/(Ca+Mg) was also calculated (0.5-4.3). The ratio $(Cl+F)/HCO_3$ ranges from 0.2 to 6.7 in a complex manner. During crystallization of rock crystal HCO_3, Ca and Mg are major ions. (Abstract by A.K.)

NIKANOROV, A.M., FEDOROV, Y.A. and KAVILADZE, M.S., 1980, Deuterium in gas-filled inclusions in halite of Upper Jurassic deposits of the northeastern Caucasus: In: Characteristics of the chemical composition of natural waters; analytical methods and questions of automatic evaluation, I.A. Goncharova et al., eds.: Gidrokhim. Mater., v. 77, p. 61-68 (in Russian).

NIKANOROV, A.M., KAVILADZE, M.Sh., TARASOV, M.G., FEDOROV, Yu.A. and GUBIEV, N.V., 1980, Variations of the isotopic ratios of deuterium/hydrogen in solutions of gas-liquid inclusions of minerals in sedimentary rocks: 8-i Vses. Simpoz. po Stabil'n. Izotopam v Geokhimii, Moskva, 1980, p. 175-176 (in Russian).

NIKANOROV, A.M., MAISKII, Yu.G. and SIANISYAN, E.S., 1980, Procedure for quantitative evaluation of a gas constituent of inclusions in minerals during vacuum-decrepitometric studies: Izv. Sev.-Kavk. Nauchn. Tsentra Vyssh. Shk., Esteste Nauki, 1980, no. 2, p. 53-56 (in Russian).

The method proposed uses a filter to selectively absorb a component in the gases released from a weighed portion of mineral sample during in vacuo heating. The analysis was done first without a filter, to obtain a decrepitogram (a P-T diagram with a curve of the gas content in arbitrary units) of the total gases and is then done using Anhydrone filters to absorb the H_2O in the separated gases. Decrepitograms, each with two curves (of the gas contents determined without and after absorption by the filter) were determined for limestone (>90% $CaCO_3$), anhydrite, calcite, and quartz from the Caucasus foreland and the Donets Basin. In many cases, samples did not give a curve in the decrepitogram when the filter was used, thus indicating that the inclusions in the mineral contained only water. (CA, v. 94:18337r).

NIKANOROV, A.M., SIANISYAN, E.S., FEDOROV, Yu.A. and TARASOV, M.G., 1980. Study of gas-liquid inclusions in minerals for paleoreconstruction (for example, the Mesozoic deposits of the north-east Caucasus): Gidrokhim. Mater., v. 77, p. 55-60 (in Russian).

The well-recrystd. Mesozoic limestones of the northeastern Caucasus consist of cryst. calcite contg. gas-liquid inclusions. Th and vacuum Td were determined of these inclusions; they were 150-200 for the Cenomanian, 205-25 for the Aptian-Albanian, and 240-60° for the Jurassic. The paleotemp. increased steadily with an increase in the age of the limestone. The migration pattern of subsurface solutions was studied based on the paleotemp.. chemical and isotopic compn. of water trapped as inclusions in calcites, and the compn. relict in primary liquid inclusions. The total mineralization of aq. solutions increases with an increase in age. The nature of the org. matter in the inclusions indicates vertical migration of hydrocarbons from the underlying Jurassic formations. (C.A., v. 95:173021x)

NIKIFOROV, A.M., KAVILADZE, M.Sh., MANIKHIN, V.I., FEDOROV, Yu.A. and GUBIEV, N.V., 1980, Features of the isotopic composition of hydrogen in the water of saline minerals: 8-i Vses. Simpoz. po Stabil'n. Izotopam v Geokhimii, Moskva, 1980, p. 174-175 (in Russian).

NIKOLAYEVA, L.A., BARKHUDARYAN, N.B. and GENKIN, A.D., 1980, Some characteristics of native gold quartz as indicators of the conditions of ore formation: In: New data on typomorphism of minerals: Izd. Nauka, Moscow, p. 72-80 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

NORMAN, D.I. and LANDIS, G.P., 1980, Source of mineralizing components in hydrothermal ore fluids as evidenced by $^{87}Sr/^{86}Sr$ and stable isotope data from the Pasto Bueno deposit, Peru (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 493.

Strontium isotope systematics of fluid inclusion waters, Sr-rich minerals, and rocks define probable sources of solutes in the mineralizing fluids for the well-studied Pasto Bueno deposit. Ore consists of wolframite, tetrahedrite, and base metal sulfides in quartz veins associated with a 9.5-m.y. old quartz monzonite stock ($^{87}Sr/^{86}Sr$=0.7056-0.7074) intruded into a Jurassic shale (0.7169) and Cretaceous quartzite (0.7158). The $^{87}Sr/^{86}Sr$ of fluid inclusion waters in quartz, wolframite, pyrite, and sphalerite, and of minerals rhodochrosite and fluorite range from 0.7058 to 0.7239 with Rb/Sr $\leq$0.027. Previous geologic, fluid inclusion, and stable isotope studies clearly indicated the presence of magmatic and meteoric water during mineralization; and possibly define a third water of metamorphic-connate derivation. New Sr-data indicate variation in $^{87}Sr/^{86}Sr$ of ore fluids to be related to mixing of "source" reservoirs; lower ratios compare with host Tertiary intrusions and higher values relate to Mesozoic country rocks or possibly the Precambrian basement. Systematic variations between Sr- and stable isotope preclude the likelihood of selective leaching of radiogenic Sr to produce the higher ratios. These variations do not correlate with associated wall rocks of veins. Independent variables δD and $^{87}Sr/^{86}Sr$ clearly indicate: (1) delineation of the three recognized waters involved in the mineralization process; (2) that wolframite deposition was from dominantly meteoric waters, yet major metal components were derived from the stock; (3) that sulfide mineralization was from mixed-derivation ore fluids, even though a magmatic sulfur (and possibly metal) source is indicated; and (4) that only fluorite-depositing fluids contain both waters and mineralizing components derived from the stock. (Authors' abstract)

NORMAN, D.I. and TRANGCOTCHASAN, Y., 1980, Fluid-inclusion study of the Yod Nam tin mine, southern Thailand (abst.): Papers presented at MAWAM Conference, Univ. Exeter, Dec. 1979, Inst. Mining and Metallurgy Trans., v. 89, p. B194.

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 kbar. 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 tin. (Authors' abstract)

NORONA, F., 1979, Fluid inclusions, their contribution toward determining the physicochemical conditions of formation of rocks and minerals: Comunic. Serv. Geol. Port., v. 64, p. 257-259 (in Spanish).

A review of fluid inclusion study, and summation of results obtained on tungsten deposits at Panasqueira and Borralha, Portugal. (E.R., from translation courtesy D.E. Teggin)

NOSENKO, N.A. and NAUMKIN, P.A., 1978, Temperature conditions of formation of quartz-apophyllite mineralization in skarns of the Dal'negorsk datolite deposit, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, Acad. Sci. USSR, p. 173-175 (in Russian). First author at "Ob'yedineniye-Bor," Dal'negorsk, USSR.

In the wollastonite zone of skarns, large cavities (1.2-1.6 m dia.) bear quartz-apophyllite association with datolite. Three generations of datolite yielded Th 320, 290-300 and 250-290°C, and P inclusions in quartz paragenetic with apophyllite - 280-310°C. (From the authors' abstract translated by A.K.)

NOSIK, L.P., 1980, Use of mass-spectrometry for studies of inclusions of mineral-forming media: p. 155-178 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The methods of gas and isotope analysis by mass spectrometry are presented. The studies of G sorption on mineral powder proved that CO_2 is sorbed to a significant degree and the non-sorbed gas is enriched in light isotopes, if the gas was evolved from inclusions by grinding. The author recommends instead thermal opening of inclusions for minerals that do not decompose on calcination. Next the methods of introduction of gases in the ion source, described in literature, are reviewed. The author separates gases, especially CO_2 and SO_2, using the evaporation of gases from a frozen mixture in a Dewar; gases are then 95% pure. This procedure causes change of isotope ratio of sulfur ≤0.3o/oo after first fractioning and up to 0.1-0.15o/oo after several more. Since inclusions usually bear a polycomponent gas phase and the best results are obtained in the mass spectrometry analysis when sample is compared with the standard of identical composition and as close concentrations as possible, the sample inclusion gas first may be divided into fractions, e.g., by freezing-evaporating treatment, and then analyzed. Procedure of the standard preparation and use of various ion collectors is described. The discussion of problems connected with recording of the positively charged ions includes presentation of the author's new method; the essential idea is that equilibration of signals reaching the measuring unit is performed not by change of high resistivity in amplifying unit but by introduction of a specially modified current. The modifying module is able to modify the direct current from the output of the amplifying unit, forming new electrical signals characterized by the frequency of impulse repetition. Transformed frequency is proportional to the input signal ($f = \emptyset(I)$). Such modifying units are linked to both spectrometer channels. This way the measurements of isotope composition of any chemical element, are performed under the optimum regime, with maximum accuracy of the measurement, equal in practice 0.05o/oo. Examples of use of this method for fluid inclusion studies are briefly described in the last part of the paper. (Abstract by A.K.)

NOSIK, L.P., DOLOMANOVA, Ye.I. and ROZHDESTVENSKAYA, I.V., 1980, On the possibility of determination of physico-chemical conditions of formation of tin ore deposits from mass spectrometry data on gas-liquid inclusions, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 93-102 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 45-46, Dolomanova, Nosik et al., 1978. (A.K.)

NOVIKOVA, M.I. and SHATSKAYA, V.T., 1978, Thermobarogeochemistry of ore origin at deposits of fluorite-beryl metasomatites, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 163-165 (in Russian). Authors at VIMS, Moscow, USSR.

Fluorite-beryl metasomatites are connected genetically with granitoids. Main ore mineralization (Th in fluorite, quartz and beryllium minerals) developed at 140-450°C. The highest Th were found in deposits connected with alkaline granites (250-450°C), the lowest - with leucocratic granites (140-220°C). The higher temperature fluids had higher alkalinity. (From the authors' abstract translated by A.K.)

NOZHKIN, A.D., 1980, Feldspar metasomatites of the zones of activation in the central part of the Enisey area : Theoretical and genetic mineralogy (Transactions of the W. Siberian Division of the All-Union Mineralogical Society), v. 8, p. 30-47, "Nauka" Pub. House, Novosibirsk (in Russian).

Quartz from quartz-feldspar veins cutting feldspar metasomatites bears inclusions with Th 310-380°C in L or 360-380°C in G (milky variety), 250-300°C in L (transparent variety); these T may be assumed to be the lower range of formation of feldspar metasomatites. (A.K.)

NUTI, S., FERRARA, G.C. and NOTO, P., 1980, Major constituents of the gas phase of the geothermal fluids in Travale, Italy: tentative intepretation: Proceedings of the symposium on chemical analysis of geological materials-techniques applications and interpretation, Calcutta 1979, Geol. Sur. India Special Pub. Ser., no. 1, p. 399-413. First author at Instituto Intern. per le Ricerche Geotermiche, C.N.R., Via del Buongusto 1, Pisa, Italy.

This paper presents the results of the studies of the chemical composition of the major gas species. An interpretation is made, in particular, of the relationship between the chemical species water, carbon dioxide, methane and hydrogen. Using these relationships and the isotopic results some hypotheses are made in the origin of the gas species and the possible chemical and isotopic equilibria between the different fluid components. (From the authors' abstract)

NUTI, S., NOTO, P. and FERRARA, G.C., 1980, The system H_2O-CO_2-CH_4-H_2 at Travale, Italy: tentative interpretation: Geothermics, v. 9, p. 287-295. First author at Istituto Interna. Ricerche Geotermiche, via del Buongusto 1, Pisa, Italy.

The Travale geothermal field lies south-east of the well-known geothermal field of Larderello in Tuscany, Italy. It was discovered and exploited at a later date than Larderello. In 1978 samples were taken from all the productive wells in the area for chromatographic and mass-spectrometric analyses of gases and chemical analyses of the condensate. At the same time measurements were made of fluid temperatures at the wellheads and the gas:steam ratios. The chemical composition of the major gas species is presented and interpreted, particularly the relationship between the gases, water, carbon dioxide, methane and hydrogen. Using these relationships and the isotopic results some hypotheses are made on the origin of gas species and the possible chemical and isotopic equilibria between the different fluid components. (Authors' abstract)

OCHOA, Aurelio, 1980. Metallogenic study of the Rocheray's fluorspar deposits, French Alps (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 979.

The Rocheray massif, Savoie district, contains important quartz and fluorite vein deposits: 3.5 million tons of fluorspar (41%); the sulfides are accessories. The study of fluid inclusions shows that the average minimal Tt is 385°C for the quartz and 142°C for the fluorite.

The fluids are almost exclusively aqueous alkaline solutions, between 0.6 and 6.6% in weight of NaCl. CO_2 detected by Raman analysis is negligible, and the average ratio $Na/K = 3.2$, different from the Mississippi Valley type.

The thermo-optic and decrepitometric studies of the sphalerite show similar results. (From the author's abstract)

O'HARA, P.F., 1980, Intersecting isograds in central Arizona. Evidence for CO_2-H_2O exchange during prograde metamorphism (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 299-300.

Isograds in metamorphosed Precambrian pelites, felsic metavolcanics and mafic rocks of the Northern Bradshaw Mountains, central Arizona intersect and appear folded in map view. Irregularities in isograd patterns can be ascribed to any combination of following causes: 1) variation in temperature or pressure gradients, 2) stratigraphically controlled changes in chemical composition, 3) deformation after the peak of metamorphism, or 4) metasomatic addition of components (variation in composition of the fluid phase) which significantly shift isograds. Field and petrographic evidence eliminate 1 and 2. As related to possibly 3, overall shape of the isograds indicates doming about an F_2 fold axis but detailed isograd irregularities are not related to fold geometry. Chlorite + muscovite +

quartz are stable north of the biotite isograd while the assemblage biotite + chlorite + muscovite + quartz is stable south of the isograd. The lack of an aluminous phase with biotite indicates that biotite formation presumably involves introduction of potassium, so that irregularities in the shape of the isograd could have been caused by variations in potassium content of the fluid. Northward deflections of the biotite isograd correspond to southward deflections of the amphibole isograd. Assemblages containing plagioclase + carbonate or plagioclase + carbonate + epidote are found in zones of southward deflection of the amphibole isograd indicating a higher XCO_2 in the fluid phase. Since these areas of deflection have interlayered calc-silicate and pelitic rocks, the irregular shape of the isograds is presumably caused by exchange of CO_2-rich fluids with H_2O-rich fluids during prograde metamorphism. (Author's abstract)

OHLE, E.L., 1980, Some considerations in determining the origin of ore deposits of the Mississippi Valley type-Part II: Econ. Geol., v. 75, no. 2, p. 161-172.

Any genetic theory explaining the origin of ore deposits of the Mississippi Valley type must be in accord with all aspects of the geologic setting that existed at the time the deposits were formed. The basinal brine theory is no exception. Unfortunately there is still great disagreement among geologist on most facets of the mechanism, such as the source of the metals, the timing of their release, the origin of the saline solutions, how the metals are carried, the causes of deposition, or why it occurs where it does. The facts and speculations about all of these are discussed, with the conclusion that a great deal of additional research is needed before the hypothesis can be totally accepted. (Author's abstract)

OHMOTO, Hiroshi and LASAGA, Antonio C., 1980, Kinetics of isotopic exchange and chemical reactions between sulfides and sulfates in hydrothermal solutions (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 494.

The evaluation of the applicability of fO_2-pH or fS^2 diagrams for S-bearing hydrothermal systems and the interpretation of S isotopic data both require a detailed analysis of the oxidation-reduction kinetics among the sulfur species. We have reevaluated all the published data on the S isotopic exchange experiments involving aqueous sulfides and sulfates. These data together with our experimental data on $S-H_2O-HSO_4^{-}-H_2S$ and $Na_2S_2O_3-H_2O-NaOH$ systems indicate that the isotopic exchange reaction

$H_2{}^{32}S + {}^{34}SO_4^{2-} = H_2{}^{34}S + {}^{32}SO_4^{2-}$ is a pseudo-first order reaction with respect to sulfide and sulfate, and that the rate depends strongly on T, pH, and the total sulfur content. The rate constant for the exchange reaction, k (ℓ/moles/hr) at a given T and pH can be obtained from $k = -\ell n(1 - F)/t(\Sigma S^{2-} + \Sigma SO_4^{2-})$ where F is the degree of equilibrium, t is time (hrs) and ΣS^{2-} and ΣSO_4^{2-} are the concentrations (in molar). The rate constant decreases rapidly with increasing pH but levels off at high pH. For example, at 250°C, log k = + 0.2 and -2.3 at pH = 2 and 5 respectively, but log k = -6.5 for all pH ≥ 8. The activation energies are low (~15 Kcal/mole) at pH = 2, but are in the range of 30-40 Kcal/mole at pH ≥ 4. The kinetic evidence suggests that the sulfide and sulfate species form an intermediate thio-sulfate molecule, which can sometimes undergo slow intramolecular sulfur atom exchange, before decomposing. The necessary bond breaking accounts for the high activation energy. The pH dependence arises from the equilibrium reactions between sulfide, sulfate and thiosulfate species. These rate constants also suggest that the attainment of isotopic and chemical equilibria between sulfide and sulfates can take place within 1000 yrs for typical hydrothermal fluids (pH = 4-6; $\Sigma S = 10^{-2}-10^{-3}m$) only if T $\geq$ 200°C. On the other hand, even at T = 100°C, equilibrium can be attained within 100 yrs if pH ≤ 2, such as when native sulfur is present. (Authors' abstract)

OKRUGIN, V.M., LONSHAKOV, Ye.A. and CHUMAK, B.I., 1978, Peculiarities of commercial hydrothermal mineral formation at Southern Kamchatka, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 197-198 (in Russian). First author at Inst. Volcanology of Far-East Sci. Center of Acad. Sci. of USSR, Petropavlovsk-Kamchatskiy, USSR.

Ore bodies are of stockwork-vein type connected with Miocene submarine volcanism. The largest ore bodies are polymetallic veins (pyrite - Td 340-200°C, sphalerite - Td 330-210°C, galena - Td 340-270°C, tetrahedrite - Td 340-265°C, alabandite, marcasite, pyrrhotite, chalcopyrite, arsenopyrite, chalcocite, covellite, bornite, enargite, famatinite?, molybdenite, antimonite, bismuthinite, tetradymite, altaite, hessite, argentite, proustite, pyrargyrite, pearceite?, bournonite, boulangerite, native elements: Cu, Bi, Ag, Au). Th was measured in some gangue minerals of the present ones: quartz 350-70°C (Td 400-170°C), calcite 340-215°C (Td 390-260°C), manganocalcite, rhodochrosite 270-250°C (Td 340-210°C), dolomite, fluorite, adularia, barite, gypsum, alunite, chlorite, sericite, kaolinite, montmorillonite. Inclusions are G/L, rarely with halite dm or LCO_2. (From the authors' abstract translated by A.K.)

OLANDER, D.R., MACHIELS, A.J. BALOOCH, M., MUCHOWSKI, E. and YAGNIK, S.K., 1980, Thermomigration of brine inclusions in sodium chloride single crystals: Trans. Am. Nucl. Soc., 1980, v. 34, p. 352-353.

OLANDER, D.R., MACHIELS, A.J. and YAGNIK, S., 1980, Thermal gradient migration of brine inclusions in salt: Battelle Mem. Inst. Rept. ONWI-208, 99 pp.

Theoretical and experimental study of the rate of migration of inclusions; small inclusions exhibit jumps in rate on intersecting dislocations that affect interface kinetics. (E.R.)

ONIKHIMOVSKIY, V.V. and GAVRILOV, V.I., 1979, Tin-ore belts of the Earth: "Nauka," Moscow, 128 p., price 1 rbl 40 kopecks, 950 copies printed (in Russian).

The book bears (p. 95) short reference to the characteristics Th, P and parent fluid compositions of the world tin ore deposits. (A.K.)

ONTOEV, D.O. and KANDINOV, M.N., 1980, Connection of geologic and thermobaric conditions of formation of the fluorine-iron-rare-metal deposits, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of

Far East Sci. Center of Acad. Sci. USSR, p. 41-51 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 135, Ontoev et al., 1978; note the change of the title and authors. (A.K.)

ORLOVA, G.P. and RYABCHIKOV, I.D., 1979, Solubility of carbon dioxide in aluminosilicate melts of enhanced alkalinity, and origin of carbonatite magmas: AN SSSR Izvestiya, ser. geol., 1977, no. 12, p. 5-17 (in Russian; translated in Internat. Geol. Rev., v. 21, no. 8, p. 982-992, 1979).

OSIPOV, P.V. and KLIMOVITSKAYA, Ye.F., 1977, Conditions of formation of chrysoprase in the deposit Sarykulboldy in the Central Kazakhstan, p. 153-164 in: Non-metallic mineral raw materials of weathering crust, "Nauka" Publ. House, Moscow, price 2 rbls 40 kopecks, 850 copies printed.

Inclusions in quartz veinlets in the wall rocks of the deposit have Th 168-175°C and 220-244°C; in drusy quartz, chalcedony and chrysoprase of the wall rocks - 60-90°C; inclusions in chalcedony - 48-225°C. Water leachates from chrysoprase yielded (in mg per 100 g of sample) Na 0.42-4.30, K 0.0-1.68, Mg 0.0-0.10, Ca 0.0-1.40, total Fe 0.0-0.04, HCO_3 0.54-7.30, Cl 0.28-3.55, SO_4 0.0-2.58; chalcedony Na 0.01-4.69, K 0.01-2.10, Mg 0.0-0.10, Ca 0.0-1.20, total Fe 0.0-0.03, HCO_3 1.64-7.32, Cl 0.24-3.55, SO_4 0.0-4.42; opal Na 0.09-7.34, K 0.0-3.10, Mg 0.0-0.01, Ca 010-0140, total Fe 0.0-0.02, HCO_3 0.10-6.10, Cl 0.13-8.51, SO_4 not found. (Abst. by A.K.)

OTKHMEZURI, Z.V. and DOLIDZE, I.D., 1980, On the chemical composition of fluid inclusions in ore-forming minerals of antimony-mercury-arsenic deposits (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 137.

1. The reconstruction of physico-chemical conditions of ore deposition on the basis of investigation of the main parameters of natural ore-forming processes, including the content and properties of mineral-forming solutions in their evolutional development is one of the main problems of the ore-deposition theory.

2. The authors have investigated the chemical composition of fluid inclusions in antimony, mercury, and arsenic deposits of the Southern slope of the Greater Caucasus. These deposits are formed by consecutive development of quartz-antimony, quartz-dickite-cinnabar, cinnabar-realgar, and realgar-orpiment mineral associations.

3. Fluid inclusions in minerals of quartz-antimony veins are characterized by bicarbonate and sulphate-bicarbonate compositions with sodium and calcium cations. The directional changing of content of the inclusions from bicarbonate with sodium cations at an early stage of development of antimony deposits, to sulphate-bicarbonate with predominance of calcium cation at the terminal stages, has been established.

4. Inclusions in minerals of quartz-carbonate-mercury and mercury-realgar associations are characterized by chloride-bicarbonate content with calcium cations.

5. In minerals of later realgar-orpiment associations the inclusions are characterized by chloride-bicarbonate content with directional changing of cation component from sodium at early stages of calcium at terminal stages of ore deposition. (Authors' abstract)

OVCHINNIKOV, L.N., KOZLOV, Ye.D. and MASALOVICH, A.M., 1980, Solubility of antimonite and cinnabar in water between 140° and 500°C: Dokl. Akad.

Nauk SSSR, v. 255, no. 1, p. 191-194 (in Russian; translated in Doklady Acad. Sci., Earth Sci. Sect., v. 255, 1980, p. 205-208 (1982).

PACES, Tomas, 1972, Chemical characteristics and equilibration in natural water-felsic rock-CO_2 system: Geochim. Cosmo. Acta, v. 36, p. 217-240. Author at Dept. Geol. Sci., State Univ. of New York at Buffalo, NY 14207.

Weight proportions of the major dissolved species in water from rocks of the Bohemian massif containing alkali feldspars follow the sequence $Na^+ \gg HCO_3^- > Cl^- > SO_4^{2-} > K^+ \gtrless H_4SiO_4$. For other localities a common order is $Na^+ \gg HCO_3^- > Cl^- \gg H_4SiO_4 \cong SO_4^{2-} > K^+$. Calcium and magnesium ions change their place in the sequence as the total dissolved solids increase. Cold water samples (<18°C) were in contact with a soil atmosphere in which PCO_2 ranges from 10^{-2} to 10^{-1} atm. Hot water (18°C to 72°C) was in contact with subsurface atmospheres in which PCO_2 varies widely from 10^{-5} to 10^1 atm. The high PCO_2 was observed in water from the Bohemian massif where CO_2 of a deep, possibly magmatic, origin occurs. Ground water is usually not in chemical equilibrium with respect to its rock environment but its chemical composition changes towards an equilibrium state. The equilibration of rain water or snow melt with rock probably includes (1) fast adsorption of hydroxyl ions on surfaces of aluminum silicates, (2) incongruent hydrolysis of primary aluminum silicates, (3) diffusion of cations from the inner structures of aluminum silicates into solution in exchange for hydrogen ions, and (4) reversible exchange of silica and probably alumina between the solution and amorphous surface layers of aluminum silicates. The activity of H^+ in ground water is probably a function of the rate of hydrogen diffusion into aluminum silicates and the flux of CO_2. The activity of sodium ion was found to vary with temperature and PCO_2, but residence times of ground waters and the specific surface area of the aquifer can influence the activity significantly. The activity of calcium ions may be controlled by incorporation of calcium ions in the structure of a secondary aluminum silicate such as Ca-montmorillonite. Extremely low activities of calcium ions in some waters from felsic rocks are caused by precipitation of calcium carbonate. Chemical compositions of feldspars having An_{0-40} are probably not decisive controlling factors of the calcium concentration in the group of ground-water samples studied. (Author's abstract)

PAGEL, Maurice, POTY, Bernard and SHEPPARD, S.M., 1980, Contribution to some Saskatchewan uranium deposits mainly from fluid inclusion and isotopic data, in Proc. of Internat. Uranium Symp. on the Pine Creek Geosyncline, 1980, Sym. held in Sydney, Australia, 4-8 June 1979, J. Ferguson and A.B. Goleby, eds.: Vienna Internat. Atomic Energy Agency, Vienna, 1980, p. 639-654.

Mineralogical, fluid inclusion homogenization temperature and composition studies, and D/H, $^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotope studies have been performed on the Cluff Lake and Rabbit Lake uranium deposits and their host rocks. The following aspects are emphasized:

1) Metamorphism of the basement in presence of an essentially carbonic fluid (granulite facies);

2) Evaporitic type of sedimentation with high Mg-Li-B- and organic matter at the beginning of the Athabasca basin sedimentation;

3) Presence of highly concentrated brines (~30% eq. weight NaCl) during diagenesis of the sandstone;

4) Hydrothermal alteration (around 200°C), at the boundary between

basement and cover.

Solutions during at least one stage of uranium mobilization and deposition were very similar to these diagenetic brines from the point of view of temperature, pressure, salinity, Cl/Br and stable isotopes (D/H and $^{18}O/^{16}O$). $^{13}C/^{12}C$ ratios on CO_2 are consistent with a derivation from organic matter by thermal degradation. However chloritization cannot be related to this stage and is not yet understood.

Diagenesis of the Athabasca sandstone was an important step in the formation of economic uranium concentrations. (Authors' abstract)

PALIVCOVÁ', Marie, BOJADŽIJEV, Stefan, HEJL, Václav and CVETKOVÁ, Vendulka, 1980, Ocellar texture in Vetren gabbroic bodies, Bulgaria (Gradišće Body): N. Jb. Miner. Abh. v. 139, p. 170-190.

The authors conclude that the origin of ocelli "remains obscure." (E.R.)

PAMPLIN, B.R., 1980, Crystal Growth, 2nd ed.: Oxford, Pergamon, 609 pp.

Various individually-authored chapters cover crystal growth methods including under pressure and high temperature, nucleation and growth theory, hydrodynamics of crystal growth processes, vapor phase growth, and assessment of crystalline perfection. (ER)

PAMPURA, V.D., PLYUSNIN, G.S. and SANDIMIROVA, G.P., 1980, Geochemical and isotopic composition of strontium in mineral-forming solutions of the Pauzhetka hydrothermal system (Southern Kamchatka): Geokhimiya 1980, no. 1, p. 122-135 (in Russian; translated in Geochem. Internat., v. 17, no. 1, p. 57-70, 1980 (pub. 1981)).

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

PANCHAPAKESAN, V. and PATEL, N.I., 1980, A note on the chalcopyrite-barite mineralization in the Thanewasna-Phutana area of Chandrapur district, Maharashtra: Met. Miner. Rev. (Calcutta), v. 19, no. 7, p. 11-12.

Indexed under Fluid Inclusions. (E.R.)

PANINA, L.I. and PODGORNYKH, N.G., 1979, Crystallization temperature of minerals in carbonatites of the alkaline-ultrabasic complexes, in: Problems of deep magmatism: "Nauka," Moscow, p. 222-230, price 3 rbls 20 kopecks, 900 copies printed (in Russian).

The inclusions of melts, melts-brines and melts-solutions in minerals from the Soviet carbonatite massifs yielded following Th (all in °C): alkaline rocks, Gulin 1150-1040 (pyroxene), 1100-830 (nepheline), Essey 1210-1100 (pyroxene), 1170-1150 (nepheline), Beloziminskiy 1260-1190 (pyroxene), 1120-1100 and 1060-1030 (nepheline), Tur'iy 1310-1210 (pyroxene), 1230-1130 (nepheline); magnetite-apatite rocks, Essey 1280±20 (forsterite), 1170-1140 (apatite), Yraas 1220-1120 (apatite); carbonatites, Gulin 1130-1040 (pyroxene), 1050-830 (nepheline), >750-690 (dolomite), Beloziminskiy 1260-1200 (pyroxene), 1040-1030 (nepheline), 1010-990 (apatite), >730 (ankerite), Tur'iy 1180-1190 (nepheline), >780-580 (calcite). (Abstract by A.K.)

PAN'KIN, R.P., 1980, Conditions for the formation of sulfur deposits of the Ciscarpathians (based on data from a study of relicts of mineral-forming solutions in minerals): Litol. Mineral. i Geokhimiya Mestorozhd. Samorod. Sery, Kiev, 1980, p. 96-106 (in Russian).

PANOV, B.S. and KORCHEMAGIN, V.A., 1978, Genesis of ore mineralization in Donbass, on the basis of thermobarogeochemical and isotope data (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 116-117 (in Russian). Authors at the Donetsk Polytechnical Inst., Donetsk, USSR.

Polymetallic ores of the Nagol'nyi region formed in early stage at ~330°C, in middle stage at 250-180°C and in late stage at 180-100°C. Essential part of cinnabar at the Nikitovskoe ore field crystallized at 180-110°C, and in the junction of Donbass and Priazovie massif - at 190-100°C. P was 120-150 atm for Nikitovskoe and 750-830 atm for Nagol'nyi and Pokrovo-Kireevskoe fluorite deposit. Th for various quartz samples ranges from 300 to 200°C and $\delta^{18}O$ for those quartzes was from +25.3‰ to +12.9‰, hence calculated $\delta^{18}O$ for water of mineral-forming solutions varied from +9.6‰ to -1.3‰. This suggests the mixed nature of the solutions, with meteoric water content up to 50%. (A.K.)

PAQUET, Jacques and FRANCOIS, Philippe, 1980, Experimental deformation of partially melted granitic rocks at 600-900°C and 250 MPa confining pressure: Tectonophysics, v. 68, p. 131-146.

The purpose of these experiments is to investigate the mechanical behavior of granitic rocks in anatexis conditions. Two rocks were tested at 10^{-5} sec^{-1} strain rate under 250 MPa confining pressure, from 600 to 900°C: an isotropic aplite and an anisotropic orthomylonite. Before the tests, the rocks are jacketed with copper. Their natural-water content does not exceed 1% by weight. The sample strain reaches up to 10% and is mainly localized in shear bands which appear to be filled with a mixture of glass and unmelted microblocks. On a macroscopic scale, these seem to behave as regions of incipient mylonitization filled with the melt coming from neighboring cataclase zones. Melt is produced only at grain boundaries, being squeezed out of the boundaries normal to the compression axis into the opening shear bands. The 1-mm size quartz grains of aplite are brittle: the cracks are precisely located in those planes parallel to σ_1 with trapped flattened bubbles. The feldspar grains in both the deformed samples are cataclased along cleavages. The mechanical behavior of partially melted granitic rocks might be controlled either by melt transfer into shear bands, by development of cracks from bubble planes in the quartz grains, or by cleavage in the feldspar grains. Melting can occur in the granitic materials by localized stress concentrations produced by grain boundary sliding at external PT conditions below those for melting. (Authors' abstract)

PARILOV, Iu.S., 1980, On genesis of Zhezgazgan ore deposit (according to the results of fluid inclusion study): Dokl. Akad. Nauk SSSR, v. 253, no. 6, p. 1432-1435 (in Russian).

PARK, N.Y. and PARK, K.H., 1980, The fluid inclusions in the sphalerite from the Sam-bo lead-zinc deposits: Report on Geoscience and Mineral Resources, 1980, v. 9, p. 65-72 (in Korean).

The lead-zinc ore deposits of Sam-bo mine are hydrothermal vein type and are embedded in Precambrian biotite schist at the Shiheung area, western part of Korea. Major ore minerals are sphalerite, barite, minor amounts of galena, chalcopyrite and pyrite and gangue minerals are quartz, fluorite, rhodonite, sericite and calcite. The zinc mineralization stages of Sam-bo mine consist of two stages, namely the early stage and the late stage. The vein minerals of the early stage are characterized by sphalerite and quartz. In contrast, the vein minerals of the late stage are characterized by sphalerite, quartz, galena and barite. Samples used in this study were collected from 12 localities from underground levels. The filling temperatures of 96 fluid inclusions in sphalerite and quartz of the late stage were determined. The filling temperatures of fluid inclusions range generally from 135°C for sphalerite and from 60°C to 111°C for quartz. (Authors' abstract)

PARRY, W.T., BALLANTYNE, J.M. and BRYANT, N.L., 1980, Hydrothermal alteration enthalpy and heat flow in the Roosevelt Hot Springs thermal area, Utah: J. Geophys. Res., v. 85, no. B5, p. 2559-2566.

PARRY, W.T., BALLANTYNE, J.M., BRYANT, N.L. and DEDOLPH, R.E., 1980, Geochemistry of hydrothermal alteration at the Roosevelt Hot Springs thermal area, Utah: Geochim. Cosmo. Acta, v. 44, p. 95-102. Authors at Dept. Geol. & Geophy., Univ. Utah, Salt Lake City, UT 84112.

Hot spring deposits in the Roosevelt thermal area consist of opaline sinter and sinter-cemented alluvium. Alluvium, plutonic rocks, and amphibolite-facies gneiss have been altered by acid-sulfate water to alunite and opal at the surface, and alunite, kaolinite, montmorillonite, and muscovite to a depth of 70 m. Marcasite, pyrite, chlorite, and calcite occur below the water table at about 30 m.

The thermal water is dilute (ionic strength 0.1-0.2) sodium-chloride brine. The spring water now contains 10 times as much Ca, 100 times as much Mg, and up to 2.5 times as much SO_4 as the deep water. Although the present day spring temperature is 25°C, the temperature was 85°C in 1950.

A model for development of the observed alteration is supported by observation and irreversible mass transfer calculations. Hydrothermal fluid convectively rises along major fractures. Water cools by conduction and steam separation, and the pH rises due to carbon dioxide escape. At the surface, hydrogen and sulfate ions are produced by oxidation of H_2S. The low pH water percolates downward and reacts with feldspar in the rocks to produce alunite, kaolinite, montmorillonite, and muscovite as hydrogen ion is consumed. (Authors' abstract)

PASHKOV, Yu.N., 1980, Thermometry on the basis of inclusions of mineral-forming media: p. 12-31 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

The paper discusses various aspects of devices and methods of measurement of Th and Td. First the correct ways of making P corrections to Th are discussed and next the possible errors of Th measurements are listed and the modes of their deletion are suggested. The advice is as follows: the best way of heating the preparation is immediate contact of preparation with heating element through a highly conductive plate, not glass - on the glass the T gradient reaches 4.1°C/mm. The preparation should be placed on the heat-conducting plate with conic illuminating hole of dia. equal the view field of microscope. Calculations proved that for a mass ratio of preparation to the heat-conducting element of 1:10, a mineral plate surface ~10 mm (square? diameter? - not specified, A.K.), a plate thickness 0.3-0.5 mm, a maximum T of heating 600°C, and air thermoinsulation - a heating element of 15-20W is sufficient. The author recommends air as the best thermoinsulating medium. The thermocouple should have as long as possible a contact with the thermoconducting element, and the thermocouple junction should be fixed as close to the preparation as possible. Heating rate should be small when approaching Th or other phase change. On the basis of the laboratory tests of heating stages made by Kormushin and by Groshenko, the first was recommended but not the second one. Workers of IGEM and GEOKHI proposed the heating stage construction shown in Fig. 1, working up to 700°C, with measurement accuracy ±2°C; after 30 min. of work at 700°C the outer cover of the stage has T 65-70°C. Heating coil is on the cylindrical mushroom-shaped thermoconducting element with the illuminating hole in the center and a round depression 0.5 mm deep in the top for the preparation. Thermocouple junction is fixed by metal ring in the illuminating hole, for good contact with the preparation.

The author discusses correct selection and application of thermocouples and the necessary correction. High-T heating stages proposed by Popivnyak as well as by Mikhaylov and Shatskiy have some imperfections. The author suggests that construction made at IGEM is one of the optimum solutions. The heating element is Pt30Rh wire of dia. 0.2 mm of special shape (Fig. 2). The maximum working T is 1800°C, with heating up to 1500°C in the air medium the wire works for 1000 runs, accuracy of measurements ~2%, during the run T of outer cover of the stage does not exceed 35-40°C.

The decrepitation method is presented with the routine historical and theoretical review. Special attention is paid to the calculation of the moment of inclusion break. The author calculated the distribution of tension for spherical layer surrounding an empty sphere. For isotropic body in the spheric coordinates the equation is as follows:

$$\sigma = \frac{PR_1^3}{R_1^3-R_2^3}\left[1 + \frac{R_2^3}{2R_1^3} - \frac{P_2R_2^3}{P_1}\left(\frac{1}{R_1^3} + \frac{1}{2r^3}\right)\right] , \qquad (1)$$

Where R_1 and R_2 - inner and outer radii of the empty sphere, note $R_2 = r$ (not explained, A.K.), P_1 and P_2 - internal and external pressure, σ - range of the mechanical resistance of isotropic substance. Because for decrepitation in the air $P_2 = 1$ atm and in vacuum $P_2 \approx 0$ atm, $P_1 >> P_2$, the equation (1) becomes simpler:

$$\sigma = \frac{P_1R_1^3}{R_1^3-R_2^3}\left(1 + \frac{R_2^3}{2R_1^3}\right) . \qquad (2)$$

Expressing R_2/R_1 as L, we get equation determining P necessary to the inclusion break (P_{cr}):

$$P_{cr} = \frac{2\sigma_{cr}(L^3-1)}{L^3+2} . \qquad (3)$$

This equation needs inclusions in isotropic mineral, all filled by the same solution, composition, and filling degree; then P_{cr} (and hence also T since $P = f(T)$), depends only on the inclusion size, its place in the grain and mechanical properties of the host mineral. Equation (3) graphically is a hyperbola with the limits $L = 1$; $R_2 = R_1$, and $L \to \infty$;

($R_2 >> R_1$) as in Fig. 3. Analysis of the hyperbola shows that P_{cr} changes from practically zero to a value close to 2δ, depending on L. If L ≈ 1 (inclusion wall thickness < inclusion size), decrepitation occurs when P_{cr} < mineral mechanical resistance or even before Th is achieved. When $P_{cr} = 2\delta$, all inclusions independently of their size and position in grain, should decrepitate. Hence, decrepitation of inclusions of the same genetic type should decrepitate within the wide T interval [$P = f(T)$] and the decrepitogram essentially depends on the distribution of inclusions in the sample, inclusion content, filling and mechanical properties of mineral. The decrepitation occurring even when $P_{cr} > 2\delta$ may be explained by partial dissolving of inclusion walls or formation of microfractures surrounding inclusions; in both cases the degree of filling of the inclusion decreases.

Next the author characterizes thermoacoustic decrepitation method, its possible errors and previous papers on methods. Special attention is paid to the thermovacuum method, with the discussion of the Russian electronic equipment used for construction of vacuum decrepitometers. The conclusion of this review is that the latter type of decrepitometer gives the most complete information on the decrepitation process. (Abstract by A.K.)

Fig.1

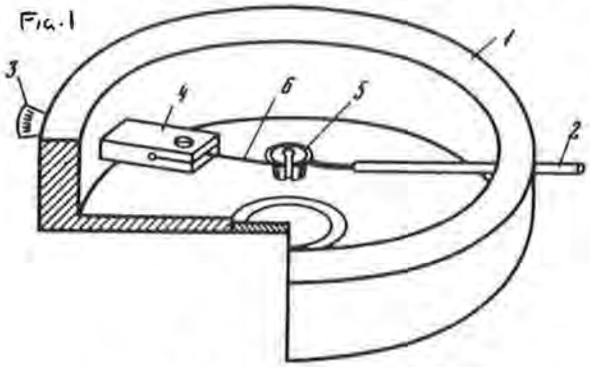

Fig.3

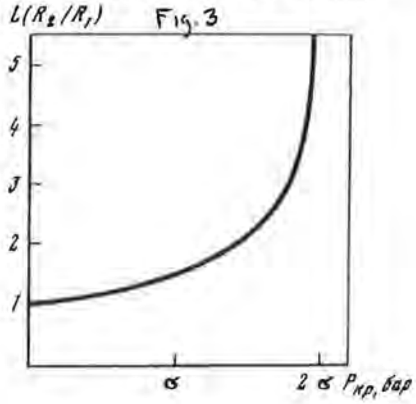

Fig.2

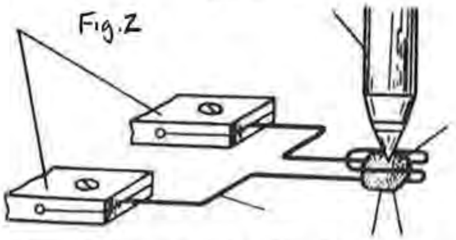

Fig. 1. Diagram of the heating stage (without cover); 1-body, 2-thermocouple, 3-current junction, 4-screw terminal of the heating element, 5-heat-conducting element, 6-heating coil.

Fig. 2. Scheme of the heating element of the high-T heating stage; 1-electric junction blocks, 2-heating wire, 3-preparation, 4-objective.

Fig. 3. The plot of P_{cr} necessary for inclusion decrepitation, versus its size and position in mineral.

PAVLUN, N.N., 1980, Thermobarogeochemical study of the Akchatau deposit, central Kazakhstan: Dokl. Akad. Nauk SSSR, v. 254, no. 1, p. 185-187 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 254, 1980, p. 60-61 (1982). Author at Univ. of L'vov, USSR.

Optimal crystallization temperature for commercial minerals (from greisen bodies) was narrow: wolframite, 435-350°C; molybdenite I, 425-390°C; molybdenite II, 445-440°C; bismuthinite, 295-275°C at P = 1600-500 atm. Boiling was frequent. Solutions were Na and K fluorides and chlorides with ≤65% salts, + CO_2. Dms include halite, sylvite, etc. Post ore galena-sphalerite-quartz stage inclusions contain only H_2O and CO_2. A vertical paleotemperature gradient for the commercial stage of 25°C/100 m was established, and 8-10°C/100 m horizontally. (E.R.)

PAVLUN', N.N. and KROCHUK, V.M., 1980, Crystal morphology peculiarities and formation temperatures of topaz from the deposit Aksay (Central Kazakhstan): Mineralog. Sborn., v. 34, no. 1, p. 77-80 (in Russian, English abstract). First author at the L'vov State Univ., L'vov, Ukrainian SSR.

Aksay deposit of molybdenite-beryl-wolframite-quartz type in greisens occurs in the Akchatau ore field. Topaz crystals, partly euhedral, are up to 8 mm long and they bear P and PS fluid inclusions. In crystals with dominate {120} prism Th are 450-435°C in G, and 442-410°C with critical phenomena. The latest PS inclusions homogenize at 405-380°C in L. Topaz crystals where prisms {120} and {110} are similarly developed bear P inclusions with Th 395-365°C in L, and 390-380°C with critical phenomena. Only basal parts of those crystals yielded Th 425-400°C in G; in T interval 415-395°C inclusions homogenize in G and L phases, proving the boiling of parent solutions. There were found also intermediate types of crystals. (Abstract by A.K.)

PAWLOWSKA, Jadwiga and WEDOW, Helmuth, Jr., 1980, Strata-bound zinc-lead deposits of the Upper Silesian region, Poland - a review of some recent research: Proc. Fifth Quadrennial IAGOD Symposium, p. 467-486.

Includes a discussion of the inclusion studies from the literature (p. 476). (E.R.)

PECHER, A., 1980, Fluid inclusions as markers of fluid pressure during deformation: some limits; data from transformations of inclusions in synthetic quartz in a Griggs apparatus (abst.): Abstracts, International Conference on the Effect of Deformation on Rocks, Göttingen, April 9-12, 1980, p. 203-206.

PEN'KOV, V.F., 1980, Evidence of generation of uraniferous bitumen from hydrocarbon-water emulsion: Dokl. Akad. Nauk SSSR, v. 250, no. 4, p. 941-945 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 250, 1980, p. 173-176 (1982).

PERNET, A., 1980, Barite veins, sulfo-antimonides and reworked Stephanian sediments of Rouvergue; preliminary results of a microthermometric study of fluid inclusions in quartz crystals. In Paleosurfaces and their metallogeny: Fr., Bur. Rech. Geol. Minieres, Mem. 104, p. 192-199 (in French).

PETERSIL'YE, I.A., IKORSKIY, S.V. and VOLOSHIN, A.V., 1978, Typomorphism of gas component of quartz, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 150 (in Russian). Authors at Geol. Inst. of Kola Division of Acad. Sci. of the USSR, Apatity, USSR.

Typomorphic indices of G evolved from ground quartz are as follows: total gas content, amount of acid and reduced gases, and ratios of methane and various other hydrocarbons. They were combined with Td, T of quartz inversion, alkaline trace elements in quartz, IR spectra and thermoluminescence. (A.K.)

PETROV, V.P., ed., 1980, Gems and precious stones: Izd. Nauk, Moscow, 290 pp.

Various references to fluid inclusions, mostly listed in this volume. (E.R.)

PETROVA, S.N., 1978, Decrepitation of barites from the Chiganak deposit (S. Kazakhstan), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 170-171 (in Russian). Author at GIGKhS*, Lyubertsy, USSR.

Td of barite (by thermovacuum method) was 240-220°C. (A.K.) (*Meaning of acronym unknown.)

PETROVSKAYA, S.G. and KUZ'MINA, T.M., 1980, Temperatures of formation of mineral associations at molybdenum mineralized occurrence Khodzhertuy, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 80-82 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, p. 142, Petrovskaya and Kuz'mina, 1978. (A.K.)

PHANG, Sonny, and STOKES, R.H., 1980, Density, viscosity, conductance, and transference number of concentrated aqueous magnesium chloride at 25°C: J. Solution Chem., v. 9, no. 7, p. 497-505.

PHILLIPS, E.R., 1980, Myrmekite as a marker between preaqueous and postaqueous phase saturation in granitic systems - discussion: G.S.A. Bull., v. 91, no. 11, p. 672-673.

A discussion of paper by Hibbard (1979, see Fluid Inclusion Research --Proceedings of COFFI, v. 12, p. 72-73). See also reply by Hibbard, G.S.A. Bull., v. 91, no. 11, p. 673. (E.R.)

PHILPOTTS, A.R., 1980a Magma unmixing in tholeiites (abst.): EOS, v. 61, p. 67-68.

PHILPOTTS, A.R., 1980b, Liquid immiscibility in melt inclusions in plagioclase phenocrysts (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 138.

Melt inclusions in plagioclase phenocrysts in many basalts and andesites exhibit evidence of silicate liquid immiscibility in the form of globules of one glass enclosed in another chemically distinct glass. Brown iron-bearing glass typically encloses globules of clear silica-rich glass, though the reverse relation is also found. The clear glass has a granitic composition, whereas the brown one, which in most cases is by far the more abundant of the two, has a composition which differs from that of the whole rock only in being depleted in plagioclase, this component having crystallized onto the walls surrounding the melt inclusions. These inclusions never contain pyroxene or magnetite crystals.

The groundmass of these basalts and andesites also commonly exhibits immiscibility, but here the silica-rich glass forms the host, surrounding globules that are considerably more iron-rich and magnesium-poor than the liquid trapped in the plagioclase phenocrysts. Also, these two liquids invariably coexist with an iron-rich, calcium pyroxene and magnetite. Immiscibility in the melt inclusions, however, is not always accompanied by immiscibility in the groundmass, and in those cases where it is absent, there is typically an abundance of equant-shaped, early crystallized magnetite grains in a silica-rich glass.

Melting experiments under controlled oxygen fugacities indicate that the immiscibility in the groundmass occurs stably, whereas that in the melt inclusions in plagioclase phenocrysts takes place metastably in a liquid that is supersaturated with pyroxene and possibly magnetite. Furthermore, immiscibility is controlled by the degree of oxidation of the magma; early crystallization of magnetite prevents residual liquids from becoming sufficiently enriched in iron to encounter the immiscibility field. The prevalence, therefore, of immiscibility in melt inclusions, even in those rocks that do not exhibit groundmass immiscibility, indicates the generally reduced state of the intratelluric magmas. Differentiation of such magmas at depth could well involve late state liquid immiscibility. (Author's abstract)

PHILPOTTS, A.R. and DOYLE, C.D., 1980, Immiscibility in tholeiites: a discussion: Min. Mag., v. 43, p. 939-940.

A discussion of Biggar, 1979 (see Fluid Inclusion Research--Proceedings of COFFI, vol. 12, p. 23), concluding that Biggar is wrong, and that tholeiites do develop stable silicate immiscibility. (E.R.)

PHILPOTTS, Anthony R., DOYLE, Christopher D., and THOMAS, Margaret A., 1980, Effect of magma oxidation state on the extent of liquid immiscibility in a tholeiitic basalt (Abst.): Geol. Soc. Amer. Abstracts and Programs, v. 12, p. 499.

PICHAVANT, M., 1979, The role of boron in silicate systems: an experimental study at 1 Kb and elevated temperatures: Ph.D. dissertation, Inst. Nat'l. Polytech. de Lorraine (in French; abstract translated and shortened by M. Logsdon).

Pockets and nodules of tourmaline, massive primary tourmalinites, boron-rich pegmatites, stockscheiders, greisens, and explosion breccias are common in the Hercynian granitic rocks of Western Europe. However, the extensive field evidence of the importance of boron is difficult to interpret because of limited experimental information for silicate-H_2O-B_2O_3 systems.

The thesis describes phase equilibria in the systems SiO_2-H_2O-B_2O_3 and SiO_2-$KAlSi_3O_8$-$NaAlSi_3O_8$-H_2O($+B_2O_3$) based on experiments at 1 Kb and elevated temperatures and theoretical considerations. The principal conclusions include:

1. The solidus is significantly lowered by the addition of B_2O_3.

2. The shape of the liquidus is modified by the addition of B_2O_3, but it does not move significantly toward lower temperatures in the system SiO_2-$KAlSi_3O_8$-$NaAlSi_3O_8$-H_2O($+B_2O_3$). This contrasts with the behavior of the ternary system, in which the liquidus is strongly depressed by B_2O_3.

3. The K/Na ratio of a coexisting vapor phase varies as a complex formation of temperature and concentration of B_2O_3. At temperatures near the solidus, the K/Na ratio is lower than for equivalent conditions in

the presence of Cl.

4. Between 750-780°C, glasses are enriched in K, Al, Si and solutions in Na and other alkalis relative to the initial gels.

5. The solubility of water in the silicate melt increases as a regular function of the concentration of B_2O_3.

6. In the system SiO_2-H_2O-B_2O_3, the solubility of quartz increases with the concentration of B_2O_3.

PINEAU, Francoise, BEHAR, Francoise, JAVOY, Marc and TOURET, Jacques, 1979, Gas chromatography and carbon isotope geochemistry of fluids in catazonal rocks from southern Norway: Sci. Geol., Mem. 53, 1979, U. Louis Pasteur de Strasbourg (in French; English summary by M. Logsdon).

As part of a long-term study of the catazonal basement rocks of southern Norway, the metamorphic fluid phase was studied using gas chromatography and carbon isotope geochemistry. Principal goals of this study were to determine the origin of CO_2 in fluid inclusions and to elucidate the controversy concerning the carbon isotope geochemistry of the upper mantle.

Eight quartz and one cordierite samples were separated from a suite of gneisses and quartzites characteristic of the Norwegian catazonal rocks. Gases evolved during stepwise heating were analyzed by gas chromatography. Inclusions from quartzites, charnokitic gneisses and closely related rocks contained only H_2O and CO_2; the cordierite sample contained large quantities of unidentified hydrocarbons.

Carbon isotopes were measured for carbonate minerals, graphite and the CO_2 in inclusions. Carbonate minerals can be divided into three categories:

1. 17 samples in which +14‰$<\delta^{18}O<$+10‰ and -10‰$<\delta^{13}C<$-6‰. These samples correspond to classical carbontites and indicate isotopic equilibrium with quartz and feldspar at temperatures between 500° and 700°C.

2. 5 samples that show a linear relationship between $\delta^{18}O$ and $\delta^{13}C$, with +15‰$<\delta^{18}O<$+23‰ and -7.5‰$<\delta^{13}C<$-4‰. These values indicate that these carbonates are later stage minerals than those of group 1, precipitating at lower temperature.

3. 3 samples with elevated $\delta^{18}O$ values between +20 and +25‰ and highly variable $\delta^{13}C$. These carbonates represent either low temperature precipitation or reequilibration of group 1 and 2 minerals with surface waters at low temperature.

Graphite is an abundant phase in the catazonal basement rocks of Norway. The isotopic study of Andreae (1974) demonstrated that graphite and related carbon-bearing phases in the Hercynian basement is organic in origin, based on $\delta^{13}C$ values which always fall between -20‰ and -30‰.

The $\delta^{13}C$ values of CO_2 in fluid inclusions varies from -23.7‰ to -7‰ and reflect local variations in formation conditions, including temperature and lithology. For example, the 1977 study by Kreulen of regional metamorphism at Naxos showed that the composition of fluid inclusions in quartz lenses can be strongly influenced by the presence of nearby graphite-rich beds. Similar influences of local heterogranitics may have been important in the catazonal rocks of southern Norway.

Based on the new Norwegian data and the work of Kreulen and Andreae, the authors propose a multi-episode model of crustal-mantle interactions:

a) Granulite facies metamorphism was simultaneous with emplacement of basic intrusions which was accompanied by a CO_2-rich fluid phase. The fluid phase was distributed irregularly in the lower crust in response to the variable physical and mechanical properties of the complex mineral assemblage. The inclusions which have very negative $\delta^{13}C$ values probably represent a fluid phase contaminated by graphite-equilibrated carbon trapped at this stage.

b) Fluid pathways formed over time in response to intermittent emplacement of basic intrusives. With time the bulk graphite content of the rocks decreased due to reactions and incorporation into the fluid phase, and the $\delta^{13}C$ composition of the CO_2 evolved toward more positive values reflecting the contribution of mantle carbon with a value near -7‰.

c) Carbonate formation more clearly reflects the juvenile origin of the carbon than does the fluid inclusion CO_2, with values between -12‰ and -6‰ being very close to those of carbonatites. Later stage carbonates reflect declining temperatures and reequilibration with other fluid phases under open-system conditions.

d) The cordierite zone, representing the transition from granulite facies to amphibolite facies, is high in hydrocarbons, but the CO_2 in inclusions in these rocks have an unusually heavy $\delta^{13}C$ value near -9‰. To explain this value, it is probably necessary to consider that the zone once was rich in graphite but has been subject to major redox fluctuations, perhaps associated with the presence of deep groundwater.

PIPEROV, N.B., PENCHEV, N.P. and ZIDAROVA, B.P., 1979, The analysis of the volatiles from fluid inclusions in hydrothermal fluorite: Chem. Geol., v. 27, p. 215-231. First author at Inst. Gen. and Inorg. Chem., Bulgarian Acad. Sci., 1040 Sofia, Bulgaria.

Volatiles from primary fluid inclusions in hydrothermal fluorite were studied. The gases released were analyzed with a mass spectrometer using an internal standard; water-vapor pressure was measured manometrically.

To extract the volatiles, both heating and grinding in vacuum were used. In the thermal treatment, volatiles from other sources besides the inclusions were also found: H_2 and hydrocarbons, as well as additional amounts of H_2O and CO_2. The vacuum grinding, on the other hand, leads to volatile deficiency, especially with respect to H_2O and CO_2, due to retention of these components on the ground material.

The study of the dependence of amount of volatiles released upon heating, on the grain size of the mineral fractions, was used as additional information for evaluating the amounts of volatiles coming from a source other than inclusions.

The thermal studies were supplemented by decrepitophonic measurements.

It is concluded that the volatiles from inclusions are represented practically only by CO_2 and H_2O in a 1:100 molar ratio. Conclusions about the conditions of mineral formation are drawn. (Authors' abstract)

PISKUNOV, Yu.G. and MAKIYEVSKIY, V.P., 1978, Temperature conditions of formation of a deposit of the Lower Priamur'ye, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 185-186 (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center of Acad. Sci. of USSR, Vladivostok.

The deposit* occurs in large volcanic-tectonic structure and belongs to Au-Ag type and sulfide-low formation. The first, hydrothermal-metasomatic stage caused origin of Au-Ag ores (Th 200-180°C, P 900-180 atm). The second, skarn-hydrothermal stage caused recrystallization of ores and leakage of fluid inclusions. (From the authors' abstract translated by A.K.) (*Deposit name not given, A.K.)

PISKUNOV, Yu.G., ZAREMBSKIY, Ye.P. and KOZLOVA, L.A., 1980, Problems of skarn mineralogy at a deposit in the Lower Priamur'ye, p. 65-73 in: Mineralogy of native elements, publ. by Far-East Sci. Center, Vladivostok, 154 pp., 500 copies printed, price 1 rbl. 40 kopecks (in Russian).

The unnamed deposit occurs in the E. part of the Amgun synclinorium in andesites, their lavas and tuffs. Minerals of skarn zones gave the following Td: grossularite 580-340°C, bustamite 560-180°C, andradite 560-190°C, epidote (pistacite) 470-310°C, magnetite 550-320°C, actinolite 450-190°C, calcite 230°C, quartz 290-160°C, sulfides 280-270°C. (Abstract by A.K.)

PISUTHA-ARNOND, V. and OHMOTO, H., 1980, Chemical and isotopic composition of the Kuroko ore-forming fluids (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 500-501.

Fluid inclusions in 20 samples of sulfides and quartz from 5 Kuroko deposits were extracted in vacuo, and their isotopic compositions, cations and dissolved gases were determined. The isotopic and chemical compositions of extracted fluids show wide variation (e.g., $\delta D = -5$ to $-50‰$; Na = 0.5±.2 m; K = 0.07±.01 m; Ca = 0.02±.02 m; Mg = 0.01±.005 m; CO_2 = 0.25±.10 m; and salinity = 3.8±1.5 wt.%. The salinity values are in good agreement with those obtained from freezing temperature measurements of fluid inclusions. Temperatures estimated from Na-K-Ca geothermometry are 200 to 350°C, which generally agree with those estimated by other geochemical methods. The pH values of the Kuroko ore fluids, calculated from cation chemistry, CO_2 content, and the observed alteration assemblages (i.e., sericite + quartz + Mg-chlorite - calcite), are 4.5±.5 for the entire temperature range of mineralization. The isotopic and chemical compositions of the Kuroko fluids are similar to those of fluids in experimental seawater-rhyolite and seawater-dacite systems at T = 200-350°C and low water/rock ratios. This supports the theory that the Kuroko ore-forming fluids evolved from seawater through high temperature interactions with felsic volcanics. The CO_2-salinity-T data of the fluid inclusions together with the observation that the inclusions are all simple liquid-rich type (i.e., no boiling) indicate that the Kuroko ores were formed in a deep ocean at depths greater than ~1500 meters. (Authors' abstract)

POLEMIO, Mario, BUFO, Sabino and PAOLETTI, Sergio, 1980, Evaluation of ionic strength and salinity of groundwaters: effect of the ionic composition: Geochim. Cosmo. Acta, v. 44, p. 809-814. First author at Istituto di Chimica Agraria, Via Amendola, 165/A I 70126 Bari, Italy.

An improved method has been used for rapid determination of the ionic strength (I) and the salinity of Apulian groundwaters. The parameters required are the electrolytic conductivity (EC) and the total solute concentration (C_T) of the solutions. A simple empirical relation between I, EC and C_T is presented. The relation holds over a wide concentration and composition range. The combined use of C_T and of the ratio I/C_T is shown to be effective in defining the salinity of groundwaters. (Authors' abstract)

POLYKOVSKIY, V.S., 1978, Thermobarogeochemical conditions of formation of fluorite ore mineralization in Middle Asia, (Abst.): Abstracts of the

Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 137-138 (in Russian). Author at Ministry of Geology of Uzbekistan, Tashkent.

The following types of fluorite mineralization were distinguished: pegmatitic (380-120°C, 350-150 atm), skarn (300-130°C, 350-200 atm), pneumatolytic-hydrothermal, including rare-metal greisens (330-90°C, 500-400 atm), hydrothermal (300-85°C, 500-90 atm). The intervals 280-150°C and 300-120 atm are most suitable for fluorite precipitation. Parent solutions of high T fluorite deposits bear 7-20 mg of salts per 100 g of sample, consisting of ions Cl 63.3, SO_4 25.5, HCO_3 11.2, Ca 63.2, Na 32.5, NH_4 3.7, K 0.6 or Cl 39.8, SO_4 32.7, HCO_3 26.5, F 1, Na 51.3, Ca 24.3, Mg 16.2, K 5.4, NH_4 2.8; moderate- and low-T deposits - up to 3 mg per 100 g of fluorite, ionic composition Cl 53.3, HCO_3 33.3, SO_4 11.1, F 2.3, Ca 50, Na 24, K 12, Mg 10, NH_4 4 or SO_4 41, HCO_3 33.3, Cl 25.6, Na 50, Ca 39.5, K 10.5. Gases in early phase (quartz-fluorite at 250-200°C) have $H_2>N_2>CO_2$; in medium phase (violet and green fluorite and barite at 230-100°C) - $N_2>>H_2>CO_2$; late phase (colorless fluorite and calcite at 110-90°C) - $H_2>CO$(sic.)$>N_2$. (Author's abstract translated and shortened by A.K.)

POMARLEANU, Vasile and SABLIOVSCHI, Victor, 1980, Contribution to the geochemistry of muscovite from Romania (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 139.

Th of inclusions in muscovite from metamorphic and pegmatitic rocks (220-600°C) were apparently obtained to check on another geothermometer based on the chemical composition. (E.R.)

PONOMAREVA, N.I., 1980, Comparative characteristics of composition of gas-liquid inclusions in quartz from pegmatites of the Northern Karelia: Geol. Rudn. Mest., v. 22, no. 2, p. 18-26 (in Russian). Author at Sci.-Res. Inst. of the Earth's Crust of the Leningrad State Univ., Leningrad, USSR.

The samples for water leachates were taken from mica, mica-ceramic and ceramic pegmatites. S inclusions in quartz were opened by decrepitation at 200°C (heating time 2 hours), then leached. Following this, leachates from the remaining essentially P inclusions were prepared. Results were controlled by following calculation X = (Total anions - total cations)/(total anions + total cations)·100%, where ions are stated µg-equiv.(sic.). The paper presents 24 analyses of water leachates from quartz with ions determined: Na, K, Mg, Ca, Cl, F, SO_4, HCO_3. On the basis of the data obtained the ionic strength and activity coefficients of electrolytes were calculated. Solutions in inclusions have SO_4-Cl-HCO_3 composition. Microcline-free pegmatites differ from microcline-bearing ones in high Ca, low Na and K contents, and low values of K/Ca ratio. Mica pegmatites, unlike mica-ceramic ones, have lower values of Na/Ca and K/Ca, and they occupy intermediate position between microcline-free and essentially microcline pegmatites. Mica pegmatites have fluids essentially richer in Cl and SO_4 than ceramic pegmatites. (Abstract by A.K.)

POPIVNYAK, I.V., DEMIN, B.G., LEVITSKIY, V.V. and KOPTIL', V.I., 1980, New data on volatile components of mineral-forming media of the mantle: Dokl. Akad. Nauk SSSR, v. 254, no. 5, p. 1238-1241 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 254, 1980, p. 223-

226 (1982). First author at Univ. L'vov, USSR.

Gases were extracted, by crushing in vacuum, from melt inclusions trapped in pyrope grains from the Sytykan kimberlite pipe and in olivine from the Udachnaya pipe. Four analyses by multiple gas chromatography, permitting separating of CO_2, O_2, N_2, H_2, He, and hydrocarbons from methane to hexane.

The inclusions in red garnet contain glass and 2 or 3 solids and opaque phases. Th = 1290°-900°C. Orange garnet has similar inclusions, but mostly decrepitated, with a halo of secondaries. N_2 62-88 vol.%, CH_4 0.02, CO_2 2-31, O_2 7-13, H_2 0.14-0.3. Higher hydrocarbons were much lower than methane, but most were present. Three samples with 11-13% O_2 had 83-88% N_2, but are assumed to come from the mantle. (E.R.)

POPOV, V.A., 1980a, Quartz from the Berezovskoe gold-ore deposit in the Urals, in: Mineralogical studies of the hydrothermal deposits of the Urals, p. 3-10: The Ural Sci. Center of Acad. Sci. USSR Publ. House, Sverdlovsk, price 95 kopeck, 700 copies printed (in Russian).

The paper bears some reference Th and P determinations and the author's conclusion that "separation of gases during fracture formation and trapping of mostly non-equilibrium solutions by quartz invalidate here such common methods of study of vein quartz as pH of suspensions, water leachates, decrepitation, H_2O/CO_2 ratio, since they don't submit exact information either for theoretical modelling of processes or for economic evaluation of the ores." (A.K.)

POPOV, V.A., 1980b, Characteristics of main rock-forming minerals of hydrothermalites of the Badzhal'skiy Ridge, in: Mineralogical studies of the hydrothermal deposits of the Urals, p. 61-70: The Ural Sci. Center of Acad. Sci. USSR Publ. House, Sverdlovsk, price 95 kopeeck, 700 copies printed (in Russian).

In the samples of hydrothermal rocks from Badzhal'skiy tin ore region (Khabarovsk country, i.e., not in the Urals, A.K.) tourmaline has Td 300-350°C. (A.K.)

POPOVA, V.I., 1980, Mineralogy of ores of the Berezovoe tin ore deposit, in: Mineralogical studies of the hydrothermal deposits of the Urals, p. 82-93: The Ural Sci. Center of Acad. Sci. USSR Publ. House, Sverdlovsk, price 95 kopeeck, 700 copies printed (in Russian).

The Td of minerals from the Berezovoe tin deposit (Khingano-Olonoy region, Far East) are as follows: quartz 190-230°C, 310-350°C, 410-450°C, arsenopyrite 300-320°C, chalcopyrite 250°C. (A.K.)

POPP, R.K. and FRANTZ, J.D., 1979, Mineral solution equilibria-II. An experimental study of mineral solubilities and the thermodynamic properties of aqueous $CaCl_2$ in the system $CaO-SiO_2-H_2O-HCl$: Geochim. Cosmo. Acta, v. 43, p. 1777-1790. Authors at Carnegie Inst. Wash., Geophy. Lab., 2801 Upton St., NW, Wash., DC 20008.

Speciation of aqueous calcium chloride and the solubility of wollastonite represented by the reaction

$$\text{wollastonite} + 2HCl^\circ \rightleftarrows CaCl_2^\circ + \text{quartz} + H_2O$$

were experimentally investigated at 1 and 2 kbar in the range 425-600°C using rapid-quench hydrothermal techniques and a modified Ag + AgCl buffer technique (Frantz and Popp, 1979). Variation in the measured concentration in HCl° as a function of total dissolved calcium was used to identify associated aqueous $CaCl_2^0$ as the predominant calcium species in the fluid at temperatures above 500°C at 2 kbar. The data were used to calculate the equilibrium constant for the above reaction as a function of temperature and pressure, from which the difference in Gibbs free energy of formation between $CaCl_2^0$ and HCl° at 1 and 2 kbar, 450°-600°C was calculated. Solubility constants for minerals in the system $MgO-CaO-SiO_2-H_2O-HCl-CO_2$ were calculated using the data from this study and from Frantz and Popp (1979). Calculated mineral solubilities were used to calculate the solution compositions and solid alteration products resulting from interactions of a Ca-Mg silicate mineral (diopside) with hydrothermal solutions containing a range of different total chloride concentrations. High total chloride (2.0 m) in the solution results in Si-Mg enrichment in the solids and Ca enrichment in the fluid, whereas low total chloride (0.008 m) results in Mg enrichment in the solids and Ca-Si enrichment in the fluid. (Authors' abstract)

POTTER, R.W., II and HAAS, J.L., Jr., 1978, Models for calculating density and vapor pressure of geothermal brines: J. Res. U.S. Geol. Survey, v. 6, no. 2, Mar.-Apr. 1978, p. 247-257.

In a model for estimating density of a brine, the density of a natural brine at a known temperature, pressure, and composition can be calculated from the densities of the component salt solutions in the complex brine. A model for estimating vapor pressure requires two direct or indirect estimates of the vapor pressure and uses a published "reference-substance principle" to extrapolate these data 200° to 300° above the temperature of the highest observation. The methods can be used to estimate the partial molal volume and partial molal enthalpy of H_2O in the natural brine and the partial molal volume change and partial molal heat change for the H_2O component in the vaporization process. The equations for density and vapor pressure and the derived thermochemical properties will help in designing turbines for operation with geothermal and geopressured brines, in optimizing production conditions, and in physical and chemical modeling of a geothermal reservoir. (Authors' abstract)

POTY, B. and WEISBROD, A., 1978, Equilibria between fluids and minerals: Rapport Annuel - Centre de Recherches Petrographiques et Geochimiques, 1978, p. 73-116 (in French).

Indexed under Fluid Inclusions. (E.R.)

PRASOLOV, E.M., LOBKOV, V.A. and YAKUTSENI, V.P., 1980, Rate and depth of methane generation in the Earth's crust, as shown by isotope data: Dokl. Akad. Nauk SSSR, v. 252, no. 6, p. 1476-1479 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 185-188 (1982).

PRICE, W.F. and BAILEY, D.K., 1980, A carbon dioxide-rich volatile phase in Mount Etna volcanism: Min. Mag., v. 43, p. 675-677.

Gases were extracted by heating at 1100°C for 2 hours, from samples of whole rock and plagioclase phenocrysts. Analysis was by mass spectrometry. H_2O and CO_2 were major, CH_4 next, and 0.05 to 0.45% each of SO_2, HCl, H_2S, and Ar. (E.R.)

PROSKURYAKOV, A.A., 1980, P-T characteristics of quartz veins as a criterion of their ore capacity (on the example of one of the gold ore deposits in Middle Asia), in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 158-161 (in Russian).

Quartz veins in the deposit may be divided into three groups: ore-free "preintrusive" quartz veins of metamorphic origin formed under conditions of high P (up to 3000 atm), from solutions with a dense mixture of CO_2, N_2 and hydrocarbons; quartz of the gold ore stage crystallized at T $\leq$450°C, and P 1500-1300 atm, under conditions of high saturation by fluid. In the beginning of ore stage solutions were mostly CO_2-rich, and in its end they were of highly concentrated alkaline-chloride type. Quartz veins of the final part of the ore stage formed from moderately concentrated relatively cold solutions under low P. Results of complex thermobarogeochemical studies may be used for establishing the prospecting criteria for gold and other ores. (Author's abstract translated by A.K.; note - abstract of this paper was not printed in the Abstract volume of the Vladivostok Meeting, 1978.)

PSHENICHNYI, G.N. and ANDRYANOVA, N.A., 1978, Regeneration temperatures in the sulfide deposits of the Southern Urals (abst.): Abstracts of the Sixth All-Union Meeting, Valdivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 108-109 (in Russian). Authors at Geol. Inst. of Bashkirian Division of Acad. Sci. USSR, Ufa, USSR.

G/L inclusions in quartz paragenetic with chalcopyrite, bornite and chalcocite of regeneration ores in the Uchalinskoe deposit, have Th in ranges 95-425°C, mostly in L. Five T groups of inclusions were distinguished (380-425, 300-360, 260-300, 170-220 and 95-160°C). (A.K.)

PUGIN, V.A. and KHITAROV, N.I., 1980, Variolites as an example of liquid immiscibility in magmas: Geokhimiya 1980, no. 4, p. 496-512 (in Russian; translated in Geochem. Internat., v. 17, no. 2, p. 102-117, 1980 (pub. 1981)). Authors at V.I. Vernadskiy Inst. Geochem. & Anal. Chem., Acad. Sci. of the USSR, Moscow.

Separation of basaltic material of variolites into two components (varioles and matrix) indicates that liquid immiscibility in basalts can lead to formation of acid and ultrabasic branches of the melts. The ultrabasic branch may contain from three to four times more volatiles than the acid branch. Experimental investigations on a variolite have confirmed the petrochemical data. The experimental work has established the layer separation region; the conditions of variolite formation are discussed. An investigation of the chemical compositions of the products of liquid immiscibility (liquates) has shown that this process can favor formation of iron ore deposits. (Authors' abstract)

PUGIN, V.A. and KHITAROV, N.I., 1980, Variolites as an example of magma immiscibility: Geokhimiya, no. 4, p. 496-512 (in Russian, English abstract). Authors at Inst. Geochem. and Anal. Chem., Moscow, USSR.

See previous item.

PUNIN, Yu.O, PETROV, T.G. and TREYVUS, Ye.B., 1980, Low-temperature modelling of processes of mineral formation: Zapiski Vses. Min. Obshch.,

v. 109, no. 5, p. 516-529 (in Russian). Authors at Leningrad State Univ., Leningrad, USSR. (See translations)

PUTNAM, B.R., 1980, Fluid inclusion and microchemical analysis of the Hansonburg Mississippi Valley type ore deposits in central New Mexico (abst.): N.M. Geol. (Socorro), v. 2, no. 3.

PUZANOV, L.S., 1978, Systematics of magmatic types of fluorite mineralization, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 130-131 (in Russian). Author at All-Union Inst. of Mineral Raw Materials, Moscow, USSR.

Fluorite carbonatites of E. Sayans (Bol'she-Tagnin massif) and Tuva depression bear abundant fluorite with solidified inclusions having Th 600-720°C and 700-760°C (P 4-6 kbar), respectively. At the boundary of Aldan shield and Siberian platform, the quartz-fluorite and carbonate-quartz-fluorite bodies (Th of inclusions in fluorite ranges from 800 to 870°C) occur in monzonite-syenite and leucitite-alkaline syenite. Accessory magmatic fluorite is connected with acid melts forming granites and pegmatites; Th in this fluorite is 580-855°C, P 0.5-1, 5 kbar. (A.K.)

PUZANOV, L.S., PARTSEVSKIY, A.I. and BEBIK, A.N., 1978, Conditions of formation of fluorite ore at the Samodumovskoe deposit in the Aldan, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 167-168 (in Russian). Authors at VIMS, Moscow, USSR.

Magmatic fluorite at the Samodumovskoe deposit in the Central Aldan occurs with quartz, carbonate and hornblende. Inclusions in this fluorite bear 70-80% of dms, up to 10% of G and 10-20% of L, Th 800-870°C. PS magmatic inclusions bear L and G CO_2, CH_4 and H_2S, dms and LH_2O. Hydrothermal-pneumatolytic-stage fluorite bears inclusions with Th 520-130°C. (From the authors' abstract translated by A.K.)

RAADE, Gunnar and HAUG, Jan, 1980, Rare fluorides from a soda granite in the Oslo Region, Norway: Mineral. Record, March-April, p. 83-91.

Miarolitic cavities in a granite contain many different fluoride phases, which are compared with other fluoride localities (and should be considered as potential dms in inclusions, as these cavities are, in effect, drained fluid inclusions). (E.R.)

RABOTNOV, V.T. (Deceased), KULIBAKINA, I.B., AREF'YEV, O.A. and GULYAYEVA, N.D., 1980, Relic hydrocarbons in crystalline basement rocks of the Siberian platform: Dokl. Akad. Nauk SSSR, v. 252, no. 5, p. 1207-1210 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 66-68 (1982). Authors at All-Union Nat. Gas Res. Instit., Vidnoye (Moscow Oblast), USSR.

Twenty analyses of chloroform-extractable bitumen are presented. (E.R.)

RADTKE, A.S., RYE, R.O. and DICKSON, F.W., 1980, Geology and stable isotope studies of the Carlin gold deposit, Nevada: Econ. Geol., v. 75, no. 5, p. 641-659. First author at U.S. Geol. Survey, 345 Middlefield Rd., Menlo Park, CA 94025.

The Carlin gold deposit, largest of the epithermal disseminated replacement-type gold deposits discovered to date in the United States, formed as a result of hydrothermal processes associated with a shallow-seated late Tertiary igneous event. The orebodies formed by the replacement of carbonate minerals, principally calcite, in thin-bedded argillaceous arenaceous dolomitic beds favorable for mineralization within the upper 245+ m of the Roberts Mountains Formation. Early hydrothermal fluids dissolved calcite and deposited quartz. Fluids during the main hydrothermal stage introduced Si, Al, K, Ba, Fe, S, and organic materials, plus Au, As, Sb, Hg, and Tl; quartz and pyrite were deposited, potassium clays formed, and more calcite was dissolved. Sulfides and sulfosalts containing As, Sb, Hg, and Tl, and base metal sulfides of Pb, Zn, and Cu probably formed later in the paragenesis.

The main stage of ore deposition was terminated with the deposition of barite veins and the onset of boiling. The fluids lost H_2O, CO_2, H_2S, and other components, leading to the production of H_2SO_4 in the upper levels of the deposit and to subsequent intense acid leaching and oxidation of rocks and ore near the surface. Within this zone, calcite and large amounts of dolomite were removed, sulfides and organic compounds oxidized, kaolinite and anhydrite formed, and silica was added. After the hydrothermal event, the upper part of the deposit underwent weak oxidation by cooler ground water.

Fluid inclusion evidence indicates that main-stage mineralization temperatures were 175° to 200°C. During later stage acid leaching and vein formation, when boiling was widespread in the hydrothermal fluids, temperatures may have reached as high as 275° to 300°C. The salinity of the fluids increased markedly from about 3 ± 1 equivalent weight percent NaCl during the main stage to as much as 17.4 percent during the later boiling. The salinity as well as the temperatures of fluids during late-stage supergene oxidation were quite low.

Hydrogen and oxygen isotope data indicate that the hydrothermal fluids were highly exchanged meteoric waters of δD -140 to -160 per mil and that $\delta^{18}O$ values increased with boiling from about 3 ± 3 to over 10 per mil. Along some fracture zones the hydrothermal fluids mixed with unexchanged surface water. The $\delta^{18}O$ values of different forms of silica (sedimentary chert, jasperoid, and quartz veinlets) are distinctive, as are different generations of calcite, and may be used as an aid to sort out obscure paragenetic features. (From the authors' abstract)

RADTKE, A.S., WITTKOPP, R.W. and HEROPOULOS, Chris, 1980, Genesis of gold-bearing quartz veins of the Alleghany district, Calif. (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 148. First author at Radtke and Assocs., Palo Alto, Calif.

Gold-bearing quartz viens in the Alleghany district occur along steeply dipping enechelon faults cutting phyllite, amphibolite, and quartzite. Early hydrothermal fluids moved upward along faults and precipitated quartz plus minor arsenopyrite, pyrite, and gold. Fluid inclusion studies show filling temperatures of 195 to >300°C, salinities of 10 to >20 wt.% NaCl equivalent, and daughter minerals of dawsonite, muscovite, and paragonite. During vein formation all types of wallrock underwent chloritic and sericitic alteration. Sealing of faults by quartz caused later fluids to move upward along contacts between serpentinite and other rock types. These fluids deposited quartz, magnesite-ankerite, and large amounts of arsenopyrite and gold, forming rich ore shoots in veins 50-100 feet from serpentinite contacts. Fluid inclusion data show filling temperature of 180 to 290°C, salinities of 3 to 16 wt.% NaCl equivalent, and a

CO_2 content as much as 20%. These fluids altered serpentinite to magnesite and lesser dolomite, chromite to mariposite, and leached silica. Arsenic in the fluids reacted with nickel sulfides to form sulfarsenides. Wallrock alteration along veins by CO_3-rich solutions is restricted to local formation of ankerite superimposed on the earlier alteration.

Precipitation of gold from late fluids to form high-grade shoots could have been due to (1) reaction between solutions undersaturated with quartz along serpentinite contacts with earlier quartz in veins, and (or) (2) boiling off of CO_2 causing increase in solution pH and lower gold solubilities, or (3) mixing with cool low salinity meteoric water. (Authors' abstract)

RAKHMANOV, A.M. and ABDULLAEV, M.Yu., 1980, Stages and physico-chemical conditions of formation of skarn-rare-metal deposit Sarymat, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 55-61 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 1, Abdullaev and Rakhmanov. (A.K.)

RAKHMANOV, A.M., ISKANDAROV, F.Sh. and DUROV, S.I., 1980, Thermometric and cryometric studies of gaseous-liquid inclusions in quartz crystals from the rare-metal deposit Mushiston, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 52-54 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 149, Rakhmanov et al. (A.K.)

RAMASAMY, Ramachandran and SHAPENKO, Vladimir, 1980, Fluid inclusion studies in carbonatites of Tiruppattur, India (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 79.

Carbonatites occur in three different geological settings near Sevvattur, Jogipatti and Onnakarai Villages amidst the ultramafic and alkaline complex of Tiruppattur, India. Minerals of carbonatites and their associated alkaline rocks contain inclusions of CO_2 and hydrocarbons. Zircon, apatite, diopsidic acmite and oligoclase have high temperature primary melt inclusions while the calcite and dolomite matrix has hydrothermal primary and secondary inclusions. In lamprophyres and syenites, presence of primary inclusions of similar types are found both in mafic minerals and feldsic matrixes. Solid globular primary calcite inclusions are found in orthoclases at the contacts of carbonatites/syenites/pyroxenites. These factors suggest that magmatic differentiation with intermittent liquid immiscibility is the effective process for the formation of alkaline rocks and carbonatites from a common parent magma. During the initial stages of carbonatite formation, oxygen is much absorbed from the magmas by the formation of magnetite, riebeckite, apatite and other minerals while CO_2 and other volatiles are enriched during the late stages of magmatic evolution. Enrichment of CO_2 reduces the effect of fenitization in the surrounding rocks. From the studies of fluid inclusions of these carbonatites it is concluded that trends of oxidation, higher level emplacement, depth of formation, volatile content, decreasing size of inclusions and liquid CO_2 content move up form Sevvattur to Jogipatti and towards Onnakarai carbonatites. (Authors' abstract)

RAMBOZ, C., 1980a, Fluid-inclusion study of intragranitic wolframite-scheelite showing from Ardeche, France (abstr.): Papers presented at MAWAM Conference, Univ. Exeter, Dec. 1979, Inst. Mining and Metallurgy Trans., v. 89, Sect. B, p. B194.

In the southern border of the Saint Cierge granite, wolframite, scheelite and apatite are concentrated in strongly muscovitized facies that contain <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, Fluid phases associated with Sn-W deposits from South of Massif Central, France (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 80.

Fluid phases associated with tin and tungsten mineralizations have been investigated in various showings and economic deposits from South of Massif Central. Several types of fluid inclusions are found in all these deposits, which are two-phase inclusions at 31°C; according to their filling and behavior on cooling and heating, two main types of inclusions are distinguished:

+ Gas-rich inclusions (type I) are characterized by a vapor-bubble representing more than 50% of the cavity volume; they all contain pure liquid CO_2, as indicated by the formation of solid CO_2 below -100°C*(type I_1); and in some cases, the appearance of a meniscus of liquid CO_2 below 31°C (type I_B); they homogenize above 350°C by expansion of the carbonic phase in the cavity. * sic

+ Liquid-rich inclusions (type II) contain a vapor-bubble which represents 10 to 50% of the inclusion volume. Some of them are carbonic inclusions, as indicated by the formation of solid CO_2 and a complex CO_2-clathrate, on cooling. (type II_A); in addition, some inclusions show a meniscus of liquid CO_2 below 31°C (type II_B); in type II_C inclusions, the presence of CO_2 is indetectable since no clathrate is formed on cooling.

All type II inclusions homogenize by disappearance of the gas bubble below 360°C.

- Most type I inclusions are interpreted to represent a CO_2-rich steam trapped between 400°C and 500°C, at around 500 bars. Evidence exists that this steam contains in solution various amounts of silica, tin, tungsten, boron, phosphorus.

- As both pressure and temperature decrease, condensation of the steam may occur, generating carbonic-bearing liquids, sometimes enriched in salts: dilution of the steam by aqueous liquids is also observed in some deposits.

It is interpreted that deposition of silica, cassiterite, wolframite, scheelite, tourmaline, apatite is related to both those phenomena. (Author's abstract)

RAMBOZ, C., 1980c, Problems posed by the determination of the composition of complex carbonic fluids with the aid of microthermometric techniques: Acad. Sci. (Paris), C.R., Ser. D, v. 290, no. 7, p. 499-501 (in French).

RANDOLPH, A.K., 1979, Geology and porphyry copper-type alteration-mineralization of igneous rocks at the Christmas mine, Gila County, Arizona: U.S. Geol. Survey Open-File Rept. 79-844, 209 pp.

The Christmas copper deposit, located in southern Gila County, Arizona, is part of the major porphyry copper province of southwestern North America. Although Christmas is known for skarn deposits in Paleozoic carbonate rocks, ore-grade porphyry-type copper mineralization also occurs in a composite granodioritic intrusive complex and adjacent mafic volcanic country rocks. This study considers the nature, distribution, and genesis of alteration-mineralization in the igneous rock environment at Christmas.

Early (Stage I) chalcopyrite-bornite (-molybdenite) mineralization and genetically related K-silicate alteration are centered on the Christmas stock. K-silicate alteration is manifested by pervasive hornblende-destructive biotitization in the stock, biotitization of basaltic volcanic wall rocks, and a continuous stockwork of K-feldspar veinlets and quartz-K-feldspar veins in the stock and quartz-sulfide veins in volcanic rocks. Younger (Stage II) pyrite-chalcopyrite mineralization and quartz-sericite-chlorite alteration occur in a zone overlapping with but largely peripheral to the zone of Stage I stockwork veins. Within the Christmas intrusive complex, K-silicate-altered rocks in the central stock are flanked east and west by zones of fracture-controlled quartz-sericite alteration and strong pyritization. In volcanic rocks quartz-chlorite-pyrite-chalcopyrite veins are superimposed on earlier biotitization and crosscut Stage I quartz-sulfide veins. Beyond the zones of quartz-sericite alteration, biotite rhyodacite porphyry dikes contain the propylitic alteration assemblage epidote-chlorite-albite-sphene.

Chemical analyses indicate the following changes during pervasive alteration of igneous rocks: (1) addition of Si, K, H, S, and Cu, and loss of Fe^{3+} and Ca during intense biotitization of basalt; (2) loss of Na and Ca, increase of Fe^{3+}/Fe^{2+}, and strong H-metasomatism during sericitization of quartz diorite; and (3) increase in Ca, Na, and Fe^{3+}/Fe^{2+}, and loss of K during intense propylitization of biotite rhyodacite porphyry dikes. Thorough biotitization of biotite granodiorite porphyry in the Christmas stock was largely an isochemical process.

Fluid-inclusion petrography reveals that Stage I veins are characterized by low to moderate populations of moderate-salinity and gas-rich inclusions, and sparse but ubiquitous halite-bearing inclusions. Moderate-salinity and gas-rich inclusions become less abundant, and halite-bearing inclusions are absent in Stage II veins. The distribution of gas-rich inclusions suggests that fluids were boiling during Stage I mineralization, particularly at higher levels in the porphyry copper system.

A sequential two-stage model for intrusion, alteration, and mineralization at Christmas is proposed. During Stage I, K-silicate alteration, stockwork veining, and chalcopyrite-bornite mineralization were broadly contemporaneous with emplacement of quartz diorite and repeated surges of biotite granodiorite porphyry. The fracture-controlled, predominantly hydrolitic alteration and high total sulfide, pyrite-chalcopyrite mineralization of Stage II probably commenced with the first significant incursion of ground water into the porphyry copper system. A convection cell model may reasonably account for the distribution of Stage II alteration and mineralization.

At Christmas the tendency to form biotite during K-metasomatism of basalt has greatly expanded the dimensions of the K-silicate alteration zone. The recognition and interpretation of secondary biotite in mafic volcanic terranes should be an important contribution to future exploration for porphyry copper deposits in the region. (From the author's abstract)

RANKIN, A.H., ALDERTON, D.H. and THOMPSON, M., 1980, Uranium: carbon ratios in fluid inclusions; implications for the transport of uranium in hydrothermal fluids associated with granites (abst.): Mineralog. Soc. Bull. (London), no. 49, p. 11.

Uranium has been detected in fluid inclusions in quartz from several granites in the UK and in uranium-bearing vein quartz from southwest England using inductively coupled plasma emission spectroscopy. Material is ejected from the inclusions during sudden decrepitation on heating the sample. This is then transferred into the plasma for qualitative analysis via a stream of argon. A number of other trace and minor elements have been detected in the resulting decrepitate. Of these carbon is of particular interest. It shows a strong positive correlation with uranium for the samples from southwest England; this correlation is less pronounced for the samples from outside this area. Results indicate that carbon plays an important role in the transport of uranium in hydrothermal systems. It is believed that the ability to detect uranium in fluid inclusions, rapidly and at low cost, has important implications in the field of mineral exploration. (Authors' abstract)

REKHARSKIY, V.I. (ed.), 1980, Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House, 200 pp. (in Russian; price 1 rbl., 80 kopecks; 850 copies printed).

This book, edited under the sponsorship of the Institute of Geology, Ore Deposits, Petrography, Mineralogy, and Geochemistry of the Academy of Sciences of the USSR, contains 13 papers, listed below, from prominent Russian fluid inclusion investigators, intended to review the more important methods and devices for fluid inclusion study and to promote those that they believed are most important. The individual papers are abstracted in this volume. (A.K.)

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REKHARSKIY, V.I., PASHKOV, Yu.N., IGNAT'YEVA, I.B. and NOSIK, L.P., 1980, Conditions of formation of ore-bearing hydrothermal-metasomatic formations at the molybdenum deposits, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 83-86 (in Russian).

Essentially the same as in the entry Rekharskiy et al., Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 150-151. (A.K.)

REYF, F.G., 1980, Conditions and mechanism of generation of ore-forming solutions at the tungsten deposits of Transbaikalia: Geokhimiya, no. 11, p. 1675-1684 (in Russian, English abst.). Author at Geol. Inst. of Buryatian Div. of Siberian Branch of Acad. Sci. USSR, Ulan-Ude, USSR.

Quartz from granitic massifs in Transbaikalia has melt inclusions and coeval liquid inclusions with dms. Melt inclusions contain also L H_2O+G phases which homogenize in L phase at 265-155°C; total homogenization of melt inclusions in early quartz in the massif Kpokoynoe was at 1020-985°C (88 incl.), coeval liquid inclusions $LH_2O+G \rightarrow L$ at 220-207°C, total homogenization ≥835°C (55 inclusions), same massif, late magmatic quartz - 1025-920°C (21 inclusions) and $GCO_2+LCO_2+LH_2O \rightarrow L$ 19-20°C (24 incl.); massif Khangilay - melt inclusions Th 950°C (24 inclusions) and coeval $G+LH_2O$+dms - Th 480°C (8 inclusions). Te of solutions is -25.8 to -22.5°C, Tm of last ice crystal -7.3 to -1.4°C. On cooling chlorides or acicular crystals with features of fluorides precipitate from solution. Determined P was ~5.5 kbar. Similar inclusions in quartz from granite of the massif Soktuy yielded Th 1235-940°C (75 melt inclusions) and ≥510°C (30 G+L+2 dms inclusions), solution of Cl-F type. Those solutions may be accepted as parent for ore mineralization. (Abstract by A.K.)

RHODES, J.M., DUNGAN, M.A., BLANCHARD, D.P. and LONG, P.E., 1979, Magma mixing at mid-ocean ridges: evidence from basalts drilled near 22°N on the Mid-Atlantic Ridge. In J. Francheteau, ed., Processes at Mid-Ocean Ridges: Tectonophysics, v. 55, p. 35-61. First author at Lockheed Electronics Co., Inc., Houston, Texas.

Summarizes the results of a detailed petrological, geochemical and experimental study of basalts recovered during Legs 45 and 46 of the Deep Sea Drilling Project, and presents evidence that magma mixing has played an important role, along with crystal fractionation, in the evolution of these and other sea-floor basalts. Three major lines of evidence are considered, including phenocryst mineralogy, melt inclusion compositions, and whole rock major and trace element chemistry. Taken together, this evidence indicates that "primitive" magmas and their attendant phenocrysts are episodically injected into fractionating magma chambers containing more evolved cogenetic magmas. The dominant products of this steady-state process of repeated magma injection, mixing and fractionation are moderately evolved ocean floor basalts. Compositional extremes, including "primitive," mantle-derived primary magmas and highly evolved differentiation products, will be rare. This model accounts for several enigmatic petrological characteristics of ocean-floor basalts previously inadequately explained by partial melting and crystal fractionation processes. Consequently, it is suggested that magma mixing is a fundamental process that is intrinsically interrelated with crystal fractionation in ocean-floor basalt petrogenesis. (Authors' abstract)

RICE, Jack M., 1980, Stability of clinohumite, chondrodite and norbergite in mixed-volatile (CO_2-H_2O-HF) fluids (Abst.): Geol. Soc. Amer. Abstracts and Programs, v. 12, p. 509.

RICKARD, D.T. and LINDBLOM, S., 1980, Fluid inclusion and related studies of sphalerite from the Laisvall sandstone lead-zinc deposit, Sweden: Soc. Geol. Belg., Ann., v. 102, no. 2, p. 485-495.

RIMSTIDT, J.D. and BARNES, H.L., 1980, The kinetics of silica-water reactions: Geochim. Cosmo. Acta, v. 44, p. 1683-1699. Authors at Ore Dep. Res. Sec., The Penns. State Univ., Univ. Park, PA 16802.

A differential rate equation for silica-water reactions from 0-300°C has been derived based on stoichiometry and activities of the reactants in the reaction $SiO_2(s) + 2H_2O(l) = H_4SiO_4(aq)$. From these experiments, it is concluded that the quartz geothermometer will give the most accurate results if samples are taken from the hottest, highest flow rate, thermal springs which occur above highly fractured areas. (From the authors' abstract)

RIPLEY, E.M. and OHMOTO, Hiroshi, 1979, Oxygen and hydrogen isotopic studies of ore deposition and metamorphism at the Raul mine, Peru: Geochim. Cosmo. Acta, v. 43, p. 1633-1643. First author at Dept. Geol., Indiana Univ., Bloomington, IN 47405.

The volcano-sedimentary sequence at the Raul mine, central Peru, consists of andesitic volcanics, graywackes, and siltstones, and has been metamorphosed to the upper greenschist-lower amphibolite facies at temperatures of 400-500°C. Isotopic data (O and H) have been collected from: (a) quartz and magnetite from stratiform ores, (b) amphiboles from amphibolite units that host stratiform ores, (c) calcite from late veins, (d) detrital quartz from graywackes, and (e) whole rocks.

Interunit differences in quartz and magnetite $\delta^{18}O$ values suggest that these minerals have resisted isotopic exchange during metamorphism, and that quartz-magnetite isotopic temperatures (380-414°C) represent primary formational temperatures. Calculated $\delta^{18}O$ values of water in equilibrium with quartz and magnetite range from 9.1 to 12.6‰.

Amphibole $\delta^{18}O$ and δD values show no interunit differences and suggest that the amphiboles have exchanged isotopes with a large metamorphic fluid reservoir. Calculated $\delta^{18}OH_2O$ and δDH_2O values range from 8 to 12‰ and -3 to +42‰, respectively.

$\delta^{18}OH_2O$ values calculated from $\delta^{18}O$ calcite and fluid inclusion filling temperatures range from 7.5 to 10‰. Water extracted from fluid inclusions in calcite has a δD value of -20‰.

$\delta^{18}O$ values of metamorphosed graywackes and volcanic sediments are not atypical, but andesitic lavas are ^{18}O-rich (8-10‰) compared to normal andesites.

Waters involved in ore deposition, metamorphism, and late vein formation at Raul are all thought to have a common source, principally seawater. The $\delta^{18}OH_2O$ and δDH_2O values could be produced by evaporation of seawater, shale ultrafiltration, and isotopic exchange with host rocks during deep circulation through the volcano-sedimentary pile.

A model is proposed whereby coastal ocean water is restricted from the open sea by volcanic island arcs, and subsequently undergoes evaporation. Circulation of this water is initiated by heat associated with seafloor volcanism. ^{18}O-enrichment in andesites may be produced by isotopic exchange with high ^{18}O waters at elevated temperatures and sufficiently high water/rock ratios. (Authors' abstract)

RIVERIN, Gerald and HODGSON, C.J., 1980, Wall-rock alteration at the Millenbach Cu-Zn mine, Noranda, Quebec: Econ. Geol, v. 75, p. 424-444.

Pipe-shaped zones of altered rock containing disseminated and stockwork vein mineralization underlie each of the several Archean volcanogenic Cu-Zn ore lenses at the Millenbach mine. The rocks and mineralization have been metamorphosed first to hornblende hornfels assemblages, then retrograded to greenschist facies assemblages, but the metamorphism has not significantly affected the bulk composition of the rocks. The alteration pipes show a distinct mineralogical zoning in which a core zone containing either anthophyllite-bearing assemblages or massive chlorite grades outward into a biotite-rich zone characterized by a spotted texture. Normative calculations were used to show that alteration pipes initially had a chlorite core which graded laterally and vertically into a sericite-rich outer zone and finally into unaltered rocks. Similar zoning is present on the selvedges of individual sulfide veins within the alteration pipes. Volume was conserved, and a distinctive metasomatic trend developed across the alteration pipes and vein selvedges during the alteration process. The most characteristic features of the altered rocks are increased Fe and Mg, and decreased Ca and Na, relative to fresh rocks. K and Al have generally been added at the margins and leached at the cores of pipes. Chemical zoning across vein selvedges is similar. The zoning of alteration types on vein borders, and to a certain extent in the pipes as a whole, is interpreted as due to the progressive reaction of an initially homogeneous hydrothermal solution with the rocks as the fluid moved upward in, and outward from, permeable channelways in the discharge conduit of a submarine, sea water-dominated hydrothermal system. However, an additional cause of vertical, and to a lesser extent lateral, zoning is thought to have been the existence of a strong vertical thermal gradient, as well a lateral variations in the permeability in the pipes. The thermal gradient could have been caused by the discharge fluid column being under hydrostatic pressure and everywhere at its boiling point. The fluid was probably evolved sea water which was in equilibrium with the rocks at depth in the system and then degenerated, causing alteration and sulfide deposition as a result of cooling and chemical changes associated with boiling as it rose in the conduit systems. (Authors' abstract)

RIVERS, Mark L. and GHIORSO, Mark S., 1980, Free energy minimization in multicomponent systems: applications to silicate liquid immiscibility (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 511

ROBERTS, W.H. and CORDELL, R.J., eds., 1980, Problems of petroleum migration: AAPG Studies in Geology No. 10, 273 pp.

Pertinent to many aspects of fluid inclusions in sediments. (E.R.)

ROBINSON, B.W., 1980, Isotopic evidence on the origin of sulfur in Mississippi Valley-type deposits, particularly in the British Isles; Proceedings of the Fifth Quadrennial IAGOD Symposium, Vol. 1, J.D. Ridge, ed.: Stuttgart, E. Schweizerbart Verlag., p. 487-493. Author at Instit. Nuclear Sci., DSIR, Lower Hutt, New Zealand.

The Mississippi Valley-type deposits of the U.S. typically have a wide spread of $\delta^{34}S$ values for sulfide and sulfate minerals (-20 to +30‰). Although the normal $\delta^{34}S$ trend of barite >sulfides is found, isotopic equilibrium is not achieved at the low temperatures of ore deposition (maximum about 200°C). Only rarely is sulfide-sulfide mineral isotopic equilibrium achieved. The interpretation of these results initially called upon bacterial reduction of connate sulfate, but more recently, equilibrium models have been suggested. However, the temperature regime is both too high for bacterial activity and too low for sulfur-isotopic equilibrium. Thus, kinetic isotope effects, together with the mixing of sulfur sources (both oxidized and reduced) appear to provide plausible working models to explain the spectrum of results.

A large range of sulfur-isotope results also has been found in the deposits of the British Isles (North Pennines, Derbyshire, and Silvermines, Ireland). Barites from Silvermines and the North Pennines have $\delta^{34}S$ around +19‰ and probably represent connate Carboniferous seawater sulfate. Sulfate reduction at depth is thought to have produced the H_2S for sulfide mineral deposition ($\delta^{34}S$ -6 to +15‰) in the North Pennines. At Silvermines, the sulfur in the vein deposits (-8 to +4‰) appears to be of deep-seated origin, but the bulk of the stratiform sulfide bodies (-36 to -13‰) were formed through biogenic reduction of sulfate.

New data for the Derbyshire area show spreads in both the galena (-23 to +7‰) and barite (+4 to +23‰) $\delta^{34}S$ values. Isotopic equilibrium is not present in the sulfide-sulfide and the majority of the sulfate-sulfide mineral pairs. However, the barites lie along equilibrium precipitation lines on a plot of $\delta^{34}S$ versus $\delta^{18}O$. Only the samples with high isotopic values may approach equilibrium. Much of the trend must be explained by the mixing of two sulfates: (1) connate Carboniferous seawater sulfate (high-isotopic values) and (2) regenerated fresh-water sulfate from H_2S oxidation (low-isotopic values). The sulfide sulfur also may have had dual origins: (1) H_2S with slightly positive $\delta^{34}S$ values, from the kinetic reduction of connate sulfate by carbonaceous material in the limestones, and (2) sulfur from kerogens in the limestones with $\delta^{34}S$ down to -30‰. This ore deposit, studied in detail, shows the sulfur sources and their modes of generation to be varied, a feature common in this type of mineralization. (Author's abstract)

ROBINSON, B.W., and CHRISTIE, A.B., 1980, Epithermal silver-gold mineralization, Maratoto Mine, New Zealand: Stable isotopes and fluid inclusions; Proceedings of the Fifth Quadrennial IAGOD Symposium, Vol. 1, J.D. Ridge, ed.: Stuttgart, E. Schweizerbart Verlag., p. 719-730. First author at Instit. Nuclear Sci., DSIR, Lower Hutt, New Zealand.

In the Coromandel Peninsula precious- and base-metal quartz veins occur dominantly in hydrothermally altered Cormandel group andesites and dacites (Miocene to lower Pliocene), but also in Jurassic graywackes and Pliocene rhyolites. Samples from the Camoola and Silver Queen veins (Martoto Mine), within the andesites, exhibit the general paragenetic sequence of stages: (1) quartz and calcite with minor pyrite; (2) sulfide and silver minerals, carbonates, and quartz; (3) vug quartz with overgrowths of calcite and pyrite.

Stage 1 and 2 sulfides (pyrite, chalcopyrite, sphalerite, and aguilarite) have $\delta^{34}S_{CDT}$ values of +2.2‰ and yield sulfur-isotope temperatures of 290±60 and 275±100°C for stage 2. Primary fluid inclusions in quartz and calcite (two-phase liquid-vapor) give filling temperatures of 270±30°C. With pressure corrections, they indicate a temperature of 285±35°C for stages 1, 2 and early stage 3.

Stage 1 and 2 calcites have $\delta^{18}O_{SMOW}$ and $\delta^{13}C_{PDB}$ values around +3±3 and -8±1‰, respectively. Higher isotopic ratios for late stage 3 calcite suggest temperatures of deposition as low as 50°C ($\delta^{18}O$ and $\delta^{13}C$ about +18 and -1‰, respectively). The calcites show a positive linear relationship on a plot of $\delta^{13}C$ versus $\delta^{18}O$ and lie about on a theoretical curve for calcite precipitating in equilibrium with an excess of H_2CO_3 in solution and $\delta^{13}C$ about -7±1‰. The inferred large quantity of carbon in solution and its isotopic composition suggest the source to be magmatic CO_2. Reduced sulfur in the ore fluid would have a $\delta^{34}S$ value of about +4‰, but stage 3 pyrite has a $\delta^{34}S$ value of around +16‰. The latter may reflect the isotopic composition of the ΣS in the fluid that originated as sulfur from the graywackes and underwent reduction by ferrous iron or hydrogen in the rocks.

Water from primary (plus some pseudo-secondary and secondary) inclusions in stage 3 quartz yielded δD_{SMOW} of -45±4‰. This value, together with calculated oxygen isotopic ratios for the ore fluid (-6‰ early, -4‰ main stage), suggests it to be deeply circulating meteoric water similar to present-day geothermal waters. The salinity of the fluids is low (up to 3.7 equivalent wt % NaCl), and leachates show the following elements to be present in order of abundance: Cl, Na, Ca, K, Li, Zn.

The measured concentration of CO_2 in the fluid inclusions and the presence of calcite in the veins allow a pH of 5.8 to be calculated for the Maratoto fluid (pH neutral at 285°C is about 5.5). Kaolinite present in the wall rocks and the measured K+ concentration of the fluid inclusions suggests a pH of less than 5.6. The fluid probably increased in pH after reacting with the wall rocks and moving into the veins, thus causing the deposition of calcite, the sulfides, and Ag-Au minerals. (Authors' abstract)

ROEDDER, Edwin, 1980a, Fluid-rock interaction in igneous and metamorphic processes as evidenced by fluid inclusions (Abst.): Fortschr. der Mineral., v. 58, Beiheft 1, p. 109.

Fluid inclusions trapped within minerals during their growth ("primary"), or at some later time during the healing of fractures ("secondary"), provide samples of fluids that were present at the time and place of trapping. However, 1) the recognition of primary inclusions is frequently difficult, except for silicate melt inclusions; 2) some igneous and most metamorphic rocks provide few if any verifiably primary inclusions; 3) a variety of changes can occur after trapping; and 4) the fluid inclusions in most igneous and metamorphic rocks are generally difficult to work with experimentally. In spite of these problems, the recent inclusion studies summarized here have provided important data on the temperatures, pressures, and chemistry of many igneous and metamorphic processes.

All data from fluid inclusions in igneous rocks must be evaluated in terms of two questions: 1) is the inclusion fluid a representative sample?; 2) has the composition of the fluid in the inclusion mainly controlled, or been controlled by, the solid phases in the rock before trapping? If two immiscible fluids were present, the fluids that are trapped will generally be grossly nonrepresentative of the bulk fluid, and may consist of only one of the two fluids. Examples include silicate melt and dense CO_2 fluid, as in the formation of most olivine nodules, or silicate melt and hydrosaline melt, as in some granites and pegmatites. However, even the qualitative recognition of the previous existence of an immiscible assemblage from study of the inclusions can be useful. The compositions of such fluids were probably close to equilibrium with each other and with the solid phases present at the time of trapping. Because a volatile-rich phase, in particular, probably has a very small mass fraction, its composition is effectively controlled by that of the bulk of the magma.

Late-stage processes, such as formation of greisen or skarn, albitization, and the hydrothermal alteration around metal deposits, solfataras, and geothermal systems generally form by fluid-solid interactions in which the mass ratio of fluid to affected rock is large. In such environments, the largest changes occur in the solids as they approach compositions in equilibrium with the fluid. Effectively infinite ratios may prevail along an armored passageway, but intermediate apparent ratios may prevail during infiltration of a porous zone. This wide range in mass ratio can result in a wide range of fluid-inclusion compositions. "Immiscibility" (i.e., boiling) in aqueous fluids may be easily recognized in fluid inclusions and also may cause significant changes in fluid composition and hence in solid-phase assemblage.

Studies of inclusions in metamorphic rocks show that fluids squeezed out of the metamorphic pile in the early, low-temperature stages have a wide range in salinity and may contain major N_2 and CH_4 and higher hydrocarbons. Later fluids may be from dehydration reactions and tend to be richer in CO_2 from decarbonation reactions; cation ratios are presumably controlled by the silicate phases with which they equilibrated. Salinity may also vary widely, for several possible reasons, and a continuum may exist between the fluids in high-temperature metamorphism and those in late-stage igneous processes.

Not all fluid-inclusion data can be interpreted unambiguously at present. For example, the apparently primary, very high-methane gas inclusions in nepheline in several alkalic intrusions are difficult to interpret in terms of known gas reactions. Similarly, evidence from fluid inclusions clearly indicates immiscibility between granitic (or pegmatitic) silicate and hydrosaline fluids in some occurrences, and a continuum in the evolution of others, but unfortunately most examples are ambiguous. Thus, the study of fluid inclusions has not always been successful, but it has provided an important source of data, some of which is otherwise unobtainable, on many geologic problems. (Author's abstract)

ROEDDER, Edwin, 1980b, Significance of high Ca-Al melt inclusions in olivine crystals from the Murchison type II carbonaceous chondrite (Abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France 4-6 July, 1980, p. 139-140.

The Murchison chondrite meteorite has been studied extensively. It consists of olivine-pyroxene aggregates and isolated crystals, which formed at high temperatures, in a hydrous, carbonaceous matrix, mainly layer lattice silicates, which formed at low temperatures. The olivine crystals contain Ca-Al-silicate melt inclusions. Several workers (Fuchs, Grossman, Olsen and others) have proposed that the melt inclusions represent globules of melt formed by direct (metastable?) condensation from the solar nebula; they further have proposed that the globules were subsequently enclosed, while still viscous, by olivine crystals growing from a vapor phase (mainly hydrogen) at about 1170°C and $\leq 10^{-3}$ atm. My studies of the inclusions indicate that this theory is incorrect, and that the inclusions and the olivine formed from a gas-bearing melt. The evidence is as follows: 1) glass (now phyllosilicates) coats the outer faces of some sharply euhedral olivines; 2) pseudosecondary planes of troilite, glass and "vapor" inclusions are found in olivine; and 3) several ~300 μm iron-rich olivines were found that have thick, almost inclusion-free rims and sharply defined, more magnesian cores that are densely and uniformly crowded ($\sim 5 \times 10^{10} \cdot cm^{-3}$) with <1 μm, mainly "vapor"-rich inclusions. These observations, and the lines of evidence presented by other workers, are most compatible with a relatively high temperature, two-stage formation of the olivine crystals from a gas-bearing, olivine-rich silicate melt containing some Ca and Al, rather than from a vapor phase. (Author's abstract)

ROEDDER, Edwin and BELKIN, H.E., 1980a, Thermal gradient migration of fluid inclusions in single crystals of salt from the Waste Isolation Pilot Plant Site (WIPP): Scientific Basis for Nuclear Waste Management, v. 2, p. 453-464.

Selected salt single crystals from core samples of bedded salt from the WIPP site have been tested to determine the rate of migration of their liquid-filled (fluid) inclusions in thermal gradients. Gradients of $1.5°C \cdot cm^{-1}$, maintained for periods of 3-10 days, at ambient temperatures of 108°-260°C, resulted in rates of movement of $1.2\text{-}5.4\ cm \cdot yr^{-1}$ for cubic inclusions 1 mm on an edge. Inclusions 0.1 mm on an edge moved only ~30% as fast. Increase in ambient temperature and/or gradient increased the rate, in approximately direct proportion. The migration rate for inclusions in different parts of a given sample, however, may vary by a factor of 3, for unknown reasons, and some other interesting observed phenomena are still unexplained. (Authors' abstract)

ROEDDER, E. and BELKIN, H.E., 1980b, Migration of fluid inclusions in polycrystalline salt under thermal gradients in the laboratory and in Salt Block II: Proc. 1980 Nat'l. Waste Terminal Storage Program Information Meeting, ONWI 212, p. 361-363.

The authors disagree with various aspects of the interpretation of Lambert (1980, this issue) on the migration of fluid inclusions in this experiment. (See also previous item.) (E.R.)

ROEDDER, E. and BODNAR, R.J., 1980a, Geologic pressure determinations from fluid inclusion studies (Abst.): EOS, v. 61, p. 393.

Temperatures by inclusion homogenization usually must be corrected for pressure via an independent estimate of pressure at the time of inclusion trapping, e.g., from geologic reconstructions of the probable overburden. Quite apart from such independent estimates, many methods have been proposed to obtain, estimate, or place upper or lower limits on the pressure at the time of inclusion trapping from the inclusions themselves. We have found that, unfortunately, several of the most commonly used methods have major errors in concept and/or application that invalidate the results. Included here are the methods of Lemmlein and Klevtsov, and of Lyakhov, for inclusions finally homogenizing by the solution of a salt crystal, that of Nacken for separate CO_2 and H_2O inclusions, and that of Naumov and Malinin for mixed CO_2-H_2O inclusions.

Unless an independent geothermometer is also available, single inclusions can yield only data that are functions of both P and T, but pairs of inclusions trapped from fluids that were immiscible at trapping (e.g., water and steam, or some water and CO_2) can yield both P and T. Inclusions of an immiscible water (or CO_2) phase, along with silicate melt inclusions, are a special example, in that the latter, in effect, provide an independent thermometer; hence, the pair can provide a geobarometer.

All such fluid-inclusion pressure determinations require 1) careful microscopy to prove inclusion origin and freedom from subsequent alteration processes; 2) good thermometric data on both heating and cooling; 3) good compositional data (in part from (2)); and 4) good experimental P-V-T-X data on the appropriate systems, over the required range. Lack of (4) is the most serious handicap to accurate geobarometery at present. (Authors' abstract)

ROEDDER, E. and BODNAR, R.J., 1980b, Geologic pressure determinations from fluid inclusion studies: Ann. Rev. Earth and Plan. Sci., v. 8, p. 263-301.
See previous item. (E.R.)

ROEDDER, E. and BODNAR, R.J., 1980c, Errors in geologic pressure determinations from fluid inclusion studies (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 82.
See previous item. (E.R.)

ROGOVA, V.P., 1980, Formation conditions of charoite rock-new raw material for jewelry, in: Gem minerals-Proceedings of the XI General Meeting of IMA: "Nauka," Leningrad, p. 79-86, price 70 kopecks, 9100 copies printed (in Russian, English abst.).

The minerals in charoite rock (Murunskiy massif, Aldan shield) a product of K-Ca metasomatism of alkaline rocks, bear fluid inclusions with following Th: tinaxite syngenetic with charoite (the latter forms 50-90% of rock) - 400°C, quartz from veinlets in charoite rock- 350°C. (A.K.)

ROMANCHEV, B.N. and FLEROV, G.B., 1980, Temperatures of lavas of the Great Fracture eruption of Tolbachik 1975-1976 (Kamchatka): Geokhimiya, no. 5, p. 688-697 (in Russian, English abstract). First author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

The eruption first extruded lavas of a high-magnesian, moderately alkaline type, next changing to final subalkaline Al-rich basalts. Inclusions in olivine, pyroxene and plagioclase consist of several silicate phases, ore mineral, glass, LCO_2 and GCO_2 (at room T); CO_2 phases are absent in minerals of the subalkaline Al-rich basalts suggesting its crystallization under subsurface conditions. Th, °C, of inclusions in plagioclase were 1200-1140, in pyroxene 1250-1140, in olivine 1260-1140. The results were analyzed in terms of the system diopside-anorthite-forsterite. General considerations suggested the mixing of magmas generated in independent magmatic chambers at various depths. (Abstract by A.K.)

ROMANCHEV, B.P., 1980, [Information available from] magmatogene inclusions (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General

Meeting, Orleans, France, 4-6 July, 1980, p. 141.
A review of magmatic inclusions. (E.R.)

RONA, P.A., 1980, TAG Hydrothermal Field: Mid-Atlantic Ridge crest at latitude 26°N: J. Geol. Soc. London, v. 137, p. 385-402.

Results of ongoing interdisciplinary investigation of the TAG Hydrothermal Field since discovery in 1972 by the NOAA Trans-Atlantic Geotraverse (TAG) Project are synthesized to document the first and only known active submarine hydrothermal field on a slow-spreading oceanic ridge. The structural setting of the field is the E wall of the rift valley of the Mid-Atlantic Ridge at lat. 26°N where high-intensity hydrothermal activity is favored by exceptionally close spacing of faults (tens and metres) that enhances permeability and facilitates voluminous circulation, and by projection of the wall directly over intrusive heat sources beneath the rift valley that increases thermal gradients which vigorously drive the upwelling limb of a sub-seafloor hydrothermal convection cell discharging through faults in the wall. A low in residual magnetic intensity coincides with the field and is attributed to hydrothermal alteration of the magnetic mineral component of basalt in the discharge zone. Hydrothermal precipitates in the form of manganese oxide crusts of extreme purity (40% Mn) and rapid deposition rate (200 mm$\cdot 10^{-6}$ yr) cover about 10% of the sea-floor within the field, distributed along faults sub-parallel to the rift valley. The composition and mineralogy of basalts exposed at the sea-floor is indicative of low-temperature zeolite metamorphic facies. Thin sediments of the field exhibit average metal-to-aluminum ratios and non-detrital metal accumulation rates (Fe, Mn, Ni, Co, Cu, Cr) that are high relative to other areas of the Mid-Atlantic Ridge. Present hydrothermal activity is evidenced in the near-bottom water by temperature anomalies and excesses of the primordial isotope ^{3}He, and the surrounding water column by increases in weak-acid soluble suspended particulate matter enriched in certain metals (Fe x 10; Mn 10%). The observed distribution of hydrothermal products indicates that the special structural and thermal conditions that have concentrated hydrothermal activity in the TAG Hydrothermal Field have persisted for at least 1.4 x 10^6 yr. (Author's abstract)

RONA, P.A., BOSTRÖM, Kurt, EPSTEIN, Samuel, 1980, Hydrothermal quartz vug from the Mid-Atlantic Ridge: Geology, v. 8, p. 569-572. First author at Nat. Oceanic & Atmosph. Admin., 15 Rickenbacker Causeway, Miami, FL 33149.

A site dredged on the east wall of the rift valley of the Mid-Atlantic Ridge at lat 24°21'N is characterized by a low in residual magnetic intensity similar to that observed at the TAG Hydrothermal Field in a structurally equivalent position 250 km to the north. Tholeiitic basalts that have undergone hydrothermal alteration, forming chlorites, analcime, calcite, and quartz-rich rocks, were recovered. The quartz is a late remobilization product, occurring in cracks and vugs as massive fillings and euhedral crystals. Oxygen-isotope thermometry indicates that the quartz was deposited from hydrothermal solutions comprising either sea water at 200°C or primary water at 330°C, consistent with a history of intense hydrothermal activity and the use of the magnetic low as a signature to identify such activity. (Authors' abstract)

ROSASCO, G.J., 1980, Raman microprobe spectroscopy, Chapt. 4, p. 223-282, _in_ Advances in Infrared and Raman Spectroscopy, v. 7, R.J.H. Clark and

R.E. Hester, eds., London, Heyden Co. Author at Nat. Bureau of Standards, Washington, DC 20234, USA.

ROSE, W.I., Jr., STOIBER, R.E. and MALINCONICO, L.L., 1980, Budget of S and Cl released from shallow magma bodies at Fuego volcano, Guatemala (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 67.

ROSSI DE TOSELLI, J., SAMANIEGO, A. and HORN, E.E., 1980, Microthermometrical investigations on minerals of the El Extrano Mine, Ancash - Peru - 7 Geowiss: Lateinamerika Koll. Heidelberg, Tagungsheft, 19.11.1980, p. 76-77 (in German).

Fluid inclusion measurements in quartz and sphalerite. (E.Horn)

ROSSOVSKIY, L.N., 1980, Rare-metal pegmatites with precious stones and conditions of their formation (on the example of Hindukush): Zapiski Vses. Min. Obshch., v. 109, no. 3, p. 301-311 (in Russian). Author at Krasnoyarsk Div. of Siberian Sci.-Res. Inst. of Geol., Geoph. and Min. Raw Materials, Krasnoyarsk, USSR.

Pegmatites of the massif Lagman, Afghanistan (granodiorites, plagiogranites, quartz diorites, biotite granites, two-mica granites) bear precious kunzite, tourmaline and morganite. Th values are in ranges 280-120°C for drusy pegmatitic minerals (the above plus rock crystal), and 120-100°C for pollucite. (A.K.)

ROSSOVSKIY, L.N. and KONOVALENKO, S.I., 1980, Gemstones in the pegmatites of Hindukush, Southern Pamirs and Western Himalaya, in: Gem minerals-Proceedings of the XI General Meeting of IMA: "Nauka," Leningrad, p. 52-62, price 70 kopecks, 9100 copies printed (in Russian, English abst.).

Pegmatites of the deposit Kulam (Hindukush) bear minerals with following Th: pollucite 405-390°C and 350-335°C, rock crystal, tourmaline, kunzite 280-250°C and 130-120°C, regenerated kunzite 270-160°C, metamorphic pegmatites from the SW Pamirs bear diaspore which formed at 290-310°C, as appears from Th plus pressure correction. (Abstract by A.K.)

ROST, R., DOLGOV, Y.A. and VISHNEVSKIY, S.A., 1978, Gases in inclusions of impact glass in the Ries crater, West Germany, and finds of high-pressure carbon polymorphs: Dokl. Akad. Nauk SSSR, v. 241, no. 3, p. 695-698 (in Russian; translated in Dokl. Acad. Sci. USSR Earth Sci. Sect., v. 241, p. 165-168, 1980).

Abstracted in Fluid Inclusion Research--Proc. of COFFI, v. 11, p. 184-185 (1978). (E.R.)

ROTH, A., 1980, Quartz mineralization on the NE-margin of the Brilon Anticline: Dipl. Arb., Göttingen 1980, 73 p. (in German).

Fluid inclusion measurements in quartz. (E.Horn)

ROYZENMAN, F.M., 1980, VIth All-Union Meeting on Thermobarogeochemistry: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 5, p. 142-143 (in Russian).

A short review of problems discussed during the 1978 Vladivostok meeting. (A.K.)

ROYZENMAN, F.M., RONENSON, B.M., ROYZENMAN, V.M., UTYONKOV, V.A. and FORTUNATOV, S.P., 1980, Conditions of formation and regularities of distribution of phlogopite-bearing metasomatites of Aldan, p. 108-117 in: Iron- and magnesium metasomatism and ore formation, "Nauka" Publ. House, Moscow, 196 pp. 800 copies printed, price 2 rbls. 30 kopecks (in Russian).

Td of diopside schists are 700 and 760°C, plagiomigmatites - 540-600°C, plagiomicrocline migmatites - 460-540°C, diopside skarns - 540-600°C and 460-540°C, post-magmatic Mg skarns - 660-820°C and 300-480°C, phlogopite-diopside metasomatites - >300°C. (A.K.)

ROYZENMAN, F.M., VALYASHKO, L.M., PETROVA, M.G., FORTUNATOV, S.P. and ELINSON, M.M., 1980, Relation of CO_2 and H_2O in ore-forming solutions of rare-metal and muscovite-bearing pegmatites, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 62-65 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 212, Royzenman et al.; note the changes of the title and authors. (A.K.)

ROZEN, O.M., SIDORENKO, S.A. and KUZNETSOVA, N.N., 1977. Scapolite and apatite as indicators of composition of volatiles in metamorphism of the granulite complex of the Kola Peninsula: Dokl. Akad. Nauk SSSR, v. 237, no. 2, p. 441-444 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sec., p. 211-213, 1980).

RUIZ, Joaquin and KESLER, S.E., 1980, Geochemistry of the Las Cuevas fluorite deposit, San Luis Potosi, central Mexico (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 513.

Las Cuevas, the largest known high-grade fluorite deposit in the world, is found at the contact between the Lower Cretaceous Doctores Formation limestone and a Tertiary rhyolite breccia. The deposit formed initially by replacement of the limestone followed by open-space filling, and consists mostly of fluorite with minor amounts of calcite, quartz, chalcedony and Fe and Mn oxides. There is a distinct compositional zonation within the deposit, with silica content increasing toward the rhyolite breccia and calcite increasing as the limestone is approached.

K/Ar and Rb/Sr data obtained from the altered rhyolite breccia indicate that the mineralization is about 30 my old, which coincides with the time of major volcanism in the area. Fluid inclusions in open-space filling fluorite, which constitutes about 40% of the total fluorite in the deposit homogenize at temperatures of 60°C to 130°C and exhibit salinities close to 0 wt.% (equivalent NaCl). Strontium isotopic ratios of the fluorite, limestone and igneous rocks associated with the deposit indicate that all the calcium in the fluorite was derived from the limestone.

The fluid inclusion data show that the ore-forming solutions were essentially heated meteoric water and the close spatial and temporal association between the deposit and the igneous rocks argues for these as the source for the heat and the fluorine. The lack of calcite in the initial stages of fluorite deposition and the presence of kaolinite as alteration of the wall-rock indicates initially acid conditions. A change in pH, temperature decrease and addition of calcium to the fluorine bearing solutions were the causes of deposition. (Authors' abstract)

RUIZ, Joaquin, KESLER, S.E., JONES, L.M., and SUTTER, J.F., 1980, Geology and geochemistry of the Las Cuevas fluorite deposit, San Luis Potosi, Mexico: Econ. Geol., v. 75, no. 8, p. 1200-1209. First author at Dept. Geosci., The Univ. Michigan, Ann Arbor, MI 48109.

The Las Cuevas fluorite deposit, which is one of the largest high-grade fluorite deposits known, is located in the Zaragoza-Rio Verde fluorite district of central Mexico. K-Ar and Rb-Sr data indicate that the mineralization at Las Cuevas took place about 30 m.y. ago, which coincides with major Cenozoic volcanism in northern Mexico. The deposit is at the contact between Lower Cretaceous limestone and Tertiary rhyolite breccia and was formed by replacement of the limestone followed by open-space filling. It consists almost entirely of fluorite with minor amounts of calcite and silica. There is a distinct compositional zonation within the deposit, with silica increasing toward the rhyolite breccia and calcite increasing toward the limestone.

Fluid inclusions in open-space-filling fluorite, which constitutes about 40 percent of the total fluorite in the deposit, homogenize at temperatures of 60° to 130°C and exhibit salinities close to 0 weight percent (equivalent NaCl). Isotopic ratios of strontium in fluorite, igneous rocks, and limestone indicate that all the calcium in the fluorite came from the limestone.

The fluid inclusion data show that the ore-forming solutions were essentially heated meteoric waters. The close spatial and temporal association between the mineralization and the volcanic rocks argues for these as the heat and fluorine source. The lack of calcite in the initial stages of fluorite deposition and the presence of kaolinite as the alteration of the wall rock indicate initially acid solutions. A change in pH temperature decrease, and addition of calcium to the ore-forming solutions were the causes of deposition. (Authors' abstract)

RUMBLE, Douglas, III, 1980, Oxygen isotope fractionation during regional metamorphism: Carnegie Inst. of Washington Yearbook 79, for 1979-80, p. 328-332.

RUNDKVIST, D.V., 1980, Present concepts on geological structure and zoning of the Cornwall deposits (England): Geol. Rudn. Mest., v. 22, no. 6, p. 3-17 (in Russian). Author at VSEGEI, Leningrad, USSR.

The paper bears reference Th on quartz-cassiterite-fluorite-sphalerite-galena-chalcopyrite veins in Cornwall (450-80°C). (A.K.)

RUVALCABA-RUIZ, D.C., 1980, Geology, alteration and fluid inclusions of the Santo Elena and Santo Nino fissure vein deposits in Fresnillo, Mexico: M.S. thesis, Colorado State Univ., 80 pp.

RYABCHIKOV, I.D., 1980, Nature of kimberlite "magmas": Geol. Rudn. Mest., v. 22, no. 6, p. 18-26 (in Russian). Author at IGEM, Moscow, USSR.

Pertinent to gas composition in fluid inclusions. (A.K.)

RYABCHIKOV, I.D. and BOETTCHER, A.L., 1980a, Composition of water fluids in equilibrium with phlogopite-bearing mantle parageneses at elevated temperatures and pressures: Izvestiya AN SSSR, ser. geol., no. 3, p. 56-62 (in Russian). First author at Inst. Geol. Ore Deposits, Petrogr. Mineral. and Geochem. of Acad. Sci. USSR, Moscow.

Pertinent to studies of inclusions in mantle materials. (A.K.)

RYABCHIKOV, I.D. and BOETTCHER, A.L., 1980b, Experimental evidence at high pressure for potassic metasomatism in the mantle of the Earth : Am. Mineral., v. 65, p. 915-919. First author at Inst. Geol. Ore Deposits, 35 Staromonetny, Moscow, 109017, USSR.

To assess the concentration of potassium in aqueous fluids as a model for metasomatism of the mantle of the Earth, we experimentally determined the solubility of potassium in an aqueous vapor in equilibrium with phlogopite and other phases to pressures of 30 kbar at 1100°C. The concentration of potassium (in grams of K_2O per 100 g H_2O) is 4 at 11 kbar, 7 at 20 kbar, and 25 at 30 kbar. Such values are sufficient to transfer from the interior of the Earth all of the K_2O to the continental crust during formation of the hydrosphere by outgassing. However, it is likely that most of this transport was by silicate-rich liquids. (Authors' abstract)

RYABCHIKOV, I.D., ORLOVA, G.P., EFIMOV, A.S. and KALENCHUK, G.Ye., 1980, Copper in the system granite-melt: Geokhimiya, no. 9, p. 1320-1326 (in Russian, English abst.). Authors at Inst. Geol. of Ore Deposits, Petrography Mineral. and Geochem., Moscow, USSR.

Pertinent to Cu content in melt inclusions. (A.K.)

RYABCHIKOV, I.D. and WALL, V.G., 1980, Exchange reactions between apatite and supercritical fluid: Geol. Rudn. Mest., v. 22, no. 3, p. 89-94 (in Russian). First author at IGEM, Moscow, USSR.

Pertinent to composition of fluid inclusions. (A.K.)

SAAD, D., PADOVA, J. and MARCUS, Y., 1980, Thermodynamics of mixed electrolyte solutions. XI. An isopiestic study of the quaternary system $NaCl-KCl-CaCl_2-H_2O$ at 25°C: J. Solution Chem., v. 9, no. 4, p. 259-268.

SABOURAUD, C., MACQUAR, J.C. and ROUVIER, H., 1980, Fluid inclusions, readings and false readings of deposit conditions. Some examples taken from lead, zinc, barium, and fluorine minerals south of the French central massif: Mineral. Deposita (Berl.), v. 15, p. 211-230. Authors at Lab. Geol. Appl., Univ. Pierre Marie Curie, Paris, France (in French).

Fluid inclusion investigation was carried out on minerals from Pb Zn deposits occurring in early Mesozoic beds and in the basement. Studied minerals are the following: stratabound or vein quartz crystals and fluorite, late dolomite syncrystallized with a last generation of sphalerite filling geodes or fissures, or dolomite massively recrystallized. Fluid inclusion data have been used to know their crystallization conditions and their evolution. Quartz and fluorite were deposited at low temperature (≤50°C), and were submitted to a heating after the low temperature crystallization. This heating is recognizable through the secondary inclusions (Th of 120°C), but also through a natural decrepitation of primary cavities. Dolomite (re)crystallized within conditions identical to those which ruled the latest stages of quartz and fluorite evolution. Our observations come in opposition to some classical reconstitutions; we propose: in a first stage, low temperature crystallization, and in a second one a heating. We insist on the necessity 1) to know precisely the mineral succession, 2) to establish the chronology of the numerous inclusions families, and to be sure that the filling of primary cavities is undamaged. In the example of the Saint-Laurent-les-Bains fluorite, fluids contained in naturally stretched primary cavities give a very good

Th histogram which cannot be used to determine the formation temperature. We must admit that the study of fluid inclusions is not sufficient to allow a choice between one or another genetic model. We cannot obtain precision about the heating cause and, furthermore, about the time passed between the late heating and the early crystallization in a low temperature environment. (Authors' abstract)

SABOURAUD, C., MACQUAR, J. and ROUVIER, H.E., 1980b, Fluid inclusions: witness and false witness of depositional environment; examples based on concentrations of Pb, Zn, Ba, and F in the southern Central Massif, France: Int. Geol. Congr., 26th, Abstracts, v. 3, p. 1003 (in French).

See previous item. (E.R.)

SABOURAUD, Christiane and SALEHI SIAVOCHANI, Hassan, 1980, Replacement of solid primary inclusions inside dipyramidal quartz of the Eocene of Northern Tunisia: Bull. Minéral., v. 103, p. 54-58 (in French with English abstract). First author at E.R. no. 45 C.N.R.S., Lab. Géol., École Normale Supérieure, 46, rue d'Ulm, 75230 Paris Cedex 05, France.

Anhydrite primary inclusions trapped by dipyramidal quartz crystals have been replaced in situ by glauconite. This late glauconite has all features of primary inclusions. (Authors' abstract)

SAFONOV, Yu.G., RADHAKRISHNA, B.P., RAO, B.K., VASUDEV, V.N., RAJU, K.K., NOSIK, L.P. and PASHKOV, Y.N., 1980, Mineralogical and geochemical features of endogene gold and copper deposits of South India: J. Geol. Soc. India, v. 21, p. 365-378. First author at Inst. Geol. Ore Dep. (IGEM), Acad. Sci., 35, Staromonetnii Street, Moscow, USSR.

Fluid inclusions were studied from the Kolar gold, the Hutti gold, and the Ingaldhal copper ore deposits. The Kolar samples contain either halite and sylvite dms and have Th 260-280, or contain CO_2 (CO_2 liquid:H_2O liquid = 1:1), and have Th 270-305°C. A thermal gradient with sample depth was determined. Hutti and Ingaldhal samples were similar but have lower Th. (E.R.)

SAKAI, H., GUNNLAUGSSON, E., TOMASSON, J. and ROUSE, J.E., 1980, Sulfur isotope systematics in Icelandic geothermal systems and influence of seawater circulation at Reykjaines : Geochim. Cosmo. Acta, v. 44, p. 1223-1231.

SAKHAROVA, M.S., BATRAKOVA, Yu.A. and POSUKHOVA, T.V., 1980, Laboratory data on the effects of solution composition on the deposition of native silver: Geokhimiya 1980, no. 5, p. 680-687 (in Russian; translated in Geochem Internat., v. 17, no. 3, p. 30-36, 1980 (pub. 1981)).

SAKHAROVA, M.S. and BRYZGALOV, I.A., 1981, Mineralogy of silver in quartz-adularia-rhodonite volcanogenic hydrothermal veins: Geol. Rudn. Mest., v. 23, no. 6, p. 36-48 (in Russian). Authors at Moscow State Univ., USSR.

The paper bears some reference data on Th. (A.K.)

SALIOT, Pierre, 1979, The movement of ions in solution during Alpine metamorphism: A review of current knowledge concerning Na, K, Mg, Cl, Br and Li, in Mass Transfer in the Earth's Crust, Sci. Geolog. Memoire 53, p.

101-104 (in French).

Early geochemical studies of high pressure - low temperature metamorphism in the Alps used fluid inclusion evidence from minerals in Alpine fissures to help define the role of alkali metasomatism in forming sodic minerals (e.g., albite, glaucophane, jadite and paragonite) which are used to estimate the physical conditions of metamorphism. Increasingly, it has become important to identify and understand the mechanisms of metasomatism, as well as the elements involved. The unique structure of the Alps permits one to study rocks of very different chemistries which are involved in the same sequences of metamorphism. In particular, by considering pelitic sediments, basic and acidic igneous rocks, and carbonates, it is possible to suggest that concentration gradients for certain ions in solution may be an important factor in metamorphic processes. Integrated studies of Alpine metamorphism now include three essential components: (1) fluid inclusion studies of crystals from the Alpine clefts, (2) geochemical studies of selected overlying rocks which have been spilitized or dolomitized, and (3) examination of geologic structures and tectonic mechanisms which could have permitted the flow of metamorphic fluids. (Author's abstract, modified by M.J. Logsdon)

SAL'NIKOV, V.N. and GAN'KINA, L.N., 1979, Observation of electromagnetic pulses in hot rock specimens emitted by segregation of mineralizing solutions: Geologiya i Razvedka, 1978, no. 5, p. 61-68 (in Russian; translated in Internat. Geol. Rev., v. 21, no. 2, p. 210-216, 1979). Authors at Tomsk Polytechnic Inst.

Electromagnetic pulses with wavelengths in the radio frequency range are emitted by heating or cooling rocks. The authors claim that measures of this emission, plus thermoluminescence and electrical conductivity, provide "more accurate and reliable" temperature ranges for mineral formation, and the ore content of the veins. (E.R.)

SAMARTSEV, I.T., GUSEVA, L.D. and INSHINA, V.M., 1980, Endogene zoning of the gold ore deposits of the Middle Urals: Izvestiya AN SSSR, ser. geol., no. 11, p. 98-108 (in Russian). Authors at Div. Exper. Studies of Central Sci.-Research Geol.-Prosp. Inst., Tula, USSR.

Fluid inclusion studies in minerals from unspecified Au ore deposits in the Middle Urals were performed by homogenization and decrepitation methods. Deposits formed in a wide T interval. Quartz, albite and ankerite of early associations yielded T 200-420°C. High Th are typical of anhydrite (200-250°C) formed before main mass of sulfides. Th and Td of quartz from the commercial stages are in ranges 100 (rarer 70) to 350°C, and carbonates of the final stages of ore formation - 50-150°C. Temperature zoning in each deposit is such that deep levels and side parts of the deposit are formed by high-T mineral associations, and central parts - by both low- and high-T associations. Inside the deposit zones Th increases from the inner to the outer side of the zone. (Abstract by A.K.)

SAMARTSEV, I.T., OVSYANNIKOV, I.I. and INSHINA, V.M., 1980, Gypsum-anhydrite mineralization at certain gold-ore deposits of the Middle Urals: Izvestiya AN SSR, ser. geol., no. 2, p. 70-74 (in Russian). Authors at Div. Exper. Studies of the Central Sci.-Research Geol.-Prosp. Inst., Tula, USSR.

Gypsum and anhydrite were found at the deep levels of Au vein deposits Blagodat', Krylatovskoe and Shaydurikhinskoe. Th of inclusions in anhydrite were as follows: Blagodat' - 230-280°C (early quartz and ankerite 250-380°C), Krylatovskoe - 180-230°C (early quartz ≥300°C). (A.K.)

SAMCHUK, A.I. and MITSKYEVICH, B.F., 1980, Complex ion formation of beryllium in carbonate solutions: Geokhimiya, no. 9, p. 1371-1376 (in Russian, English abst.). Authors at Inst. of Geochem. and Physics of Minerals of Acad. Sci. of Ukr. SSR, Kiev, Ukrainian SSR.

Pertinent to fluid composition in low-T inclusions. (A.K.)

SAMSONOV, Ya.P. and MENCHINSKIY, V.V., 1977, Geological-structural peculiarities and formation conditions of the chrysoprase deposit Sarykulboldy (Central Kazakhstan), p. 147-152, in: Non-metallic mineral raw materials of weathering crust, "Nauka" Publ. House, Moscow, price 2 rbls 40 kop'ecks, 850 copies printed.

The L (cold-water) inclusions are typical of all chrysoprase varieties. They are oval, 0.001-0.01 mm long, at -10°C they heterogenize → L+G, Th ranges up to 40-45°C. Relic quartz bears two-phase G/L and polyphase inclusions with Th 220-240°C. (Abst. by A.K.)

SASAKI, Akira and ISHIHARA, Shunso, 1980, Sulfur isotope characteristics of granitoids and related mineral deposits in Japan : Proc. of the Fifth Quadrennial IAGOD Symposium, 5. Iagod Symp. 22, E. Schweizerbart'sche Verlagsbuchhandlung (Nagele u. Obermiller) Stuttgart, Germany, 1980, p. 326-335. Authors at Geol. Survey of Japan, 1-1-3, Higashi, Yatabe, Ibaraki, 305, Japan.

Two series of granitoids in Japan, the magnetite-series and the ilmenite-series, distinguished by Ishihara (1977) on the basis of opaque mineral assemblages, are each characterized by an individual trend of rock-sulfur-isotope data. The magnetite-series granitoids have positive $\delta^{34}S$ values ranging from +1 to +9‰, not too far from the common igneous value, whereas the ilmenite-series granitoids are dominated by the negative values ranging from -11 to +1‰. The negative $\delta^{34}S$ trend of the ilmenite-series granitoids is consistent with the thesis that their parent magma has been influenced by continental-crust material in which the ^{32}S-enriched sedimentary sulfur may have been predominant.

Ore sulfurs of granitic affinity have parallel isotopic trends with the rock sulfur but show some depletion in ^{34}S as compared with the host granitoid. Partitioning of sulfur isotopes between the oxidized- and reduced-sulfur species in the magma-ore fluid system and subsequent deposition of the sulfide sulfur in ores may explain this rock-ore sulfur-isotopic relation.

Regional isotopic study of ore sulfur, combined with the data of rock sulfur of related magmatism, appears to be useful for metallogenic discussion. (Authors' abstract)

SASSEN, Robert, 1980, Biodegradation of crude oil and mineral deposition in a shallow Gulf Coast salt dome: Org. Geochem., v. 2, no. 3-4, p. 153-166.

Indexed under Fluid Inclusions. (E.R.)

SATO, Juichi, MAEDA, Hiroyuki, KINRYU, Yukuo and ONO, Shuji, 1980, Mineral paragenesis and fluid inclusion data of the Ohe polymetallic vein-type deposits, Hokkaido, Japan : Mining Geol., v. 30, no. 5, p. 277-288.

Continued next page.

The Ohe ore deposits, occurring in the Miocene volcanic pyroclastics and quartz diorite of the "Green Tuff" region in southwestern Hokkaido, belong to the epithermal fissure-filling vein-type of polymetallic character. This paper presents the data concerning the stages of mineralization, variation in metal content of the ores, ore mineralogy and fluid inclusions, mainly obtained for the representative Senzai vein. Four stages of mineralization can be discriminated based upon the structural and mineral paragenetic features of the vein. Among them Stages II and III represent the main mineralization, depositing major sulphides of Fe, Cu, Zn, Pb as well as rhodochrosite with various minor sulphides, Au-Ag minerals, Mn-minerals and wolframite. The Senzai vein has 6 major ore zones that have resulted from lateral and vertical changes in its mineralogy and metal content.

The ranges of the homogenization temperature and salinity of fluid inclusions in the minerals of Stage II are 195°-314°C (259°C on the average), and 4.2-6.3 wt% (4.5 wt% on the average) equivalent to NaCl, respectively. The corresponding data for Stage III mineralization are 171°-285°C (211°C), and 1.6-3.1 wt% (2.5 wt%). Temperature gradients of the ore deposition are approximately 0.6°C and 1.5°C per 10 m at Stages II and III respectively. The sulphur fugacity and the temperature estimated for a representative phase of the mineralization are in the range of 10^{-15} to 10^{-11} atm., and 187°-275°C, respectively. (Authors' abstract)

SAVEL'YEVA, N.I. and NAUMOV, G.B., 1980, Peculiarities of opening of fluid inclusions for determination of their compositions by water leachate method: p. 109-117 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

Results of analyses of fluid inclusions by water leachate method, made in various laboratories differ greatly. Good results are obtainable only by thorough analysis under identical conditions. Artifical admixture of 1% ground mica to quartz caused decrease(sic.) of alkali content in leachate (20-30%). The main reason for errors in inclusion analyses is incomplete, selective leaching. The authors prefer rather decrepitation method for inclusion opening, on the basis of studies of grinding and decrepitation opening of inclusions controlled by cryometric determination. (Abstract by A.K.)

SAWKINS, F.J., 1980, Single-stage versus two-stage ore deposition in subduction-related volcanoplutonic arcs; Proceedings of the Fifth Quadrennial IAGOD Symposium, Vol. 1, J.D. Ridge, ed.: Stuttgart, E. Schweizerbart Verlag., p. 143-154. Author at Univ. Minnesota, Dept. Geol. & Geophys., Minneapolis, Minn. 55455.

Large-scale plate convergence leads to intense magmatic activity and the building of volcanoplutonic arc systems. The disseminated, replacement, vein, and massive-sulfide metal deposits found in such arcs all relate to such magmatism, although the nature of this relationship differs.

Fluid-inclusion and stable-isotope studies of metal deposits in volcanoplutonic arcs are now sufficiently numerous to demonstrate that most porphyry-copper deposits are related directly to magmatic fluids (single-stage), although they are subject to modification by inward-collapsing meteoric-water geothermal systems. At the other extreme, systems that generate precious metal vein or massive-sulfide deposits appear to be dominated by meteoric and seawater (two-stage), respectively, although participation of small, but possibly significant, amounts of magmatic fluids cannot be ruled out. Silver-bearing base-metal vein and replacement deposits can exhibit either magmatic (single-stage), meteoric (two-stage), or mixed genetic affiliation.

The spacing and vertical extent of individual deposits are distinctive for single-stage versus two-stage type deposits. Single-stage deposits tend to have greater vertical extent (>800 m) and spacings of tens of kilometers. Two-stage deposits have a more restricted vertical extent but can occur in groups only kilometers apart. These differences are a direct function of the nature of the ore-generating systems in each case, and their recognition should be helpful to the exploration geologist. (Author's abstract)

SAWKINS, F.J. and RYE, R.V., 1980, Additional geochemical data on the Messina copper deposits, Transvaal, South Africa - A reply: Econ. Geol., v. 75, p. 481-482.

A rebuttal to criticism by McCarthy and Jacobsen (1980; this volume). (E.R.)

SAZONOV, A.M., IL'YENOK, S.S., LI, L.V. and ANAN'YEV, A.A., 1978, Studies of gas-liquid inclusions in quartz from the Yenisyey area (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 207-209 (in Russian). Authors at the Tomsk Polytechnical Inst., Tomsk, USSR.

Numerous gold deposits of the Yenisyey area consist of quartz veins, sometimes with subordinate carbonates or sulfides. Cataclasis strongly changed the habit of fluid inclusions in quartz, and mylonitization usually eliminates the inclusions. Solutions released from inclusions during mylonitization displayed important role in mobilization of the dispersed gold and its redeposition. Au content in recrystallized parts of veins is an order of magnitude higher than in unaltered. The highest Th of P inclusions is 500°C in L phase, suggesting high P 2-3 kbar; solutions are of $Cl-HCO_3-K>Na$ type with significant presence of B, P and As. At 300-250°C inclusions contained $SO_4-Cl-K\approx Na$ to $K<Na$ solutions. At the lowest T $Ca+Mg>Na+K$, anions were Cl and HCO_3, Na:K = 5:1 to 30:1. Also S inclusions were investigated. Moreover, 233 samples of ore quartz were investigated by decrepitation with contemporaneous determination of Au in quartz (no other details about the position of Au - dispersed in quartz or present in inclusion fluids? A.K.). Four ranges of high Au concentrations were obtained at Td 540-520, 440-420, 280-240 and 200-160°C, that permitted distinguishing the gold ore stages. (From the authors' abstract, translated by A.K.)

SCHMIDT, S.T., 1980, Investigations on stratabound ore mineral contents in the southern "Gotthardmassiv Trias" in the Lukmanier-Greina-Region: Dipl. Arb., Heidelberg, 122 p. (in German).

Fluid inclusion investigations (pp. 76-95). (E.Horn)

SCHNEIDER, G.M., ed., 1980, Extraction with supercritical gases: Weinheim, Germany, Verlag Chemie, 189 pp.

Nine papers on the subject, including data on the surprisingly high solubility of various organic compounds in supercritical CO_2. (E.R.)

SCHOCH, A.E., 1980, The Cape granite series (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 86.

Continued next page.

Fluid inclusion studies indicate that at least some of the younger magmas had high primary CO_2/H_2O ratios which affected the textures of the crystallization products. (From the author's abstract)

SCHOCH, Aylva, WINKLER, Peter and TOURET, Jacques, 1980, A CO_2-granite from the Saldanha-Darling batholith, South Africa (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 87.

The occurrence of granites with textural peculiarities resulting from crystallization of CO_2-saturated melts have been predicted by several authors (Wyllie 1979, Holloway 1976). The Klipberg evengrained granite may represent such a case with $XCO_2 = 0,75$, according to fluid inclusion compositions. Because the fluid inclusions in the quartz grains exhibit highly spread physical characteristics, over 1000 measurements were made. Only 10% of the inclusions contain H_2O as well as CO_2, indicating that the unmixing event was highly efficient. That immiscibility did indeed take place is proved by rare CO_2 inclusions with inherited halite cubes (about 50 were observed). According to physical properties the CO_2 inclusions can be divided into three types although there are no morphological distinctions: (i) 30% with Th + 16 to 18°C (holding rare halite cubes), (ii) 15% with Th + 11 to 13°C, but with low Tm owing to the presence of hydrocarbons, corresponding to 10% CH_4 according to the criteria of Swanenberg, 1979, (iii) 10% with Th varying between 18 and 19°C. The H_2O inclusions are distributed between the CO_2 inclusions, but exhibit properties which vary with the height of the intrusion. The highest samples have Tm + 22°C, Th + 235-240°C, and samples from the deepest borehole core yielded Tm = 4 to 5°C, Th = 250-255°C. The uranium content of the Klipberg granite is quite low, varying between 5 and 13 ppm, with thorium between 22 and 49 ppm. Neither the coarsely porphyrite granitic wall rocks of the Darling granite not the more distant metasedimentary envelope of the batholith could have contributed much CO_2 to the Klipberg magma. (Authors' abstract)

SCHOELL, Martin, 1980, The hydrogen and carbon isotopic composition of methane from natural gases of various origins: Geochim. Cosmo. Acta, v. 44, p. 649-661. Author at Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, 3000 Hannover 51, West Gemany.

The deuterium concentrations (δD vs SMOW) of biogenic methanes from world-wide occurrences range from -180 to -280‰ and were found to be depleted in deuterium by approx. 160‰ compared to the deuterium concentration of their associated waters. Theoretical considerations support this relationship to be the result of bacterial transformation of CO_2 to methane and is therefore indicative of the biogenic origin of methane.

Thermogenic gases with high C_{2+} concentrations (wet gases associated with crude oil) have D/H ratios from -260 to -150‰ with deuterium contents tending to increase with decreasing wetness. Dry gases which are not associated with petroleum are more enriched in deuterium (-180 to -130‰) and show an increase in deuterium with increasing rank of the source beds as it is similarly known for carbon-13.

Many dry gases in young sedimentary basins were found to contain significant amounts of C_{2+} hydrocarbons. These gases cannot be grouped with either the biogenic or thermogenic gases and their methane is concluded to be of mixed biogenic and thermochemical origin.

Using a $\delta^{13}C/\delta D$ diagrammatic display of the isotope data of methanes the various genetic groups of natural gases can be defined more clearly. (Author's abstract)

SCHORSCHER, H.D. and LETERRIER, Jacques, 1980, Metasomatic formation of granitic rocks: Petrology and Chemistry (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 87.

Archean migmatites in the Itabira region, Brazil, were transformed by regional Proterozoic mylonitization and infiltration metasomatism into granitoids of igneous aspect. The most important processes during the mylonitization were saussuritization and sericitization of primary feldspars and subsequent K-feldspathization. The resultant replacement perthites are the main constituents of the new granitoids. Their metasomatic origin is documented by the extreme content of primary fluid inclusions making up to 10-20 vol.% of the K-feldspar-phase of the perthites. The P-T conditions of the process were estimated from mineral paragenesis using a model of combined regional, cataclastic, and hydrothermal metamorphism: $P_s = 4\text{-}7$ kb; $P_f = 1.5\text{-}2.5$ kb; T = 350-450°C. Two-feldspar geothermometry and preliminary fluid inclusion data are in the range of 360-420°C. The chemical study (>5,000 data) shows considerable reduction of K, Rb, Sr during the mylonitization. The Na_2O/K_2O ratios increase from initial mean values of ~1.3 for non-cataclastic Archean rocks to max. values of >3 (mean ~2.4) in the cataclastic rocks. The continuous transition from mylonite gneisses to granitoids is marked by strongly increasing contents of Si, K, Rb, F and decreasing contents of Ca, Mg, Sr, Ba. The Na_2O/K_2O ratio decreases continuously and reaches min. values in the granitoids (all <1.0, mean ~0.6). Results on the behavior of U, Th, Li, Cs, Ce, La, Y, among others, during the metasomatic fluid-solid exchange reactions will be presented. (Authors' abstract)

SCHROLL, E. and PAK, E., 1980, Sulphur isotope composition of barites from the Eastern and Southern Alps: Tschermaks Min. Petr. Mitt., v. 27, p. 79-91 (in German). First author at Geotech. Inst. Bundesversuchs- und Forschungsanstalt Arsenal, Wien.

The isotopic compositions of 91 barite samples originating from 47 occurrences of the Eastern and Southern Alps have been investigated. Barites of most strata-bound deposits reflect the isotopic composition of the sea-water sulfate at the time of deposition. In general, it can be shown that the sulphur in barites of strata-bound Alpine deposits has been derived from lower Paleozoic, Devonian, Carboniferous, Permian or Triassic sea-water sulfate. Only in a few cases has the isotopic composition been changed significantly by inorganic or bacterial fractionation processes. (Authors abstract)

SCHULIEN, S., 1980, Mg-Fe partitioning between biotite and a supercritical chloride solution: Contrib. Min. Pet., v. 74, no. 1, p. 85-94.

SEIFERT, F., 1980, The granulite complex of Finnish Lapland and adjacent rock series, in Mobile Earth; International Geodynamics Project; final report of the Federal Republic of Germany, H. Closs et al., ed.: Harold Boldt Verlag, FRG, p. 235-236.

Indexed under Fluid Inclusions. (E.R.)

SELVERSTONE, Jane and STERN, C.R., 1980, Fluid inclusions in granulite xenoliths within alkali basalts: direct evidence for CO_2 in the lower continental crust and mantle of Chile (abst.): Geol. Soc. Am. Prog. Abstracts, v. 12, p. 519. Authors at Dept. Geol. Sci., Univ. Colorado, Boulder, CO 80309.

Continued next page.

Granulite xenoliths within alkali olivine basalts of the Pali-Aike volcanic field, located in southern Chilean Patagonia, South America, consist of the mineral assemblages cpx + opx ± plag ± ol ± green spinel indicating P-T conditions of equilibration in the range 7-12 kb and 800°-1200°C which suggests that the xenoliths are accidental inclusions from the lower continental crust incorporated in the mantle-derived basalt during its rise to the surface.

Examination of fluid inclusions in the granulites indicates the ubiquitous presence of an essentially pure CO_2 fluid phase. Inclusions of three different parageneses have been recognized: (1) Small (<2 μm) CO_2 inclusions along all exsolution lamellae in cpx. These probably represent the precipitation of structurally bound CO_2 from cpx during cooling and recrystallization of the granulites and are considerd the most primary inclusions. (2) Clusters of CO_2 inclusions evenly distributed throughout individual mineral grains. These inclusions are not associated with any fractures, but they obliterate type (1) inclusions in cpx grains and are thus younger than type (1) fluids. These pseudosecondary inclusions divide into two groups, one with ρ=0.94-1.01 g/cm^3 and the other with ρ=0.70-0.80 g/cm^3, interpreted as corresponding to fluids entrapped at different stages during moderate pressure, P=7 kb and P=4 kb respectively at 900°C, metamorphism. (3) Secondary CO_2 ± glass inclusions with ρ=0.59-0.69 g/cm^3 occurring along well healed fractures where basalt has penetrated the xenoliths. These inclusions are probably related to exsolution of CO_2 from the mantle-derived basaltic host en route to the surface rather than to lower crustal processes. Similar inclusions in both phenocrysts and an augite megacryst within the basalt support this conclusion. These data suggest that CO_2 is an important constituent of the lower continental crust, indicated by type (1) and (2) inclusions, and the mantle, indicated by type (3) inclusions. (Authors' abstract)

SEN'KOVSKIY, A.Yu., 1980, Some peculiar properties of cassiterite from the deposit Vodorazdel'noe (East Chukotka): Mineralog. Sborn., v. 34, no. 2, p. 72-75 (in Russian, English abstract). Author at Ukr. Sci.-Research Geol.-Prosp. Inst. of Acad. Sci. of Ukr. SSR, L'vov, Ukrainian SSR.

The Vodorazdel'noe deposit (Iul'tin belt of the Val'kumey-Telekay metallogenic subzone) occurs in apical part of Telekay intrusive and adjacent skarns in quartz-tourmaline metasomatites and it belongs to cassiterite-silicate formation. Ore bodies are veins 1.5-2 m thick and ~1 km long. Td of cassiterite from the section Perekatnyi was 420-520°C, and from the section Sherl - 340-400°C, Th are in ranges 300-420°C. (Abstract by A.K.)

SHAN, Lin, 1980, The research of the inclusions clearly observed from the microscope heating set: Reviews of mineralogy and petrology, 1980, no. 4, p. 211-216 (in Chinese with English abstract).

It is a prerequisite for the determination of heat by uniform method to clearly see the inclusions from the microscope heating set. According to the appreciation in our work, the main requirements for the observation of the inclusions are:

(1) To prepare the thin plate with fair transparency and its surface with high plane and smooth.

(2) To reduce the heat-resisting glass slices.

(3) To adopt the intensity light source.

(4) To use the condenser lens with long focal distance and to adjust

the plate just at the same level as the focus. With these requirements, the minute inclusions can be clearly seen from the microscope heating set. (Author's abstract, sic.)

SHAN, Lin and ZHANG, Wenzhi, 1980, Research on inclusion radioactivity and its importance in prospecting: Kexue Tongbao, v. 25, no. 4, p. 318-322 (in English). First author at Fuzhou Geological College, China.

During explosion by heating, the radioactive gas in the inclusions formed in a uranium-bearing hydrothermal deposit is liberated and it is found that the closer the inclusions are to the ore body, the higher will be the density of the gas. This characteristic can be used in working out a new method for uranium prospecting. This article describes the geochemistry of the radioactive inclusions and the method to determine their emanation, on the basis of the samples collected from certain ore bodies. (Authors' abstract)

SHANKS, W.C., III and BISCHOFF, J.L., 1980, Geochemistry, sulfur isotope composition, and accumulation rates of Red Sea geothermal deposits: Econ. Geol., v. 75, p. 445-459.

Geochemical studies of metalliferous sediments from the Atlantis II Deep reveal a variable history of hot brine activity. Radiocarbon dating indicates that sedimentation began in the deep about 28,000 years ago. The lowermost unit (DOP) consists mainly of detrital biogenic carbonates with occasional thin beds of iron oxide or sulfide minerals. Sulfur isotope composition and carbon-sulfur relations indicate that some of these sulfide layers have a hydrothermal source whereas others formed by bacterial sulfate reduction in the sediments. DOP zone sedimentation rates were about 25 cm/1,000 year.

Continuous brine activity began in the west basin of the Atlantis II Deep about 15,000 years ago with deposition of the lower sulfide zone (SU_1). Sulfur isotope values average 5.4 (range 1 to 14) in this unit as in the upper sulfide (SU_2) and amorphous silicate (AM) zone. Overall hydrothermal sedimentation rates average 100 cm/1,000 year. However, low sulfur values and negative sulfur isotope values in the central oxide zone (CO) indicate a period of less vigorous brine influx. Facies variations are related to the rate of brine influx and the size of the brine pool rather than changes in the bulk composition or temperature of the inflowing brine.

Organic carbon and sulfide sulfur values in the SU_2, SU_1, and AM zones indicate direct hydrothermal addition of sulfide. Sulfur isotope values can best be explained by inorganic sulfate reduction in the subsurface brine and nonequilibrium sulfur isotope fractionation. (Authors' abstract)

SHAPENKO, V.V. and RATKIN, V.V., 1980, Genesis of silicic volcanic rocks as shown by study of inclusions in quartz: Dokl. Akad. Nauk SSSR, v. 255, no. 5, p. 1247-1251 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 255, 1980, p. 152-155 (1982). First author at Instit. Geochem. & Analy. Chem., USSR Acad. Sci., Moscow, USSR.

Quartz phenocrysts from a series of rhyolite porphyries were examined. All >50 µm were naturally "punctured" (decrepitated?). Using the quenching method, the onset of melting ranged from 700-900°C; Th 820-1150°C, although inclusions in a given phenocryst had a small range. All inclusions ⩾20 µ m burst during heating. Many were seen to fracture, leak, and the crack heal, leading to spurious values of Th, ⩾100° too high.

Equilibrium achieved in 2-8 hrs. for sealed inclusions, but >20 hours needed if inclusion was punctured. Some halite-bearing inclusions interpreted as immiscible fluid. (E.R.)

SHATSKY, V.S. and LEBEDEV, A.S., 1978, Inclusions in synthetic beryls (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 191 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

1. Inclusions in beryl synthesized under different P-T conditions from solutions of various composition, including H_2O-CO_2, have been studied. The data provide evidence the hermiticity of inclusions in beryls even at high pressure (about 2000 bar).

2. Fissure healing processes and alteration of the form of pseudosecondary inclusions formed during monocrystal growth, are studied. It is shown that if the compound is almost insoluble, the conclusions of G.G. Lemmlein that "the formation of secondary inclusions of liquids is the result of dendrite-like fissure healing in crystals," are confirmed.

3. The reasons for discrepancy between experimental data and some data on the temperatures of beryl crystallization are discussed. The analysis of the available literature data shows that when determining the temperature of mineral formation, the correction for pressure at Th, which is rather significant due to constant presence of carbon dioxide in inclusions, is not always taken into account. (Translation courtesy Dr. A.P. Berzina)

SHAYAKUBOV, T.Sh., 1978, Temperature conditions of sulfide-polymetallic ores in the volcanic-tectonic structure Chakchar (SW branch of the Gissar chain) (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 106-107 (in Russian). Author at "Tashkentgeologia," Tashkent, USSR.

Decrepitation temperatures (640-140°C) of quartz and calcite from the ore field Chakchar. (A.K.)

SHAYAKUBOV, T.Sh., 1980, Temperature conditions of formation of pyrite-polymetal ores of the Chakchar volcanic-tectonic structure, in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 184-187 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 13, 1980. (A.K.) See previous item.

SHCHEKA, S.A. and VOLYNETS, O.N., 1979, Reaction olivine+anorthite in gabbroid inclusions of the volcano Kikhpinych (Kamchatha), in: Problems of deep magmatism: "Nauka," Moscow, p. 197-205, price 3 rbls 20 kopecks, 900 copies printed (in Russian).

The reaction front of plagioclase+olivine is followed in plagioclase by G/L, fassaite and ore mineral inclusions. (A.K.)

SHCHERBAN', I.P., DOLGOV, Yu.A., BOROVIKOVA, G.A. and GIBSHER, N.A., 1980, Physico-chemical conditions of formation of the Rubtsovskoe pyrite-polymetallic deposit of the Rudnyi Altai, on the basis of thermodynamic and thermobarometric data: Geologiya i Geofizika, no. 1, p. 84-92 (in

Russian, English abstract). Authors at Inst. Geol. and Geophys., Novosibirsk, USSR.

The deposit Rubtsovskoe occurs in early-Paleozoic metamorphic schists, Devonian and Carboniferous detrital-pyroclastic beds and alaskite granites plus plagioclase porphyries. The deposit formed in a volcanic ring structure of dia. 5.5-6 km. Two types of ores are distinguished: early hydrothermal-sedimentary stratabound and late hydrothermal-metasomatic veinlets. Ores consist of pyrite, chalcopyrite, galena, sphalerite and other sulfides, quartz, chlorite, carbonate, and rarely barite (in the late ores). In individual associations the physico-chemical parameters (by fluid inclusion studies) are as follows (T in °C, total salt concentrations in wt.%, G concentration in vol.% of total G by individual inclusion analysis, number of determinations 13-40 for Th, 2-13 for the others): quartz-hydromica Th 300, Tm -3 to -5, Te -15 to -20, "acid gases" 7-8, CO_2 25-30, hydrocarbons 0-26, CO 0-6, H_2 46-47, N_2+rare G 18-22; polymetal hydrothermal-sedimentary Th 260-275, Tm -1 to -3, Te -10 to -15, total salt 5-6 or not det., "acid G" 27-54, CO_2 30-33, hydrocarbons 0-25, CO 0-9, H_2 4-7, N_2+rare G 0-8; polymetallic hydrothermal-metasomatic Th 260-270, Tm 0 to -2, Te -10 to -12, "acid G" 39-42, CO_2 30-32, hydrocarbons 15-17, CO nil, H_2O -4, N_2+rare G 10; barite-polymetallic Th 230, Tm -1 to -2, Te -10, "acid gases" 43, CO_2 46, hydrocarbons 4, CO 5, H_2 nil, N_2+rare G nil; quartz-carbonate Th 150-160, Tm 0 to +1, Te -6 to -7, total salts 2-3 or no determinations, "acid gases" 39-43, CO_2 38-42, hydrocarbons 0-4, CO_2 nil, H_2 10-14, N_2+rare G 0-14. Pressure determined from plots of phase equilibria of the system $NaCl-H_2O$ was 50-60 atm. (Abstract by A.K.)

SHCHIRITSA, A.S. and KALYUZHNYI, V.A., 1978, Evolution of composition of gas components of mineral-forming fluids of rock crystal of hydrothermal genesis, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 145-147 (in Russian). First author at Inst. of Geochem. and Physics of Minerals, Kiev, Ukrainian SSR.

Main G components of quartz-forming solutions are CO_2, N_2 and CH_4. CO_2 occurs almost always and usually occupies over 50% of total G, whereas N_2 and CH_4 make up less than 10%. Studies of G in individual inclusions (by mass spectrometry? A.K.) in quartz from Donbass, Pamirs and Krivoy Rog revealed some general features of G evolution in hydrothermal solutions. Vein quartz and root parts of euhedral quartz crystals formed from a homogeneous fluid (40-50% CO_2 + 60-50% H_2O). During following heterogenization the nitrogen content increases to 18% and CH_4 appears (3-5%). Individual stages were extremely rich in N_2 or CH_4 and essentially nitrogen or methane inclusions then formed, also from heterogeneous fluid. During the third period CO_2 content decreased greatly. (Abstract by A.K.)

SHELTON, K.L. and ORVILLE, P.M., 1980, Formation of synthetic fluid inclusions in natural quartz: Am. Mineralogist, v. 65, p. 1233-1236. Authors at Dept. Geol. & Geophy., Yale Univ., New Haven, CT 06520

Planes of water-rich fluid inclusions were created in natural quartz by partially annealing laboratory-induced fractures in a hydrothermal apparatus at 600°C and 2 kbar in the presence of water. The size, distribution, and morphology of the synthetic fluid inclusions show a remarkable similarity to fluid inclusions in quartz from metamorphic terranes. Fluid inclusion trains appear to be localized along former fracture-surface step lineations; their size varies proportionally and abundance inversely with the spacing of step lineations on the original fracture surface. Thin island-like inclusions grade to elongate ellipsoids with minimum dimensions considerably greater than the original crack width and appear to have developed at the expense of the immediate crack walls. The surface of the unclosed portion of the crack appears unchanged, suggesting a preferential solution and precipitation phenomenon where the inclusions developed. Fluid density of the inclusions, determined by microthermometric measurement of the homogenization temperature, is in agreement with the fluid density under the experimental annealing conditions. These observations suggest that the total density of the trapped fluid in the inclusions is the same as that of the homogeneous fluid phase present at the time of fluid inclusion formation. (Authors' abstract)

SHI, Jixi and LI, Benchao, 1980, Origin of rich magnetite ores in the Gongchangling area as evidenced by fluid inclusion studies from the Anshan-Benxi Region, Northeast China: Geochimica, 1980, no. 3, p. 43-53 (in Chinese with English abstract). Authors at Inst. of Geochem., Chinese Acad. Sci., Kweiyang, PRC.

Gongchangling high-grade magnetite ores, which constitute one of the major rich iron deposits in China, occur in the BIF(sic.) of the Anshan-Group in Precambrian metamorphic rocks. But their origin has long been a controversial problem, although most researchers are in favor of the concept that they are genetically related to hydrothermal processes connected with migmatite.

On the basis of field observation, this problem has been dealt with in this paper in the light of fluid inclusion studies. The results show that hydrothermal activity was widespread in this region, and can be divided into two stages. The late stage hydrothermal activity was intensively developed around rich iron deposits. The formation temperature of the late stage hydrothermal fluids is in the range of 487-505°C, and they are slightly alkaline, with a salinity of 13.2-23.1 wt.%, consisting mainly of Na^+, Ca^{++}, Cl^-, SO_4^-(sic.), etc.

As revealed by temperature measurements, the formation temperatures of fluid inclusions are quite uniform from place to place within vast areas of this region, and the comparison of the composition between rich ores and migmatite and wall rocks indicates that the late hydrothermal fluids are of metamorphic origin. The authors suggest that the rich magnetite ores in the Gongchangling Range seem to be the result of a reworking process (alteration) by metamorphic hydrothermal fluids in response to regional metamorphism of some sedimentary ore deposits that were originally relatively rich in iron. (Authors' abstract)

SHIOMI, Y., KURODA, T. and OGAWA, T., 1980, Thermal analysis of a growing crystal in an aqueous solution: J. Crystal Growth, v. 50, p. 397-403. Authors at Dept. Phys., Gakushuin Univ., Mejiro, Tokyo 171, Japan.

The temperature profiles around growing crystals in aqueous solutions of Rochelle salt were measured with accuracy of 0.005°C in a two-dimensional cell which was used for elimination of thermal convection current in the cell. The temperature distribution became stationary after 2 h from injection of the mother liquid, but the concentration distribution did not become stationary because the diffusion constant of solute in the solution was much smaller than the thermal diffusivity of the solution. The growth rate was linearly proportional to the temperature gradient at every growing interface. Since crystal growth is a typical interaction process between thermal and mineral flow, the experimental results were analyzed by such an interaction model. The analysis confirms that the material flow is limited by diffusion within a layer width of about a few hundreds micrometers on the growing interface. (Authors' abstract)

SHIREY, S.B., SIMMONS, Gene and PADOVANI, E.R., 1980, Angular, oriented microtubes in metamorphic plagioclase: Geology, v. 8, no. 5, p. 240-244.

SHIREY, S.B., SIMMONS, Gene and PADOVANI, E.R., 1980, Angular, oriented microtubes in metamorphic plagioclase: Geology, v. 8, p. 240-244. Authors at Dept. Earth & Planet. Sci., Mass. Inst. of Tech., Cambridge, MA 02139.

Angular, oriented microtubes are abundant in oligoclase in medium-grained gneiss from southeastern Pennsylvania. The microtubes are isolated, elongate voids that extend through the thin section with rectangular to square cross sections ~2 μm on a side.

The microtubes occur in planar sets of from 5 to 40 equal-sized individuals, spaced 2 to 5 μm apart; single occurrences have never been observed. The walls are either parallel or perpendicular to [010] of the host. Oligoclase also contains open intragranular cracks with zigzag morphology and matching, stair-step-shaped walls. We suggest that angular, oriented microtubes form by displacement and healing along zigzag intragranular cracks. This hypothesis explains unique properties of microtubes: regular spacing, equal size, rectangular cross section, crystallographically controlled orientation, and existence in sets. Angular, oriented microtubes are perhaps indicators of fracturing under conditions of low in situ confining pressure followed by release of shear stress along microcrack planes. (Authors' abstract).

SHMULOVICH, K.I. and KOTOVA, N.P., 1980, Effect of electrolytes on CO_2 activity in supercritical aqueous solutions: Dokl. Akad. Nauk SSSR, v. 253, no. 4, p. 952-956 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 169-172).

SHMULOVICH, K.I., MAZUR, V.A., KALINICHEV, A.G. and KHODOREVSKAYA, L.I., 1980, P-V-T relations and activity-concentration of components in systems of the type H_2O-nonpolar gas: Geokhimiya, no. 11, p. 1625-1639 (in Russian, English abst.). First author at Inst. Experimental Mineralogy of Acad. Sci. USSR, Chernogolovka, USR.

Volume effects of mixing in the systems H_2O-Ar, H_2O-N_2, H_2-CH_4 and H_2O-H_2 were calculated and compared with experimental data. Also activity coefficients were calculated for T 400-600°C and P up to 2 kbar. (A.K.)

SHNAY, G.K., 1980, Heterogeneity of dunites in ultrabasic-alkaline massifs (on the example of Inagli massif): Izvestiya AN SSSR, ser. geol., no. 4, p. 2-25 (in Russian). Author at All-Union Sci.-Research Geol. Inst., Leningrad, USSR.

Chrysotile from olivinites and clinopyroxene and olivine from pyroxenites bear P inclusions similar to melt crystallized inclusions in minerals of effusive rocks; the inclusions bear mica and pyroxene. Td of inclusions in forsterite from dunites are 620-640°C, in chrysotile from olivinites 460-480°C. (A.K.)

SHOJI, Tetsuya,1980, Formation of feldspar-bearing skarn from the assemblage calcite-biotite-quartz in H_2O-CO_2 mixtures: Mining Geol. (Japan), v. 30, no. 1, p. 19-26 (in English).

SHRADER, Nancy and FEISS, P. Geoffrey, 1980, Fluid inclusion filling temperatures in quartz veins at the Boy Scout-Jones molybdenum prospect, Halifax County, North Carolina (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 208.

The Boy Scout-Jones molybdenum prospect in Halifax City, NC, is a subeconomic, porphyry-type molybdenite-pyrite-chalcopyrite occurrence contained within a 307 ± 6 m.y. old granite stock located on the Piedmont-Coastal Plain boundary about 2 mi. east of Hollister, NC. The mineralization is contained in disseminations and NW trending quartz veins which extend from the granite into the overlying metasediments and metavolcanics of the Eastern Slate Belt. The veins range in thickness from 1" to 10' and are medium to coarse grained. The quartz is fairly translucent. A second set of quartz veins, barren of sulfides, trend northeasterly and are milky with a sugary texture.

Fluid inclusions are present in both sets of quartz veins. The samples studied were taken from cores held by the NC Division of Resource Planning and Evaluation. The mineralized quartz is dominated by primary fluid inclusions with a few secondary inclusions aligned along annealed fractures. The barren quartz has fewer primary inclusions and more secondary. In all inclusions, no daughter minerals were observed and all contain between 20 and 35 volume percent vapor phase. The size of primary inclusions ranges from 20 to 50 microns. Homogenization temperatures were determined using the heating/freezing stage at UNC-CH. Preliminary calibration of the stage (using Thomas 6608-M10 reagent set) gives pressure corrected filling temperatures of 620-625°C for the NW trending, mineralized veins and 371-377°C for the NE trending, barren ones. It appears that the molybdenum mineralization is related to high temperature quartz veining, presumably associated with intrusion of the granite, while the barren veins were produced by a lower temperature, post-magmatic event. (Authors' abstract)

SHRIER, Tracy and PARRY, William T., 1980, A hydrothermal model for the N. Canning uranium deposit, Owl Creek mountains, Wyoming (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 304.

Analysis of drill core from and surrounding the N. Canning deposit on the south flank of Copper Mtn. suggest that a low temperature hydrothermal system may have transported and precipitated uranium. Archean quartz-monzonite contains 5 ppm U regionally, but over 20 ppm in a central core. Isotope systematics show 30-50% uranium losses in Tertiary time. Temperatures greater than 150°C would have been generated in this monzonite (heat production from 35 ppm pre-loss U, 28 ppm Th, and 4.5% K O) in a few million years under 1.4 Km of Cambrian to Cretaceous sedimentary cover. Laramide faulting would open the heated rock to (convective?) water circulation. Epidote and sericite alteration is suggestive of hydrothermal fluids and secondary fluid inclusions in quartz average 138°C.

Uranium is found in breccias and fractures in the monzonite, and in overlying Tertiary sediments. Na-montmorillonite invariably forms the matrix around stable and secondary K-feldspar and quartz in breccias. Uraninite and pitchblende (?) occur as disseminated fracture fillings and encrustations on lithic fragments. Hematite staining occurs around uranium mineralization and pyrite is disseminated in fractures and intimately associated with uraninite.

Activity diagrams show that aK/aH ratios will remain constant while aNa/aH ratios increase as plagioclase alters to sericite and then montmorillonite. The assemblage uraninite-pyrite-hematite is stable within fO_2 values of 10^{-52} to 10^{-35} and pS_2 values of 10^{-20} to $10^{-6.5}$ atm. at an assumed $pCO_2 = 10^{-2}$ atm and total U = 10 ppb.

As evidence of organic matter was not found, and pyrite is stable with uraninite, it is proposed that oxidation of magnetite caused reduction and precipitation of uraninite from solution. Mineralization in the overlying Tertiary sediments is the result of relocation of the vein uranium in the supergene environment. (Authors' abstract)

SHUGUROVA, N.A. and SHOKHONOVA, L.A., 1978, Recommended methods in the analysis of the composition of the gas phase of individual inclusions in minerals (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 186 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

Up to now, gases in inclusions have been analyzed more effectively in gas bubbles of >0.06 mm diameter. Such large inclusions are typical mainly of hydrothermal minerals.

However, most inclusions in magmatic and metamorphic minerals are <0.06 mm diameter. This generally makes gas analysis difficult, due to additional difficulties in observing gas absorption in different absorbents, and errors in measuring initial bubble dimensions increase; as a result they do not allow effective calculation of the separate gas components. In this connection, at the stage of improvement of working out techniques, a method of estimation of initial bubble dimensions is of primary importance in analyzing bubbles <0.06 mm and especially for fast-absorbing gases (H_2S, SO_2, HCl, HF, NH_3) and their various relations. Such measurements have to be made not at the moment of inclusion breaking, as this is practically impossible, but some time later (i.e., in 10-15 sec).

The methods handbook gives experimentally determined chronometrical diagrams of absorption, using which, it is possible to separate qualitatively and quantitatively a mixture of such gases as H_2S, SO_2, HCl, HF and NH_3 from CO_2. In addition, the nomograph given in the handbook and built on the separation curve, makes possible a qualitative separation of H_2S from CO_2.

The problem of inert liquids for a mixture of gas components is very important and urgent at present. Preparation of inert liquids is an independent and rather important stage. The accuracy and reproduction of the method depends largely on a thorough preparation, freshness and manner of storage and control of the liquid properties. (Translation courtesy Dr. A.P. Berzina)

SHVADUS, M.I., 1977, Inclusions in fluorite from granite of Transbaikal: Dokl. Akad. Nauk SSSR, v. 237, no. 3, p. 706-708 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth Sci. Sect., p. 217-219, 1980).

Abstract in Fluid Inclusion Research--Proc. of COFFI, v. 10, p. 261-262. (E.R.)

SIDER, H., COTTARD, F. PAGEL, M. and RAMBOZ, C., 1980, The contribution of fluid inclusions to the study of the Sn-W-Mo-Bi mineralization of Las

Sombras mine (Galicia) Spain: Reun. Annu. Sci. Terre (Paris), v. 8, p. 325 (in French).

SIDOROV, A.A. and GONCHAROV, V.I., 1978, Thermobarogeochemical criteria of plutonic and volcanic ore mineralization of the North-East USSR, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 176-177 (in Russian). Authors at North-Eastern Complex Sci.-Res. Inst. of Far-East Sci. Center of Acad. Sci. of the USSR, Magadan, USSR.

Plutonic deposits of Sn, Cu+Mo, Au, Au+Ag and Sb+Hg formed at 2-2.5 km depth, Th 360-200°C, P 1300-200 atm, and a vertical T gradient 8 to 10°C per 100 m. The stages of mineral formation are very distinct; solutions bear chlorides of alkaline metals; dms occupy up to 50% of inclusion volume; gases are CO_2, N_2, H_2 and sometimes CH_4.

Volcanic deposits formed at depths to 1.5 km, in connection with hydrothermal-explosive brecciation. Ore process developed at 230-250°C in metacolloid veins formed at 320-380°C and a zone of argillization above the ore bodies formed at $\leq$150-180°C and generally at P 5-85 atm; solution composition was HCO_3, Cl, Ca, Na, K. Explosive-hydrothermal breccias were mineralized at 700-210°C, P 1000-100 atm, with variable T gradients and highly mineralized solutions. (From the authors' abstract translated by A.K.)

SIMKIV, Zh.A. and MYAZ', N.I., 1980, Method of study of composition of gas-liquid inclusions in sulfide minerals: Mineralog. Sborn., v. 34, no. 1, p. 65-67 (in Russian, English abstract). Authors at L'vov State Univ., L'vov, Ukrainian SSR.

The methods used on samples of sphalerite (Archon deposit, N. Caucasus) and cinnabar (Levo-Sakyndzha deposit, Soviet NE Asia) were described. The applied methods are listed below:

No.	Sample wt., g	Prelim. washing	Drying, T, °C	Grinding	Sample wt. to leaching water volume	Mixing hours	Heating, hours & °C	Time of contact of mineral with leaching water, hrs.	Filtration	No. of subsequent leachates	Author of the method
1.	250-400	Alcohol	20	Agate mortar under water	1:3	0.5 at 20°C	0.3 at 40-50	24	Decantation	2	Khetchikov et al., 1966
2.	100-200	Distilled water, alcohol	20	Agate mortar under water	1:3	0.75 at 20°C	0.75 at 50-60	1.5	Schott filter No. 4	3	Govorov et al., 1968
3.	100	Distilled water	70	China mortar, dry	1:2	0.25 at 20°C	1 at 70	2.15	Paper filter, vacuum	3	Myaz' and Simkiv, 1975

The authors found that pre-washing with alcohol causes contamination of sample by Ca, Na, Cl and F, and should be eliminated. Hence the authors recommend the method used in the L'vov Univ. for water leachates from quartz (item 3 in the above table). Nine subsequent leachates were prepared by this method from sphalerite and cinnabar, and it appeared that after the third leaching, complete removal of inclusion components was achieved. The solubility background for sphalerite consists of Cl, Fe, and subordinate Mg, Ca, Na, SO_4, $HSiO_3$(?) and F in decreasing concentration. Also pH changes only to the third leachate, inclusively. The background for cinnabar consists of Cl, $HSiO_3$(?), K, Na; after the third leachate Ca, Mg, HCO_3 and F are not detectable in later leachates. (Abstract by A.K.)

SIMKIV, Zh.A. and POZDEYEV, K.M., 1980, Thermobarogeochemical index of commercial ore mineralization (on the example of polymetallic deposits of Northern Caucasus), in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry; Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 178-183 (in Russian).

See Fluid Inclusion Research-Proceedings of COFFI, v. 12, 1979, p. 176, Simkiv, 1978. (A.K.)

SIMMONS, W.B., Jr. and HEINRICH, E.W., 1980, Rare-earth pegmatites of the South Platte district, Colorado: Colo. Geol. Survey, Resource Series 11, 131 pp. First author at Dept. Earth Sci., Univ. New Orleans, New Orleans, Louisiana 70122.

The South Platte district, Jefferson County, Colorado, consists of a distinctive cluster of well-zoned, complex, rare-earth-, fluorine-, iron-rich pegmatites underlain chiefly by consanguineous granitic rocks of the Pikes Peak batholith. Normative analysis indicates that the granite and quartz monzonite formed from liquids of essentially similar composition. Plots of Ab/An and Ab/Q ratios for water-saturated melts indicate that the granite crystallized under lower PH_2O conditions than the quartz monzonite. Loss of water vapor at the margin of the batholith is believed to have resulted in marginal crystallization of a one-feldspar, hypersolvus granite whose early solidification acted as an armor to confine water in the interior part of the pluton. Hence the remaining interior magma, with its higher water vapor content, crystallized at lower temperatures as a subsolvus two-feldspar quartz monzonite.

The district is characterized by over 50 large, complex, concentrically zoned, nearly vertical pegmatites, which all occur within the pluton rather than marginal or exterior to it. In shape and external structure, two end-member types are distinguishable: 1) vertical pipe-like bodies with essentially circular plans, and 2) vertical to steeply dipping, thick ellipsoidal lenses. Pegmatites of the central group are restricted to elevations between 6800 and 7800 feet within the granite, forming a clearly defined level or niveau of pegmatites. The concentric internal zonation consists of the following generalized, idealized sequence: 1) very poorly developed border zone (usually absent), 2) wall zone of biotite graphic granite, 3) outer-intermediate zone of giant biotite crystals (rarely present), 4) intermediate zone of microcline-perthite, 5) core-margin zone of green fluorite, 6) large core massive quartz or quartz-microline, 7) secondary replacement units superimposed on the primary zonal sequence and containing albite, fluorite, rare-earth minerals, and hematite. The core-margin green fluorite is believed to be primary. The bulk composition of an average South Platte pegmatite consists of 42 percent microcline, 10 percent quartz, and 2 percent biotite. Fractional crystallization of the Pikes Peak magma resulted in water-enriched liquid segregates of residual fluids which became the parent fluid from which the pegmatites crystallized.

Whole-rock neutron activation analysis of the granitic rocks reveals that the parental magmas was anomalously rare-earth rich. Calculations show that volumetrically the pegmatites are enriched in rare earths as compared with the granitic rocks. The wall and intermediate zones of the pegmatites are strongly depleted in rare earths indicating that within the pegmatites these elements were partitioned into the residual pegmatitic fluids, from which the replacement units formed. The original chemical nature of the magma appears to have been the most important factor in the formation of the rare earth-rich deposits. The bulk of the granitic magma apparently retained most of its original rare-earth content. The large concentrations of these elements found in the pegmatites are due chiefly to original concentration with fractionation becoming an effective agency only in the volatile-rich residual pegmatitic fluids. (From the author's abstract)

Fluid inclusions in quartz core and core-margin fluorite were studied (pages 70-77). Liquid-rich and gas-rich inclusions were reported, some with small amounts of CO_2 liquid; daughter crystals reported included halite, sylvite, anhydrite, dawsonite(?), and unknowns. Th for primary inclusions ranged from 98 to 431°C. Salinities of water phase ranged between 7 and 14 wt % NaCl equiv. (not including samples with NaCl daughter crystals). (E.R.)

SIMONOV, M.A., and 8 others, 1977, The new mineral hexahydroborite, $Ca[B(OH)_4]_2 \cdot 2H_2O$: Vses. Mineralog. Obshch. Zapiski, v. 106, no. 6, p. 691-697, (in Russian; translated in Internat. Geol. Rev., v. 21, no. 4, p. 491-496, 1979). Author at Moscow Univ. and All-Union Sci. Res. Inst. of Mineral Resources (VIMS), Moscow.

The crystals have large numbers of liquid-gas inclusions, with <10 vol. % vapor, or no vapor. (E.R.)

SIMONOV, V.A., 1978, On inclusions in synthetic sodalite (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 198 (in Russian). Author at Instit. Geol. Geophys. of the SB AS USSR.

Some minerals: feldspars, micas, cancrinite and sodalite have been synthesized from melts-brines under the conditions of mineral crystallization of miaskite-pegmatites from the Ilmensky reservation, determined from inclusions of mineral forming environment in natural minerals (T = 700-750°C, P = 1500-1800 bars).

Primary inclusions of melts-brines with their phase composition (gas 40% + crystals 30-40% + liquid 20-30%) approximately corresponding to autoclave filling and phase correlation in inclusions in natural miaskite-pegmatite minerals, have been found in synthetic sodalite. The highest Th of inclusions in synthetic sodalite (710°C) corresponds to the synthesis temperatures.

Thus, the possibility of crystallization of miaskite-pegmatite minerals from melt-brines and the conformity of mineral-forming parameters, obtained by inclusion research, to the conditions existing in nature, is proved experimentally. This suggests the study of melt and brine inclusions in natural minerals for the synthetic reproduction of their analogues. (Translation courtesy Dr. A.P. Berzina)

SIMONOV, V.A., SHUGUROVA, N.A. and DOLGOV, Yu.A., 1978, Research on individual inclusion composition by atomic absorption analysis (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 157 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

The chemical structure of inclusions is usually examined in two ways: general analysis of all inclusions by water extraction method, and ultramicrochemical analysis of individual sufficiently large inclusions.

The method of determination of composition of individual inclusions of the most common size (up to a few tens of microns) by atomic absorption analysis, is proposed. The chosen inclusion is opened in a special device filled with doubly distilled water of measured volume. The doubly distilled water containing the liquid and dissolved crystal phases of the inclusion is analyzed by atomic absorption.

Inclusions in synthetic sodalite and some minerals from the Ilmensky reservation pegmatites have been examined for verification and construction of the proposed method. The quantitative cation composition of individual inclusions in these minerals has been obtained. (Translation courtesy Dr. A.P. Berzina)

SINGH, J.R. and PANDEY S.N., 1980, Chemistry of waters from some geothermal fields in India: Proceedings of the symposium on chemical analysis of geological materials-techniques applications and interpretation, Calcutta 1979, Geol. Sur. India Special Pub. Ser., no. 1, p. 435-448. Authors at Geol. Surv. of India, Lucknow.

Chemical studies of different water samples from Puga, Chumathang (both in Distt. Ladakh, J and K), Parvaty Valley, Sutlej Valley (H.P.), Sohna (Haryana) and West Coast (Maharashtra) have been carried out.

Approximately constant Cl/B ratio nearly 1 in Puga geothermal waters indicates that waters of different hot springs and bore holes are coming from same source. Average base temperature as indicated by Na-K-Ca thermometry is around 300°C. There is large variation in Cl/B ratios in waters from Parvaty Valley (2.5 to 22), Sutlej Valley (4.0 to 16.0) and West Coast (6 to 1460) which indicates the existence of more than one reservoir of different chemical nature. Base temperatures in all other fields are found to be lower than those in the Puga Valley.

Na-K thermometry is applicable only in Puga Valley where Na/K ratios are between 8 to 20. Average base temperature from this chemical thermometer is found to be around 250°C in Puga Valley. (Authors' abstract)

SINKEVICH, T.P., VIKULOVA, L.P. and NOVIKOVA, A.N., 1978, Typomorphism of quartz and conditions of formation of one of gold ore deposits in the Eastern Siberia* (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 204-205 (in Russian). Authors at East-Siberian Sci.-Res. Inst. Geol., Geoph. and Mineral Raw Materials, Irkutsk, USSR.

Veinlet-disseminated quartz-sulfide mineralization in Upper Proterozoic coal-bearing shales yielded Th in quartz in ranges 390-50°C; commercial ores formed at 230-275°C from L solutions. CO_2-G (i.e., LCO_2-G? - A.K.) inclusions (about 40% of all inclusions) have Th 210-330°C. (A.K.)

*The deposit name not given, A.K.

SINYAKOV, V.I., 1980, Temperature conditions of formation of magnetite ores of the skarn deposits : Theoretical and genetic mineralogy (Transactions of the W. Siberian Division of the All-Union Mineralogical Society), v. 8, p. 73-83, "Nauka" Pub. House, Novosibirsk (in Russian).

Specimens of magnetite from the following skarn deposits in the Kuznetsk-Sayan province were studied by means of the decrepitation method: Tey, Lespromkhoznoe, Temirtau, Irbin, Central Stocks, Amfiteatr, Begunets, Tel'bess, Abakan, Tabrat. T of magnetite precipitation was estimated to be 580-420°C, with two subdivisons: in Mg-skarns - 580-460°C, and in Ca-skarns - 560-420°C. Chlorite-amphibole-magnetite ores yielded T 540-420°C. (Abstract by A.K.)

SIROTIN, S.K. and SIROTIN, K.M., 1978, Temperature conditions of formation of gold ore metasomatites in the Kumak ore field: inclusion homogenization and decrepitation results (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 213 (in Russian). Authors at Sci.-Res. Inst. of Geol. of the Mining Office, Saratov, USSR.

Gold ores are connected with metasomatized subvolcanic dacites. Four associations were distinguished: I pre-ore quartz-albite with sericite, 380-400°C*, II quartz-albite-epidote-chlorite-gold ore, 295-345°C*, III quartz-carbonate-sulfide-gold ore with ilmenite and apatite, 210-245°C*, IV post-ore quartz-carbonate, 165-200°C*. Fluid inclusions were studied in quartz, albite, calcite, epidote and ankerite. Decrepitometric logging of drilling cores was performed for samples taken each 2 m, sometimes more frequently, Td typical of ore zones are 190-250°C, 250-280°C, 360-440°C, 450-480°C (intervals from beginning to the end of mass decrepitation. (Authors' abstract, translated by A.K.)

*Not specified whether Td or Th, A.K.

SISSON, V.B., 1979, Petrologic and fluid inclusion studies of the Wissahickon Formation, southeastern Pennsylvania and the Lessard Formation, Ontario, Canada: Geology honor thesis, Bryn Mawr College, Bryn Mawr, PA, 75 pp.

A combined petrologic and fluid inclusion study of two rock suites, selected from areas of known metamorphic conditions, shows how the fluid composition can be related to metamorphic conditions based on observed mineral assemblages. In pelites of the Wissahickon Formation of southeastern Pennsylvania, no conclusive results were obtained due to a lack of homogenization data. The fluids in the matrix quartz are generally CO_2-H_2O fluids with low salinities. Density determinations of pure H_2O inclusions indicate that this fluid is probably associated with the peak metamorphism and also tentatively restrict the pressure of the metamorphism to 7 Kb. In the calc-silicates of the Lessard Formation, Ontario, Canada, the fluid inclusions are mostly intermediate density pure CO_2 or aqueous brines with high salinities (23 weight % NaCl equivalent) and a high proportion is $CaCl_2$. The density determinations in both the aqueous saline inclusions and in the CO_2 inclusions suggest that these fluids were both associated with the peak metamorphism. The low density CO_2 inclusions found in recrystallized quartz grains suggest a possible uplift path. Lack of mixed brine and CO_2 solutions is possible evidence of immiscibility at peak metamorphic conditions. (Author's abstract)

SKARZHINSKIY, V.I., KOPTYUKH, Yu.M., KUDELAYA, V.K., KUZNETSOV, Yu.A., KUZNETSOVA, S.V. and OSTAVNENKO, A.I., 1980, Mineral associations of gold ore mineralization in the Hercynian and Alpine folded structures of Ukrainia, p. 42-45 in: Mineralogy of native elements, publ. by Far-East Sci. Center, Vladivostok, 154 pp., 500 copies printed, price 1 rbl. 40 kopecks (in Russian).

Gold-silver formation in Transcarpathia formed at T from 350-300 to 100-80°C, gold-polymetal formation, high T association at 350-250°C (gold-bearing quartz, ankerite, pyrite, arsenopyrite); low T association at 300-

100°C (quartz, ankerite, sphalerite, bournonite, galena, chalcopyrite, tetrahedrite). (A.K.)

SLACK, J.F., 1980, Multistage vein ores of the Lake City district, western San Juan mountains, Colorado: Econ. Geol., v. 74, p. 963-984. Author at U.S. Geol. Survey, Fed. Ctr., Reston, VA 22092.

Polymetallic vein ores of the Lake City district, in the western San Juan Mountains, Colorado, have produced approximately $12 million in Ag, Au, Pb, Zn, and minor Cu since 1874. Veins cut intermediate to silicic Tertiary volcanic rocks in an arcuate belt around the north, northeast, and east sides of the 22.5-m.y.-old Lake City caldera. The veins, typically 0.5 to 1.5 m wide and as much as 2,000 m long, fill steeply dipping (⩾60°) radial, transverse, and concentric fractures and faults outside the ring fault of the Lake City caldera and within the moat area of the older (28 m.y.) Uncompahgre caldera. Evidence of open-space filling (banding, crustification, vugs) is widespread. Multiple periods of mineral deposition in the veins are documented by compound structures in which ore and gangue minerals were repeatedly brecciated and rehealed by other minerals. Wall-rock alteration characteristically is quartz-sericite-pyrite, grading laterally outward into rocks affected by regional preore propylitization.

Two distinct mineral suites have been recognized in the veins, an older quartz-base metal assemblage (QBMA) and a younger barite-precious metal assemblage (BPMA). The quartz-base metal assemblage forms veins in fractures and faults exclusively on the north side of the Lake City caldera, where vein minerals include: pyrite; unzoned green or yellow sphalerite (⩽0.8 mole percent FeS); galena; chalcopyrite; sparse tetrahedrite-tennantite; rare arsenopyrite, hematite, and gold in a gangue of quartz; generally minor rhodochrosite; and traces of pyroxmangite, calcite, sericite, and fluorite. At the Ute-Ulay mine, the largest producer of the district, this assemblage has been divided into four stages (from oldest to youngest): Ia, early quartz-pyrite; Ib, banded quartz-sulfide ores; Ic, massive rhodochrosite; and Id, late quartz-carbonate-fluorite. On a district-wide scale, the quartz-base metal assemblage shows a concentric mineral zonation outward from the ring fault, from an inner quartz-chalcopyrite zone, through a middle hybrid zone, to an outer carbonate-tetrahedrite zone. Mineral zoning is best seen laterally along the 1-km length of the Ute-Hidden Treasure vein system at the Ute-Ulay mine, from quartz and sulfides at the southwest end nearest the ring fault, to massive rhodochrosite, sericite, and tetrahedrite at the northeast end.

The barite-precious metal assemblage, younger than the quartz-base metal assemblage on the basis of crosscutting textures and patterns of hydrothermal leaching, fills radial fractures and faults on the northeastern and eastern sides of the caldera. Barite-precious metal assemblage ore minerals include: pyrite, Ag-rich tetrahedrite, galena, distinctively banded red-brown sphalerite (⩽3 mole percent FeS), chalcopyrite, numerous Ag-Cu-Pb sulfo-salts, minor arsenopyrite, and rare hematite and magnetite; pitchblend, electrum, and Au-Ag tellurides are found locally. Gangue minerals are diagnostic barite, quartz (commonly as banded jasperoid), minor rhodochrosite, and rare sericite and clays. Major paragenetic divisions are: stage IIa, barite-sulfosalt ores; stage IIb, Au-Ag telluride ores; and stage IIc, late barite-chalcedony. A vertical zoning pattern is especially prominent, with barite, tetrahedrite, and tellurides more abundant at higher elevations.

Fluid inclusions were examined in minerals from many veins throughout the district. All observed inclusions are simple liquid-vapor types without immiscible liquid CO_2 or daughter minerals. Detailed heating and freezing studies on inclusions in quartz, sphalerite, and fluorite from the quartz-base metal assemblage document a general time-space decrease in filling temperatures (260°-185°C) and salinities (~4-0.1 equiv. wt. percent NaCl) along the Ute-Hidden Treasure vein system. Quartz and sphalerite from the barite-precious metal assemblage uniquely contain primary liquid-rich and vapor-rich inclusions that at the Ute-Ulay mine yield temperatures of 206° to 385°C and salinities of 1.3 to 12.4 equiv. wt. percent NaCl. The inclusion data suggest boiling of barite-precious metal assemblage fluids occurs at ~250°C, a depth of 450 m, and a hydrostatic pressure of approximately 40 bars. Throttling or irreversible adiabatic expansion of the fluid may have taken place at constrictions in the vein, where the barite-precious metal assemblage crosscuts and fills fractures within the older quartz-base metal assemblage.

Evaluation of the environments of ore deposition suggests that the quartz-base metal assemblage and the barite-precious metal assemblage formed under generally similar geochemical conditions. Mineral stability relationships and the Fe contents of sphalerites limit the conditions of the quartz-base metal assemblage formation and the principal part of the barite-precious metal assemblage formation to the sulfate-dominant part of the pyrite stability field, with $\Sigma S = 0.01$ m and pH = 4.5 to 5.7 (sericite stable), at 250°C. Minor excursions from this environment took place during formation of the barite-precious metal assemblage, including early jasperoid formation on the acid side of the kaolinite-muscovite boundary, and main-stage ores deposited locally near the pyrite-hematite-magnetite triple point. Major differences in mineralogy between the quartz- and barite-rich assemblages, together with the similarity of the geochemical environments, suggest differences in the original bulk composition of the hydrothermal fluids which deposited them.

Integrated field and laboratory studies suggest that the two assemblages formed from two separate hydrothermal systems generated independently during the Lake City caldera cycle. Fractures hosting the quartz-base metal assemblage were initially opened during resurgent doming of the Uncompahgre-San Juan-Silverton calderas 27.5 m.y. ago and were reactivated and mineralized probably contemporaneously with the emplacement of granite porphyry bodies intruded during resurgence of the Lake City caldera, 22.5 m.y. ago. The Red Mountain plug dome, emplaced along the eastern ring fault zone late in the caldera cycle, initiated a separate hydrothermal system that deposited the younger barite-precious metal assemblage. The Lake City caldera is unique among ash-flow calderas of the San Juan Mountains, for it possesses alteration and mineralization that are closely related both in time and space to the caldera cycle itself. (Author's abstract)

SMIRNOV, M.Yu., DOMNINA, M.I., DONSKIKH, A.V., KOTOV, N.V. and SHINKAREV, N.F., 1980, Genetic connection of metabasites, granitoids and alkaline rocks of the Northern Timan (geological and experimental data): Zapiski Vses. Min. Obshch., v. 109, no. 4, p. 412-423 (in Russian). Authors at Leningrad Univ., Leningrad, USSR.

Four water leachates were made from granites (2 samples) and quartz syenites (2 samples). Results, in mg per liter: K+Na 33-84, Ca 2-16, Mg 0.8-4, Cl 17-71, SO_4 16-26, HCO_3 43-150. Metagabbroids were treated by such solutions at 600°C, PH_2O 1 kbar, resulting in synthetic analogues of alkaline and feldspathoid rocks. (A.K.)

SMITH, L.E., CONE, J.T. and VAN HOOK, W.A., 1980, Enthalpies of dilution of aqueous electrolytes: the NaCl/H_2O system: J. Solution Chem., v. 9, no. 2, p. 81-95.

SMITH, R.W., NORMAN, D.I. and POPP, C.J., 1980, Calculated solubility of molybdenite in hydrothermal solutions (abst.): Geol. Soc. Am., Abstracts with Programs, v. 12, p. 525.

Stockwork molybdenum deposits are characterized by mineralization in quartz-pyrite-molybdenite veins. In addition fluorite and other fluorine-bearing minerals are associated with these deposits. Reported fluid inclusion filling temperatures indicate mineralization temperatures of ~350°C and pressures of ~150 bars.

Using thermodynamic properties of oxidized aqueous molybdenum species reported at 25°C, the high temperature properties of these species are estimated. From these estimates the solubility of molybdenite in slightly acidic aqueous solutions buffered by magnetite-pyrite-pyrrhotite or nickel-nickel oxide-pyrite-phrrhotite are calculated at 250°, 300° and 350°C. Several conclusions regarding molybdenite solubility are reached. They are: 1) molybdenite is soluble to the extent of several thousand ppm in ore forming solutions at 350°C; 2) significant amounts of molybdenum are transported as $HMoO_4^-$ with lesser amount transported as H_2MoO_4 and MoO_3F^-; 3) chloride and sulfide complexes are not significant; 4) the solubility is extremely temperature dependent, decreasing $\sim 10^6$ for a temperature change of 350°C to 300°C; and 5) powellite is $\sim 10^3$ time more soluble than molybdenite. These solubility calculations are consistent with depositional temperatures and lack of powellite that are observed in stockwork molybdenum deposits. They indicate that fluorine is not necessary for transport in hydrothermal solutions. In addition these calculations predict that rising ore solution would deposit molybdenite in a narrow confined zone as temperature decreased. (Authors' abstract)

SMOLIN, P.P., 1980, Stoichiometric geochemical aspects of antidromous evolution of ophiolites: Dokl. Akad. Nauk SSSR, v. 252, no. 2, p. 435-439 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 86-89 (1982). Author at Instit. Geol. of Ore Deposits, Petrog., Mineral. & Geochem., USSR Acad. Sci., Moscow, USSR.

Immiscibility is considered as a process in formation of the Troodos pluton. (E.R.)

SOBOLEV, A.V., DMITRIEV, L.V., BARSUKOV, V.L., NEVSOROV, V.N. and SLUTSKY, A.B., 1980, The formation conditions of the high-magnesium olivines from the monomineralic fraction of Luna 24 regolith: Proc. Lunar Planet. Sci. Conf. 11th, p. 105-116. Authors at Vernadsky Inst. Geochem. Anal. Chem., USSR Acad. Sci., Vorobievskoe Shosse 47a, Moscow, USSR.

An investigation was conducted into the nature of the olivines from the monomineralic fraction of the Luna 24 regolith, specifically those olivines with Fo contents >65%. The following types of inclusions were observed: 1) lamellae with compositions of Cr-melilite; 2) symplectites, similar to the A-B types of Bell et al. (1975); 3) intergrowths of Cr-rich low-Ca pyroxene and augite; 4) melt inclusions. Two groups of melt inclusions were found: they differ mainly in Ca/Al ratio and SiO_2 content. Heating experiments were performd on the melt inclusions. The high-Mg olivines crystallized at 1300°-1360°C with P >100 atm such as occur in ultramafic and basaltic VLT magma mixing. Upon cooling of these magmas, a hybrid magma saturated with fluid depleted in H_2O and CO_2 could be derived. Upon extended annealing of olivine at 1100°C, lamellae formed with a corresponding change in the olivine composition. These experimental data demonstrate the genetic relationship between the high-Mg olivines and the low-Ca pyroxenes in the Luna 24 regolith. (Authors' abstract)

SOBOLEV, N.V., OVTCHINNIKOV, Yu.I. and RODINOVO, A.A., 1978, Inclusions in clinopyroxene megacrysts from "Kakanui" volcanic breccia, New Zealand (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 107 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

Over 20 clinopyroxene samples from "Kakanui" breccias in New Zealand were studied. They are mostly single crystals of similar chemical composition, augite with high Al_2O_3 content (10%) and variable admixture of Na_2O (1-2%) and TiO_2 (0,8-1,7%). Several types of inclusions have been found to occur in the clinopyroxenes. Some crystals contain octahedral and ovoidal inclusions of the ore mineral (0.03-0.05 mm), which were not changed by heating. Secondary melt inclusions (0.01-0.005 mm), containing liquid and gaseous CO_2 are partly recrystallized. Homogenization of CO_2 to liquid phase occurred at 19.2°C with complete homogenization of inclusions at 1250-1270°C, which permits one to evaluate the minimum pressure as 6 kbars. (Translation courtesy of Dr. A.P. Berzina)

SOBOLEV, V.K. and STANKOVSKIY, 1980, Carbonate inclusions in chrome spinellids from kimberlite sheets: Dokl. Akad. Nauk USSR, v. 251, no. 6, p. 1477-1478 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 251, 1980, p. 140-141 (1982).

SOBOLEV, V.S. and 6 others, 1980, Petrologic and physico-chemical aspects of metamorphogenic ore mineralization: Geol. Surv. Finland Bull. 307, p. 84-97 (in English).

Includes a discussion of Th values from the literature. (E.R.)

SOBOLEV, V.S., BAKUMENKO, I.T. and CHUPIN, V.P., 1980, Inclusions of solidified melt in quartz from regenerated granite of Lake Onega: Dokl. Akad. Nauk SSSR, v. 254, no. 5, p. 1211-1213 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 254, 1980, p. 157-159 (1982). Authors at Instit. Geol. & Geophy., Siberian Div., USSR Acad. Sci., Novosibirsk, USSR.

In this classic locality described by Belyankin and Turtsev (in 1925), granitic rocks have been partly melted by intrusions of gabbro-diabase, and in part regenerated as granitic magmas. Melt inclusions occur in quartz from the regenerated granite. On heating some samples, the vapor bubble contracted sharply by 730--750°C, but inclusions decrepitated, implying the presence of volatiles. Th probably would be 780-800°C. Other samples had Th = 640°±20°C, thus requiring considerable H_2O.

Quartz from granophyre in the gabbro-diabase dikes had Th 1150-940°C and from another (related?) intrusion, 1200-1080°C. (E.R.)

SOBOLEV, V.S., KOSTYUK, V.P., BAZAROVA, T.Yu. and POSPELOVA, L.N., 1980, Composition of inclusions of melt in phenocrysts in syenite porphyry: Dokl. Akad. Nauk SSSR, v. 252, no. 2, p. 439-442 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 90-93 (1982). Authors at Instit. Geol. & Geophys., Siberian Div., USSR Acad. Sci., Novosibirsk, USSR.

Th of melt inclusions in early clinopyroxene 1240-1140°C; apatite 1200-1150°; garnet 1070-1030°; late clinopyroxene 1070-980°; biotite ≥950°; sodalite minerals 1060-930°C. Aqueous inclusions with salt daughter crystals in various minerals had Th 750°C. Nine electron microprobe anlayses are given for glass of melt inclusions; they show a great range in SiO_2 (from 29 to 64%). (E.R.)

SOBOLEV, V.S., BAZAROVA, T.Yu. and KOSTYUK, V.P., 1980, The role of hybridism in the formation of a hauyne-sodalite syenite porphyry: Geologiya i Geofizika, v. 21, no. 11, p. 19-26 (in Russian; translated in Soviet Geology and Geophysics, v. 21, no. 11, p. 15-20).

The possibility of the mixing of two magmas of different compositions is demonstrated by the example of the crystallization of a hauyne-sodalite syenite porphyry. One of these magmas was basic and potassic, the other a phonolite magma. Analyses of the rocks, phenocryst minerals, and melt inclusions in them are presented. (Authors' abstract)

SOBOLEVA, G.I., CHIZHIK, O.Ye., KHARLAMOV, Ye.S., KHAKIMOV, A.Kh. and KHITAROV, D.N., 1978, Physico-chemical conditions of formation of emeralds in a deposit of the greisen type, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 161-163 (in Russian). Authors at VIMS, Moscow, USSR.

Th, triple water leachates and cryometric determinations were performed for beryl (emerald), phenakite, chrysoberyl, apatite and plagioclase. Pneumatolytic conditions were at 450-400°C, hydrothermal ones at 400-140, with boiling at ~350°C. Before boiling solutions were of the K-Li-Rb-Al-Ca-F type, and after boiling they were of the Na-F-HCO_2 type, in both cases of low concentration. Calculated P was 330-420 bars (depth of formation 2-3 km). Main G component was CO_2. (Abstract by A.K.)

SOKOLOV, S.V. (1979) On the differences of phase composition of inclusions in minerals: Zapiski Vses. Mineral. Obshch., 1979, pt. 2, p. 202-206 (in Russian).

(See translations)

SOKOLOV, S.V., 1980, Complex evaluation of temperatures of formation of magmatic rocks (on the example of ultramafites of the alkaline-ultrabasic formation): p. 50-60 in Rekharskiy, V.I., ed., Methods and devices for studies of inclusions of mineral-forming media: Moscow, "Nauka" Publ. House (in Russian).

P crystallized inclusions in rock-forming pyroxenes of the studied olivine-pyroxene and pyroxene rocks from the Kola region yielded Th 1330-1165°C, and mineral equilibria geothermometers - very similar temperatures 1260-1160°C. (A.K.)

SOKOLOV, S.V. and MEYSNER, L.D., 1980, Identification of nepheline varieties from the intensity of light emitted at the second optical harmonic: Dokl. Akad. Nauk SSSR, v. 254, no. 6, p. 1453-1456 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 254, 1980, p. 180-183 (1982). Authors at All-Union Instit. Econ. Geol., Moscow, USSR.

Incidental to the optical studies, Th of primary melt inclusions was desired. Th was calculated to range from 800 to 1100°C in various samples from the Kovdor alkalic pluton, on the basis fo other mineralogical thermometers. (E.R.)

SOLOVOVA, I.P., LAPIN, V.V. and DMITRIYEV, Yu.I., 1980, Studies of melt inclusions in minerals of basites of Philippines Sea: Geokhimiya, no. 3, p. 458-4 (in Russian). Authors at Inst. Geol., Ore Deposits, Petrogr., Mineral. and Geochem. of Acad. Sci. of the USSR, Moscow, USSR.

The authors investigated specimens of tholeiitic basites from drilling cores made during the sixth and 31st cruises of "Glomar Challenger" in the Philippines Sea, gotten from the Oceanographic Inst. in California. Samples from uplifts of the ocean floor are plagiophyric basalts (boreholes nos. 292 and 57) and from flat areas of the ocean floor - aphyric basalts with poorly crystallized matrix, gabbro-dolerites and quartz norites (boreholes nos. 291 and 293. Plagioclase An_{65-85} from plagiophyric basalts bears numerous melt inclusions 2-80 µm long, filled mostly by devitrified glass. Rocks from borehole no. 57 yielded Th, °C: 1315-1190 (plagioclase), 1200-1175 (olivine); borehole no. 292 - 1355-1280 (plagioclase), 1210-1110 (pyroxene); borehole no. 291 - 1350-1260 (plagioclase), 1110 (pyroxene); borehole no. 293 - 330-265 (P, quartz), 345-265 (S, plagioclase). Microprobe analysis of the homogeneous glass in inclusions in plagioclase gave the following composition (wt.%): SiO_2 53.9, MgO 5.2, FeO 8.3, MnO 0.16, CaO 12.3, Al_2O_3 17.9, TiO_2 1.1, Na_2O 1.9, K_2O 0.12. (Abstract by A.K.)

SOTNIKOV, V.I., BERZINA, A.P., ZHAMSRAN, M. and MYAGMAR, L., 1980, Molybdenum-copper deposit Tsagan-Suburga (Mongolia): Geol. Rudn. Mest., v. 22, no. 3, p. 34-46 (in Russian). First author at Inst. Geol. Geoph. of Siberian Branch of Acad. Sci. USSR.

The deposit Tsagan-Suburga occurs in S. Mongolian metallogenic belt. It consists of veinlet-dispersed sulfide mineralization in zones of sericitization and K-feldspathization and it is connected with Carboniferous granitoid complex of small intrusive bodies in S. Mongolian volcanic belt. T interval of ore-forming process in quartz-sulfide veinlets (Th) is 250-400°C, in quartz-K-feldspar nests and veinlets 320-440°C in L or 390-550°C in G. Fluid present during granite formation was rich in CO_2 plus (HCl+HF). Granosyenite porphyry formed in the presence of N_2. Early hydrothermal stage developed with action of Cl and F. Isotope Ar composition suggests mixing deep fluids with meteoric waters. (Authors' abstract translated and extended by A.K.)

SOTNIKOV, V.I., KASTRYKIN, Iu.P. and NIKITINA, E.I., 1980, Temperature conditions of the formation of molybdenum mineralization in the central part of the Stanovoy Range: Dokl. Akad. Nauk SSSR, v. 254, no. 4, p. 990-992 (in Russian).

SPARROW, E.M., RAMSEY, J.W. and KEMINK, R.G., 1979, Freezing controlled by natural convection: J. Heat Transfer Trans ASME, v. 101, p. 578-584 CODEN: JHTRAO ISSN: 0022-1481.

SPOONER, E.T.C., 1980, Cu-pyrite mineralization and seawater convection in oceanic crust - the ophiolitic ore deposits of Cyprus: Geol. Assoc. of Canada Spec. Paper 20, p. 685-704.

One of the major discoveries of recent years about the physical and chemical behavior of the solid Earth and the oceans is the scale of the phenomenon of convective seawater circulation within the upper 3 to 5 km of the oceanic crust at spreading ridges. Analysis of the discrepancy between observed conductive heat flow and that predicted on the basis of a purely conductive cooling model suggests that the total ocean mass may circulate through basaltic oceanic crust at ridges once every 3 to 10 Ma.

An important point concerning hydrothermal circulation to arise from studies of ophiolitic rocks is that the formation of economically significant (on land) cupriferous pyrite ore deposits appears to be a natural side effect of seawater convection. This suggestion has recently received considerable support from the discovery of massive sulphide mounds (Francheteau et al., 1979) and turbulent, buoyant plumes of hot water at 380° ± 30°C precipitating sulphides at 21°N on the East Pacific Rise (Spiess et al., 1980).

The geometry of circulatory flow in the ophiolitic sequence of Cyprus appears to have consisted of axially symmetric cells containing central plumes of hot ascending fluid which were positionally fixed through time with respect to enclosing rock. Parmentier and Spooner (1978) have modeled such hydrothermal circulation by finite difference approximations. Fluid inclusion studies and theoretical models suggest that the principal factors which caused localized ore deposition were surface and near-surface cooling due to mixing, and conductive heat loss.

The possible effects of subduction of compositionally modified oceanic crust on the generation of magmas and associated mineral deposits at convergent plate boundaries are clear. For example, large quantities of reduced seawater sulphate, in association with hydroxyl and chloride, could be added to oceanic crust by seawater/rock interaction at ridges. Release of water from the descending slab at subduction zones might then cause wet melting of mantle material and could produce volatile rich siliceous magmas enriched in chloride and sulphur. Such a simple model could explain the amounts of magmatically released water, chlorine and sulphur required for the formation of porphyry Cu ± Mo ± Au deposits spatially associated with calc-alkaline intrusive rocks. (Author's abstract)

STALDER, H.A., 1980, Fluid inclusions in the quartz crystals from the alpine fissures. In Stalder, H.A., Sicher, V. and Lussman, L., eds., The minerals from the Gotthard train tunnel and the Gotthard road tunnel no. 2: Gurtneller, Switzerland, Repof AG (in German), p. 114-129.

A review of Stalder's fluid inclusion studies with numerous excellent photomicrographs. (E.R.)

STALDER, H.A. and SCHENKER, F., 1980, Chemical and mineralogical alterations in the surrounding rocks from the alpine fissures. In Stalder, H.A., Sicher, V. and Lussman, L., eds., The minerals from the Gotthard train tunnel and the Gotthard road tunnel no. 2: Gurtneller, Switzerland, Repof AG (in German), p. 130-134.

A review of the chemical and mineralogical changes, with 23 complete chemical analyses. (E.R.)

STALDER, H.A., SICHER, V. and LUSSMAN, L., eds., 1980, The minerals from the Gotthard train tunnel and the Gotthard road tunnel no. 2: Gurtneller, Switzerland, Repof AG 160 pp. (in German).

Includes discussions of fluid inclusion studies (see Stalder, 1980, and Stalder and Schenker, 1980, above). (E.R.)

STANLEY, C.J. and VAUGHAN, D.J., 1980, Interpretative studies of copper mineralization to the south of Keswick, England: Trans. Inst. Min. Met., v. 89, sect. 3, p. B25-B30. First author at Dept. Min., British Museum (Natural History), London.

Includes a review of fluid inclusion measurements by Shepherd. (E.R.)

STARK, Jack H. and THOMPSON, Tommy B., 1980, Mineralogy and paragenesis of the Mena mine vein, Front Range, Colorado (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 305.

The Mena mine is one of several Laramide Schwartzwalder-type uranium vein deposits in the Front Range of Colorado localized along northwesterly-trending faults where the faults transect a hornblende gneiss contact with biotite-quartz-feldspar gneiss. Additional controls on vein localization include deviations in fault strike or dip and fault intersections. Open-space fillings characterize the vein textures. Four stages of mineralization, separated by fracturing, are recognized: stage 1, adularia and pyrrhotite; stage 2, ankerite, sulfosalts, and Fe and Cu sulfides; stage 3, ankerite, pitchblende, quartz, hematite, niccolite, native bismuth, Cu-Mo sulfide, arsenides, and Pb, Zn, and Cu sulfides; stage 4, calcite, Fe and Cu sulfides, native silver and electrum. Wallrock alteration rarely exceeds a few centimeters and consists of chlorite, sericite and adularia - overprinted by hematite and ankerite. The presence of early pyrrhotite succeeded by pyrite, marcasite, chalcopyrite and bornite; presence of native elements in late stages of vein formation; enrichment of ore assemblage in carbonate during stages 2, 3, and 4; and presence of vapor-rich fluid inclusions in ankerite place considerable restrictions on ore fluid fO_2, fS_2, Eh and ore precipitation mechanisms. Increase in fS_2 characterizes stage 2 while later stages (3 and 4) showed increases in fO_2. Eh must have dropped throughout stage 3 and early stage 4 with fluctuations in both fO_2 and fS_2. Boiling of ore fluids appears to have been an important control on carbonate and possibly pitchblende precipitation. (Authors' abstract)

STEMPROK. Miroslav, 1980, Mineralization associated with acid magmatism (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 1012.

IGCP project of the above title existed 1974 - 80 with 36 participating countries. It contributed to the knowledge of tin, tungsten, molybdenum, beryllium, niobium and tantalum deposits closely associated with acid magmatic rocks and to the correlation of ore-bearing granites by geochemical and mineralogical criteria. Similarities in the geochemical development of granitoids of different ages in many ore-bearing provinces were observed and geochemical criteria were found useful in distinguishing ore-bearing and barren granites. Broad temperature interval of mineralization between 420 to 250°C was measured by fluid inclusion method. The temperature and the state of the solutions are, therefore, less frequently used among the variables in the classification of deposits. On the contrary directly measurable ones such as geological environment and mineral content are still preferred. Models for the derivation of metals from granites postulate either their enrichment into alkaline residual fluid or the equilibrium of fractionating granite magma with fluids rich in chlorides and fluorides. Geochemical data on various lithologies indicate that both igneous and sedimentary rocks can become a potential source of tin and associated metals provided that suitable conditions for magmatic differentiation were established. (Author's abstract)

STENINA, N.G., CHEPUROV, A.I. and TITOV, A.T., 1978, Electron microscope study of inclusions in natural quartz (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 1, Thermobarogeochemistry in geology: Vladivostok, Acad. Sci. USSR, p. 168 (in Russian). Authors at Instit. Geol. Geophys. of the SB AS USSR.

Inclusions of submicroscopical sizes in quartz from the blocky zone of rare-metal pegmatites of one of the East Siberian deposits have been studied by means of transmission electron microscopy.

Three types of inclusions have been revealed in quartz foils of 0.5-0.7 μ m thickness: a) crystalline, b) amorphous and c) gas-fluid.

Diffraction contrast analysis of their electron microscope images has shown that crystalline inclusions of sizes from 0.01 to 0.1 μm are another phase and have coherent interfaces with the quartz matrix. These inclusions interact with each other.

The amorphous state of inclusions of the second type is proved by their microdiffraction patterns and absorption contrast images. They are about 1 mm in size. (Ed. note - in foils <1 μm thick?)

Gas-fluid inclusions are connected with dislocations in the quartz structure. They are ≤0.1 μm in size.

The samples have been heat treated. Inclusions of the third type remain stable on heating to <250°C for a short time (5 hours). Samples heat treatment at 500°C for >20 hours leads to the disappearance of the submicroscopical inclusions of the given type, while the larger inclusions remain stable. (Translation courtesy Dr. A.P. Berzina)

STEPANOV, V.A. and IGONIN, I.P., 1978, Composition of gas-liquid inclusions and temperature of formation of quartz of gold-ore veins of a region of Upper Priamur'ye, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 189 (in Russian). First author at Far-East Territorial Geol. Office, Khabarovsk, USSR.

The gold-ore quartz veins* belong to sulfide-poor formation of moderate and deep levels; they formed during four stages: pre-ore, early commercial, main commercial and post-ore. Pre-ore quartz yielded Th 310-270°C, Td 360-300°C; early commercial quartz - Th 250-240°C, Td 285-260°C (LCO_2+LH_2O inclusions are rare); main commercial gold-bearing quartz - Th 215-170°C, Td 235-190°C. Pre-ore solutions were of HCO_3-Na-Ca type, early commercial and main commerical - Cl-HCO_3-Na. Gases consist of CO_2, CO, CH_4; CO_2 content decreases from pre-ore to main commerical stage, and simultaneously the CO content increases. (From the authors' abstract translated by A.K.) (*Region name not given, A.K.)

STEVENS, E.L., 1980, Inclusions in N.S.W. gemstones: The Australian Gemmologist, v. 14, no. 3, p. 23-26.

STEWART, D.B., JONES, B.F., ROEDDER, E. and POTTER, R.W., II, 1980, Summary of United States Geological Survey Investigations of fluid-rock-waste reactions in evaporite environments under repository conditions: Underground Disposal of Radioactive Wastes, v. 1, p. 335-344, Intern. Atom. Energy Agency, Vienna.

The interstitial and inclusion fluids contained in rock salt and anhydrite, though present in amounts less than 1 weight percent, are chemically aggressive and may react with canisters of wastes. The three basic types of fluids are: (1) bitterns residual from saline mineral precipitation including later recrystallization reactions; (2) brines containing residual solutes from the formation of evaporite that have been extensively modified by reactions with contiguous carbonate or clastic rocks; and (3) re-solution brines resulting from secondary, dehydration of evaporite minerals or solution of saline minerals by undersaturated infiltrating waters. Fluid composition can indicate that meteoric flow systems have contacted evaporites or that fluids from evaporites have migrated into other formations. The movement of fluids trapped in fluid inclusions in salt from southeast New Mexico is most sensitive to ambient temperature and to inclusion size, although several other factors such as thermal gradient and vapor/liquid ratio are also important. There is no evidence of a threshold temperature for movement of inclusions. Empirical data are given for determining the amount of brine reaching the heat source if the temperature, approximate amount of total dissolved solids, and Ca:Mg ratio in the brine are known. $SrCl_2$ and CsCl can reach high concentrations in saturated NaCl solutions and greatly depress the liquidus. The possibility that such fluids, if generated, could migrate from a high-level waste repository must be minimized because the fluid would contain its own radiogenic energy source in the first decades after repository closure, thus changing the thermal evolution of the repository from designed values. (Authors' abstract)

STOLYAROV, Yu.M., 1980, Hypogene sulfide-sulfate zoning of copper porphyry deposits: Geol. Rudn. Mest., v. 22, no. 3, p. 47-57 (in Russian). Author at Central Sci.-Res. Geol.-Prosp. Inst., Tula, USSR.

The paper bears some reference Th data for quartz and anhydrite. (A.K.)

STRASHNENKO, G.I. and SERYKH, N.M., 1978, Paleotemperature conditions of formation of deposits of rock crystal in the Southern Urals, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 152-154 (in Russian). Authors at "Uralkvartssamotsvety," Pervoural'skiy, USSR.

Temperatures of formation of rock crystals were determined for two deposits, "A" and "B," by the methods of inclusion homogenization, water index ($H_2O:CO_2$), and structural Al content; these are respectively 310 and 190, 470 and 350, 233 and 123°C. Thus they vary strongly between the methods, but the differences between the deposits are almost the same, i.e., 120-110°C. (A.K.)

STRATSIMIROV, S., 1980, Mineral thermometric studies on quartz from the Medet deposit: God. VMGI-Sofia, v. 25, 1980, p. 209-219 (in Russian).

Single-phase (mainly gaseous), two-phase (gaseous-liquid), and multi-phase inclusions (with daughter phases, mostly halite and sylvine) have been observed. The single-phase and multi-phase inclusions are typical of the early quartz. The following temperatures (in °C) and Th intervals of the fluid inclusions in quartz from the successive mineral parageneses have been measured: (1) aplite-micropegmatite - 416 (400-430), (2) quartz-andradite-rutile-magnetite-hematite - 370, (3) quartz-pyrite-chalcopyrite-molybdenite - 335 (320-350), (4) quartz-molybdenite - 310 (300-320), (5) quartz-pyrite - 295 (280-310), (6) quartz-sphalerite-galena - 240, (7) quartz-carbonate - 220 (200-240). It is assumed that ore formation was accompanied by boiling of the fluids. (Author's abstract)

STRAUB, J. and SCHEFFLER, K. (eds.), 1980, Water and steam: Oxford, Pergamon Press, 684 pp.

Includes equilibrium, transport, and other properties of value to understanding aqueous inclusions at P and T. The most pertinent items are abstracted in this volume. (E.R.)

STUPAKOV, G.P. and PETRUKHA, L.M., 1978, Homogenization temperatures and chemical composition of inclusions in rock crystal from quartz veins in amphibolites and schists, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 154-155 (in Russian). Authors at VNIISIMS, Alexandrov, USSR.

In one of the deposits in the Urals rock-crystal-bearing veins occur in amphibolites and crystalline schists. Th of inclusions in quartz from amphibolites are in a narrow range 300-260°C, but in a wide range in schists 325-183°C. In the first case parent solutions contain ions (in %-equiv.) Ca (50), Cl (45), HCO_3 (40), Na (30-35) and subordinate SO_4, in the second - Na (74), Cl (75), and some Ca, SO_4, HCO_3. In both cases gases in inclusions range from H_2S, CO_2, H_2, N_2 + rare gases to mixture poorer in H_2S, H_2 and CO_2, and richer in N_2 + rare gases. High quality parts of quartz crystals bear inclusions with average Th 265°C. (A.K.)

SUNDARAM, R.M., REDDY, M.N. and BALLURKAR, A., 1980, Thermometric studies on quartz samples from Agnigundala mineralized belt: The Indian Mineral., v. 21, no. 2, p. 41-45. First author at Centre of Explor. Geophy., Osmania Univ., Hyderabad-500 007.

Thermometric studies were carried out on fluid inclusions of quartz samples associated with sulfide mineralization of Agnigundala area. Three types of fluid inclusions occur in the quartz samples; (a) moderately-saline (b) highly-saline and (c) gas-rich. The liquid inclusions in quartz samples form Agnigundala area are characterized by abundance of those of moderate salinity and the determination of their Th is helpful in the thermometry of the deposits. (Authors' abstract)

SUSAK, N.J. and McGEE, K.A., 1980, A routine for estimating the solubility of methane in pure water or NaCl brines by using the Texas Instruments TI-59 calculator - with tables: U.S. Geol. Survey Open-File Report 80-371, 17 pp.

SUTHERLAND, D.S., 1980, Two examples of fluidization from the Tororo carbonatite complex, southeast Uganda : Proceedings of Geol. Ass., v. 91, no. 1/2, p. 39-45. Author at Dept. Geol, The Univ., Leicester, LE17RH.

Carbonatite with closely-spaced subspherical structures composed of magnetite and calcite can be interpreted variously as fluidized droplet intrusion, a fluidized fragmental rock, or an amygdaloidal carbonatite with amygdale infilling of hydrothermal type similar to magnetite-carbonatite dykes. Mafic fragmental dykes in the same area are termed "fluidization breccias;" they contain abundant, very well-rounded fragments, sorted according to size, among which hornblendites predominate, the analyzed hornblende being a pargasite-ferrohastingsite. Other fragments include abundant ijolites, and fewer carbonatites. The dyke matrix consists of altered fragments with recrystallized biotite, calcite, analcime and magnetite. (Author's abstract)

SUTTON, R.L., Jr., 1980, Enhydros: Explorers Journal, v. 58, v. 4, p. 177-178.

A reprint of 1964 article from *Lapidary Journal*. (E.R.)

SVERJENSKY, Dimitri A., 1980, The origin of a Mississippi Valley-type deposit in the Viburnum trend, southeast Missouri (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 531.

Petrologic and isotopic studies of base-metal sulfide mineralization in the Buick mine have revealed evidence of repetitive precipitation and dissolution of both galena and sphalerite. During an early stage of the mineralization, fine-grained pyrite and marcasite replaced the dolostone host-rock. The iron disulfides were later replaced during the main stage of sphalerite precipitation while the ore-forming solutions dissolved the dolostone host-rock. Following the sphalerite precipitation, two main stages of galena were precipitated. An early cuboctahedral stage of galena precipitation, during which galena replaced dolostone and grew in vugs in the dolostone or in early sphalerite was followed by precipitation of cubic galena and minor amounts of pale sphalerite. The two stages of galena precipitation were separated by a period during which the early dark sphalerite and cuboctahedral galena were partially dissolved and marcasite was precipitated.

Neither a sulfate-reduction model in which sulfate was reduced by organic matter or methane, nor mixing models in which base metals and reduced sulfur travelled separately to the site of deposition can explain the repetitive precipitation and dissolution of the galena and sphalerite. A simple alternative explanation is that the base-metal sulfides were precipitated from hot brines that transported base metals as chloride complexes together with reduced sulfur in the same solutions to the site of deposition. Dissolution was caused by decreases of pH, probably associated with precipitation of marcasite or dolomite. (Author's abstract)

SVESHNIKOVA, Ye.V., BOGATIKOV, O.A., FRIKH-KHAR, D.I., ASHIKHMINA, N.A., MAGIDOVICH, T.S., LAPUTINA, I.P., LAZ'KO, Ye.Ye., GORSHKOV, A.I., DRYNKIN, V.I., KARPOVA, O.V., SUKHANOV, M.K., GENKIN, A.D. and UDOVKINA, N.G., 1980, Minerals of lunar soil brought by "Luna-24" automatic station, *in*: Cosmic mineralogy, Proceedings of the XI General Meeting of IMA: "Nauka," Leningrad, p. 24-31, price 1 rbl 20 kopecks, 1300 copies printed (in Russian, English summary).

Clinopyroxenes from the studied lunar samples bear glass and glass-gas inclusions and mineral inclusions of ulvite, troilite, tridymite, quartz, kamacite; Fe, Mg and Ca content in inclusion glass is strongly variable, admixtures of Cl, S and P were found. Glass often bears micro-vacuoles filled by gas and tiny crystals of halite and sylvite with minor admixture of oldhamite and kamacite (microdiffraction and microprobe determinations). Halite and sylvite probably crystallized from G phase, which formed due to impact phenomena. (Abstract by A.K.)

SVISERO, D.P., CAMARGO, W.G.R. and NAZÁRIO, G., 1972, Infrared spectra of diamonds from Alto Araguai, Brazil: An. Ac. Bras. Cienc. (Proceedings of Brazilian Acad. of Sci.), v. 44, no. 3/4, p. 441-449 (in Portuguese; translation courtesy K. Fuzikawa).

Diamond crystals from placers of the Paraná Basin of Mato Grosso and Goias, Brazil, have been studied in realtion to their absorption in infrared region of the spectrum.

Type I diamonds are the more frequent ones (94%), having either N platelets parallel to the (100) plane of the diamond crystals (type Ia) or N atoms replacing carbon in the crystal net of diamond (type Ib).

The N-free diamonds (type IIa) are relatively rare (6%), and the semiconducting variety (type IIb) are completely absent among the investigated samples.

In addition to N, impurities of H have been determined in some diamond crystals. The source of N is still unknown, but it could be suggested that the C, N, and H might all be derived from an old organic sediment, later enclosed in the kimberlitic magma by crustal convection. (Authors' abstract)

SWANENBERG, H.E., 1980, Fluid inclusions in high-grade metamorphic rocks from S.W. Norway: Geologica Ultraiectina, no. 25, 147 p. (in English).

In part one of this thesis, isochoric sections, based on a modified Redlich-Kwong equation, are presented for the systems CO_2, CO_2-N_2, N_2-CH_4 and H_2O-CO_2. This allows the P-T interpretation of fluid inclusion freezing data in terms of the above mentioned reference systems.

Part two deals with fluid inclusions in quartz of high-grade metamorphic rocks from S.W. Norway. This region is essentially a plutonic complex of anorthosite masses and a layered lopolithic intrusion (in the southwest) surrounded by HT-LP granulite-facies rocks and by high-grade amphibolite-facies rocks (prevailing in the northeastern part).

The major types of fluid inclusions are: 1. H_2O-rich, 2. CO_2-rich, 3. H_2O-CO_2 and 4. N_2-rich. On a regional scale, CO_2-rich inclusions seem to predominate in the granulite-facies rocks. Abundant CO_2-rich inclusions (with low densities) have been found close to a dolerite dike. In general, the variability in properties of types 1-3 at the scale of a handspecimen is not clearly related to the high-grade mineralogy. N_2-rich inclusions have been found in quartz-rich rocks in the vicinity of mafic rocks (preferably with amphibole or clinopyroxene) and in a number of pegmatites.

Most fluid inclusions are arranged along trails. Transposition of trails indicates that the inclusions are able to migrate, possibly as the result of stress. Not uncommonly, trails that (in part) consist of carbonic inclusions are oriented subbasally.

Temperatures of liquid phase homogenization of type 2 (essentially CO_2 with some N_2) display a wide range in individual samples, particularly in strongly retromorphic or deformed rocks. In general, however, the values are rather low, compared with most other granulite-facies terranes. In terms of CO_2-equivalent density, the freezing data of type 2 reflect a range of 0.70 to 1.23 g/cc. Type 4 yields 0.45-0.75 g/cc N_2. There is a striking incompatibility between the occurrence of extremely dense inclusions and the HT-LP conditions of granulite-facies metamorphism.

It is suggested that pre-existing inclusions are able to re-equilibrate towards higher densities when, during an initial isobaric cooling, the retrograde P-T path of the rock complex intersects isochores of increasing density. Extremely high densities, mainly found in intensely deformed or retromorphosed rocks, possibly result from tectonic overpressures (Caledonian influence?) which may amount up to 3.5 kbars at relatively low temperatures. Interaction of H_2O-rich fluids, possibly introduced during a late-stage uplift, and (pre-existing) CO_2 at about 300°C and 1-2 kbars (hydrostatic pressure) could effectively explain a number of thermo-optical properties of mixed H_2O-CO_2 inclusions. (Author's abstract)

TAKENOUCHI, Sukune, 1978, Fluid inclusion studies, section VII-3 in H. Imai, Geological Studies of the Mineral Deposits in Japan and East Asia, Tokyo, Univ. Tokyo Press, p. 312-334.

A review of fluid inclusion studies in a number of Japanese ore deposits, particularly the Takatori, Akagane, Suzuyama, Kamioka mines. Includes also cross sections of Japanese heating and freezing stages. (E.R.)

TAKENOUCHI, Sukune, 1980a, Fluid inclusion studies of several Philippine porphyry copper deposits (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 1018.

Fluid inclusions from several Philippine porphyry copper deposits were studied. Geologic ages of these deposits were divided into the Palaeocene and Late Miocene. Three types of fluid inclusions, that is, highly saline polyphase, gaseous, and liquid inclusions were found in these deposits. The modes of occurrence of fluid inclusions vary from deposit to deposit, and depend not on their geologic ages but on their geologic structures. In a vertically extended pipe-shaped deposit, polyphase inclusions as well as gaseous inclusions predominate suggesting an intense contribution of boiling magmatic waters in the formation of ore deposits. In a laterally extended deposit, minute liquid inclusions predominate over polyphase and gaseous inclusions. This would indicate a strong effect of circulating meteoric waters which flushed out polyphase inclusions trapped in early stages. The Santo Tomas II deposit of the Late Miocene in the northern Luzon Island is the typical one of the former type. The Biga deposit of the Atlas mine in Cebu Island is of the Palaeocene age and belongs to the latter type. The other deposits studied in the present work are considered to be the intermediate of the two types. (Author's abstract)

TAKENOUCHI, Sukune, 1980b, Fluid inclusion studies in Japan and their application to mineral exploration: Reports of Fourth Joint Meeting, MMIJ-AIME, 1980, Tokyo, Tech. Session A-1, p. 1-16.

Data of the fluid inclusion studies which have been carried out up to date in Japan, are briefly summarized, and the result is discussed from the standpoint of mineral exploration. Homogenization temperatures of fluid inclusions in vein-type deposits of Tertiary and Late Cretaceous age, range between 130° and 360°C, but the temperature range of main mineralization is from 200° to 300°C, and the base-metal mineralization is not prominent above 300°C. Systematic change of temperature and salinity is observed in fluid inclusions from the genetically related igneous rocks to veins far from the center of mineralization. Salinities of ore-forming fluids of Tertiary vein-type deposits are generally low, and the stable isotopic composition indicates a high possibility of participation of meteoric water to the mineralization, but there are some exceptions such as the Taishu and Ani deposits where the salinity of fluids reaches as high as 20 wt.%. It is considered that stockwork orebodies of the Kuroko deposits which are found in rhyolite domes underneath the bedded orebodies have served as pathways for the ore-forming fluids of the bedded orebodies. Therefore, the fluid inclusion studies of the stockwork orebodies provide data on the fluids which were still in solid rocks of the sea floor and not mixed with much of cold sea water. At the top of stockwork orebodies, the temperatures of fluid inclusions evidently drop but in the deeper places the temperatures are around 300°C and the gradient of temperature is small. Fluid inclusion data of the Philippine porphyry copper desposits are interesting to mention compared with those of hydrothermal veins and genetically related igneous rocks. The deposits are characterized by the presence of high-salinity and high-temperature polyphase inclusions. From the result of geologic and fluid inclusion study, it is inferred that an intense activity of high-salinity and high-temperature boiling fluids of magmatic origin has participated at the formation of vertically extended pipe-like orebodies, whereas at the formation of flat-lying mushroom-like orebodies the participation of low-salinity solutions of meteoric origin at the waning stages of hydrothermal activity, were so intense that most of polyphase inclusions formed in earlier stages were flushed out. Fluid inclusion data combined with the data of mineralization will provide us information on the condition of mineralization, the change of which is valuable for the exploration guide. Techniques to extract more reliable and accurate information from fluid inclusions should be developed for the progress of exploration methods. (Author's abstract)

TAKENOUCHI, Sukune, 1980c, Preliminary studies on fluid inclusions of the Santo Tomas II (Philex) and Tapian (Marcopper) prophyry copper deposits in the Philippines: Mining Geol. (Japan) Spec. Issue, no. 8, p. 141-150. Author at Dept. Min. Dev. Engrg., Univ. Tokyo, Hongo, Tokyo, Japan.

Preliminary studies on fluid inclusions of two porphyry copper deposits in the Philippines were carried out and the results were compared with those of the Mamut deposit, Sabah, Malaysia and the Panguna deposit, Bougainville.

The Santo Tomas II (Philex) deposit which is located in northern Luzon, is a nearly vertical pipe-shaped orebody formed in a Miocene quartz diorite complex and Late Cretaceous metavolcanics. Three types of fluid inclusions were found in quartz samples, but high-salinity polyphase inclusions were predominant. High temperatures of disappearance of halite and bubble in polyphase inclusions, and the coexistence of gaseous and polyphase inclusions are striking indicators of the participation of boiling high-salinity and high-temperature fluids during ore formation. The salinity and temperature of those fluids were estimated to be 50-70 wt% and higher than 500°C, respectively. Scarcity of liquid inclusions homogenizing between 200° and 250°C suggests a feeble inundation of low-salinity and moderate-temperature hydrothermal solutions of meteoric origin.

The Tapian (Marcopper) deposit, which is located in the center of Marinduque Island, is a flat lying platy orebody formed mainly in a Miocene quartz diorite complex. The pattern of wall-rock alteration and copper grade are irregular. Biotitization is limited and phyllic alteration predominates in the ore zone. Three types of fluid inclusions were observed, but, in general, liquid inclusions predominated; all were very small.

Filling temperatures of liquid inclusions were distributed over a wide temperature range between 100° and 380°C. Upon heating, the bubble in polyphase inclusion disappeared at a lower temperature (160°-460°C) than did halite (300°-550°C), suggesting fluid pressures higher than the vapor pressures of solutions. The salinity was estimated to be 35-50 wt%. The occurrence of abundant fluid inclusions without daughter salts indicates intense activities of low-salinity hydrothermal solutions during and after the ore formation.

Polyphase inclusions from the Panguna deposit, Bougainville, homogenize either by the disappearance of the bubble or by the dissolution of halite. NaCl and KCl concentration of polyphase inclusions was estimated to be 30-45 wt% and 12-18 wt%, respectively. Though the number of samples was limited, the two modes of homogenization of polyphase inclusion suggest a change of fluid pressure. From these results, it is concluded that the occurrence of fluid inclusions in porphyry copper deposits is indicative of the activities of hydrothermal systems during and after the mineralization and intimately related to the shape of the orebody and the pattern of wall-rock alteration. (Author's abstract)

TALANTSEV, A.S., 1980, Evaluation of depth to roots of ore-forming systems: Dokl. Akad. Nauk SSSR, v. 250, no. 5, p. 1212-1215 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 250, 1980, p. 105-108 (1982).

TAUSON, V.L. and ABRAMOVICH, MG., 1980, Hydrothermal study of the ZnS-HgS system: Geokhimiya, no. 6, p. 808-820, 1980 (in Russian; translated in Geoch. Inter., v. 17, no. 3, 1980, p. 117-128, 1981).

TAYLOR, G.J., WARNER, R.D., KEIL, K., MA, M.-S. and SCHMITT, R.A., 1980, Silicate liquid immiscibility, evolved lunar rocks and the formation of KREEP : Proc. Conf. Lunar Highlands Crust, 1980, p. 339-352.

TAYLOR, H.P. and SILVER, L.T., 1978, Oxygen isotope relationships in plutonic igneous rocks of the Peninsular Ranges batholith, southern and Baja California: U.S. Geol. Survey Open file Report 78-701, p. 423-426.

TEDIASHVILI, K.A. and AKHVLEDIANI, R.A., 1978, The discovery of fluorite in the Kvaisa lead-zinc deposit, Georgian Republic: Soobshcheniya Akademiy Nauk Gruzinskoy SSR, 1978, v. 91, no. 2, p. 373-376 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

TERASHIMA, Shigeru and ISHIHARA, Shunso, 1980, Anomalous chlorine contents of Miocene granitoids from Tsushima, Japan: J. Japan. Assoc. Min., Petr. Econ. Geol., v. 75, p. 62-67.

Miocene granite and granodiorite of Tsushima islands contain 700-1400 ppm Cl in general, which are higher in one order of magnitude than chlorine contents of common granitoids in Japan. The Miocene granitoids belong to so-called calc-alkaline series but slightly potassic, and contain no Cl-minerals. The main cause for the anomalous values seems to be chlorine trapped in fluid inclusions contained in various rock-forming minerals. Ratios of chlorine contained in fluid inclusions and rock-forming minerals appear to increase with increasing silica contents. This Cl-enrichment in aqueous phase during the magmatic fractionation as well as original high content may have played an important role for lead-zinc mineralization of the Taishu mine. (Authors' abstract)

TERESHCHENKO, S.I., 1980, Gas-liquid inclusions in garnets, chapter 9 in: Rock-forming garnets of the Ukrainian shield: "Naukova Dumka," Kiev, p. 77-79, price 2 rbls 70 kopecks, 900 copies printed (in Russian).

Inclusions were studied in garnets of rocks of granulite facies from Pobuzh'ye and Priazov'ye (two-pyroxene-magnetite quartzites, garnet-two-pyroxene-quartz schists and gneisses). Garnets bear only P and S LCO_2 + GCO_2 inclusions; LH_2O inclusions were not found. P LCO_2 inclusions are extremely rare, their dia. is 0.005-0.009 mm, Th in LCO_2 10-19°C, indicating a CO_2 density of 0.856-0.776 g/cm^3, S inclusions have Th in LCO_2 18-29°C; density 0.786-0.630 g/cm^3. Also inclusions of "dry" gases (without L phase) were found. P from CO_2 density varies from 3x10^8 Pa to 4x10^8 Pa. Thus, metamorphic fluid was CO_2, extremely low in H_2O. (Abstract by A.K.)

TERESHCHENKO, S.I. and LUGOVAYA, I.P., 1978, Genesis of the Beregovskoe polymetallic deposit from thermobarogeochemical and isotope analysis data (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 113-114 (in Russian). Authors at Inst. Geochem. and Physics of Minerals, Kiev, Ukrainian SSR.

Quartz in the Beregovskoe polymetallic deposit formed at 95-335°C, but mostly at 315-335°C; ores precipitated at 100-200°C. Isotopes O, C and S were studied; $\delta^{18}O$ of quartz (SMOW) was +4.4 to 11.0‰ and, calculated from these values, $\delta^{18}O$ for hydrothermal solutions ranged from +5.2 to -7.2‰, suggesting the mixing of ascending hydrotherms with descending surface waters. (A.K.)

THOMAS, R. and BAUMANN, L., 1980, Results of thermometric and cryometric investigations on cassiterites from the Erzgebirge Mts.: Z. geol. Wiss., Berlin, v. 8, no. 10, p. 1281-1299 (in German with English abstract).

Extensive thermometric and cryometric investigations of cassiterites and other minerals of the tin-tungsten-mineralization of the Erzgebirge were carried out. Besides a brief statement of the methodology which was used, the results are discussed. Referring to the cassiterites five types of homogenization were detected (tab 1). The predominant part of the inclusions in cassiterite homogenize in the liquid phase.

From the thermometric results we can distinguish four postmagmatic formation stages of cassiterite: pegmatitic, ≥550°C; high-hydrothermal, 450(±20)°C; pneumatolytic, 382(±20)°C; and hydrothermal, 350 to 270°C. The gelcassiterite (wood-tin) which occurs in the Erzgebirge wasn't taken into account.

The position and relation of the cassiterites to the most significant paragenetic attendant minerals is shown in figure 8. Those mineralization states obtained for the cassiterite are also perceivable in this table. One should especially pay attention to the relatively limited field of temperature of the pneumatolytic-hydrothermal transition-stage (420 to 360°C) which concerns all minerals.

The results of the cryometric investigations (salinity; tab 2) show an intensive change of the salinity including the pH-value of mineral-forming solutions simultaneously with the precipitation of the cassiterite II-stage (intensive separation of pneumatolytic solutions!).

Measurements of the specific volume of the included solutions show (tab 3) that the precipitation of minerals occurred in the intermediate density range, e.g. according to the prevailing P-T conditions it came to a mineralization out of the liquid, gaseous or fluid phase, and often these three states do co-exist.

By means of inclusion investigations which were carried out on several minerals of the cassiterite associations the four stages of formation are verified with temperature, pressure and salinity data (tab 4). The formation of cassiterite in the postmagmatic deposits of the Erzgebirge occurred above all from solutions rich in Na^+-, (K^+)-, Cl^-- and F^--solutions. The main precipitation was associated with two stages of formation (II and III), both with rather limited temperature and pressure data. Repeated tectonically induced pressure decrease determines decisively the genetic process. Due to retrograde boiling and cavitation phenomena which are both linked with each other one can observe additional hydraulic fracturing of the rock- and granular-formation. Those greisenizations often occurring in tin deposits of the Erzgebirge can be partly traced back to these processes. The process of repeated transition of a high temperature mineral-forming solution in a supercritical state, connected with intensive changes of the solubility products and stabilities of complexes, is characteristic for the precipitation of the tin-tungsten-formation of the Erzgebirge.

The results obtained on cassiterite of the Erzgebirge naturally fit with the totality of the results of inclusion investigations at other minerals important for the ore formation (e.g. quartz). (Authors' abstract)

THOMPSON, M., RANKIN, A.H., WALTON, S.J., HALLS, C. and FOO, B.N., 1980, The analysis of fluid inclusion decrepitate by inductively-coupled plasma atomic emission spectroscopy; an exploratory study: Chem. Geol., v. 30, p. 121-133. Authors at Dept. Geol., Imperial College, London SW7 2BP, Great Britain.

Inductively coupled plasma atomic emission spectrometry (ICP) has been used to investigate the composition of fluid inclusions in samples of pegmatite topaz from Malaysia and carbonatite apatite from Kenya. In this preliminary study we describe a method whereby material ejected from the sample during decrepitation at elevated temperatures is transferred to the plasma by a stream of Ar. Up to 40 elements can be determined simultaneously in the resulting decrepitate. The method is rapid and permits the determination of a number of important elements which, in conventional fluid inclusion isolates, are present in a concentration so low that there are problems of detection even with sensitive methods such as ICP. A further advantage of the ICP-linked decrepitation method is the small sample size (~0.5 g) normally required. Comparison of results obtained by the proposed method and the ICP analysis of leachates for the same sample shows that most elements give higher values of X/Na by the decrepitation method. Possible explanations for this difference include: (1) selectivity of decrepitation as a means of nebulishing inclusion contents; (2) hydrolysis and precipitation or adsorption of metal ions during the leaching method; and (3) extraction of Na^+ ions from the host mineral during leaching. Regardless of these differences on-line decrepitation is a highly efficient method of nebulishing inclusion fluids for introduction into the plasma, and the method has considerable potential as a routine means of analyzing inclusions. (Authors' abstract)

THOMPSON, T.B., LYTTLE, Thomas and PIERSON, J.R., 1980, Genesis of the Bokan Mountain, Alaska, uranium-thorium deposit: Report on Dept. Energy Contract DE-AC13-76GJ01664, Dept. of Earth Resources, Colorado State Univ., Fort Collins, Colorado 80523.

The Bokan Granite complex is a mid-Devonian peralkaline ring dike complex with vein and pipe-shaped zones of uranium-thorium mineralization in microveinlets with sulfides, calcite, fluorite, and quartz. Fluid inclusion analyses on fluorite and quartz associated with the ore minerals indicate that the ore fluid had low salinity and temperatures near 320°C. Sulfur and carbon isotope analyses on contemporaneous pyrite and calcite indicate the ore fluids had a pH of 4.5 and were moderately reducing. (From the authors' abstract)

THOMS, R.L. and MARTINEZ, J.D., 1980, Blowouts in domal salts: Fifth Internat. Symp. on Salt-Northern Ohio Geol. Soc., p. 405-411. Authors at Inst. Environ. Studies, Louisiana State Univ., Baton Rouge, LA 70803.

"Blowouts" are known to occur in many U.S. Gulf Coast salt domes. A blowout refers to a moderately violent to violent ejection of salt, reportedly accompanied by release of gas, which produces a cavity in the salt. When blowouts occur in room and pillar salt mines they usually are precipitated by routine blasting of an advancing wall or face. The aftermath of a blowout is a cavity and a significant amount of granulated and small pieces of "crackle salt" which are ejected onto the mine floor. The cavity frequently is a vertically inclined, elongated opening into the mine ceiling, and is called a "chimney" by miners. Blowouts and their possible causes and significance relative to the increasingly important practice of storage in mined openings in salt domes are discussed in some detail. (Authors' abstract)

THOMSEN, Leon, 1980, ^{129}Xe on the outgassing of the atmosphere: J. Geophy. Res., v. 85, no. B8, p. 4374-4378. Author at Dept. Geol. Sci., State Univ. of New York, Binghamton, NY 13901.

Because of the short half-life of its parent (^{129}I, 17 m.y.) and its own chemical inertness, ^{129}Xe offers unique insight into the problem of the outgassing history of the earth's atmosphere. Because the current atmosphere is different in Xe isotopic patterns than is the interior, the present atmosphere must have been largely outgassed before these patterns finished changing, that is, very early in earth history. Furthermore, there can have been no significant delay in the onset of outgassing; that is, the earth must have been initially hot. Because ancient sedimentary rocks indicate that the atmospheric Xe patterns have not changed substantially for over 3 b.y., models presuming a separate, lower mantle reservoir do not alter these conditions. Similar conclusions have been reached before but have always carried a heavier burden of debatable assumptions. (Author's abstract)

TISHKIN, A.I. and GORBUNOV, V.Yu., 1980, Anhydrite from metamorphic rocks of the Aldan Shield: Izvestiya AN SSSR, no. 10, p. 101-114 (in Russian). Authors at Inst. Geol. Ore Deposits, Petrogr., Mineral. and Geochem. of Acad. Sci. USSR, Moscow.

Anhydrite, occurring locally in metamorphic Archean diopside-hypersthene-plagioclase rocks of granulite facies yielded Td 240-500°C. (A.K.)

TKACHENKO, G.A. and KOKORIN, A.M., 1980, Structural-morphological features and some peculiarities of genesis of tin ore deposits in the Northern Sikhote Alin', p. 43-46 *in*: Structure, composition and genesis of tin-ore deposit of the Far East, publ. by Far-East Sci. Center, Vladivostok, 136 pp., 500 copies printed, price 1 rbl. 25 kopecks (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

In the volcanic-plutonic-detrital complex several tin ore deposits formed and the following Th are typical of those deposits: Mopau, main association quartz-cassiterite, 450-175°C; Udzhakinskoe (quartz, cassiterite, arsenopyrite, wolframite, scheelite and sulfides in veins), main ores formed at 475-420°C, mineralization down to 150-175°C; Pionerskoe, upper parts of cassiterite-sulfide veins formed at 380-175°C, at deeper levels - at 420-440°C. (Abstract by A.K.)

TOLSTIKHIN, I.N., 1980, The problem of accumulation and degassing of Earth in the light of modern isotopic data: Geokhimya, 1980, no. 3, p. 335-350 (in Russian).

TOMILENKO, A.A. and DOLGOV, Yu.A., 1978, Conditions of formation of the "granulated" quartz of the chain Borus (W. Sayans), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 159-161 (in Russian). Authors at Inst. Geol. Geophys. of Sib. Branch of Acad. Sci. USSR, Novosibirsk, USSR.

Jadeites and albitites occur in ultrabasites surrounded by metamorphic rocks of greenschist and epidote-amphibolite facies. Albitites bear lenses of "granulated" quartz with P inclusions of LCH_4, heterogenizing at ~-150°C. L in such inclusions froze at -185°C and had Tm -182.5°C (T of triple point of CH_4), and Th from -126 to -147°C. Specific volume of CH_4 was 2.48-2.71 cm^3/g. G analysis of individual inclusions revealed mostly CH_4, H_2 up to 24 vol. % and small amount of N_2 + rare gases. CO_2 and H_2O were not found. PS of syngenetic one-phase inclusions of LCH_4+CO_2 and water-salt solutions occur in marginal zones of quartz (sic., note differences between presumably coeval P and PS inclusion; A.K.). Homogenization (CO_2+CH_4) was at -87 to -89°C, Tm -182.5°C. Salt concentrations in water-salt solutions was ~10 wt% (probably $MgCl_2$, Te -33°C). Quartz bears also late LCO_2-LH_2O S inclusions. Coarse-grained quartz from veins bears inclusions with Th 340-390°C in L, G consist of CO_2, "acid gases" and N_2, total salt ($MgCl_2$) content <10 wt%. Secondary post-jadeite albite bears water-salt inclusions with Th≤300°C in L phase. Thus, "granulated" quartz formed under action of H_2-CH_4 fluid at T>400°C and P≤8 kbar. The earlier albite-jadeite and jadeite rocks formed at 650-700°C and P>10 kbar. (Authors' abstract translated and shortened by A.K.)

TORRANCE, K.E., CHAN, V.W.C. and TURCOTTE, D.L., 1980, A model of hydrothermal convection in an aquifer: J. Geophys. Res., v. 85, no. B5, p. 2554-2558.

TOURET, Jacques, 1980, Regional metamorphism: the fluid regime and petrogenetic grids: Mém. h. sér. Soc. géol. de France, 1980, no. 10, p. 63-70 (in French with English abstract).

As a consequence of a model on the fluid redistribution in the continental crust and upper mantle, a limited number of petrogenetic grids are proposed. They characterize two types of metamorphism, water-excess metamorphism, from the surface of the domain of regional anatexis and water-deficient metamorphism (excess CO_2), typical for the lower crust and upper mantle. (Author's abstract)

TOURET, J., CLOCCHIATTI, R., MASSARE, D. and CHIKHAUI, L., 1980, Inclusions of glass and fluid in the minerals of peridotites (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 142 (in French).

TREMAINE, P.R. and LeBLANC, J.C., 1980, The solubility of magnetite and the hydrolysis and oxidation of Fe^{2+} in water to 300°C: J. Solution Chem., v. 9, no. 6, p. 415-442.

TRUFANOV, V.N., GRANOVSKIY, A.G., KURSHEV, S.A., MAYSKIY, Yu.G. and PROKOPOV, N.S., 1978, Ore-silicate melt-solutions in processes of formation of sulfide deposits (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 111-112 (in Russian). Authors at Rostov Univ., Rostov-on-Don, USSR.

The authors presume that many sulfide deposits with minerals bearing highly concentrated solutions in inclusions (60-80% of solids) might form from ore-silicate melt-solutions. (A.K.)

TSAMBEL, B., ZHUKOV, F. and SAVCHENKO, D., 1980, Genetic and isotope-geochemical pecularities of pyrite-ore genesis in the Male Karpaty Mts. (Western Slovakia): Mineralia Slov., v. 12, no. 6, p. 533-540 (in Russian).

Results of isotopic and thermobarometric investigations realized on samples of pyritic ore from the Male Karpaty area proved the enrichment of light sulphur isotope S^{32} in investigated samples. Due to metamorphic overprint, the amount of the heavy sulphur isotope increases by 3 p.c. whereas the isotopic composition of the organogenous carbon remains unchanged. Thermobarometric data point to temperature range of 200-350°C whereas temperatures about 100-200°C were stated for less recrystalized ore and for inclusions in secondary carbonates. Results prove the syngenetic nature of mineralization with the surrounding rock sequence. (Authors' abstract)

TSUSUE, Akio, 1980, On behavior of fluorine and chlorine in granitic magmas: J. Japan. Assoc. Min. Petrol., Econ. Geol., Special Vol. 2, p. 335-342 (in Japanese with English abstract).

The geochemistry of fluorine and chlorine is reviewed in terms of the abundance in granitic rocks and their rock-forming minerals and of the behavior of F and Cl in granitic magmas.

The F and Cl contents of rock-forming minerals in the granitic rocks from the Ryoke, Sanyo-Naegi, and Sanin-Shirakawa belts of Southwest Japan were analyzed by an electron microprobe analyzer (Figs. 1 and 2). The granitic rocks range from granite to quartz diorite, but include some diorites.

The abundance of Cl in apatite correlates negatively with rock D.I.

(differentiation indices), while the abundance of F in apatite correlates positively with rock D.I. The abundance of Cl in apatite in the granitic rocks of the Sanin-Shirakawa belt is generally higher than that of Cl in apatite of the Ryoke and Sanyo-Naegi belts, while the abundance of F in apatite in the granitic rocks of the Sanin-Shirakawa belt is generally lower than that of F in apatite of the Ryoke and Sanyo-Naegi belts, although it is apparent that individual districts exhibit characteristic fluorine-chlorine abundances.

Apatites in the granitic rocks genetically related to tungsten mineralization and granite pegmatite formation are F-OH apatites. (Author's abstract)

TU, Guangzhi and YIN, Hanhui, 1980, On the genesis of some stratabound carbonate-hosted Pb-Zn mineralization, as examplified by the Chinese deposits (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 1023.

Stratabound carbonate-hosted Pb-Zn deposits without obvious genetic connection with granitic magmatism are well developed in many parts of China. Based on field observation, studies on ore microscopy, lead and sulfur isotopes, fluid inclusions and trace elements geochemistry, these carbonate-hosted Pb-Zn deposits can be genetically classified into the following three groups:

1. Slightly deformed sedimentary Pb-Zn deposits;
2. Strongly deformed sedimentary Pb-Zn deposits;
3. Epigenetic Pb-Zn deposits.

(Authors' abstract)

TU, K.-C., WANG, Z.-G. and YU, X.-Y., 1980, Genesis of granitic rocks in South China related mineralization: Mining Geology (Japan) Spec. Issue, no. 8, p. 189-196.

Granites of South China cover an area of 190,000 Km^2, approximately 1/5 of the total area. There can be distinguished several important periods of granite formation: Sipu period, Xuefeng period, Early and Late Caledonian, Hercynian, Indosinian, Early and Late Yenshanian, on geological and geochronogical basis.

Granites of South China are of multiple origin. Only very few granitic bodies were formed by the process proposed by Bowen some 50 years ago, i.e., by the process of crystallization differentiation from a basaltic magma. Besides, the final product of differentiation is usually granodiorite or tonalite, hardly reaching the stage of biotite granite, the predominant granite of southern China.

Granites formed by either anatexis or replacement extensively occur in South China, constituting more than 95% of total granites. In earlier geological history (since Precambrian till Early Caledonian), predominated granites were formed by granitization, but in later periods anatectic granites played much more important role. It is believed that the Yenshanian granites, which make up about 60% of total granites, are mostly anatectic.

Granites of various origin are discussed from the studies of order-disorder phenomenon in feldspars, interrelationship of the main rock-forming minerals, gas-liquid inclusions, trace elements distribution and rare-earth geochemistry.

The important W, Sn, Nb, Ta ore deposits in South China are genetically related with granites almost exclusively of Yenshanian period. The older granites are generally barren in mineralization of economic significance except for REE. This observation may be explained tentatively by the long history of evolution of granites in South China. As time elapses, granites turn to be more salic, enriched in alkalies, volatiles and various metals, but more impoverished in V, Cr, Co, Ba and Sr. Multiple remelting of older granites and multiple differentiation of the resulting magma are the causes of accumulation of ore metals towards the more final stages of regional magmatic activities. This may hold true not only for South China, but also for other granite-related W-Sn-Nb-Ta mineralization districts in the world. (Authors' abstract)

TVALCHRELIDZE, A.G. and NAROZAULI, I.G., 1978a, Conditions of formation of stratiform sulfide deposits of Bolshoi (Great) Caucasus (thermobarogeochemical and experimental data) (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 99-101 (in Russian). Authors at Caucasian Inst. of Mineral Raw Materials, Tbilise.

In Cu-Zn-sulfide ores of Peredovoi chain the pre-ore quartz-chlorite and quartz-sericite-chlorite metasomatites formed at 230-250°C and massive ores at 150-180°C. Cu-pyrrhotite ores in aspidic shales (Kyzyl-Dere, Kats-Dag, Adange) are polygenic, but T was <150°C. (A.K.)

TVALCHRELIDZE, A.G. and NAROZAULI, I.G., 1978b, The temperature formation conditions of the Urup chalcopyrite deposit: Soobshcheniya Akademiy Nauk Gruzinskoy SSR, v. 91, no. 2, p. 377-380 (in Russian).

Indexed under Fluid Inclusions. (E.R.)

UCHAMEYSHVILI, N.Ye., MALININ, S.D. and KHITAROV, N.I., 1980, Geochemical data for processes of formation of barite deposits : "Nauka" Pub. House, Moscow, 124 pp (in Russian). Authors at the Inst. Geochem. Anal. Chem. of Acad. Sci. of the USSR, Moscow, USSR.

General problems of the barium geochemistry and genesis of barite deposits are considered in the book; analysis of the data obtained from fluid inclusion studies is presented and chemical properties of barite-forming solutions are discussed. Experimental studies on barite solubility are used as the physico-chemical basis of barite-formation process. All the methods used provide a basis for understanding the geochemical aspects of barite origin and its association with other minerals. (Authors' abstract translated by A.K.) (The studied deposits: Great Caucasus - deposits Chordi, Telnari, Khordisara, Zubi, Gvedi, Okurestiu, Tkhmori, Vanis-Tsivtskali, Belorechinskoe, Dzhalankol, Indysh, Kizilchuk, Zgid, Kionskaya vein, Levoberezhnoe; Little Caucasus - deposits Bashkishlag, Chovdar; Middle Asia - deposits Takob, Zambarak, Barite Hill, Arpaklen, Begler, Yely-Tsu and Bestyube. A.K.)

UNNI, C.K. and SCHILLING, J.-G., 1980, Chlorine and bromine in Hawaiian lavas (abst.): EOS, Trans. Am. Geophy. Union, v. 61, p. 407.

UVAD'YEV, M.D. and PALEY, L.Z., 1978, Conditions of formation of quartz veins in shallow gold deposits (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivistok, Acad. Sci. USSR, p. 211-212 (in Russian). Authors at OME SAIGIMS, Tashkent, USSR.

The veins bear quartz of five essential generations, here characterized by Td. The earliest ore-forming fluids (700-800°C) contained dissolved in it mostly silicates. (A.K.)

VAKHRUSHEV, V.A., MAKAGON, V.M. and SINITSKAYA, Y.G., 1977, Genesis of amethyst in magnetite deposits of the Angara-Kata iron-ore field, Siberian platform: Dokl. Akad. Nauk SSSR, v. 239, no. 3, p. 680-683 (in Russian; translated in Dokl. Acad. Sci. USSR, Earth. Sci. Sects., v. 239, p. 147-150, 1980).

Abstracted in Fluid Inclusion Research--Proc. of COFFI, v. 11, p. 219 (1978). (E.R.)

VAKIN, E.A. and KUTYEV, F.S., 1980, Depth of origin of the gas content in thermal waters: Bull. Volcanol., v. 43, p. 85-94. Authors at Instit. of Volcano., Acad. Sci. of USSR, Piip Avenue 9, Petropavlovsk, Kamchatsky, USSR.

The gas composition of recent thermal waters is in perfect conformity with their geologic-tectonic positions.

The composition of gas-liquid (sic.; actually glass-gas) inclusions in the basic-hyperbasic xenoliths of basaltoid lavas depends on the depth from which xenoliths are supplied. (The depth is determined by using the methods of geological thermobarometers.)

By comparing available data we came to the conclusion that the gas compositions of thermal waters reflect the depth of generation of deep fluid which heats them and depends on the penetration depth of the fluid-conducting fissure zones. (Authors' abstract)

VALLEY, J.W. and ESSENE, E.J., 1980, Calc-silicate reactions in Adirondack marbles - role of fluids and solid solutions - summary: Geol. Soc. Am. Bull., v. 91, no. 2, p. 114-117.

VALYAYEV, B.M., PROKHOROV, V.S., GRINCHENKO, Yu.I., LYUSTIKH, A.Ye. and TITKOV, G.A., 1980, Isotopic distribution in carbon of mud-volcano gases of the southern USSR as related to their origin: Dokl. Akad. Nauk SSSR, v. 254, no. 6, p. 1459-1461 (in Russian; translated in Doklady Acad. Sci. USSr, Earth Sci. Sect., v. 254, 1980, p. 232-234 (1982). Authors at Geol. Instit., USSR Acad. Sci., Moscow, USSR.

$\delta^{13}C$ for CH_4 from six mud volcano provinces ranges from -3.9 to -6.73 (most ~-4.5); CO_2 from -0.98 to +1.13 (most ~0). Authors suggest that the data show "that the plutonic, possibly metamorphic origin of their carbon dioxide need no longer be disputed." (E.R.)

VANKO, D.A. and BISHOP, F.C., 1980, Experimental determination of NaCl-rich scapolite stability, (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 540.

NaCl-rich scapolite is found replacing plagioclase in gabbro from the Humboldt lopolith in western Nevada. Therefore, the reaction plag + NaCl = scapolite has been investigated in standard cold-seal pressure vessels at pressures ranging from 0.8 to 2.9 kb and temperatures of 600° to 800°C. Starting material comprised the nonmagnetic fraction of a natural scapolitized gabbro (scapolite Ma_{80}, plagioclase An_{24}, and minor analcime, calcite and sphene) together with halite and H_2O yielding fluids having molar X(NaCl) (defined as $NaCl/(NaCl+H_2O)$ between 0.4 and 0.95. Duration of the experiments varied from 3 weeks to 3 months, depending on run temperature. Results were determined by comparing X-ray scans of the run products with those of the starting material, and by optical inspection. At 600° and 650°C lower salinity runs with X(NaCl) ⩽0.63 showed weak plagioclase growth, whereas higher salinity runs with X(NaCl) ⩾0.67 showed no reaction after 3 months. In experiments at 700°C and 1.7 kb scapolite was formed at the expense of plagioclase with X(NaCl) >0.64, whereas the reverse reaction occurred below that fluid composition. At 750°C and 1.7 kb, the corresponding composition marking reaction reversal is about X(NaCl) = 0.68. Results of isothermal series at varying pressures suggest that the X(NaCl) necessary to stablize scapolite decreases with increasing pressure. In the T and P range investigated, sodic scapolite appears to be stable only in the presence of high-salinity hydrothermal fluids. Such fluids can exist in nature, as analyzed fluid inclusions from skarns having equivalent X(NaCl) >0.5 have been reported. (Authors' abstract)

VARLAMOV, A.A., KOZLOV, S.S. and MATVEEVA, L.I., 1980, On the nature of brine manifestations in the mines of the Starobin potash deposits: Dokl. Akad. Nauk Belorusia SSR, v. 24, v. 11, p. 1022-1025 (in Russian).

Presents 10 analyses for HCO_3, SO_4, Cl, Br, Ca, Mg, Na, and K.(E.R.)

VASILENKO, V.N. and TITARENKO, A.V., 1978, Comparative characteristics of conditions of formation of sulfide ores of Northern Caucasus and Southern Urals (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Valdivostok, Acad. Sci. USSR, p. 103-104 (in Russian). Authors at Rostov Univ., Rostov-on-Don, USSR.

The abstract contains a comparison of Td of mostly sulfide minerals from several ore deposits. (A.K.)

VASIL'EV, V.I., 1979, Second find of twalchrelidzeite $Hg_{12}(Sb, As)_8S_{15}$ in ores of mercury deposits: Geologiya i Geofizika, v. 20, no. 9, p. 159-162 (in Russian; translated in Soviet Geol. and Geophys., v. 20, p. 130-132, 1979).

The mineral occurs in association with quartz veins and pyrrhotite, cubanite, chalcopyrite, and cinnabar. Alteration includes chloritization, pyritization, and fericitization. Inclusions in quartz had Th = 110-135°C. (E.R.)

VASILKOVA, N.K., KULIKOV, I.V., LYAPUNOV, S.M. and MINEEV, D.A., 1980, Fluorite as an indicator of origin conditions and zonality of Tyrnyauz scheelite-fluorite ores: Mineralog. Zhurn., v. 2, no. 6, p. 45-57 (in Russian, English abstract).

Geological and mineralogical studies of scheelite-fluorite ores from the Tyrnyauz deposit show their late origin under specific conditions at the phase of an intense increase of tectonic-magmatic activity. The intrusion of liaprites and formation of explosive breccias occurred at that time.

The data of crystallomorphological, thermobarogeochemistry and spectroscopical investigations and those from neutron activation analysis confirmed by experiments, made it possible to consider the fluorite origin to have taken place from a highly concentrated heterogeneous solution under high-temperature conditions (400-700°C). The general typomorphic genetic peculiarity of Tyrnyauz fluorite is an excessively low content of REE (less than $n \cdot 10^{-4}\%$) and of other admixtures. A vertical zonality and differences in fluorite typomorphic peculiarities in a 1 km section of the deposit were discovered. This may be used for determining the erosional level of newly found ore bodies. Zones of fugitive constituent break-through (breccias, fault crossings) are particularly perspective with respect to the discovery of tungsten, basmuth and polymetallic ores. Some differences are characteristic of the fluorites from these places: increased content of REE, rather increased relative concentration of hole F-centres, alteration of physical properties. These data can be used in prospecting for new ore bodies in the Tyrnyauz deposit region. (Authors abstract)

VDOVYKIN, G.P., MEL'NIKOV, F.P., MITIN, S.N., STAROBINETS, I.S. and STATIVKO, G.S., 1980, Thermobarometry of Lower Cambrian salts of the Kuyumbinskaya and Peledui areas and the Vendian salt of the Verkhnevilyuchanskaya area (eastern Siberia) according to gas-liquid inclusions: Dokl. Akad. Nauk SSSR, v. 253, no. 5, p. 1207-1210 (in Russian).

Trap rocks intruded into the Lower Cambrian halite-bearing formations reacted with the sedimentry rocks and caused contact metamorphism. The gases separated by dissolving halite from the Kuyumbinskaya region have a hydrocarbon-nitrogeneous composition; whereas the gases separated from other rocks in this region primarily have nitrogeneous compositions. Halite collected 131 and 138 m from the base of a trap sill has primary single-phase (liquid) fluid inclusions; whereas halite sampled 46 and 64 m from the top of the sill contained no primary fluid inclusions. The inclusions in the halite 138 m from the sill base had maximum Th 316-320° and pressure $\leq$160 atm; for the samples taken 46 and 64 m from the sill roof the corresponding values were 348-350° and 180-200 atm. Heat transfer during trap intrusion and crystallization caused recrystallization of the halite and the difference in the paleothermodn. conditions of fluid inclusion preservation. (CA, v. 94:18586w)

VDOVYKIN, G.P. and SHOROKHOV, N.R., 1980, Gases of the Lower Cambrian salt of the Mirnyi, Kuyumbin, Ust'-Kama areas and salt of Vend age of the Upper Vilyukhan area (East Siberia): Geologiya i Geofizika, no. 6, p. 135-138 (in Russian, English abstract). Authors at VNIIGAZ, Moscow, USSR.

The salt specimens from boreholes (depth 787 to 2055 m), taken from beds overlying oil-bearing beds, were analyzed for G content released by dissolving of salt. Analysis was made by G chromatography method, the results are as follows (in vol.%): N_2 50-97, CO_2 2.3-11, H_2 0.04-48, He traces to 0.08, CH_4 0.05-4.0, C_2H_6 0.01-0.45, C_3H_8 0.005-0.13, iso-C_4H_{10} traces to 0.05, n-C_4H_{10} traces to 0.15, iso-C_5H_{12} traces to 0.06, n-C_5H_{12} traces to 0.46, iso-C_6H_{14} 0.03-0.07, n-C_6H_{14} 0.015-0.1. The following sources of G are listed: 1) ancient atmosphere (the main source), 2) water of concentrated brines, 3) syngenetic biogenic processes, 4) migration from hydrocarbon reservoir, 5) radiolysis of H_2O under action of ^{40}K, 6) crystalline basement (for He mostly). (Abstract by A.K.)

VETO AKOS, Eva, 1980, Fluid inclusion test for reconstructing the paleotemperature of the Mesozoic near Pecs, southern Hungary: Magy. All. Foldt. Intez. Evi Jel., v. 1980, p. 309-318 (in Hungarian).

VIKRE, P.G., 1980, Fluid inclusions in silver-antimony-arsenic minerals from precious metal vein deposits: Econ. Geol., v. 75, p. 338-339.

Pyrargyrite and host quartz from Tonopah, Nevada, have fluid inclusions. Th of inclusions in quartz was 247.5-275.5. Pyrargyrite inclusion gave laboratory problems but was in same range. A proustite crystal had a similar-appearing % bubble and probably would have similar Th. Hence these minerals are not supergene as had been thought. (E.R.)

VOLLBRECHT, A., 1980, Tectogenetic development of the Münchberger Gneismasse (investigations on quartz grain-structure and microthermometry on fluid inclusions: Diss. Göttingen, 1980, 187 p. (in German).

Fluid inclusion measurements in quartz. (E. Horn)

VORTSEPNEV, V.V., 1978, Origin of disseminated ore of the Talnakh deposit: Dokl. Akad. Nauk SSSR, v. 239, p. 454-456 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 239, p. 120-122, 1980).

Abstract in <u>Fluid Inclusion Research--Proceedings of COFFI</u>, v. 11, p. 223 (1978). (E.R.)

VOYTOV, G.I., 1977, Isotope characteristics of the Khibiny spontaneous gases: Doklady Akad. Nauk SSSR, v. 236, p. 975-978 (in Russian).

Eight analyses are given for H_2, He, N_2, CH_4, (hydrocarbons), and CO_2. Hydrocarbons are analyzed for CH_4, C_2H_6, C_2H_4, C_3H_8, C_3H_6, C_4H_8, and CxHy, where x>4. The ratios of Xe - 129, 130, 131, 134 and 136 are given for three samples (E.R.)

A partial translation , courtesy M. Fleischer, is given below (from p. 977):

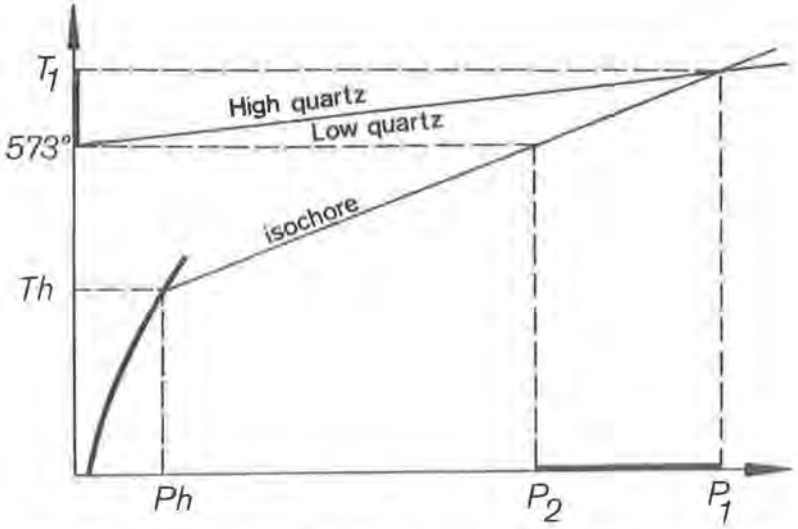
Thus, the observed stream of free gases in Khibina, consisting of a complex mixture of hydrocarbons, hydrogen, N, He, and CO_2 is extraordinarily stable in time both in chemical composition of the escaping gas and also in the intensity of their appearance.

For the gases of the free stream the following features are characteristic: (a) high content of the heavy isotope of C (13C) in the hydrocarbons at decrease of its content with increasing molecular weight of the individual hydrocarbons; (b) comparatively isotopically-light H in the hydrocarbon gases at maintenance of the same tendency in the content of deuterium in the individual hydrocarbons, also the tendency in the distribution of ^{13}C, and apparently the high content of deuterium in the composition of molecular H; (c) high contents of ^{3}He and $^{40}Ar_{rad}$; (d) high contents of the heavy isotope of xenon. The ratio of individual gases in the stream is sharply disrupted by earthquake movements.

VOZNYAK, D.K. and SHCHIRITSA, A.S., 1978, Reticulate inclusions in quartz and their origin, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 148-149 (in Russian). Authors at Inst. of Geochem. and Physics of Minerals of Acad. Sci. of Ukr. SSR, Kiev, Ukrainian SSR.

Inclusions healing reticulate fractures in quartz have similar Th, Tm, pH of inclusion fluid (individual inclusion measurements) in all studied crystals, so all reticulate inclusions were formed from the same fluid. Formation of reticulate fractures is connected with high→low quartz inversion on cooling or low→high quartz inversion due to pressure decrease. The former is more probable, and thus conditions of trapping of reticulate inclusions may be determined by the intersection of isochore of the inclusion and curve of equilibrium for high-low quartz. If the latter is true, the trapping conditions are: T higher than T inversion under 1 atm (573°C) but lower than T_1 (see figure), P between P_1 and P_2. The procedure was applied for reticulate inclusions in quartz from "zanorysh" pegmatites from Volhynia, Karakhstan and Mongolia. (Authors' abstract translated and shortened by A.K.)

Figure. Relation between high-low quartz equilibrium curve and possible PT parameters of trapping of reticulate inclusions.



WALENCZAK, Zygmunt, 1980, Anomalous temperatures of decrepitation of the bituminous substance bearing inclusions in minerals: Archiwum Mineralogiczne, v. 36, no. 2, p. 65-82 (in Polish with 3-page English summary).

WALKER, V.A., 1980, Breccia pipes at Copper Creek, Arizona; evidence for multiple stages of hydrothermal activity (Abst.): Geol. Soc. Amer. Abstracts and Programs, v. 12, p. 307.

The Copper Creek mining district, Arizona, is noted for its abundance of breccia pipes. Cu-Mo mineralization occurs in several of these pipes, and a Pb-Ag vein lies along the eastern edge of the district. The results of a fluid inclusion study on three variably mineralized breccia pipes and the Pb-Ag vein suggest that some of the breccia pipes and the vein were subjected to several pulses of hydrothermal activity, with sulphide deposition resulting from low salinity, moderate temperature fluids. Up to three chemically and temporally distinct fluids were recognized: an early, hypersaline fluid showing evidence for boiling at temperatures in excess of 800°C; a hypersaline, sulphide-bearing fluid with homogenization temperatures in the range 300-500°C from which sulphides were not deposited; and a late, low salinity, moderate temperature fluid (300-500°C) with which copper sulphide mineralization is apparently associated. While one of the pipes containing high temperature, hypersaline fluid inclusions is cemented primarily by potassium feldspar and biotite, the other pipes and the vein are filled by quartz and sericite. The single pipe showing potassium feldspar cement is one of a group of pipes of similar mineralogy which may be controlled by an early NNW tectonic fabric. An ENE-trending set of fractures superimposed upon the earlier fabric appears to be important in the localization of the pipes cemented by quartz and sericite. Consideration of the fluid inclusion results in conjunction with other geological relationships suggest that breccia pipes at Copper Creek are of two distinct generations. K-Ar age dating of sericite from several pipes in the district substantiates this, suggesting a time differential on the order of 12 million years. (Author's abstract)

WALLER, William, 1980, Tiny gas bubbles yield clues to climate. Smithsonian Research Reports, no. 29, Spring, 1980, p. 6-8.

A popular review of studies of ^{14}C in CO_2 and the chemical analysis of the gas bubbles in Antarctic ice. (E.R.)

WALSH, J.N. and HOWIE, R.A., 1980, An evaluation of the performance of an inductively coupled plasma source spectrometer for the determination of the major and trace constituents of silicate rocks and minerals: Min. Mag., v. 43, p. 967-974. Authors at Dept. Geol., King's College, Strand, Loundon WC2R 2LS.

The results of a study on the suitability of the inductively coupled plasma source spectrometer for the analysis of rocks and minerals are presented. The preparation of a stable solution of the elements to be measured is a prerequisite, and the methods of sample preparation are described. It is shown that it is possible to measure all the major elements (excluding H_2O and Fe^{2+}) with acceptable precision and accuracy, and a wide range of trace elements down to the ppm level in the rock or mineral. Excluding sample preparation time, analysis and print-out of results as percent or ppm requires 1-2 minutes for complete analysis. Data on possible interferences (spectral line overlap etc.) are presented and, using some analyses of rocks and minerals comparisons are made with other analytical methods. (Authors' abstract)

WALTHER, J.V. and HELGESON, H.C., 1980, Description and interpretation of metasomatic phase relations at high pressures and temperatures: 1. Equilibrium activities of ionic species in nonideal mixtures of CO_2 and H_2O: Am. J. Sci., v. 280, Summer 1980, p. 575-606. First author at Dept. Geol. Sci., Northwestern Univ., Evanston, IL 60201.

Correlation of ionic activity diagrams incorporating explicit provision for solvation of aqueous species with temperature-XCO_2 diagrams depicting equilibrium among minerals and fluids in the system CaO-MgO-SiO_2-HCl-CO_2-H_2O facilitates thermodynamic analysis of multivariant high pressure/temperature phase relations in siliceous dolomites. Comparative calculations indicate that solvation and nonideal mixing in the system CO_2-H_2O may have a dramatic effect on the equilibrium activities and total concentrations of ionic species in fluids coexisting with calc-silicate mineral assemblages. Under certain circumstances the concentration of calcium in these fluids probably exceeds by several orders of magnitude the concentation of magnesium, which may then be essentially conserved among solids during metasomatic reaction of the fluid phase with its mineralogic environment. Application of activity diagrams to metamorphic systems affords a comprehensive basis for correlating field and laboratory observations with fluid inclusion studies and the solution chemistry of metamorphic fluids at high pressures and temperatures. (Authors' abstract)

WANG, Honing, TSU, T.C. and GIANG, H.S., 1980, Characteristics of inclusions in minerals of granites of various origin in S. China: Scientia Sinica, 1980, no. 1, p. 51-59 (in Chinese).

WATSON, E.B., 1979, Diffusion of cesium ions in H_2O-saturated granitic melt: Science, v. 205, p. 1259-1260. Author at Dept. Geol., Rensselaer Polytech. Inst., Troy, NY 12181.

The intrinsic self-diffusion coefficient (D) for cesium-134 in a granitic melt containing 6.1 to 6.3 percent (by weight) of dissolved H_2O is three to four orders of magnitude higher than the values reported for chemically similar but dry granitic glass. For the temperature interval 700° to 800°C and a confining pressure of 2 kilobars, cesium diffusivity is given by $D = 7.19 \times 10^{-5} \exp(-19.52 \times 10^{3}/RT)$, where R is the gas constant and T is the absolute temperature; the activation energy of about 20 kilocalories per mole is less than half the value for H_2O-free glass. The observed increase in ionic mobility that accompanies solution of H_2O implies sharply reduced equilibration times for chemical processes that occur in H_2O-bearing silicate melts. (Author's abstract)

WEBSTER, E.A. and HOLLOWAY, J.R., 1980, The partitioning of REE's, Sc, Rb and Cs between a silicic melt and a Cl fluid (Abst.): EOS, v. 61, p. 1152.

The partitioning of Sm, Eu, Tb, Yb, Lu, Sc, Rb, and Cs between a Si rich melt (79 wt % SiO_2) and an aqueous Cl fluid (.8 molal Cl) has been experimentally determined. Runs were conducted for 10 days at 4 kb and 1000°C in an internally heated argon media pressure vessel. Pt capsules were used. The starting materials were a synthetic Fe-free analogue of the Bishop Tuff and a KCl-$NaCl$-H_2O solution. A vapor to melt ratio of ~4:1 was used (200 mg fluid to 50 mg glass). Reversals were obtained by running duplicate capsules with the trace elements initially in either the fluid or in the glass. Relative to the original glass mass, approximate concentrations of 50 ppm Rb were used. Trace element concentrations in the starting glass, final glass and vapor solute were determined by INAA.

This Cl fluid does not cause any fractionation between the REE's but does fractionate alkali elements from the REE's. Distribution values (D_i) in mass units are shown below. Mass partition coefficients as concentration in melt/concentration in fluid (including H_2O) can be obtained by multiplying the D_i values by 9.07 ± 1.15 for all elements but Sc and by 9.46 ± .46 for Sc. The uncertainty is chiefly due to incomplete solute recovery.

element	$D_i = \frac{\text{concentration in glass}}{\text{concentration in solute}}$
Sc	9.34 ± .45
Rb	.285 ± .042
Cs	.248 ± .030
Sm	9.47 ± .51
Eu	7.60 ± .60
Tb	10.09 ± .70
Yb	10.74 ± .58
Lu	9.24 ± 1.75

WEISBROD, Alain, 1980, Interactions between magmas, rocks and aqueous solutions at the late- to post-magmatic stages in granitoids and associated ore deposits (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 103.

Petrological and fluid inclusion studies have been carried out on "specialized" granitic facies and early hydrothermal veins from various porphyry copper systems and Variscan Sn-W districts. The results are compared with the experimental data obtained on parts of the system H_2O-Cl-F-B-Li granite.

In porphyries, there are many evidences of the coexistence of magmatic and hydrothermal events. Generation of early, probably co-magmatic, very concentrated brines is tentatively explained by interaction of a regular water - undersaturated granodioritic melt with moderately saline aqueous solutions.

The Sn-W specialized granites, aplites, pegmatites, generally are strongly enriched with Li, F, B, H_2O, and (but not always) Al. Although the peraluminous character may be primary, those chemical features have been often acquired during the late stages of the evolution: residual or immiscible "highly differenciated" melt, or late intrusions not directly cogenetic with the main magma. But very often, the pecularities of those rocks can also be explained by contamination of regular granites or granodiorites during the late magmatic to post magmatic stages (direct contamination of the magma, generation of relatively small amounts of new magmas from a more or less entirely crystallized rock, regular subsolidus hydrothermal processes), as a result of interactions with circulating aqueous solutions equilibrated with the bulk of the environment of the intrusives.

Such an hypothesis yields new insights on the origin and transport of metals, and the spacial and chronological arrangements of ores in and around the granitoidic intrusions. (Author's abstract)

WENDLANDT, R.F. and HARRISON, W.J., 1979, Rare earth partitioning between immiscible carbonate and silicate liquids and CO_2 vapor: results and implications for the formation of light rare earth-enriched rocks: Contrib. Mineral. Petrol., v. 69, p. 409-419. First author at U.S. Geol. Survey, 959 Natl. Ctr., Reston, VA 22092.

Melting relations at 5 and 20 kbar on the composition join sanidine-potassium carbonate are dominated by a two-liquid region that covers over 60% of the join at 1,300°C. At this temperature, the silicate melt contains approximately 19 wt % carbonate component at 5 kbar and 32 wt % carbonate component at 20 kbar. The conjugate carbonate melt contains less than 5 wt % silicate component, and it varies less as a function of temperature than does the silicate melt.

Partition coefficients for Ce, Sm, and Tm between the immiscible carbonate and silicate melts at 1,200° and 1,300°C at 5 and 20 kbar are in favor of the carbonate melt by a factor of 2-3 for light REE and 5-8 for heavy REE. The effect of pressure on partitioning cannot be evaluated independently because of complementary changes in melt compositions.

Minimum REE partition coefficients for CO_2 vapor/carbonate melt and CO_2 vapor/silicate melt can be calculated from the carbonate melt/silicate melt partition coefficients, the known proportions of melt, and maximum estimates of the proportion of CO_2 vapor. The vapor phase is enriched in light REE relative to both melts at 20 kbar and enriched in all REE, especially the light elements, at 5 kbar. The enrichment of REE in CO_2 vapor relative to both melts is 3-4 orders of magnitude in excess of that in water vapor (Mysen, 1979) at 5 kbar and is approximately the same as that in water vapor at 20 kbar.

Mantle metasomatism by a CO_2-rich vapor enriched in light REE, occurring as a precursor to magma genesis, may explain the enhanced REE contents and light REE enrichment of carbonatites, alkali-rich silicate melts, and kimberlites. Light REE enrichment in fenites and the granular suite of nodules from kimberlites attests to the mobility of REE in CO_2-rich fluids under both mantle and crustal conditions. (Authors' abstract)

WENGELER, H., KNOBEL, R., KATHREIN, H., DEMORTIER, G., HEINEN, H.J. and FREUND, F., 1980, Atomic carbon in solid solution in oxides: A $^{12}C(d,p)$ ^{13}C study;Direct evidence for atomic carbon: A laser microprobe study; Molecular hydrogen in oxides: An infrared study (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 84.

WERRE, R.W., Jr., BODNAR, R.J. BETHKE, P.M. and BARTON, P.B., Jr., 1980, [Novel heating/freezing fluid inclusions stage] (abst.): U.S. Geol. Survey Prof. Paper 1175, p. 190.

See abstract by same authors, Fluid Inclusion Research--Proceedings of COFFI, v. 12, p. 198. (E.R.)

WHITE, D.R., Jr., ROBINSON, R.A. and BATES, R.G., 1980, Activity coefficient of hydrochloric acid in HCl/MgCl$_2$ mixtures and HCl/NaCl/MgCl$_2$ mixtures from 5 to 45°C: J. Solution Chem., v. 9, no. 7, p. 457-465.

WILKINS, R.W.T. and BIRD, J.R., 1980a, Characterization of healed fracture surfaces in fluorite by etching and proton irradiation : Lithos, v. 13, p. 11-18. First author at CSIRO Div. Mineral., P.O. Box 136, NSW, Australia 2113.

Healed fracture surfaces in fluorite, which are not visible by conventional optical microscopy, can be revealed by etching or proton irradiation. Due to the semi-brittle nature of the mineral under conditions appropriate to the late stages of development of many ore deposits, healed fractures are often associated with some evidence of plastic deformation. Simple healed fractures consist of a single sub-boundary of very low angle, typically <0.02 degree, often decorated by <50 μm diameter fluid inclusions. Complex healed fractures consist of a zone with at least two sub-boundaries enclosing a thin layer of fluorite, which is almost in the same orientation as the surrounding crystal. This type of healed fracture is accompanied by small numbers of large fluid inclusions, typically >100 μm diameter. Simple healed fractures form by autoepitaxial growth under conditions of high supersaturation in tight cracks. Complex healed fractures originate from more open cracks, the surfaces being initially etched before being healed by growth of a layer of fluorite under conditions of low supersaturation, probably by the screw dislocation mechanism. (Authors' abstract)

WILKINS, Ronald W.T. and BIRD, J.R., 1980b, The use of proton irradiation to reveal growth and deformation features in fluorite : Am. Mineral., v. 65, p. 374-380. First author at CSIRO Div. of Mineral., North Ryde, NSW, Australia.

It has long been known that natural fluorite, exposed to X-ray, γ-ray, or electron radiation develops diffuse purple-pink color banding. However, irradiation from 2.5 MeV protons or α-particles with doses of from 5 to 50 μC/mm^2 develops color banding in extraordinary detail. This color banding is crossed by colored lines which are shown to be decorated growth dislocations. Deformation-induced dislocations decorated in the same manner are difficult to resolve by optical microscopy; nevertheless the effects of both brittle and plastic deformation are revealed by proton irradiation. Healed fracture surfaces, subgrain boundries, kink- and deformation-band boundaries are all colored by the irradiation treatment. Although proton irradiation of fluorite provides the same type of information as that obtainable by X-ray topography, the technique is direct, rapid, has high resolution, and is applicable to samples with any degree of deformation. (Authors' abstract)

WILLMS, J., 1980, Fluorite occurrences in Telemark and in the region around Oslo (southern Norway): Products of Precambrian magmatism or late Paleozoic plate tectonics?): Diss. Hamburg, 1980, 86 p. (in German).

Fluid inclusion measurements in fluorite. (E. Horn)

WILSON, J.W., KESLER, S.E., CLOKE, P.L. and KELLY, W.C., 1980, Fluid inclusion geochemistry of the Granisle and Bell porphyry copper deposits, British Columbia: Econ. Geol., v. 75, p. 45-61.

The Granisle and Bell porphyry copper deposits, in north central British Columbia, share numerous similarities but differ in that ore at Granisle is associated with potassic alteration, whereas ore at Bell is associated with an overprint of sericitic alteration. Fluid inclusions in the deposits can be classified as a vapor-rich type A and liquid-rich types B (liquid + vapor); C (liquid + vapor + halite); D (liquid + vapor + halite + sylvite); E (liquid + vapor + halite + K-Fe-Cl phase); F (liquid + vapor + halite + sylvite + K-Fe-Cl phase); and G (liquid + vapor + halite + at least one unidentified phase). Type A inclusions constitute between 25 and 90 percent of the inclusions at Granisle and a relatively constant 70 percent at Bell. Of the liquid-rich inclusions, types D and F dominate at Granisle and types C and E dominate at Bell. Type B inclusions are rare in both deposits. About 90 percent of the liquid-rich inclusions at Granisle homogenize by vapor disappearance; the dominant types D and F inclusions exhibit a bimodal distribution of homogenization temperature with maxima at 500° and 900°C. About 75 percent of the inclusions at Bell homogenize by halite disappearance after disappearance of the vapor, with the dominant type C inclusions homogenizing largely between 400° and 600°C. Types D and F inclusions in both deposits fall along the same linear compositional trend in the NaCl-KCl-H_2O system regardless of their temperature or conditions of homogenization.

Our interpretation of these observations in the context of phase equilibria in the NaCl-KCl-H_2O system and the Na/K/Ca geothermometer indicates that:

1. Potassic alteration and ore at Granisle formed at temperatures ranging from 400° to possibly 800°C from solutions with salinities of up to 70 percent and K/Na atomic ratios of over 0.2. These solutions were probably derived directly from a magma and changed composition by crystallization of halite but not by cooling or mixing with meteoric water.

2. Sericitic alteration and ore at Bell formed at temperatures of 400° to 600°C from solutions with K/Na atomic ratios of 0.2 or less and salinities similar to those at Granisle. These solutions probably resulted from equilibration of meteoric water with the host intrusions at about 500°C and enhancement of salinity by boiling.

3. Most crystallization at Granisle took place during periods of high pressure whereas that at Bell occurred during periods of lowered pressure.

Comparison of our results with fluid inclusion data on other porphyry copper deposits suggests that deposits containing undisturbed potassic zones are similar to Granisle and deposits with sericitic and phyllic overprints are similar to Bell. (Authors' abstract)

WOERMANN. Eduard and ROSENHAUER, Matthias. 1980, Fluids in the Earth's mantle (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 1, p. 105.

Fluid inclusions in ultramatic nodules from kimberlites prove that a fluid phase, consisting of CO_2 with subordinate H_2O is present in the source region of these rocks. Graphite and diamond indicate reducing conditions. Primary carbonates have not been found in peridotitic nodules.

Laboratory experiments show that solidus temperatures in model mantle systems decrease by solution of H_2O and at pressures above 20 kb by CO_2 in the melt. In the subsolidus range carbonates are stable at pressures above 22 kb. Low oxygen fugacities reduce the activities of H_2O and of CO_2 and tend to increase the solidus temperatures in model mantle systems. The CCO-plane in the P-T-fO_2 volume is a critical limit for stability of graphite or diamond. Subsolidus carbonation reactions are displaced towards lower temperatures/higher pressures of fO_2 below CCO.

Various models for the control of oxygen fugacity in the mantle have been proposed. Sato assumes that in view of the low oxidative capacity of iron and the low Fe^{3+}/Fe^{2+} ratio the CCO-buffer is dominating. Eggler favors a carbon-carbonate buffer estatite + magnesite + olivine + graphite. Rosenhauer et al. proposed that the ferric-ferrous ratio of the silicates is a dominating factor. (Authors' abstract)

WOODRUFF, M.S., 1980, Strontium isotope compositions of Mississippi Valley-type deposits enclosed in Cambrian, Ordovician and Mississippian host carbonates: M.S. thesis, Miami Univ., Oxford, Ohio, USA, 69 pp.

Indexed under Fluid Inclusions. (E.R.)

WOTRUBA, N.J., 1978, Fluid inclusion geothermometry of the ores of the Metaline mining district, Washington: M.S. thesis, Washington State Univ.

The Metaline zinc-lead district is located in Pend Oreille County, in extreme northeastern Washington. Ore deposits in the Middle Cambrian Metaline Limestone occur in the Josephine Breccia, which directly underlies the Ordovician Ledbetter Slate, and in the Yellowhead horizon, which is located in the middle dolomite unit of the Metaline Limestone. The ore minerals are sphalerite and galena, with associated dolomite, quartz, calcite, and minor barite. In both ore horizons the ore minerals are in the breccia matrix, and the breccia clasts are predominantly dolomite. Ore textures indicative of open space filling predominate over replacement textures.

Ninety-five thin, doubly polished slabs of quartz, sphalerite, dolomite, calcite, and barite were examined for fluid inclusions. All fluid inclusions are simple liquid-rich two phase inclusions having no daughter minerals. The Th are as follows: sphalerite and quartz, 135° to 240°C, averaging 180°C; dolomite, 135°C to 210°C, averaging 165°C; and calcite, 100° to 175°C, averaging 125°C. Fluid inclusions in barite contain only liquid. The pressure correction is estimated to be +17° to +19°C for all of the temperatures. The correction for fluid salinity is estimated to be +10°C(sic).

There is no difference in Th between samples from the Josephine Breccia and from the Yellowhead horizon. Neither is there any spatial Th difference between any of the localities, indicating that the ore is not directly related to the Cretaceous Kaniksu batholith, which outcrops several miles to the south of the district. However, it is possible that the Kaniksu batholith provided heat to deeply circulating ore fluids.

Since there is no apparent temperature difference between the breccia clasts and the matrix, the initial dolomitization, the brecciation, and the ore deposition probably made up one long sequence of events which occurred within one temperature range.

The fluid inclusion temperatures do not indicate a specific mode of origin for the Metaline deposits, except that they rule out syngenesis. The Th present data which, at least, place these deposits within the realm of Mississippi Valley deposits. The origin of these deposits is still controversial. (Author's abstract)

YAJIMA, Junkichi and OHTA, Eijun, 1979, Two-stage mineralization and formation process of the Toyoha deposits, Hokkaido, Japan: Mining Geol., v. 29, no. 5, p. 291-306. Authors at Geol. Survey of Japan, Hokkaido Br., Minami-1, Nishi-18, Sapporo 060.

The formation process of the Toyoha deposits is discussed from considerations on geological environment, mineral association and on the result of fluid inclusion studies. It is well known that mineralization at the Toyoha deposits is divided into two stages, the earlier and the later ones. More than 15 veins are arranged in major three directions, E-W, NW-SE and N-S. Most of the veins of E-W system are earlier ones, while those of NW-SE and N-S systems were formed by the later mineralization. Pyrite, sphalerite and galena are common and abundant minerals throughout two stages. In the earlier stage, arsenopyrite is found at the eastern lower part (Harima), whereas hematite increases towards the western upper side (Chikugo, Tajima). In the later, pyrrhotite and graphite associated with tin and tungsten minerals occur at eastern and southeastern areas (Sorachi, Izumo), while carbonates and Sb-minerals are found at western and northwestern areas (Soya, Oshima).

Temperature and salinity of fluid inclusions have a decreasing tendency from Izumo to Soya, and from Harima to Tajima. From these evidences together with the existence of heat source at southeastern deeper zone, the model of the formation of the Toyoha deposits is proposed. By this model, the consistent explanation for the occurrence of overall minerals in the mine has become possible. The model also leads to some important suggestions for exploration. (Authors' abstract)

YAKOVLEV, O.I. and KOSOLAPOV, A.I., 1980, Influence of partial pressure of oxygen on evaporation of melts of rocks: Geokhimiya, no. 2, p. 211-216 (in Russian, English abstract). First author at Inst. Geochem. and Anal. Chem., Moscow, USSR.

Pertinent to melt inclusion studies. (A.K.)

YAMAN, S. and GUILHAUMOU, N., 1980, Fluobarite deposits of the Chaillac Basin, Indre; thermo-optical analysis of aqueous inclusions in fluorspar from Rossignol, Charbonniere and Chatenet (abst.): Paleosurfaces and their metallogeny, Fr. Bur. Rech. Geol. Minieres, Mem. 104, p. 383 (in French).

Indexed under Fluid Inclusions. (E.R.)

YARDLEY, W.D., 1980, The behavior of the fluid phase during the metamorphic cycle and its bearing on rock deformation: Geol. Soc. N. Zealand Program and Abstracts, 1980 Annual Conf., p. 102. Author at Geol. Dept., Univ. Otago, Dunedin.

Continued next page.

Metamorphism of sediments drives off fluids, but we have little idea of how they make their way through the rock pile. A study of fluid inclusions from synmetamorphic quartz veins in a sequence of amphibolite facies rocks from Ireland shows that most veins have been pathways for fluids derived from the host layer. There is only minor mixing of fluids, e.g., infiltration of H_2O into marble units. In addition, a major episode of veining synchronous with the metamorphic peak and D3 deformation may represent larger scale fluid movements during folding.

Continual liberation of fluid during heating means that P-fluid = P-total and deformation mechanisms that require a pervasive fluid phase will be important. However, on cooling, P-fluid is buffered by retrograde changes; calculations for appropriate equilibria show that within 50° of T-max, effective pressures (P-total - P-fluid) of several kb will be generated, inhibiting deformation by fluid-dependent mechanisms. This change in the mechanical properties of the rocks may explain why folding after the metamorphic maximum is usually minor compared with that which occurred at the same or lower temperatures during heating. (Author's abstract)

YEH, H.-W., 1980, D/H ratios and late-stage dehydration of shales during burial : Geochim. Cosmo. Acta, 44, p. 341-352.

YEZHOV, Yu.A., 1978, Chemical inversion in the subsurface hydrosphere: Sovetskaya Geologiya, 1978, no. 12, p. 132-136 (in Russian; translated in Internat. Geol. Rev., v. 22, no. 9, p. 1057-1060, 1980). Author at Inst. Geol. & Geochem., Res. Ctr., USSR Acad. Sci.

A quite common nature of chemical inversion in subsurface hydrosphere is shown in examples of several oil- and gas-bearing regions of the USSR. In particular, when the data of sampling from deep wells of the Volgo-Urals, Mangyshlak, and Western Turkmenian regions were compared, it became obvious that the composite chemical profile of subsurface hydrosphere consists of a vertical alternation of three zones: of increasing (I-II-IIIa genetic types of subsurface waters), maximum (IIIb), and decreasing water mineralization (III'a-II'-I'). The depth of occurrence of the lower inversion branch of zonality depends on the geotectonic activity at depth. It is closer to the Earth's surface in regions of Alpine tectogenesis, whereas in regions of ancient folding it lies at great depths which have not yet been reached by most deep wells.

The formation of the inversion zone in the Earth's crust is connected with penetration from below of ascending demineralized fluids of sodium bicarbonate type (I'). The latter is due to the presence at great depths of large quantities of free carbonic acid which is involved in hydrolytic processes of decomposition of sodium-containing minerals and produces sodium-type waters. (Author's abstract)

YORK, D., HANES, J.A., KUYBIDA, P., HALL, C.M., KENYON, W.J., MASLIWEC, A., SCOTT, S.D. and SPOONER, E.T.C.,1980a, The direct dating of ore minerals (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 399.

Preliminary results are presented of the first modern attempt to date the common sulphide minerals directly. K and Ar concentrations and the Ar isotope ratios in pyrites, galenas, sphalerites, and chalcopyrites have been determined. Sample localities include: Geco, Renabie, Sudbury, Ontario; St. Jo Mine, S.E. Mo.; and Broken Hill, Australia. Very low values of K and Ar have been found. The K contents of pyrites were the highest, ranging from 5 to 65 ppm. Galenas and sphalerite were usually lower with K <1 ppm. This means that the only likely way in which such minerals may be directly dated is via the ^{40}Ar/^{39}Ar approach. Measured ^{40}Ar/^{36}Ar ratios were often low (~300-500) and there is evidence that the different mineral types from a given deposit may trap isotopically different initial Ar. Multiple sample analyses combined with isochron plots will be essential in geochronological interpretation. We have firmly established, however, that the project is experimentally feasible. Whenever it occurred in the ore samples, we have extracted micaceous material for dating, as a reference. ^{40}Ar/^{39}Ar step-heating runs on 2 biotites from Geco samples yielded excellent plateaus of approximately 2.62 b.y. age. A virtually identical result was found for a white mica from a Kidd Creek Ont. sample. These two deposits evidently cooled through about 300°C at this time and have suffered no significant heating since. (Authors' abstract)

YORK, Derek, HANES, J.A., KUYBIDA, P., HALL, C.M., KENYON, W.J., MASLIWEC, A., SCOTT, S.D. and SPOONER, E.T., 1980, The direct dating of ore minerals (abst.): Int'l. Geol. Cong., 26th, Abstracts, v. 3, p. 1036.

Preliminary results are presented of the first modern attempt to date sulphide ore minerals directly. The K and Ar concentrations and the argon isotope ratios in pyrites, galenas and sphalerites have been determined. Very low values of these elements were found. The K-contents of pyrites were the highest, ranging from 5 - 65 ppm. Galenas and spalerite were usually lower in potassium with K $\lesssim$1 ppm sometimes. This means that the only way in which such minerals can be directly dated is via the ^{40}Ar/^{39}Ar approach to K-Ar dating. Our analyses show that it may well be possible eventually to date pyrites in this way using an isochron approach. Two pyrites from Geco (Ontario) are consistent with a 2.6 b.y. age. In contrast, the galena and sphalerite have too little K ($\lesssim$300 ppb) to be dateable at the moment. Minute quantities of biotite were found in Geco ore samples from two different levels. ^{40}Ar/^{39}Ar step-heating analyses were carried out on these and both yielded beautiful plateaus in the age spectra showing that these samples cooled through approximately 300°C about 2.62 b.y. ago and have subsequently undergone no significant heating. The consistency of the pyrite data with this age may be fortuitous, but is encouraging. In order to examine the behavior of sulphides from a different environment, two pyrites and one galena from Mississippi Valley Type material were examined. From the Geco and Mississippi Valley Type results, we conclude that pyrites have geochronological potential and merit detailed further analysis. Because of their lower K-contents, galenas will be more difficult to evalute thoroughly. (Authors' abstract)

YPMA, P.J. and FUZIKAWA, Kazuo, 1980, Fluid inclusion and oxygen isotope studies of the Nabarlek and Jabiluka uranium deposits, Northern territory, Australia, in Proc. Internat. Uranium Symp. on the Pine Creek Geosyncline, 1980, Symp. held in Sydney, Australia, 4-8 June 1979, J. Ferguson and A.B. Goleby, eds.: Vienna, Internat. Atomic Energy Agency, p. 375-395. Authors at Dept. Econ. Geol., Univ. Adelaide, P.O. Box 498, Adelaide S.A., 5000, Australia.

Fluid inclusion and oxygen isotope studies of silicates and carbonates spatially associated with pitchblende and uraninite deposits of Nabarlek and Jabiluka indicate the following limitations on genetic models for these deposits:

1) Late metamorphic fluids with NaCl and high density CO_2 occur as remnants in pockets of quartz in the ore zone, but are more common in the non-retrograde amphibolite facies metamorphic sequence of the Lower Cahill Formation. Their homogenization temperatures are well above 350°C; decrepitation is very common; entrapment pressures exceed $1200 kg/cm^2$.

2) Highly specialized fluid inclusions in quartz and carbonates seem to be restricted to the immediate host rock of the deposits.

3) Heterogeneous entrapment of chlorite, sericite and pitchblende in fluid inclusions in quartz point to contemporaneity between alteration products of host rock, uranous-oxide mineralization, and fluid inclusions.

4) The fluids were heterogeneous as they feature the mixing of a very saline brine with a more dilute carbon dioxide-rich fluid, both of which occur in the same growth zones of quartz crystals coeval with the mineralization.

5) As a result of mixing, exsolution of CO_2 occurred. The brines vary in salinity with compositions of up to 20-30 wt% $CaCl_2$ plus 5-10 wt% $MgCl_2$ plus 10-20 wt% NaCl, and minor amounts of KCl, and $FeCl_2$. The brines are rarely over-saturated at 25°C. Homogenization temperatures vary between 160° and 110°C, featuring a decrease in temperature of a quartz I-pitchblende-quartz II paragenesis. The decrease in temperature is accompanied by an increase in salinity. The small vapor-phase of the brine inclusions may contain CH_4.

6) Vapor-rich inclusions contain medium density CO_2 and CH_4 with up to 45 vol. % CH_4 in the CO_2-rich phase. Salinities of these fluids are generally less than those of the brines. Entrapment pressures were probably in the $250\text{-}350 kg/cm^2$ range.

7) Oxygen isotope data of material of known homogenization temperature points to water of meteoric origin with $\delta^{18}O$ values between -5 and +1 per mil.

The data are compatible with a genetic model in which uranium deposition occurred at the confluence of a dilute carbon dioxide-rich phase of meteoric origin with a hypersaline brine causing the exsolution of CO_2 and CH_4. This event could have effected uranium precipitation as: a) uranyl carbonates carried by the CO_2-rich solutions were decomposed; b) uranyl compounds adsorbed to clay minerals were desorbed, and c) the pH decreased at the contact with the more acid hypersaline brine. Fluid inclusions point to numerous salinity reversals and hence a multiple process of uranyl adsorption, desorption, reduction and precipitation, presumably lasting for many millions of years where the uranium concentration itself formed the thermal drive for circulating fluids. (Authors' abstract)

YU, Cimei and LU, Huanzhang, 1980, An investigation into the genesis of Shilu iron deposit in special reference to its fluid inclusions; Geochimica, 1980, no. 4, p. 356-367 (in Chinese).

Shilu iron deposit is one of the highly economically important rich iron deposits in China. Based upon the research results on its ore composition and fluid inclusions, it can be reasonably explained that the genesis of this iron deposit is such that marine volcanic sediments there suffered later regional metamorphism ranges from 465 to 536°C, while that of hydrothemal reformation from 344 to 396°C. The latter seems to be related to the migmatization of Zhan Xian stock near Shilu iron deposit. Due to the hydrothermal reformation, the ore-forming materials were mobilized and transferred from the marine sedimentary rocks, subsequently redepositing and concentrating as a rich iron deposit in the present site. (Authors' abstract)

YUDIN, I.M., 1978, Essential directions and results of thermobarogeochemical studies of copper porphyry deposits (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 123-124 (in Russian). Author at Central Sci.-Research Geol.-Prosp. Inst., Moscow, USSR.

Parent subvolcanic intrusions of copper porphyry deposits formed at 1100-800°C, next two stages of formation of explosive breccias occurred (700-600 and 300-250°C, ~2000 atm); ore metasomatites developed at 800-600°C (initial) to 450-200°C (main stage) and 120-70°C (final stage), P decreases from 1500 to 80 atm. Best preserved T zones were found in N. American deposits by Roedder: Th in central parts 640-725°C, in periphery 295-330°C. (A.K.)

YURGENSON, G.A. and TUMUROV, G.T., 1980, Perfection of crystal structure of vein quartz: Izv. Vyssh. Uchebn. Zaved.-Geol. i Razvedka, no. 6, p. 50-59 (in Russian). Author at Transbaikalian Sci.-Research Inst., USSR.

Vein quartz yielded following Th: deposit Baley (Transbaikalia) 150-315°C, Karamken (Soviet NE Asia) 250-310°C, Obukhovskaya vein (Transbaikalia) 150-220°C, Sredne-Golgotay (Transbaikalia) 150-200°C and 240-330°C, Kazakovskoe (Transbaikalia) 240-360°C, Karal'-Veyem (Soviet NE Asia) 200-360°C, Belukha (Transbaikalia) 240-320°C. (A.K.)

YUSHKIN, N.P., 1980, Experience of intermediate-scale topomineralogy: "Nauka" Publ. House, Leningrad, 376 pp., 750 copies printed, price 4 rbls. (in Russian).

The book contains fluid inclusion data on minerals from Pay-Khoy-Novaya Zemlia province, cited from the earlier published papers in the following pages: fluorite 252-253 and 291-292, quartz 255 and 320, calcite and axinite 320, quartz, calcite, sulfides and fluorite 328-331. (A.K.)

YUSUPOV, S.Sh. and KHAYRETDINOV, I.A., 1978, PTX parameters of crystallization of morions and amethysts at Vatikha (Middle Urals), (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 143-144 (in Russian). Authors at Geol. Inst. of Bashkirian Division of Acad. Sci. USSR, Ufa, USSR.

Quartz crystals from the deposit Vatikha consist of three zones: a) early nebulous smoky zone with inclusions bearing LH_2O 10-15 vol. % + LCO_2 40-50 vol. % + GCO_2 35-40 vol. %; total mol. % of CO_2 44-68%; Th in LCO_2 265-240°C, P 1300-600 atm; b) morion zone bears inclusions with LH_2O 10-30 vol. % + G(H_2O?) 75-90 vol. %; total salt concentration 10-13% NaCl equivalent; Th 310-370°C; P 200-90 atm, and other inclusions with LH_2O 10-20 vol. % + LCO_2 20 vol. % + GCO_2 60-70 vol. %; total CO_2 concentration 36-46 mol. %; Th 325-300°C; P 350-300 atm; c) late amethyst zone with P inclusions bearing LH_2O 59-75 vol. % + LCO_2 15-30 vol. % + GCO_2 15-30 vol. %; Th in L phase 310-265°C; at Th 310°C P was 160 atm (CO_2 total concentration 12.2 mol. %); PS inclusions with LH_2O 85-50 vol. %, G 15-50 vol. %; total salt as NaCl equivalent 5-6%; Th 315-235°C; P 90-25 atm; S inclusions have Th 138-80°C. (Authors' abstract translated by A.K.)

ZAGRUZINA, I.A., GOLUBCHINA, M.N., MIRONYUK, Ye.P. and RUDAKOVA, Zh.N., 1978, Isotope composition of sulfide sulfur in some gold ore deposits of the BAM zone: Zapiski Vses. Min. Obshch., v. 109, no. 3, p. 290-300 (in Russian). Authors at All-Union Sci.-Res. Geol. Inst. (VSEGEI), Leningrad, USSR.

The commercial stage of one of gold-quartz formation deposits from the Southern Muy Crest formed at Th 250-270°C. (A.K.)

ZAKIROV, I.V. and KALINICHEV, A.G., 1980, Nonideal behavior of homogeneous gas mixtures as a function of the critical temperatures of the components: Dokl. Akad. Nauk SSSR, v. 253, no. 5, p. 1214-1216 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 253, 1980, p. 236-238.

ZALISHCHAK, B.L., BYEDA, V.D., PETRACHENKO, R.I., MOISEENKO, V.G., PAKHOMOVA, V.A., KALINKIN, N.Ya. and BAKH, A.S., 1979, Peculiarities of endogene mineralization of the Khaykta radial-concentric structure (Upper Priamur'ye), p. 192-195 in: Geology of the continent margins, Publ. House of Far-East Sci. Center, Vladivostok, 208 pp., 800 copies printed, price 1 rbl. 90 kopecks (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

The structure occurs in the Sergachinskaya structural zone, in Proterozoic rocks of the Stanovaya area, activated during Mesozoic. Granitoid rocks are altered to greisens of three facies (from periphery to the center of the alteration zones): 1) quartz + anorthite No. 90-95 + almandine + spessartite + biotite, Th 500-600°C; 2) quartz + muscovite + almandine + spessartite, Th 300-400°C; 3) quartz + muscovite, Th <300°C. (A.K.)

ZALISHCHAK, B.L., PETRACHENKO, R.I., PISKLINOV, Yu.G., BYEDA, V.D., ZAREMBSKIY, Ye.P. and PAKHOMOVA, V.A., 1978, Main features of formation of the Ul' volcanic-plutonic structure (Lower Priamur'ye), p. 130-139 in: Genesis of endogene mineralization of the Far East, 168 pp., 600 copies printed, price 2 rbls., Publ. House of the Far-East Sci. Center, Vladivostok (in Russian). Authors at Far-East Geol. Inst. of Far-East Sci. Center, Vladivostok, USSR.

The Ul' volcanic-plutonic structure in the N. part of Sikhote Alin', formed in the late Cretaceous to Neogene. Hydrothermal activity in this area was determined as occurring at T ≤450°C (Th and Td, metasomatites of hydromica, chlorite, montmorillonite, adularia and quartz type with apatite, tetrahedrite, sulfosalts, sphalerite, galena, chalcopyrite and pyrite). Skarn-hydrothermal parageneses formed at T ≥700°C, including associations: pyroxene-garnet-wollastonite (550-700°C), epidote-garnet (500-550°C), tremolite-epidote with magnetite (500-400°C), actinolite-chlorite with sulfides (≥400°C). Late carbonate-polymetallic veinlets formed at 370-125°C. (Abstract by A.K.)

ZAREMBO, V.I., L'VOV, S.N. and MATUZENKO, M.Yu., 1980, Saturated vapor pressure of water and activity coefficients of calcium chloride in the $CaCl_2$-H_2O system at 423-623 K: Geokhimiya 1980, no. 4, p. 610-614 (in Russian; translated in Geochem. Internat., v. 17, no. 2, p. 159-162, 1980 (pub. 1981)).

Pertinent to properties of inclusion solutions. (A.K.)

ZAREMBO, V.I., YEGOROV, V.Ya. and L'VOV, S.N., 1980, Activities of water and coefficients of activity of sodium and potassium hydroxides in systems NaOH-H_2O and KOH-H_2O at temperatures 423-623 K: Geokhimiya, no. 3, p. 454-457 (in Russian).

ZAREMBSKIY, Ye.P., 1980, Types of mineralization in one of the gold-ore deposits of the Lower Priamur'ye, p. 57-64 in: Mineralogy of native elements, publ. by Far-East Sci. Center, Vladivostok, 156 pp., 500 copies printed, price 1 rbl. 40 kopecks (in Russian).

The unnamed deposit in the Ul' depression, E. Sikhote Alin', occurs in the latest Cretaceous-Paleocene detrital-volcanic beds, metamorphosed under greenschist facies conditions, and bears quartz-gold ore mineralization with rhodochrosite, tetrahedrite, and argentite formed at Th 250-100°C. (A.K.)

ZATSIKHA, B.V. and LYUBINETSKAYA, A.V., 1978, Organic carbon-bearing minerals in mercury parageneses of the Ukraine, (Abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry and Ore Genesis: Vladivostok, Acad. Sci. USSR, p. 127-128 (in Russian). Authors at Oil and Gas Inst., Ivano-Frankovsk, Ukrainian SSR.

Calcite, fluorite and quartz from Transcarpathians and Donbass bear organic minerals in inclusions formed due to hydrothermal alterations of oil. Inclusions in pre-ore quartz (Th 160-265°C, P 200-300 atm) bear CH_4, traces of heavy hydrocarbons and bitumoids. In calcite (Th 250°), CH_4 occupies up to 12% (vol. of total gas? A.K.). Cinnabar (Th 150-120°C) bears up to 4.4% of CH_4 and together with mercury sulfides-asphalt, curtisite, carpathite, and hatchettite were found. Pre-ore fluorite from Slavyanska Hg deposit (Th 410-415°C, P 440-560 atm) bears 9.8% of CH_4, quartz (Th 200-220°C, P 420-650 atm) -38.9% CH_4, 0.1% C_2H_6 and 0.05% C_3H_8. Similar features are typical of other deposits of the studied region. (A.K.)

ZATSIKHA, B.V. and RUSAKOV, N.F., 1980, Thermobarogeochemical conditions of formation of molybdenite at the Elenovskiy diorite massif (W. Priazov'ye), in Thermobarogeochemistry and Ore Genesis, Materials of the Sixth All-Union Meeting on Thermobarogeochemistry: Vladivostok, Publ. House of Far East Sci. Center of Acad. Sci. USSR, p. 76-79 (in Russian).

The mineralogical description of molybdenite mineralization is given. By thermobarogeochemical methods, the temperature, P, salt and G composition of molybdenite-forming solutions are characterized. New type of molybdenum ore genesis is distinguished, connected with metasomatic processes in rocks submitted to ultrametamorphism. This type may be described as characterized by very high P of CO_2 (1500-2000 atm) and low concentration of SO_4-HCO_3-Cl-Na hydrothermal solutions. (Authors' abstract translated by A.K.; abstract of this lecture was not printed in the Abstract volumes of the Vladivostok Meeting, 1978).

ZEMANN, Josef, 1980, Hydrogen in "dry" silicates (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 197.

IR transmission spectroscopy has shown that gem quality crystals of titanite (sphene), andalusite, kyanite, and diopside contain OH-groups. Recent developments in IR instrumentation allow to extend this method to rock forming silicates. It could thus be shown that the intensity of the OH stretching frequency band in kyanite varies greatly depending on the rock type. (From the author's abstract)

ZEUCH, D.H. and GREEN, H.W., II, 1980, Substructural trends in an experimentally deformed synthetic dunite (abst.): EOS, Trans. Am. Geophys. Union, v. 61, p. 1128.

ZHDANOV, A.V., SATUNKIN, G.A., TATARCHENKO, V.A. and TALYANSKAYA, N.N., 1980, Cylindrical pores in a growing crystal : J. Crystal Growth, v. 49, p. 659-664. Authors at Inst. Solid State Phys. of USSR Acad. Sci., Chernogolovka, USSR.

Conditions of steady-state growth of cylindrical pores are found by means of numerical calculations of the impurity concentration field in front of the hemispherical portion of a gas bubble trapped into a growing crystal; the poreward impurity flowrate from the melt is calculated. A qualitative stability analysis for growth of this type of pores is given. (Authors' abstract)

ZHDANOV, V.V., 1980, Zones of regional basification and their ores, p. 29-40 in: Iron- and magnesium metasomatism and ore formation, "Nauka" Publ. House, Moscow, 196 pp. 800 copies printed, price 2 rbls. 30 kopecks (in Russian).

Early pre-ore pyroxene and garnet-pyroxene skarns at the Zaimandrovskiy region, Kola Peninsula formed at 550-600°C (Td of pyroxene). Polyzonal Mg skarns in ferruginous quartzites of the Olen'ya Tundra formed at 350-400°C. (A.K.)

ZHENG, S.-H., HOU, F.-G. and MU, Z.-G., 1980, Oxygen and hydrogen stable isotopic analysis in the fluid inclusion of minerals: Heh Hua Hsueh Yu Fang She Hua Hsueh, v. 2, no. 3, p. 181-185 (in Chinese). Authors at Dept. Geol. Peking Univ., Peking, PRC.

Metallic U and BrFs are used, resp., to prep. H and O exts. from the water released by high-temp. decrepitation of fluid inclusion-contg. minerals. The δD values detd. for the U-extd. H are compatible with those obtained for H extd. by Mg-powder methods and yield precision and mean deviation values of ±2.5 and ±1.2‰, resp. Detns. of $\delta^{18}O$ in the O exts. have a mean deviation of ±0.5‰. (C.A. v. 93, 207897p.)

ZHOVTULYA, B.D., KALYUZHNYI, V.A. and REMESHILO, B.G., 1980, Carbon-containing gases in basic and ultrabasic rocks (according to the data of a study of fluid inclusions in minerals): Teor. Vopr. Neftegazovoi Geologii, Kiev, 1980, p. 65-73 (in Russian).

ZHUKOV, F.I. and GNATENKO, O.V., 1978, The formation stages of sodium metasomatite zone according to isotopic and thermobarometric data: Akad. Nauk Ukr. RSR, Dopovidi, Ser. B., Geol., Geofiz., Khim., Biol., 1978, no. 2, p. 109-111 (in Ukrainian).

The article deals with the data of lead isotopic composition for rocks and ores and the results of temperature measurements for gaseous-liquid inclusion homogenization in mineral-forming environments to investigate the formation stages of sodium metasomatite zone and the associated uranium mineralization in the Pre-Cambrian rocks. (Authors' abstract)

ZHUKOV, F.I., LESNOY, D.A. and TERESHCHENKO, S.I., 1978, Formation temperature and isotope sulfur composition in sulfide-polymetal ores of the Koksu-Tekeli ore region (abst.): Abstracts of the Sixth All-Union Meeting, Vladivostok, Sept. 15-18, 1978, v. 2, Thermobarogeochemistry in ore genesis: Vladivostok, Acad. Sci. USSR, p. 105-106 (in Russian). Authors at Inst. of Geochemistry and Physics of Minerals, Kiev, Ukrainian SSR.

Quartz and carbonate from stratiform ores in quartz-carbonate-coal-bearing shales have Th 210-320 and 170-260°C, respectively (P inclusions). The lower the T of formation of sulfide parageneses, the higher are the contents of ^{32}S. (A.K.)

ZIDAROVA, B. and DUDEROV, N., 1980, Solubility of fluorite in aqueous solutions of NH_4Cl under hydrothermal conditions: Geochem., Miner. and Petrol. (Bulgaria), v. 12, p. 29-37 (in Russian with English Abstract).

ZIEGENBEIN, Dieter and JOHANNES, Wilhelm, 1980, Graphite in C-H-O fluids: an unsuitable compound to buffer fluid composition at temperatures up to 700°C: N. Jb. Miner. Mh., 1980, H.7, p. 289-305 (in English).

Experiments with sealed gold and sealed platinum capsules containing graphite and a fluid phase of C-H-O composition were carried out at temperatures of 600-700°C and up to 2 kbars pressure. The sample containers were exposed to different H_2 fugacities using pure argon, argon-hydrogen mixtures, and water with NiO or Ni + NiO added to the pressure medium. After quench the gas phase was analyzed for the following compounds: CO_2, CO, H_2O and CH_4. The experimentally determined fluid compositions were compared with those calculated from thermodynamic data.

The following results were obtained: 1) Experimentally determined compositions of C-H-O fluids differed considerably from those calculated assuming graphite-gas equilibrium. 2) Graphite reacted very sluggishly with the gas phase and heterogeneous equilibria were not attained (in runs up to 60 days duration). 3) In runs in which graphite should be oxidized the O_2 fugacity remained high in comparison with calculated data (the observed O_2 fugacities scattered in a wide range of ±2 log units; the fluids were almost binary mixtures of H_2O and CO_2). 4) In runs in which graphite should be formed by reduction of CO_2 by H_2 the O_2 fugacities were considerably lower compared with calculated data (the O_2 fugacities scattered in a narrow range of ±0.2 log units; CO and CH_4 were present). (Authors' abstract)

ZIMMERMANN, J.L., 1980, Water, carbon dioxide and organic compounds in cordierites; kinetic of release, determination of sites, petrogenetic interest (abst.): Internat. Mineralog. Assoc. Collected Abstracts, 12th General Meeting, Orleans, France, 4-6 July, 1980, p. 143-144 (in French; translation courtesy of R. Clocchiatti).

The samples correspond to various geographical and genetic origins: 1) Cordierites of the Akland and Tvedestrand amphibolite facies, of the Dypvag and Tromoy island granulite facies (Southern Norway); 2) Cordierite, associated with a Variscan low pressure type metamorphism, from a Velay granite (La Palisse quarry); 3) Cordierites belonging to biotite bearing-anthophyllite gneiss (Ihossy, Madagascar) 4) Cordierites of a very low pressure metamorphic suite connected with the Rond peridotites (Betic range, Spain); and 5) Cordierite of a very high pressure metamorphism suite from the Beni Bousera area (internal Rif, Morocco).

Fluids are extracted by vacuum heating and analysed by mass spectrometry. The temperature may rise in two different ways: 1) by successive steps of 100° from 100°C to 1200°C, with analysis of each gaseous fraction released, or 2) in a continuous and linear way at speeds selected in advance. This way it is possible to proceed to quantitative and semi-quantitative determinations of the major gas compounds and to carry out a kinetic study of their release. The release can be regarded as a diffusion process (Carlaw and Jaeger), or as a dissociation reaction (Horowitz and Metzger).

The minerals of the granulite facies are much poorer in fluids than those of the amphibole facies; furthermore, the composition of these fluid phases varies remarkably depending on the facies. Carbon dioxide, carbon monoxide and organic compounds (CH_4, C_2H_2, C_2H_4, CnH_{2n+2},...) are in large amount in the granulite facies. On the contrary, the fluid phase of the amphibolite facies is mainly aqueous (even though carbon compounds are not excluded). These results are comparable to those of J. Touret (1970, 71, 73); however, and as was shown by Lepezin and Melenevsky (1977), water remains a major component, even in the cordierites of granulite facies where its molar percentage, according to our results, reaches 55 to 65% of the whole fluid phase, while it reaches 85 to 90% in the amphibolite facies. In a broad way, it appears that the water content would be somewhat proportional to the pressure of the aqueous phase at the time of the mineral formation.

The kinetic study of the release of fluids, mainly dehydration, may furnish valuable indications on the thermal history of the host body. The higher the crystallization temperature, the higher the degasing curves and the greater the activation energy needed for dehydration. If the dehydration is a first order reaction, as it seems to be for cordierites, the temperature of maximum dehydration rate is also the temperature at which water is still soluble in the silicate, and thus corresponds to the very beginning of solidification. In many cases, the temperatures found here are close to those determined from petrographic studies. When the dQ/dt f(T) curve displays several peaks (therefore several activation energies), they indicate several energetic "sites", or they may denote that the mineral suffered several thermal events during its history. However, this latter assumption remains daring, considering the complexity of past geological phenomena and the possible presence of large size impurities that may plug the annular voids and modify the kinetics of the degasing process. (Authors' abstract)

ZIMMERMANN, J.L., ARNOLD, M. and GUILLOU, J.J., 1980, Barite veins, sulfoantimonides and reworked Stephanian sediments of Rouvergue; difference between the chemistry of fluid inclusions and the composition of volatiles extracted from quartz crystals: Paleosurfaces and their metallogeny, Fr. Bur. Rech. Geol. Minieres, Mem. 104, p. 200-203 (in French).

Indexed under Fluid Inclusions. (E.R.)

ZIMMERMANN, J.L., MICHEL, Arnold and GUILLOU, J.J., 1979, Chemical differences between fluids from visible inclusions and from inframicropores in a low-temperature quartz vein of Gour Nègre (Gard)[France]: C.R. Acad. Sci. Paris, v. 288, Ser. D, p. 863-866 (in French).

Fluids in low-temperature micromosaic quartz from veins in low-grade schists and carbonaceous sandstones of Mt. Rouvergue were analyzed by mass spectrometry. Visible inclusions are simple, single- or two-phase, aqueous fluids. However, during stepwise heating to 400°C, an organic carbon-rich vapor evolved. Because CO_2 and CH_4 are not present in significant quantities in the visible inclusions, the authors conclude that the carbon compounds are localized in inframicropores in the mosaic structure. (M. Logsdon)

ZOLENSKY, Michael and BODNAR, R.J., 1980, Identification of fluid inclusion daughter minerals using Gandolfi X-ray techniques (Abst.): Geol. Soc. Amer. Abstracts with Programs, v. 12, p. 555. Continued next page.

Unequivocal identifications of individual daughter minerals extracted from fluid inclusions have been obtained using micro-techniques in conjunction with the Gandolfi X-ray camera. This development represents a major advance in fluid inclusion research because solid phases from preselected fluid inclusions may now be unambiguously identified. Precise centering of the sample, which is mounted on a drawn-glass fiber, in a finely-collimated X-ray beam enables crystalline daughter phases as small as 2 µm to be routinely identified and interpretation of the X-ray pattern provides a method of recognizing pseudomorphism and distinguishing between different polytypes, polymorphs, and compositionally similar phases. Application of this technique allows the worker to not only measure the homogenization and freezing temperatures of a fluid inclusion of known origin but also to identify any daughter minerals that might be present in that same inclusion, providing considerably more information on the physico-chemical conditions attending mineral deposition than is available from conventional fluid inclusion analyses.

Using this new procedure, an octahedral opaque phase from a fluid inclusion in quartz was found to consist of hematite. Preliminary optical examination suggested that this mineral was magnetite and SEM energy-dispersive analysis would merely have revealed the presence of iron. Recognition of this pseudomorphism indicated that the upper limit for the oxygen fugacity of the hydrothermal fluid at the T and P of entrapment was $\sim 10^{-20}$ bars. Also, opaque tetrahedra commonly observed in fluid inclusions from porphyry copper deposits have been verified as being chalcopyrite, requiring copper solubilities in the hydrothermal fluid of several thousand ppm. (Authors' abstract)

ZOR'KIN, L.M., KORTSENSHTEYN, V.N., STADNIK, Ye.V., KOZLOV, V.G., KIR'YASHKIN, V.M., YURIN, G.A. and BORODKIN, V.A., 1980, Gaseous hydrocarbons in subsurface water in strata of oil and gas basins - a potential source of hydrocarbons: Dokl. Akad. Nauk SSSR, v. 252, no. 3, p. 681-683 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 252, 1980, p. 78-80 (1982).

ZOZULENKO, L.B., 1980, Comparison of parameters of gas-liquid inclusions in quartz veins and pebbles of conglomerates of the Enisei Ridge: Tr. Geol. Inst., Buryat. Fil., Sib. Otd., Akad. Nauk SSSR, v. 23, p. 82-90 (in Russian).

ZWAAN, P.C. and ARPS, C.E., 1980, Sphene, Sri Lanka's newest gemstone: Scr. Geol. (Leiden), v. 58, p. 11.

Indexed under Fluid Inclusions. (E.R.)

Translations

Items presented here are selected on the basis of (1) availability of a translation that has not been published elsewhere; (2) significance to inclusion research; and (3) date of publication. Thus particularly significant older items are sometimes included. 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.

GRISHINA, S.N., 1979, Microanalysis of gas phase of inclusions in minerals: Zapiski Vses. Mineral. Obsh., v. 108, no. 5, p. 617-621 (in Russian). Author at Inst. Geol. and Geophysics of Siberian Branch of Acad. Sci. USSR, Novosibirsk.

Gas analysis from inclusions was performed by use of earlier used methods (Krogh 1911, Inss 1933, Dolgov, Shugurova 1966, Shugurova 1968), but for small bubbles, few tens of microns in diameter. The inclusions are opened in inert liquid and evolved gas bubbles are selectively absorbed in chemical reagents. As inert liquid glycerine was used, but all gases are soluble in glycerine, although some of them are so slightly soluble that practically they may be called "insoluble." Solubility of gases in liquids decreases with decrease of their critical temperature (Gerasimov et al., 1973), i.e., from HF, HCl, SO_2, NH_3, H_2O, CO_2 ("soluble") to CH_4, O_2, CO, H_2, N_2 ("insoluble"). Experimentally it was verified for glycerine (Inss 1933, Slavyanskiy, Krestnikova 1953). Thus, new inert liquids are necessary to increase the group of "insoluble" gases. The following liquids are described: dehydrated glycerine (Inss 1933), glycerine distilled under vacuum (Slavyanskiy, Krestnikova 1953), castor oil (Shugurova 1968), glycerine saturated with LiCl (Kormushin et al. 1974) and solution of anhydrous LiCl in glycerine (Dolgov, Shugurova 1978). CO_2 was used in the recent paper for evaluations of properties of inert liquids.

The size of bubble of pure monocomponent gas in viscous liquid changes in accordance with equation (Epstein, Plesset 1950):

$$\frac{dR}{dt} = \frac{k(Cs-Ci)}{\rho}\left(\frac{1}{R} + \frac{1}{\sqrt{\pi kt}}\right), \qquad (1)$$

where k-coefficient of gas diffusion in liquid, t-time, R-diameter of bubble, Cs-gas concentration at infinite distance from bubble, Ci-gas solubility in liquid, ρ-gas density.

In the beginning of the process ($t \gtrsim 0$) the essential participation in change of size stems from the part $(\pi kt)^{-1/2}$, liquid immediatetly adjacent to bubble is rapidly saturated. However, starting from $t \gtrsim R^2/4\pi k$, i.e., when sphere of saturation exceeds the bubble size, the participation of the second part of the right side of equation (1) decreases and equation has simple analytical solution[1]:

$$R = R_0 \sqrt{1 - \frac{2(Cs-Ci)+k}{\rho R_0^2}}, \qquad (2)$$

where R_0-initial bubble radius. Value characterizing inert properties of liquid is the relative change of bubble volume $\delta V = [V(o)-V(t)]/V(o)$. Replacing here by R from equation (2) we have:

$$\delta V = 1 - \left[1 - \frac{2(Cs-Ci)tk}{\rho R_0^2}\right]^{3/2}, \qquad (3)$$

i.e., inert liquid is better, the smaller the value $(Cs-Ci)tk/\rho R_0^2$. For ideal inert liquid this value is equal zero. Thus, for comparison of inert liquids with use of change of bubble size, it is necessary to choose bubbles of the same size. Moreover, comparison should be made at the same temperature, because Cs and k depend on temperature.

Minute CO_2 bubbles (up to 30 μm) were obtained by gas flow through injection needle under excess P 1-2 atm. Time was counted from the moment of separation of bubble from needle. Bubble diameter was measured with micrometric ocular under the microscope as the time function. CO_2 concentration in studied bubble was controlled by absorption with glycerine solution of KOH. The experiment proved that speed of gas absorption increases as the diameter of bubble becomes smaller (Fig. 1) and temperature becomes higher (Fig. 2).

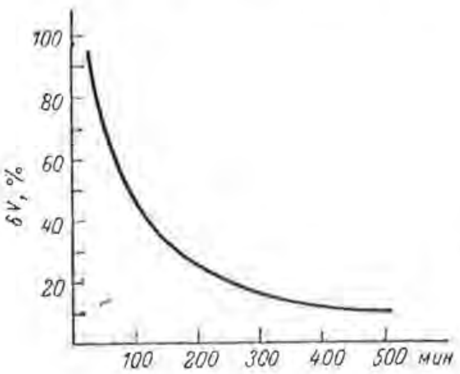


Fig. 1. Influence of the bubble diameter on the absorption rate-change of the bubble volume δV in 3 minutes.

Fig. 2. Kinetics of absorption of bubbles in mixture of 150g of glycerine and 25g of LiCl at T 24°C (1) and 16°C (2).

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[1] Diffusion coefficient of CO_2 in glycerine at 20°C $\approx 10^{-7}$ cm^2/sec, thus equation (2) is true for bubbles with dia. $\lesssim 100$ μm already after 30 sec after beginning of the process.

Fig. 3 presents the absorption curves of gas bubbles of dia. ~260 µm in various "inert" liquids (CO_2 concentration 98%, temperature 18°C). The slowest gas absorption occurs in glycerine solution of LiCl. Very concentrated solutions of LiCl have, however, too high viscosity to be used for this procedure, although absorption is then very slow. Experiments were made with glycerine-LiCl solution diluted with water to decrease the high viscosity. The empirically found composition of weight ratios glycerine 43, LiCl 32, H_2O 25 absorbes CO_2 three times slower than the liquid proposed by Dolgov and Shugurova (1978). The stability of this liquid is also a positive feature. The earlier proposed liquids absorb water from air, but the liquid used by us contains more water than hydroscopic saturation of glycerine (40%).

There are two known ways of determination of CO_2: qualitative from change of bubble volume in glycerine in the defined time (Inss 1933) and quantitative - on the basis of type of curve of separation of CO_2 and H_2S in glycerine solution of $(CH_3COO)_2Cd$ (Shugurova 1966). The first method may be also used for semiquantitative determination. The second method was proposed for a wide range of the bubble diameter (20-800 µm) and the determination error was evaluated by Shugurova as equal 20% for a bubble of dia. 20 µm and 4% for the bubble of dia. 50-60 µm, taking into account only error of the diameter measurement. However, my experiments proved that total error of CO_2 content determination may significantly exceed the above values. According to the separation curve, bubbles of pure CO_2 of above size range should be absorbed in glycerine solution of $(CH_3COO)_2Cd$ during 3 minutes with their volume decrease equal 21.8%. In fact, the volume absorption in this time interval changes from 10% for bubbles of dia. 800 µm to 80% and more for bubbles of dia. 40-60 µm.

During construction of the separation curve the following factors were not taken into account: presence of gases other than H_2S, soluble gases that might influence the kinetics of absorption in various ways, and rate of absorption depending on bubble size and temperature and change of gas composition between inclusion opening and putting the bubble into $(CH_3COO)_2Cd$ solution (during transport of bubble). The influence of the last factor may be removed by separation of CO_2 from soluble gases immediately in the medium of opening of inclusion.

It is apparent from equation (3) that the shape of the curve $R = f(t)$ depends on composition of gas, because components of the bubble have various values for Ci, Cs, k and ρ. This was confirmed experimentally (Fig. 4). In case of gas mixture equation (1) has no analytic solution, but the family of curves for various compositions may be calculated. Experimental data are necessary for this purpose, such as the diffusion coefficients of all components of gas mixture in various liquids. Construction of the calibration plots will permit determination of composition by the following way: after opening of inclusion in glycerine-water solution of LiCl the change of bubble diameter is measured and next bubble is moved to KOH glycerine solution, where the remainder of CO_2 and other soluble gases is absorbed. After calculation of total gas absorbed in the first and the second solution, the curves for the standard bubble and the studied bubble are compared, taking into account all the influencing factors. If the absorption rate for the studied bubble is higher than for the standard one, this indicates the presence of several soluble gases in the bubble; if the rate is the same - all dissolved gas is CO_2. Quantitative characteristics of gases may be obtained by comparing with the appropriate standard plots. Analyses should be performed under thermostatic conditions. (Translated and shortened by A.K.)

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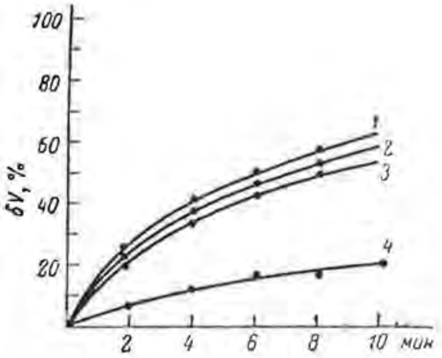

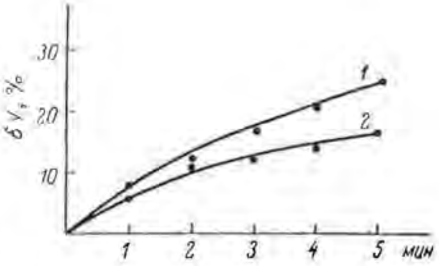

Fig. 3. Kinetics of absorption of CO_2 bubbles in various "inert" liquids at 19°C. 1-usual glycerine, 2-glycerine distilled under vacuum, 3-mixture of 150g of glycerine and 25g of LiCl, 4-mixture of glycerine, LiCl and H_2O (43:32:25 parts by weight).

Fig. 4. Kinetics of absorption of bubbles with CO_2 concentration 96 vol % (1) and 83 vol % (2). Initial diameters of bubbles 263 and 269 µm, respectively.

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PUNIN, Yu.O., PETROV, T.G. and TREYVUS, Ye.B., 1980, Low-temperature modelling of processes of mineral formation: Zapiski Vses. Min. Obshch., v. 109, no. 5, p. 516-529 (in Russian). Authors at Leningrad State Univ., Leningrad, USSR.

Chapter 6. Inclusions of solutions (p. 523-526).

G/L inclusions in crystals of minerals are used mainly for reconstruction of T, P and solution composition. However, crystals with inclusions provide also other information about growth regime, oversaturation, etc. A genetic classification of G/L inclusions in crystals was given by Lemmlein (1959). Here we will consider only two types of inclusions, most interesting from our point of view, for genetic-information analysis.

A. "Diffusion" inclusions, occurring due to insufficient substance in flow. They may belong to one of two varieties: 1) large surface (flat? A.K.) inclusions, rhythmically repeating and 2) small "point type" inclusions occurring in chains parallel to faces along layer movement.

B. "Admixture" inclusions formed due to nonuniform movement of growth layers on the etched surface (Chapter 3)-small point-type inclusions occurring as thin layers or chains parallel to faces.

A. Diffusion inclusions

Loss of stability of a flat face with formation of steps and trapping of solution inclusions occurs when solution concentration on the surface in the central part of face becomes equal to the saturation concentration (Chernov 1971, Treyvus 1979). Thus growth is limited by diffusion. Hence, the presence of inclusions of type A in a crystal is the evidence that growth was under diffusion conditions.

Since the growth velocity at the moment of trapping of an inclusion is determined by the diffusion velocity, it may be calculated on the basis of the known formulae for any hydrodynamic regime. Experimental checking made for a series of water soluble compounds (Treyvus, 1979) proved in fact the possibility of quantitative description of conditions of origin of inclusions on the basis of usual equations of mass-transport theory.

Under the known parameters of growth (growth velocity, oversaturation, T, etc.), certain critical face size l_{cr} exists, when it begins to trap inclusions. This size, easily determinable on crystals of minerals, is connected with conditions of growth by the following relationships:

1. Regime of molecular diffusion

$$l_{cr} = B_1\frac{\Delta c}{v}. \qquad (2)$$

2. Regime of constrained convection (laminar flow)

$$l_{cr} = B_2\left(\frac{\Delta c}{v}\right)^2 u. \qquad (3)$$

3. Regime of natural convection (laminar flow)

$$l_{cr} = B_3\left(\frac{\Delta c}{v}\right)^4 \Delta c. \qquad (4)$$

Where Δc-oversaturation, v-growth velocity in the moment of inclusion trapping, u-solution movement velocity, B_1, B_2 and B_3 include values not depending on oversaturation, but on T, solution composition and system geometry-viscosity, diffusion coefficient, shape coefficient, etc. (Levich, 1959). For real mineral-forming solutions values of those constants are unknown. However, during analysis of conditions of mineral formation, no absolute values of the variables on the right side of equations (2-4) are available, but interesting data on their change throughout a geologic volume, influencing change of l_{cr}.

Equations (2-4) may be simplified (with decreased accuracy) if one remembers that usually growth velocity depends on oversaturation according to equation $v \approx \beta(\Delta c)^n$, where $1 < n < 2$. Thus, including kinetic coefficient β into constants, we shall get:

$$l_{cr} = B'_1 \Delta c^{(1-n)}, \qquad (5)$$

$$l_{cr} = B'_2 \Delta c^{(1-n)} u, \qquad (6)$$

$$l_{cr} = B'_3 \Delta c^{(5-4n)}. \qquad (7)$$

Thus, critical size decreases with increase of oversaturation under any hydrodynamic regime. If a change of amount of oversaturation is obtainable from independent data (in the studied geological body), then the type of relation between l_{cr} and oversaturation makes possible the determination of type of hydrodynamic regime.

Since constants B' include viscosity, diffusion coefficient and kinetic coefficient, i.e., values depending on T, the l_{cr} also depends on T. If one takes into account that the coefficient of diffusion depends on viscosity (the Stokes' equation), a very good approximation may be written:

$$B'_1 \sim \frac{1}{\beta \nu}, \qquad (8)$$

$$B'_2 \sim \left(\frac{1}{\beta \nu}\right)^2, \qquad (9)$$

$$B'_3 \sim \left(\frac{1}{\beta \nu}\right)^4, \qquad (10)$$

where ν-viscosity. The kinetic coefficient increased with T growth and decreased with viscosity. Since β usually depends more on T than ν, thus l_{cr} decreases with T increase and growth moves toward diffusion conditions.

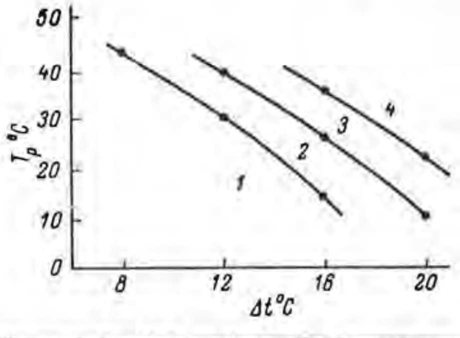

Fig. 7. Plot of signs of diffusion influence on crystal growth of KH_2PO_4 at various T and overcooling of solution. 1-flat-face growth, 2-thick layers on faces, 3-inclusions of solution in growth pyramid of the faces {101}, 4-inclusions of solution in growth pyramid of the faces {100}.

Figure 7 presents the simultaneous influence of temperature and oversaturation on the appearance of signs of diffusion growth in crystals of KH_2PO_4 (crystal sizes varied little under the experiment conditions, thus not l_{cr} but the threshold T and oversaturation for origin of the specific sign were determined).

It is noteworthy, however, that T influence on the growth regime and inclusion formation is not a result of its influence on oversaturation. Cases are possible in which β depends less on T and ν. Moreover, under higher absolute solution concentrations it is necessary in equations (2-4) to change V for $V(\rho_k - c)$, where ρ_k-density of crystal (the correction means nondiffusion precipitation of material by moving face). If T coefficient of solubility is very steep, the above correction may lead to a decrease in the diffusion resistance with T increase. An example of a decrease of probability of inclusion formation with T increase for KNO_3 is given elsewhere (Petrov, 1962). However, such cases are quite rare.

Similarly to the loss of face stability, prism growth steps may also lose their stability. Thus, prism becomes very irregular and behind the front of movement of the step the chains of "point-type" inclusions form (Belyustin, Fridman 1968; Sheftal', Kozlov 1977).

Besides information about oversaturation and growth T, crystals with inclusions also bear information about the direction of movement of parent solution. When solution flows in one direction, oversaturation along the face decreases (Levich, 1959). Thus, inclusions are moved from front edge toward the flow direction. Experiments with KNO_3 show that under a regime of free convection the inclusions occur 2.5 times (average) closer to the back edge of the face than to the front one (Petrov, 1962). Similar results were obtained by V.A. Pismennyi (1970) and Ye.B. Treyvus (1979). It is noteworthy, that determination of direction of parent flow from the deformation of the external symmetry of the crystal for minute crystals may be of low sensitivity, whereas asymmetry of distribution of diffusion is discernible for crystals of "any" size.

Finally, flat inclusions of solution, rhythmically repeating in the growth pyramid of crystal as well as dendritic crystals (extreme case of diffusion influence), permit the unique possibility of evaluating the absolute growth velocity of crystals. Mass transport and hence formation of growth inclusions and dendritic growth when crystal size and oversaturation are known, are determined by the viscosity of solution and diffusion coefficients of the solute. Since values of the latter are variable, but for drop liquids (sic. A.K.) are in relatively narrow ranges, the crystals differing in the above peculiarities, have grown with velocity comparable with growth velocity under laboratory conditions.

B. Admixture inclusions

Inclusions of solution, connected with inhibition of growth by admixtures, have been studied much less than diffusion inclusions. Unlike diffusion inclusions, these inclusions are a criterion of small oversaturation and low temperatures of growth, which are connected with the manner of their formation. If the crystal grows in a degree of oversaturation only slightly exceeding the critical one, the layers of growth expand on the face nonuniformly, omitting the parts most occupied by admixtures. Simultaneously, small isometric or flat inclusions are trapped in thin layers parallel to the face. Often "admixture" inclusions are morphologically similar to diffusion "point-type" inclusions in KH_2PO_4 and the two varieties are hardly distinguishable. In other cases the extremely characteristic "pearl luster" of faces appears, that permits the exact diagnosis of those inclusions (e.g., in $K_2Cr_2O_7$, $K_4Fe(CN)_6 \cdot 3H_2O$, potassium biphtalate). Finally, when trapping of inclusions is very intensive, crystals become "china-like," e.g. $Pb(NO_3)_2$ (Sal'nikova, Treyvus, 1973). Finding of inclusions of this type in mineral crystals is the undoubted sign of strong "poisoning" (i.e., inhibition, A.K.) of growth by admixtures. Faces with such inclusions are usually "inhibition faces." (Translated by A.K.)

SOKOLOV, S.V. (1979) On the differences of phase composition of inclusions in minerals: Zapiski Vses. Mineral. Obshch., 1979, pt. 2, p. 202-206 (in Russian).

The case in which the composition of P non-anomalous inclusions occurring in various minerals of the same paragenesis is different has not been especially considered in literature. Sometimes this difference is not significant and it means only some variations of the same phase content in vacuoles. But this difference may be large if inclusions in coexisting minerals have magmatic and hydrothermal nature, likewise in carbonatites of the ultrabasic alkaline complexes.

The author found that inclusions in minerals from carbonatites and closely related calcite-bearing apatite-nepheline-pyroxene, apatite-forsterite-magnetite and other rocks (the massif Kovdor), may be divided into two groups: 1-crystallized and crystal-fluid (60-95% of solids) ones, present in silicates (pyroxenes, nepheline, forsterite and micas) and dolomite, and rarely in apatite; 2-G/L inclusions, sometimes with dms (15-20%), typical of apatite crystals.

The same differences in phase composition of inclusions in paragenetic minerals were also found in other carbonatite massifs of the Kola Peninsula (Vuoriyarvi, Afrikanda, Turiy) and Siberia (Maymecha-Kotuy, Sette-Daban and E. Sayan provinces).

First, the syngenetic nature of nepheline, pyroxenes, forsterite and micas with apatite of the respective generations should be emphasized. This is confirmed by the following facts, excluding the supposition that silicates may be relic minerals. First, the silicates in carbonatite complexes form independent generations, differing from the earlier generations of the same silicates in ultrabasic alkaline rocks by their morphological, chemical and optical features. Second, reaction relations were not observed between silicates and apatite, although the structural subordination of apatite to silicates may be presumed as evidence of its later origin. Third, certain silicate minerals present in many samples are absent in wall-rocks, e.g., occurrence of forsterite-calcite carbonatites or calcite-bearing apatite-forsterite-magnetite ores between nepheline-pyroxene and pyroxene rocks. Last, the main evidence - the enrichment of inclusions in solid phases is typical not only of silicates but also of dolomite.

Inclusions in apatite occur either solely or in groups in central parts of host mineral grain. Usually such a group consists of coexisting G/L and polyphase inclusions. Inclusion habit varies from short- to long-prismatic and tubular and inclusion orientation is parallel to Z-axis of crystals. These features the author considers as evidence of the syngenetic formation of all discussed inclusions in apatite. Apatite bears also S inclusions of irregular habit and connection with healed fractures.

The P genetic type of crystallized and crystal-fluid inclusions in a number of cases (forsterite, mica) is undoubtedly established on the basis of occurrence in the defined growth zone of crystal. The azonal inclusions cannot be positively attributed either to the P or to S variety. Azonal inclusions, syngenetic to (the host) mineral, occur throughout the grain without visible connection with the later fissures. (...).

The studied magmatic inclusions in silicates and dolomite are not anomalous, because phase ratios and course of homogenization are the same for inclusions in each group.

On the basis of the above observations the unusual supposition may be made that conditions of crystallization of various minerals (silicates and dolomite versus apatite) that made rocks of one stage of carbonatite process were different.

Detailed thermometric studies of pegmatites (Zakharchenko 1976) showed the regular evolution of composition of inclusions in minerals from wall-rock granite to internal zones of pegmatitic bodies in the sense that in this direction the amount of solids decreases, changing from silicates to soluble salts, and the amount of water increases, i.e., silicate melts alter into (water) fluids when T decreases(...). This means the change of phase composition of inclusions in a sequence of minerals.

Similar phenomena were described for different mineral species of the same paragenesis. Comparison of inclusion types in femic minerals and nepheline from peridotites of the Gulin pluton, processes observed during heating, and Th suggest that in the final stage of crystallization the rocks the mineral-forming medium became richer in water and alkalies (Kostyuk, Panina 1970).

The possibility of a continuous evolution of the original mineral-forming media during T decrease was discussed theoretically (Nikolaev 1953) and evidenced practically (Wyllie 1969). This evolutionary process may be an explanation of essential differences in inclusion fillings in silicates and apatites from the same carbonatite complexes.

One more possible reason of differences in inclusion fillings may be immiscibility of silicate (or carbonate) melt and fluid of lower density being a parent one for apatite. Immiscibility phenomena in petrogenetic processes were evidenced by experiments and inclusion studies. Experiments in the system albite-quartz-NaCl-H_2O proved that at T>T of solidus and PH_2O>1 kbar, silicate melt coexists with gas-like fluid of low density, and more dense liquid consisting mostly of NaCl (Ryabchikov, Hamilton 1971). Silicate glass formed by quenching of this system bear two-phase L/G inclusions and polyphase ones consisting of 60-80% of halite crystals, saturated NaCl solution and G bubble. Trapping P inclusions of the above types by glass may be explained only by a heterogeneous state of the system, in which silicate melt and two immiscible fluid phases occur.

Similar conclusions were obtained by studies of inclusions in minerals, e.g., inclusions in nephelines from nephelinites of the E. African carbonatite complex Quaraha have various phase composition and various behavior on heating: some homogenize in melt, some bear coexisting silicate and salt melts (Romanchev 1972). Inclusions of the immiscible type were reproduced experimentally (Romanchev et al. 1972) and found in melitite rocks of the Kovdor massif (Sokolov, Romanchev 1976).

Confirmation of the proposed models of origin of non-anomalous inclusions filled by various phases needs more detailed studies of both inclusions and host minerals. Most important are probably catalytic, sorption and wetting properties of minerals, since the influence of the surface phenomena on process and mechanism of inclusion trapping cannot be excluded. However, other ways of elucidation of the inclusion origin are possible. The author hopes that appropriate experiments should provide evidence to explain the observed phenomena.

Sharp differences of phase composition of the discussed inclusions result in various Th in silicates and apatites of the same paragenesis; apatite-forsterite-magnetite rocks yielded Th for forsterite about 200-250°C higher than for apatite. Finding in inclusions in carbonatite minerals L and G hydrocarbons (Sokolov 1975) suggests their influence on decrease of Th of G/L inclusions (on the basis of similarity of some features of CO_2 and hydrocarbons), as it was stated in artificial and natural inclusions with CO_2 (Khetchikov et al. 1971). Thus, one may assume that crystallization of apatite was at T>Th, plus a positive correction for pressure amounting to 140°C, the real crystallization T exceeds even more the Th of liquid inclusions. On the other hand, L.Sh. Bazarov (1975) proved that presence of CO_2 in inclusions rich in solid phases causes higher Th. Since CH_4, like CO_2, increases T of silicate melting, it is very probable that hydrocarbons have a similar influence on Th increment. Moreover, Mg-Fe silicates influence L and G hydrocarbons toward polymerization and bituminization. Such processes may decrease the number of fluid phases in inclusions in silicates and hence T of complete homogenization in such cases may be higher than T of mineral formation.

Finally, the above differences in phase composition of P non-anomalous inclusions are typical of coexisting minerals of many carbonate massifs. Thus, they are the evidence of very specific conditions of carbonatite formation and genetically related rocks. Paragenesis of significantly differing inclusion fillings is usually due to the heterogeneous state of the mineral-forming medium. "Paragenesis of inclusions" is here a regularly formed family of syngenetic vacuoles, contemporaneously sealed in one process of mineral formation. Such an inclusion family should have common conditions of trapping and the same typical position in crystal. It is necessary to remember that time-space uniformity of paragenetic inclusions does not always mean their same phase composition and close Th. (Translated by A. Kozłowski)

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Indices

The user should keep in mind the following features of these indices. The indexing procedures and entries are evolving and hence are not uniform from one volume of COFFI to the next, and even within a given volume consistency cannot be claimed, so caveat emptor. Where several different items in the given category occur on the same page, the number of such items is put in parentheses after the page reference. Some items may continue on to following pages. 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 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 293. 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 listing 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	
5	24	2	1-10	Item incorrectly alphabetized - move to p. 72.
5	72	4	-	Insert Michel-Levy, Christophe, 1972, from p. 24 as item 4.
7	6	1	3	Change to France.
7	52	2	2	Change Mitt. to Monats.
8	172	3	1	Insert date, 1975.
10	120	5	3	Change Mh. to Monats.
11	v.	3	6	Change 911 to 811.
11	36	2	1-3	Delete - duplicated below.
11	229	2	1	Change to 1979.
11	229	4	1	Change to 1979.
12	26	6	1	Change to geochemistry.
12	35	3	12	Change to potassic.
12	73	5	1	This item should be entered on p. 186 under correct family name: Tan, H.T.
12	74	2	1	This item should be entered on p. 186 under correct family name of senior author: Tan, H. T.
12	75	2	3	Change Mitt. to Monats.
12	94	3	1	Add initials A.B. Darbadaev.
12	97	4	11	Change C_3H_6 to C_3H_8.
12	112	4	1	Change 1979 to 1977.
12	186	3	-	Insert two "Tan, H.T." items from p. 73 and 74 (see above).

†Partial items are also counted.

INDEX Volume	Page	Item
11	283	Inclusions in rocks, Evaporites - change entry 169 to 170.
12	283	Sample preparation procedures. Change to laboratory

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