FLUID INCLUSION RESEARCH

PROCEEDINGS OF COFFI

VOL. 5, 1972

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IMPORTANT SUBSCRIPTION INFORMATION

This is the last issue of Fluid Inclusion Research — Proceedings of COFFI on which I personally will arrange for printing and binding, and handle mailing and subscriptions. Starting with the next issue, Volume 6, for 1973, the University of Michigan Press will handle all subscriptions, printing, binding, and mailing. All subscription correspondence, and checks in payment for Volume 6 onwards, should be made out to University of Michigan Press and addressed to:

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I will continue to fill orders personally for reprints of Volumes 1-5 at $3.00 per volume, postpaid. Starting with Volume 6, however, the price will be $6.00 per volume, postpaid. Orders for Volume 6 and subsequent volumes that were prepaid at the time of publication of this notice will be honored at the old rate of $3.00 per volume, postpaid. Buyers who wish to pay for air mail delivery may continue to do so.

Although I regret the price rise, it is necessary under the new press arrangements, even though the University of Michigan Press is a non-profit organization and my services are provided without charge. However, this change in procedure will enable me to spend more time on editorial duties, as my responsibilities will now end with providing camera-ready copy to the Press, as free as possible from typographic, bibliographic, or scientific errors. It should also result in cutting down the time for publication of each volume. All correspondence concerning editorial matters, and particularly offers of help on abstracting or translation, should continue to be addressed to:

Edwin Roedder, Editor
Fluid Inclusion Research
U.S. Geological Survey — 959
Reston, VA. 22092, USA

FLUID INCLUSION RESEARCH --PROCEEDINGS OF COFFI, VOL. 5, 1972

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EDITOR'S PREFACE

Fluid Inclusion Research - Proceedings of COFFI was started in 1968 as an offshoot of the Commission on Ore-Forming Fluids in Inclusions (COFFI) of the International Association on the Genesis of Ore Deposits (IAGOD). Although closely connected with COFFI and IAGOD, the publication of Fluid Inclusion Research is independently arranged, and separately financed by subscriptions, on a non-profit basis. It was started with a loan from the International Union of Geological Sciences. The original plan was that it would provide abstracts or annotated bibliographic notes of papers published during the volume year that either contain inclusion data or are pertinent to inclusion workers, English translations of inclusion papers from foreign languages, where available and not otherwise published, and notices and programs of forthcoming meetings and symposia. Although each abstract and translation is duly credited, the Editor wishes to acknowledge, in particular, the help of Dr. M. Fleischer who provided translations of many Russian titles, figure captions, etc. Many individuals, too numerous to list, have helped by sending the Editor books, reprints, references, and copies of abstracts. He is particularly indebted to Prof. Ermakov for copies of Russian books. Chemical Abstracts, of Columbus, Ohio, has most graciously permitted the use of a limited number of their copyrighted abstracts, as indicated by "C.A.", or the full abstract citation. The Editor has revised some authors' abstracts rather extensively, particularly those from foreign language journals, in order to clarify the language, but has not attempted to bring the bibliographic citations in translated articles up to Western standards. To authors of pertinent articles that have been omitted or are misquoted here in his haste, or through language difficulties, his apologies and his request to have these things called to his attention; to authors whose Authors' abstracts have been drastically shortened, edited or revised, 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. There are gross inconsistencies in the methods of citation, transliteration, abstracting, and indexing; these shortcomings are blamed mainly on the lack of time on the Editor's part, with the exception of abstracts of articles dealing with decrepitation, to which he gives short shrift due to admitted personal bias. As before, the Editor will be glad to furnish free 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. Otherwise, photocpies of the Russian original can be provided at $.25 per page.

Organization of COFFI

The Bureau of COFFI consists of five officers as follows: Chairman--E. Roedder, USA; First V. Chairman--H. Imai, Japan; Second V. Chairman--F.P. Melnikov, USSR; Third V. Chairman--M. Solomon, Australia; and Secretary, G. Deicha, France. A series of Regional Representatives have also been established, to provide foci for coordination and exchange of information on COFFI activities. The following list is still tentative and incomplete, and will be revised in future issues.

Africa: Dr. H.M. El Shatoury, Assoc. Prof. of Geology, Egyptian Atomic Energy Authority (presently at Dept. Mineral Devel. Eng., Univ. of Tokyo, 7-3-1 Hongo, Bunkyo-Ku, Tokyo 113, Japan

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Moscow State University, Moscow, B234, U.S.S.R.

NOTICES OF MEETINGS AND SYMPOSIA

PAST SYMPOSIA

The Fourth Soviet All-Union Conference on Thermobarometry met at Rostov-on-Don in September, 1973, with 135 papers presented on various fluid inclusion subjects. The 351-page volume of extended abstracts of these papers (in Russian) has been received through the courtesy of Prof. N.P. Ermakov and many of these are being translated. As this volume of abstracts was published in 1973, the translations will appear in Fluid Inclusion Research - Proceedings of COFFI for 1973 (Volume 6).

The NATO Advanced Study Institute, "Volatiles in Metamorphism" was held in August-September, 1974 in Nancy, France and in the Alps. It involved a variety of discussions of fluid inclusion technique and application to metamorphic problems, but no publication is planned.

The Ninth General Meeting, International Mineralogical Association was held in Berlin-West and Regensburg (FRG) in September 1974; abstracts for the two Symposium Sessions on Fluid Inclusions will be given in Fluid Inclusion Research - Proceedings of COFFI for 1974 (Volume 7).

The Fourth General Meeting of the International Association on the Genesis of Ore Deposits was held at Varna, Bulgaria, in September, 1974. The abstracts for the many papers on inclusions at this meeting will also be given in Volume 7, as well as the smaller number of such papers at the International Symposium on Water-Rock Interaction (Prague, Sept. 1974) and at the Symposium on Metallization and Acid Magmatism (Karlovy Vary, Oct. 1974).

FUTURE SYMPOSIA

Plans are being laid for one or more sessions on fluid inclusions at the 25th International Geological Congress in Sidney, Australia, 16-25 August, 1976. All individuals interested should contact the Editor.

ABSTRACTS, TRANSLATED ABSTRACTS, OR ANNOTATED CITATIONS TO WORLD LITERATURE, 1972

Editor's notes: Although most of the references that follow are dated 1972, a few earlier ones are included which were missed in earlier issues of COFFI (due to oversight or unavailability) and are particularly pertinent, or had only been given before as a literature citation, without abstract. In general, older literature citations are not given if they are also to be found in the extensive bibliography in the Editor's publication: Data of Geochemistry, Sixth Edition, U.S. Geological Survey Professional Paper 440JJ, Composition of Fluid Inclusions (available from the U.S. Government Printing Office, Washington, D.C. 20402, \$2.75, Stock no. 2401-1211).

ADDY, S.K., and YPMA, J.M., 1972, Wall rock alternation as the result of regional metamorphic reactions: Oxygen isotope and microprobe studies at Ducktown, Tennessee (abst.): Geological Society of America, Abstracts with Programs, v. 4, no. 7, p. 430-431. First author at Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964.

The country rock around the massive sulfide ore bodies at Ducktown, Tennessee, consists of pelites and graywackes of staurolite grade metamorphism and shows increased grain size and chloritic alteration near the ore. Oxygen isotope analyses were carried out on ore + magnetite ± quartz ± calcite assemblage in 18 samples from the ore body and quartz ± biotite ± muscovite ± garnet ± chlorite in 16 samples from the alteration zone and 7 samples from the unaltered country rocks. Quartz-magnetite temperatures in the ore body range from 450°C to 510°C, whereas quartz-biotite temperatures are 370°C to 405°C in the alteration zone and 300°C to 390°C in the country rock. Concomitantly, a depletion in the δO_{18} values is noticed in the alteration zone compared to the unaltered country tock; quartz 11.2 ± 0.4 ‰ to 9.00 ± 0.7 ‰; muscovite 7.6 ± 0.9‰ to 5.5 ± 0.3‰; biotite 5.00 ± 0.6 to 3.3 ± 0.4‰ and garnet 7.00 ± 0.4 ‰ to 4.7 ± 0.4‰ relative to SMOW, suggesting that the ore zones were the loci of isotopically light water. The fact that garnets have also been influenced is of special interest since microprobe studies of garnets from the alteration zone indicate Fe-Mn-Mg and Ca zoning with a tendency to concentrate Mn and Ca in the core and Fe and Mg at the edges. This is regarded as a regular feature of garnet growth during regional metamorphism. Any model calling for the hydrothermal emplacement of the Ducktown ores has to take into consideration the fact that the isotopically light alteration zone was formed during the regional metamorphism. (Authors' abstract.)

AKHVLEDIANI, R. A., 1972, Mineralogy of veins of "Alpine" type of the Khdesh-Kali and Shoda deposits: Izdat. Mezhniereba, Tbilisi. 74 pp plus 29 photographs (in Russian).

A review (83 ref.) of the mineralogy of these cleft-type veins, with sections on quartz, calcite, albite, chlorite, prehnite, etc, including crystal habit, DTA etc. Table 3 lists 11 analyses of water extracts of samples of quartz, for HCO_3, Cl, SO_4, Na, K, Ca, and Mg. (E.R.)

ALBAREDE, F. and BOTTINGA, Y., 1972, Kinetic disequilibrium in trace element partitioning between phenocrysts and host lava: Geochim. Cosmochim. Acta, v. 36, p. 141-156. First author at Groupe de Recherches Geochimiques Louis Barrabe, Institut de Physique du Globe, Universite de Paris VI, et Laboratoire de Petrologie, Universite de Montpellier, 34-Montpellier, France.

By means of general crystallization models it is shown that in general the observed partition coefficients for trace element distribution between phenocrysts and host lava are not equilibrium coefficients. This disequilibrium between the host lava and the phenocrysts, as far as trace element partitioning is concerned is due to an imbalance between the rate of crystal growth and trace element diffusion in the lava and in the crystal. It is suggested that the inverse correlation of grain size and certain trace-element concentrations for lunar basalts and oceanic tholeiites might be due to these kinetic effects. (Authors' abstract)

ALYEKHIN, Yu.V., PASHKOV, Yu.N., and DISTLER, V.V., 1970, Characteristics of greisenization, as indicated by gas-liquid inclusions in minerals: Akad. Nauk SSSR, Geol. Rudnykh Mestorozh., 1970, no. 3, p. 33-40 (In Russian; translated in Internat. Geol. Review, v. 14, no. 6, p. 639-644, 1972; abstract on p.iii)

Conditions of origin of metasomatic rocks in a greisen ore deposit in eastern Zabaykal'ye are characterized. Temperatures, pressures, pH levels, and CO_2 content of the mineral-forming fluid, as captured, are determined by microscopic, cryometric, and thermometric studies of such inclusions in quartz from different hydrothermal-metasomatic formations which were identified. (Authors' abstract).

ANDERSON, A.T., & WRIGHT, T.L., 1972, Phenocrysts and glass inclusions and their bearing on oxidation and mixing of basaltic magmas, Kilauea Volcano, Hawaii.: Amer. Mineralogist, v. 57, p. 188-216. Author at Department of Geophysical Sciences, The University of Chicago, Chicago, Illinois 60637.

The textures and chemical compositions of phenocrysts and glasses reveal how the composition, temperature, and oxygen fugacity of three fractionated lavas of Kilauea volcano changed before, during, and after ascent of the magmas to the surface. Intratelluric crystallization of magnetite and ilmenite begins in fractionated liquids at about 1120°C, log $f_{O_2} = -8.1$ but with variations depending upon the nature of prior magma mixing. These conditions are consistent with initial evolution of the magmas from a submarine-type precursor in systems closed to both oxygen and water. The fractionated magmas mix together and possibly with variable amounts of less fractionated liquids prior to or during eruption. Reversely zoned oxide phenocrysts with anomalously fractionated glass inclusions result. Magma effervescence during ascent causes rapid crystallization of microphenocrysts, rise in temperature, and decrease in oxidation state. These changes are contrary to popular belief and are attested to by the compositional zoning and resorption of the oxide phenocrysts. The inferred heating and reduction (to 1180°C, log $f_{O_2} = -8.1$) are in quantitative agreement with expectations based on the effects of H_2O on crystallization temperature and of SO_2 on oxidation state. Following eruption the inferred temperatures and oxygen fugacities fell to 1050°C and log $f_{O_2} = -10.2$.

Comparison of Kilauean with other basalts and with minerals of ultramafic nodules suggests that the intratelluric redox conditions of oxide saturated basaltic magmas and mantle materials are collinear within an uncertainty of 0.5 log units f_{O_2}. Differences in redox state between various oxide saturated basalt magmas may be due to differential gas loss prior to eruption. (Authors' abstract)

ANDERSON, C.A. and NASH, J.T., 1972, Geology of the massive sulfide deposits at Jerome, Arizona--a reinterpretation: Economic Geology, v. 67, no. 7, pp. 845-863. Authors at U.S. Geol. Survey.

The massive sulfide deposits at Jerome, consisting largely of pyrite, chalcopyrite, and sphalerite, are concordant stratabound lenses in massive quartz-bearing crystal tuffs of Precambrian age and overlying bedded tuffaceous rocks. The crystal tuffs were emplaced as submarine pyroclastic flows. The evidence permits the interpretation that the massive sulfide lenses are essentially syngenetic and related to hydrothermal brines that discharged into a submarine basin. The host rocks and sulfide lenses were folded and metamorphosed. Two periods of folding can be recognized; during the second period, the older folds were deformed along vertical axes, and some of the chalcopyrite in the major lens migrated downward to form shoots of intersecting veins in the crystal tuff and chloritized tuff (black schist). Fluid inclusions in volcaniclastic and vein quartz appear to be related to deformation and metamorphism and provide no direct evidence on the nature of the primary fluids that presumable introduced the ore metals to the volcanic rocks accumulating on the sea floor. Liquid CO_2-bearing inclusions are restricted to rocks and veins near the United Verde deposit and associated chalcopyrite ore shoots. Fluids at that time were CO_2-rich, with temperatures of approximately 235°C and confining pressures of about 700 bars or less. (Authors' abstract)

ANDRUSENKO, N.I., 1971, Thermobarogeochemistry of hydrothermal solutions on the basis of inclusions in minerals, in Mineralogy and genesis of the Iceland spar deposits of the Siberian platform: Moscow, Izdatel'stvo "Nedra", pp. 178-217 (and bibliography, pp. 221-227). (Note: the 76-page typescript of the complete translation of this item, (including 136 references), by Dorothy B. Vitaliano, is available from the Editor; space permits only a summary of the major findings here.)

The Iceland spar deposits of the Siberian platform have been investigated extensively, both in the field and laboratory, as indicated in the voluminous bibliography. Some of the primary inclusions are large, containing up to 1.5 cm^3 of solution; most are two-phase (liquid plus gas), but a few small daughter crystals were identified as halite, acicular zeolite, chalcopyrite, and bowlingite (saponite). Andrusenko believes a decrepitation method is not suited for calcite, and presents only homogenization data (Table 47), along with filling coefficients determined optically. She indicates that histograms of the homogenization temperatures show that "in deposits of the same type, the maximums coincide...", using Fig. 47 as an example (sic.). Although generally the homogenization temperature decreases with growth stage, several deposits show abrupt upward jumps (e.g., "380-130-230-120-220-100-200-40-180-70-30°C"). These fluctuations in temperature (and in density) are "related to an increase in the volume of the voids upon formation of cracks and drop in pressure, and possibly to a pulsational character of arrival of solutions of different temperatures." (Ed. note: the latter explanation seems invalid, since the three temperature increases mentioned above would develop internal pressures in the earlier, denser inclusions of 1600-2000 atmospheres, and the deposits are believed to be formed at very shallow depths (i.e., low confining pressure), yet calcite decrepitates with very low internal pressures). Some lateral variation in homogenization temperature of samples from a given deposit is reported. Inclusions in associated analcite and apophyllite crystals leaked and could not be used for homogenization, but quartz and celestite yielded homogenization temperatures comparable to the calcite from the same deposit. Decrepitation temperatures are also given for associated skarn dolomite, garnet, and viluite (a synonym for grossular *or* vesuvianite; Ed.).

The extensive Soviet studies (42 analyses) of the composition of the fluids are summarized in Table 49. The same samples have been analyzed by two methods; from this A assumes that the larger amounts of bicarbonate in the aqueous extracts were due to solubility of the enclosing calcite, and this and the equivalent Ca^{++} must be subtracted. The fluids are essentially calcium-sodium chloride brines. SO_4 and F were found only in analyses from deposits where fluoride-bearing apophyllite, apatite, or sulfate minerals occur. Small amounts of free CO_2 were also found, along with N_2 and O_2 in atmospheric ratio. The low contents of bicarbonate are assumed to result from its loss on crystallization of the calcite. The ratio Na/Ca varies significantly with the type of occurrence.

Leach analyses were made from associated minerals from two types of deposits (Table 50).

The concentrations of the solutions were determined by two methods-calculation from the analyses, and cryometry (Table 51). A distinguishes three types of freezing behavior - freezing with darkening, without darkening, and without darkening, plus elimination of the vapor phase (also metastable supercooling). A uses "freezing temperature" apparently to indicate the temperature at which freezing occurs during cooling, and "melting temperature of the cryohydrate" for the disappearance of the last solid crystal during warming (Table 52), apparently under dynamic conditions.

The pH of the solutions, measured by several methods, varied over the range 4-9.8.

All of these data are brought together in a 17-page summary section on the geology, paragenesis and solution evolution for the various types of deposits (ER).

ANFILOGOV, V.N., ABRAMOV, V.A., KOVALENKO, V.I. and OGORODOVA, V.Ya., 1972, Phase ratios in the agpaitic (crystallization) zone of the system $Na_2O-K_2O-Al_2O_3-SiO_2-H_2O$ at a pressure of 1000 kg/cm^2: Akad. Nauk SSSR, Doklady, v. 204, no. 4, p. 944-947. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 204, 1972, p. 148-151). Authors at Institute of Geochemistry, Siberian Division, Academy of Sciences, USSR, Irkutsk.

Experimentally determined relationships (Figs. 1, 2, 3) and compositions of coexisting liquid and fluidal phases (Table 1) suggest among other things that alkalic granites, sodium rhyolites, and alkalic-granitic pegmatites may indeed crystallize at up to 0.3% Na_2O (weight) in the fluidal phase. A decrease in the temperature in that field would cause stratification of the granitic melt. Excess of water is one of the prerequisites of the liquation (i.e., immiscibility) of such magmas. If so, the process may not take place in effusive analogs of alkalic granites which crystallize from relatively dry magmas. As to general evolution and crystallization of the melt, 0.1 to 0.3% Na_2O in the fluid harmonizes quite well with the evolution of natural parageneses in alkalic granitoids. The phase relationships show also that melting of granite, in the system with high agpaite coefficients, begins at much lower temperatures than in the granite-H_2O system. In such circumstances the two alkalic feldspars may crystallize simultaneously, in the paragenesis which is typical of the rare-metals alkalic granitoids. (Authors' abstract, translated in Internat. Geol. Review, v. 14, no. 12, 1972, p. 1377).

ANTHONY, T.R., CLINE, H.E., 1972, The interaction of migrating liquid inclusions with grain boundaries in solids, in The Nature and Behavior of Grain Boundaries, ed. by Hsun Hu: New Hork, Plenum Press, p. 185-201.

Material similar to that covered by abstracts of Cline and Anthony (1971) and Anthony and Cline, (1971) in Fluid Inclusion Research, v. 4, 1971. (E.R.)

ANTHONY, T.R. and CLINE, H.E., 1972, The thermomigration of biphase vapor-liquid droplets in solids: Acta Metallur., v. 20, [illegible] (Authors at Metallurgy and Ceramics Laboratory, General Elect. Co., Schenectady, N.Y.

The thermomigration of biphase vapor-liquid droplets was studied in KCl as a function of droplet size and the relative proportions of gas and liquid phases in the droplets. Droplets containing more than ten volume percent of gas migrated down thermal gradients toward lower temperatures in contrast to usual thermomigration behavior of simple gas or liquid inclusions up thermal gradients in solids. By considering viscous gas flow, vapor diffusion, liquid diffusion, evaporation and condensation, and liquid currents driven by surface tension gradients, the observed thermomigration behavior of biphase vapor-liquid droplets can be adequately explained. The results of this and previous investigations were applied to the thermomigration problems associated with the proposed storage of radioactive waste products in abandoned salt mines. The results concur with previous investigations in that the thermomigration of naturally occurring brine droplets in a salt formation up thermal gradients, generated by the self-heating of these nuclear wastes, is shown to be capable of causing a slight inflow of water into the proposed nuclear waste crypts. On the basis of studies on single and bicrystals of KCl it would appear that the dispersal of radioactivity, resulting from the self-heating of nuclear wastes stored in natural salt formations, would be small. Droplet migration along the gravitational field or along the weak natural thermal gradient of the earth would be prevented by the trapping of droplets on grain boundaries in the salt and, thus, the escape of radioactivity to the outside environment is unlikely even on a geological time scale. (Authors' abstract)

ANWAR, Y.M., EL-MAHDY, O.R. and EL-DAHHAR, MOHAMED, 1972, Geology and origin of the lead-zinc ores of Um Gheig Area, Egypt (abst): Geological Society of America, Abstractswith Programs, v. 4, no. 7, p. 435-436. Authors at Geology Department, Faculty of Science, Alexandria University , Egypt.

The Um Gheig area is located 52 km south of the town of Quasseir, and 7 km inland from the Red Sea coast, in the Eastern Desert, Egypt. The exposed rock units are of Middle Miocene age and are divided into two series. The upper series are of lagoonal characteristics and contain oil-tainted limestones and gypsum formations. Those of the basal series are characterized by the dominance of calcareous matter at the top and detrital ones at the base. Their constituent rock units are limegrit, conglomerate, sand, grit, clay, and limestones. The Middle Miocene Formations are generally gently dipping about 25° to the NE and strike nearly parallel to the present shore line of the Red Sea. Several faults striking NNW-SSE and to a lesser extent

NNE-SSW and N-S cut these formations. The faults are generally steeply dipping to the west.

The ore is restricted to the Limegrit formation and it consists essentially of galena, cerussite, smithsonite, hemimorphite, and wulfenite. The minerals exhibit one or several of the following modes of occurrences: pockets, disseminations, open space fillings, encrustations, and replacements. Part of the cerrussite occurs as a tabular body (50 cm thick) within clays and limegrit. The ore exhibits the following characteristics: close confinement to one stratigraphic horizon (limegrit), erratic distribution of ore bodies and minerals among the mine levels, shallow depths and low temperature of formation. The trace elements detected are not only scarce but are heterogeneous among the different minerals. Feeders or conduits that may have acted as channel ways for ore transport are lackings. There are no potential igneous sources for the ore constituents in the immediate vicinity of the area.

The alteration is generally pervasive from slight to moderate through high degrees. Two genetic types of alteration, namely supergene alteration, and alteration due to ascending hot meteoric waters are recognized. The alteration assemblage of minerals is of simple mineralogy and reflects surface P-T, fluctuating pH and simple Eh conditions.

The character of the primary ore suggests that its source is subsurface pools of hot brines, similar to those detected in the 1960's in the Red Sea, that are abnormally enriched in Pb-Zn (20,000 times the content in normal sea water). Deposition of the ore minerals occurred in restricted arms of the sea during or shortly after the deposition of the limegrit through reduction of the Pb-Zn bearing solutions by either bacterial action or H_2S-rich hydrocarbons, or mixing of these hot brines with other sulphur-rich ones. Later rejuvenation resulted in the formation of wulfenite. (Authors' abstract.

APFEL, R.E., 1972a, The tensile strength of liquids: Sci. Amer. v.227, no. 6, p. 58-62, 67-71.

A good review of many interesting aspects of negative pressure, pertinent to several types of metastability observed in fluid inclusions (ER).

APFEL, R.E., 1972b, Water superheated to 279.5°C at atmospheric pressure: Nature Physical Science, v. 238, no. 82, pp. 63-64.

A novel experimental technique for investigation of superheated liquids is described. Pertinent to problems of metastability of fluid inclusion fluids (ER).

AUTHIER, A., 1972, X-ray topography as a tool in crystal growth studies: Journ. of Crystal Growth, 13/14, p. 34-38. Author at Laboratoire de Minéralogie-Cristallographie, associé au CNRS, 9, Quai Saint-Bernard, Paris 5, France.

X-ray topography is a non-destructive method revealing extended imperfections such as dislocations, stacking faults, growth horizons, twins, inclusions and so on; in non too imperfect crystals, it has rapidly proved a very useful tool in studying problems related to crystal growth. The configuration, nature and density of lattice defects usually vary considerably depending on the method and conditions of growth as well as on the chemical nature of the crystal. One very frequent observes very different degrees of perfection for the same crystal grown by different methods, but similar configurations of defects for different crystals grown by the same method.

The dislocation configuration arising in crystals grown from the solution will be studied in more detail. Dislocations in this case tend to be linear and their orientation closely related to that of the growth faces. They usually constitute bundles originating at inclusions and along the interface between the seed and the new crystal, which is where the majority of dislocations are created. The importance of the surface of the seed and of the initial stages of the growth is therefore primordial for the quality of the crystal to be grown. Any fluctuation of the conditions of growth will usually produce a growth horizon along which dislocations are sometimes formed. (Author's abstract)

BADHAM, J.P.N., MORTON, R.D., and ROBINSON, B.W., 1972, The geology and genesis of the Great Bear Lake silver deposits (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 4, Mineral Deposits, p. 110 (In English). First author at Department of Geology, University of Alberta, Edmonton, Alberta, Canada.

The western sector of the Bear Province contains volcanics and sedimentary rocks of the Echo Bay Group (∿ 1800 m.y.) which were deposited within shallow basinal environments of the margins of the Slave Craton (∿ 2500 m.y.). These rocks are intruded by Hudsonian granitic plutons and 'porphyries' and by diabases (∿ 1400 m.y.).

A discrete metallogenic province is characterized by numerous vein-type U-Ag-Ni, Co arsenides-Bi deposits, occurring within NE-trending fault zones which transect Echo Bay Group lithologies. The general paragenetic sequence is: uraninite, hematite, quartz - (Ni,Co) arsenides, silver, dolomite - sulfides, (Sb, Bi, Ag) sulfosalts, carbonates, quartz and fluorite.

O^{18} studies of Echo Bay dolomites reveal a range of +22 to +13‰ (SMOW) (8 samples); the values for dolomites from other deposits are consistent at about +15 ‰(SMOW) (58 samples). These data, augmented by information from fluid inclusion and other studies, indicate a depositional thermal maximum, for the Echo Bay deposit, of 230°C, with early and late depositional temperatures of 150°C and 100°C respectively. 31 samples of calcites from the deposits exhibit isotopically lower O^{18} and C^{13} values than those of the dolomites. In the Echo Bay and Norex deposits a trend toward lower δO^{18} values was detected within late-stage calcites.

It is felt that the metalliferous components of the ore deposits originated within the Echo Bay volcanics and were probably transported by brines into the fracture zones during post-Hudsonian regional faulting. (Authors' abstract).

BALITSKIY, V.S., 1972, Structural-morphological features distinctive of quartz crystals as indicators of physico-chemical conditions for mineral deposition: in Typomorphism of Minerals and its Practical Significance, F.V. Chukhrov, ed.: Moscow, "Nedra" Press, p. 131-138. (In Russian).

BARANOV, I.Ya. and VASILENKO, V.N., 1972, Mineral thermometric studies of ore and a complex of post-magmatic veinlet formations of Cu-Ni deposits and ore showings in rocks of the Precambrian crystalline basement of the southeast slopes of the Voronezh anticline: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 185-191 (in Russian).

BARKER, Colin, 1972, Pyrolysis techniques for source rock evaluation (abst.): Geol. Soc. Am. Abstracts with Programs, v. 4, no. 7, p. 443. Author at Department of Chemistry, University of Tulsa, Tulsa, Okalhoma 74104.

Source rocks of petroleum are characterized by (1) generation of hydrocarbons and (2) migration of these hydrocarbons out of the rock. The process of generation, which leads ultimately to graphite and methane, is incomplete at depths of interest to the petroleum industry. When subsurface samples are heated in the laboratory they first release hydrocarbons which have already been generated and then at higher temperatures generate more hydrocarbons by the thermal breakdown of organic matter. These processes can be monitored by heating samples in a stream of helium which sweeps the evolved hydrocarbons into an ionization detector and gives a series of peaks. With increasing sample depth the low temperature peak (generated hydrocarbons) increases in size relative to the high temperature peak (unrealized generating potential). The temperature of the peak maximum for the second peak also moves to higher temperatures with increasing depth, i.e. increasing maturation. Direct evidence that migration has occurred depends on knowing the composition of the original organic matter so that it can be compared with the present composition. If some of the organic matter was trapped between clay minerals in microreservoirs any hydrocarbons generated there would not have been free to migrate and any migration out of the rock must have been from the open pores. This would produce differences in composition between the microreservoirs and the pore spaces. Experimental techniques developed for determining the composition of hydrocarbons in the microreservoirs and pore spaces have been used to study a Miocene section which included a source bed. In the non-source section the composition of the hydrocarbons from the microreservoirs and pore spaces were very similar but appreciable differences were found for the source rocks. (Author's abstract).

BARNES, H.L., 1972, Deposition of hydrothermal ores (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 5, Geochemistry, p. 295 (In English). Author at Ore Deposits Research Section, Pennsylvania State University, 208 Deike Bldg., University Park, Pennsylvania 16802, U.S.A.

The physico-chemical causes of deposition are useful criteria for predicting geologic environments localizing ores. Such reactions differ significantly for transport via sulfide complexes or chloride complexes, the two mechanisms capable of transporting metals of hydrothermal deposits. Processes causing deposition may be ranked in order of chemical efficiency based on the fraction of dissolved metals deposited by a geologically reasonable change of environment. For most sulfide complexes, such processes in approximate order of decreasing efficiency are: oxidation, increasing acidity, decreasing temperature, dilution, and decreasing pressure; the chloride complex sequence is: mixing with sulfide-rich solutions or rocks, reduction, decreasing acidity, decreasing temperature, and decreasing pressure. Deposition from these two solutions is efficient only under quite different geologic conditions.

Mississippi Valley ores show depositional evidence of oxidation (barite), pH decrease (carbonate removal) and dilution (variable D/H ratio of inclusions) at nearly constant pressure and temperature (sphalerite inclusion data) - processes of sulfide complex precipitation. *Porphyry copper deposits* indicate pressure decrease (brecciation), temperature decrease (vertical extent), and a possible increase in acidity (sericitic alteration) - permissively via sulfide complexes. *Vein deposits* of large vertical extent may be deposited by either pressure or temperature decrease from either complex. *Contact metasomatic deposits* suggest a decrease in temperature (gradient from intrusive), an increase in acidity (carbonate replacement), and possible oxidation (for example, with andradite) and dilution (by released CO_2). *Native copper deposits* indicate reduction (bleaching of hematitic rocks) to be important and perhaps other reactions associated with chloride transport. *Stratiform volcanic-associated deposits* (such as Bathurst) suggest a solution-mixing process of problematic nature. (Authors' abstract).

BARNES, Ivan, RAPP, J.B., O'NEIL, J.R., SHEPPARD, R.A., and GUDE, A.J., III, 1972, Metamorphic assemblages and the direction of flow of metamorphic fluids in four instances of serpentinization: Contr. Mineral. and Petrol., v. 35, p. 263-276. First author at U.S. Geological Survey, Menlo Park, Calif. 94025.

Fluids related to serpentinization are of at least three types. The first reported (Barnes and O'Neil, 1969) is a fluid of local meteoric origin, the chemical and thermodynamic properties of which are entirely controlled by olivine, orthopyroxene, brucite, and serpentine reactions. It is a Ca^{+2}--OH^{-1} type and is shown experimentally to be capable of reacting with albite to yield calcium hydroxy silicates. Rodingites may form where the Ca^{+2}--OH^{-1} type waters flow across the ultramafic contact and react with siliceous country rock.

The second type of fluid has its chemical composition largely controlled before it enters the ultramafic rocks, but reactions within the ultramafic rocks fix the thermodynamic properties by reactions of orthopyroxene, olivine, calcite, brucite, and serpentine. The precipitation of brucite from this fluid clearly shows that fluid flow allows reaction products to be deposited at a distance from the point of solution. Thus, textural evidence for volume relations during serpentinization may not be valid.

The third type of fluid has its chemical properties fixed in part before the reactions with ultramafic rocks, in part by the reactions of orthopyroxene, olivine, and serpentine and in part by reactions with siliceous country rock at the contact. The reactions of the ultramafic rock and country rock with the fluid must be contemporaneous and require flow to be along the contact. This third type of fluid is grossly supersaturated with talc and tremolite, both found along the contact. The occurrence of magadiite, kenyaite, mountainite, and rhodesite along the contact is probably due to a late stage low-temperature reaction of fluids of the same thermodynamic properties as those that formed the talc and tremolite at higher temperatures. Oxygen isotope analyses of some of these minerals support this conclusion.

Rodingites form from Ca^{+2}-rich fluids flowing across the contact; talc and tremolite form from silica-rich fluids flowing along the contact.

Isotopic analyses of the fluids indicate varied origins including unaltered local meteoric water and connate water. Complexion Spring water may be a sample of only slightly altered Jurassic or Cretaceous sea water. (Authors' abstract).

BARRON, L.M., 1972, Cooling paths calculated in some ternary systems (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 2, Petrology, p. 36 (In English). Author at Geological Survey of N.S.W., P.O.Box R216, Royal Exchange, Sydney 2001, New South Wales, Australia.

Crystal fractionation paths are constructed graphically and by computer in the calculated ternary diopside-albite-anorthite system (Barron 1970). Small variations in degrees of local fractionation (F± 10%) vary the coexisting plagioclase composition as much as 5 per cent An at a fixed temperature and could cause zoning in igneous bodies which have very low thermal gradients due to convection. The liquidus in the calculated granite system shows, in agreement with Tuttle and Bowen (1958), that up to 50 per cent of the field of feldspar crystallization of granites may produce the same composition of alkali feldspar at two stages on the same crystallization path. Using a hypothetical alkali feldspar solvus of 1,050°C at Or$_{40}$, the region on the calculated ternary liquidus of two feldspars is defined, by the isotherms and icophases (sic), as a parabolic envelope from the cotectic closing towards the binary Ab-Or. This envelope need not cover the feldspar trough and the ternary minimum. Equilibrium and isolated cooling paths through the calculated two-liquid immiscibility field in quartz-fayalite-leucite (Barron, 1970) are constructed graphically. Immiscibility tie-lines that rotate rapidly with temperature will cause the equilibrium two-liquid path to deviate strongly from the isolated two-liquid path, but this does not occur in the calculated immiscibility field. Crystal fractionation occurring in cooling immiscible miscible droplets in the liquid closest to the composition of the fractionating phase. The other liquid will leave the immiscibility field. (Authors' abstract).

BARTUSKA, Miloslav, 1970, Study of volatile inclusions in rock quartz: I, Microscopic evaluation of rock quartz and porous inclusions: Silikaty, v. 14, no. 4, p. 297-307. (in Czech, with two-page summary in English). Author at Dept. of Technol. of Silicates, Chem.-Tech. Univ., Prague.

A study of the behavior of fluid inclusions in quartz during its calcination at temperatures of 800-1700° C as a ceramic raw material. See also parts II (Hlavac, et al.,) and III (Dusil, et al.). (ER).

BAUMANN, LUDWIG; HARZER, DIETER, and LEEDER, OTTO, 1972, Contribution to the characteristics of mineral-forming solutions in some hydrothermal deposits of the DDR: Ber. deutsch. Ges. für geol. Wiss., Reihe B. Mineral. und Lagerstättenf., v. 17, no. 3, p. 341-355. (in German).

Fluorites of some fluorite-barite deposits (Rottleberode and Strassberg, Harz; Schönbrunn, Vogtland etc. DDR) of economical importance have been investigated. The homogenization temperatures were measured on a heating stage microscope (10,000 measurements on 160 preparations). The results permitted statistical distinction between the different fluorite generations and the various levels in a given mine, as well as the different deposits: The homogenization temperatures range between 60°C and 400°C; 90°C - 160°C are the most frequent values. (A pressure correction is not discussed and the homogenization temperatures are given as identical with the formation temperatures of the fluorites.)

The chemical investigations of the fluid inclusions include flame photometric determinations of the Na and K content, argentometric Cl-analysis, spectroanalytic determinations of the trace elements and mass-spectrometric determinations of the gases.

The average salinity is 13% (always over 5%) and the average K/Na ratio is 0.18 (always over 0.04). These values show the same dependences as the homogenization temperatures. Determinations of O^{18} and C^{13} on the carbonates and O^{18} on quartz demonstrate a difference in the genesis of the Postvariscian (Harz, Schönbrunn, Erzgebirge, Freiberg) and the Variscian (Erzgebirge, Freiberg) deposits. With the model of pure magmatic water for the Postvariscian mineral formation, there is a good correspondence between the homogenization temperatures and the O^{18}-determinations. In the Variscian deposits on the other hand, a mixture of juvenile and surface water is present on the basis of the O^{18}-determinations. (Abstract by H.A. Stalder).

BAZAROV, L. Sh., KOSALS, Ya. A. and SENINA, V.A., 1972, Temperature of formation of zinnwaldite-amazonite-albite apogranite: Akad. Nauk SSSR, Doklady, v. 203, no. 3, p. 685-688 (in Russian). Translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 203, p. 197-199; Abstract translated in Internat. Geol. Review, v. 14, no. 9, p. 1029-1030. Authors at Inst. Geology and Geoph., Siberian Div., Acad. Sci. USSR, Novosibirsk.

Homogenization temperatures of gas-liquid inclusions in quartz from vertically and laterally zoned apogranites (table 1) were found to be, on the whole, in agreement with the crystallization temperatures of the apogranites, as indicated by the feldspars (table 2). Analysis of the results, including paragenesis and other data, suggests the following temperatures of crystallization (°C): unaltered original granites 800-1020°; microclinized muscovitized granites and protolithionite-microcline-albite apogranites 710-800°; zinnwaldite-amazonite-albite apogranites 640-710°C. This early stage of crystallization of the zinnwaldite-amazonite-albite apogranites from liquid solution was followed by further crystallization from gas solutions. The relatively small change in the temperature (710 to 640°C) and in volume of the rock was sufficient to change the state of the solution (liquid to gas), possibly because the solutions were mere films in interstitial and pore spaces within the rock. The zinnwaldite-albite-amazonite zone was forming at 410-620°C; the banded zinnwaldite (cryophyllite)-amazonite-albite zone at 400-520°; the zinnwaldite-topaz-quartz greisens (exocontactual) at 350-400°; quartz-amazonite veins at 260-350°. (Authors' abstract).

Ed.'s note: All the above homogenization temperatures are for liquid plus vapor inclusions, except the 800-1020° for the original granite, which refer to silicate melt inclusions.

BAZAROV, L.Sh., KOSALS, Ya.A., SENINA, V.A., and GORDEYEVA, V.I., 1972, Temperatures of crystallization of zoned quartz phenocrysts in apogranite: Akad. Nauk SSSR, Doklady, v. 205, no. 1, p. 175-178. (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sects., v. 205, no. 1, p. 111-113; abstract translated in Internat. Geol. Review, v. 14, no. 12, p. 1383, 1972). Authors at Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, USSR, Novosibirsk.

Quartz phenocrysts exhibit 2-8 zones. All zones have primary inclusions of gas and liquid (50 to 30% gas), and secondary inclusions of gas $\pm$ liquid + CO_2 $\pm$ solids. 4930 inclusions were homogenized, all in the liquid phase; primary inclusions homogenize at 480-410°, secondary at 380-120°C. Each successive zone shows a decrease in the homogenization temperature for primary inclusions. The gases in individual inclusions (of unspecified type) contained less than 11 vol. %Σ(HF, HCl, H_2S, SO_2, NH_3), by absorption techniques (ER).

BAZHENOVA, G.N., 1972, Composition of gas inclusions in anorthosite, charnockite and syenite of the Kalar pluton as an indicator of the conditions prevailing during metamorphism: Akad. Nauk SSSR, Doklady, v.

205, no. 1, p. 198-200 (in Russian). Translated in Doklady Acad. Sci. USSR, v. 205, no. 1, p. 156-158; abstract translated in Internat. Geol. Review, v. 14, no. 12, p. 1384, 1972. Author at O.Yu. Shmidt Institute of Earth Physics, USSR Academy of Sciences, Moscow.

Geochemically there is a radical difference between early and late stages of the metamorphism, anorthositization and granitization (charnockites, syenites) respectively, as illustrated by composition of the corresponding fluids: high H_2, CO, high CH_4, etc. in labrador (anorthosite); high CO_2, low H_2 and CH_4 in charnockite and syenite (table 1). The homogenization temperatures here are up to 950°C (labrador) and 700-800°C (feldspar from charnockites), respectively. The early and late stages may be equated with the Na "dry" and the K "wet" metamorphisms. (Authors' abstract).

BERZINA, A.P. and SOTNIKOV, V.I., 1972, Physico-chemical conditions of formation of some deposits associated with subvolcanic granites: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 164-169. (In Russian) CA 78 (10) 126794r (1973).

The subvolcanic granites of Zhyrekensk (Zh), Davendinsk (D), Sorsk (S), and Khatcheranginsk (Kh) ore deposits were formed during the Upper-Jurassic period in several stages involving volcanic and hydrothermal processes. Although different, these rocks were formed under similar thermodynamic conditions. The Zh area consists of microgranular granites, granite-porphyry, and felsites. The rocks are K feldspathized, argillized, and sericitized. The D deposits of Mo ores are assocd. with granite-porphyry and quartz-porphyry. Mo occurs in vein deposits and less often in stocks. The S area is characterized by subvolcanic, leucocratic granites and porphyry. The Kh Pb-bearing ores are assocd. with biotite granites and granite-porphyry. The cassiterite-quartz mineralization is not intense in the endocontact zones of biotite-granite stocks. The metasomatic changes of this facies include the development of K feldspar and greisen-contg. deposits. The study of liq.-gas inclusions of these minerals showed that K feldspar and albitic rocks were formed at 400-700° and 1200-2000 atm, argillized rocks at 300-400°, and greisenized rocks at 300-500° and 1000 atm.

BESKROVNYI, N. S., 1967, Petrography of bitumens and hydrocarbon gases as associates of hydrothermal activity: Leningrad, Nedra Press, 208 pp. (in Russian). (Also listed as Trudy VNIGRI, №258).

This book, although old, had a printing of only 800 copies, and a copy was sent to the Editor by the author. The book is in two parts. The first and larger part deals with the geologic conditions of the appearance of petroleum bitumens in volcanic pipes of the Siberian platform. The second deals with petroleum bitumens in crystalline rocks, including pegmatites and carbonates; uranium, gold, and other ores; quartz veins cutting Paleozoic and other metamorphic rocks in the Southern Fergana, and deep hydrocarbon flow in crystalline rocks of the Transbaikal. The 49 figures and 33 tables of data on these bitumens and their hosts, and the extensive bibliography (∿300 references) should be particularly valuable to students of these fascinating occurrences of hydrocarbons. (Based on partial translation by M. Fleischer; ER).

BESKROVNYI, N.S., 1968, Syngenetic ozokerites and mineral tars (asphalt) in hydrothermal veins of the Mir kimberlite pipe: Akad. Nauk

SSSR Doklady, v. 178, no. 1, p. 179-181 (in Russian).

BESKROVNYI, N.S. and LEBEDEV, B.A., 1971a, Occurrences of sphalerite and other hydrothermal minerals in the Gaurdak sulfur deposit, southeastern Turkmenia: Akad. Nauk SSSR, Doklady, v. 200, no. 1, p. 185-188 (in Russian). Translated in Acad. Sci. USSR, Doklady, v. 200, p. 129-131.

Celestite, fluorite, barite, danburite, hematite, gypsum, solid bitumens, quartz, sphalerite (high in Hg and Pb) oil, and gas occur in the deposit. Inclusions in colorless early fluorite homogenized at 130-160°C; those in later black fluorite (and quartz) at 70-75°; late gypsum and calcite, less than 50°C. (E.R.)

BESKROVNYI, N.S., LEBEDEV, B.A., 1971b, Petroleum manifestations in the caldera of Uzon volcano, Kamchatka: Akad. Nauk SSSR Doklady, v. 201, no. 4, p. 953-956 (in Russian).

BESKROVNYI, N.S., NABOKO, S.I., GLAVATSKIKH, S.F., ERMAKOVA, V.I., LEBEDEV, B.A., and TALIEV, S.D., 1971, The occurrence of petroleum in hydrothermal systems associated with volcanism: Akad. Nauk SSSR, Sibirskoe Otdel., Geol. i Geofiz., 1971, no. 2, p. 3-14 (in Russian).

Includes a summary of gas analyses and analyses of various hydrocarbons for C, H, S, and N+O. (ER)

BESWICK, D.M. and LANG, A.R., 1972, Some X-ray topographic observations on natural fluorite, The Philosophical Magazine, v. 26, no. 5, p. 1057-1070. Authors at H.H. Wills Physics Laboratory, University of Bristol.

Clear, generally flawless specimens, coloured and uncoloured, were studied. X-ray topographs confirmed that cold concentrated H_2SO_4 is a reliable dislocation etchant. The occurrence of Burgers vectors parallel to <110> was also confirmed. Bundles of very straight dislocations fanning out nearly perpendicular to the local growth constituted the common grown-in dislocation configuration. In between dislocation bundles dislocation-free volumes of millimetre dimensions could be found. One colourless crystal possessed a dislocation configuration closely resembling that of many melt-grown crystals, and was interpreted as evidence of crystallization of this specimen at a high temperature. Twin boundaries of interpenetrating twins appear to trap impurities which cause long-range distortions. An occurrence of fault surfaces coinciding with growth sector boundaries was discovered, indicating a growth-direction-dependent departure from cubic symmetry. Absolute measurements of 111 and 220 structure factors from x-ray Pendellösung fringe spacings could not be made with less than several per cent error because of lattice distortions. (Authors' abstract.)

BIGGAR, G.M., 1972, Diopside, lithium metasilicate, and the 1968 temperature scale: Mineralogical Magazine, June 1972, v. 38, p. 768-770.

After a discussion of the several high-temperature calibration points in use and errors in their determination, B proposed the following points" Ag (no oxygen) 961.93; Au 1064.43; $Li_2O \cdot SiO_2$ 1208; $CaO \cdot MgO \cdot SiO_2$ 1395.3; Pd 1554; and Pt 1772°C (ER).

BIRKELAND, Tore, & BJØRLYKKE, Arne, 1972, Fluid inclusion studies from the lead- and zinc-bearing veins at Tråk, Bamble: Norges geol. Unders. v. 277, p. 1-5.

Fluid inclusions in quartz show that the mineralization was derived from solutions of low salinity, at temperatures from ca. 260°C to ca. 220°C and at a pressure of 300-400 bars. The low salinity shows that the hydrothermal solution may possibly have been diluted by meteoric water. (Authors' abstract)

BLACHERE, J.R. and YOUNG, J.E., 1972, The freezing point of water in porous glass: Amer. Cer. Soc. Jour., v. 55, p. 306-308. Authors at State University of New York College of Ceramics at Alfred University, Alfred, New York 14802.

Lowering of the freezing point of water in porous glass was studied by a DTA technique. The samples contained a spectrum of average pore sizes (60-1000A radius). The freezing-point lowerings (0 to -8°C) measured from melting and freezing curves correlated, as predicted by simple capillary theory, with the average pore size of the sample. This result is discussed in terms of capillary-condensation theory and theories of frost damage in porous materials. (Authors' abstract, modified)

BLACKMAN, M. and SAMBLES, J.R.,1970, Melting of very small particles during evaporation at constant temperature: Nature, v. 226, no. 5249, p. 938, June 6, 1970.

The authors describe a method for determining the melting point very tiny particles (<10nm) and discuss its use to determine the decrease in melting point with radius (ER).

BOCHAREV, A.I., 1971, Characteristics of the formation of hydrothermal metamorphic quartz crystal geodes: Vses. Mineral. Obshch., Zap., v. 100, No. 3, p. 309-313. (in Russian).

Includes 4 analyses of leachates for Cl, HCO_3, Ca, Mg, (Na+K), and pH, and spectrographic determinations of minor elements in the host quartz. (ER).

BOCHKAREV, B.N., 1972, Activation analysis of minor elements in natural and synthetic quartz: in Experimental investigations in mineralogy, 1970-1971, A.A. Godovikov and V.S. Sobolev, eds.: Novosibirsk, Acad. Sci. USSR, Sib. Division, Inst. Geol. & Geophsy., p. 149-151 (in Russian).

Of significance in any neutron activation study of inclusions in quartz. (ER)

BOGDANOVA, V.I., 1972, Influence of admixtures on micro determination of zinc, copper and lead by means of amalgam accumulation polarography: in Experimental investigations in mineralogy, 1970-1971, A.A. Godovikov and V.S. Sobolev, eds.: Novosibirsk, Acad. Sci. USSR, Sib. Division, Inst. Geol. & Geophys., p. 134-136 (in Russian).

Of concern to inclusion study as the method has been used for heavy metals analysis. (ER)

BOGOYAVLENSKAYA, I.V., 1972, Foreign studies of inclusions of the mineral-forming media (1965-1967): in The Ore-Forming Environment Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 214-216. (In Russian)

BOGOYAVLENSKAYA, I. V., and NAUMOV, V. B., (Compilers), 1972, Inclusions of solutions and melts in minerals: Bibliography of Russian literature, 1970-1971: Moscow, Vernadski Institute 70 pp (in Russian) (N. P. Ermakov, Editor).

This is a very extensive alphabetical bibliography, listing 306 references for the years 1970-1971, and an additional 163 that were omitted in the preceeding Volume "Bibliography of Russian Literature for 100 years, 1870-1970" (see entry:Bogoyavlenskaya, I. V., Ermakov, N. P., and Naumov, V. B., 1971, in 1971 Fluid Inclusion Research). Unfortunately, there are no annotations, but the references are given more completely than is customary in many Soviet journals, and there is an author index that includes junior authors. Many of these references are to sources, e.g., theses, that are very difficult or impossible to obtain outside of the USSR. Only 300 copies of the volume were printed (the Editor has one, from which copies can be made if required). (E.R.)

BOL'SHAKOV, Yu.Ya., 1972, Gas accumulation in the evaporite formation of the Solikamsk basin: Akad. Nauk SSSR Doklady, v. 204, no. 5, p. 1222-1224. (in Russian, translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 204, p. 213-214).

A study of the gases found in inclusions in saline minerals and as mine gas (from joints and other cavities) in these Uralian evaporite deposits. The gas is under high pressure (>50 atm; termed "popping salt" in the West) and consists mainly of nitrogen, with generally $<10\%$ CH_4 and no C_2H_6. Hydrogen, helium, neon, and argon are also present (quoting data by Cherepennikov, 1949). The gas composition and amount differs with rock or mineral type, and B believes it is syngenetic. The mine gas has considerable more methane and higher alkanes, and has no relationship with rock type, hence B assigns an epigenetic origin to it. (ER).

BROCOUM, A.V., 1971, Paragenesis and fluid inclusions of the Tayoltita silver-gold bearing quartz vein deposit, Durango, Mexico: Master's thesis, Columbia Univ., N.Y.

BROWN, P.R.L., 1972, Occurrence of teschemacherite in a geothermal well at Broadlands, New Zealand: Amer. Mineral., v.57, p. 1304-1305 (Author at New Zealand Geol. Survey, Box 30368, Lower Hutt, New Zealand).

Teschemacherite, NH_4HCO_3, occurs at the wellhead of a drillhole where it forms by reaction between gases separating from deep geothermal waters. The gas content of the water discharged was calculated as 0.22 mole percent, of which 93.5 mole percent was CO_2; total NH_3 content of the waters was 5.5 ppm (Author's abstract, extended by ER).

BRYAN, W.B., 1972, Morphology of quench crystals in submarine basalts: Jour. of Geophys. Research, v. 77, no. 29, p. 5812-5819. Author at Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543

Submarine basalts from the mid-Atlantic ridge, Red Sea rift, and Joides site 105 in the western Atlantic have been studied in ultra thin, doubly polished thin sections. Most of the samples are pillow lava fragments containing a variety of skeletal crystal growth forms that can be related to three major textural zones in the pillows. Olivine appears as diffuse, lattice-like growths near quenched pillow margins, as elongated chainlike or hollow lantern-like forms within a partly crystallized variolitic zone, and as larger lantern shaped crystals within the holocrystalline pillow centers. Plagioclase forms acicular hollow prisms elongated parallel to a̲ in the variolitic zone. In cross section, these crystals often show sector zoning developed on the 001 and 010 faces. Each sector is also progressively zoned outward from a more calcic to a more sodic composition. In holocrystalline pillow cores, plagioclase forms more nearly equidimensional solid crystals with no trace of sector zoning. Pyroxene is rarely well crystallized and is typically found as feathery crystals intimately intergrown with plagioclase in the groundmass. Spinel and magnetite are ubiquitous in the samples examined, although the glassy pillow rims usually contain spinel but not magnetite. Within the variolitic zone and holocrystalline pillow interiors, magnetite appears both as skeletal crystals and as overgrowths on spinel. Sulphides (mainly pyrite) are especially abundant in the Red Sea lavas. Phenocrysts of olivine and plagioclase and subhedral and euhedral groundmass olivine and plagioclase show no evidence of growth by filling in of hollow or lattice-like crystals similar to those of the outer pillow zones. It is suggested that development of these skeletal forms is restricted to supercooled, highly viscous magma in which relatively rapid growth is combined with low rates of diffusion. Slower growth or more rapid diffusion rates or both at crystallization temperatures maintained close to the liquidus appear to promote more even growth rates and compositional homogeneity on all crystal faces; this possibility accounts for the more nearly equidimensional form and lack of sector zoning in phenocrysts and microphenocrysts. Petrographic observations support the division of sea floor basalts into 'olivine tholeiites' and 'plagioclase tholeiites', which has been suggested by other workers. The only large pyroxene crystals observed in the samples examined appear to be xenocrysts, and pyroxene is not a prominent quench (liquidus) phase in this or other samples studied. (Author's abstract) (Of pertinence to understanding silicate melt inclusions.)

BRZECZKOWSKI, Janusz, JANISZEWSKI, Tomasz, and PAWLOWSKA, Jadwiga, 1971, The decrepitation method and instruments used in the study of the temperature of formation of minerals and rocks: Przegl. Geol., v. 19, no. 8-9, p. 395-398. (in Polish with English & Russian summary). Authors at the Geol. Inst., Warsaw.

A decrepitometer, the first in Poland, was designed and built. Some details of construction and electronics are given. (ER).

BUERGER, M.J. and SHOEMAKER, G.L., 1972, A new thermal effect in opal (abst.): Geological Society of America, Abstracts with Programs, v.4, no. 7, p. 459. Authors at Institute of Materials Science, University of Connecticut, Storrs, Connecticut, 06268

Most common opal consists essentially of high cristobalite. Since it seemed possible that the minute crystallites in opal might be responsible for lowering the high-low transformation temperature to below ambient temperatures, a thermal effect in this region was sought. Differential scanning calorimeter revealed an exotherm which began at about -30°C on cooling, and an endotherm which began at about -60° on heating, but with a hysteresis between the cooling maximum and the heating minimum of about 30°. Nevertheless, powder photographs taken of the opal on both sides of the thermal effect showed only high cristobalite. Further experimentation revealed that both heat effects were sharpened and reduced in area after heating the opal to any temperature below 361°, but they vanish if the opal is preheated to 422°. Since opal is known to lose water on moderate heating, this effect was investigated and found to be rapid and nearly linear between about 100° and 361°, but substantially completed between 313° and 422°. Dried samples recovered thermal effects after reabsorbing water. It seems inescapable that the thermal effect is due to the water content of opal. Although water can be under-cooled somewhate, ice does not normally melt below 0° so the thermal effect which begins between -60° and -30° can hardly be due to ordinary melting. The low temperature of the effect may be related to the capillary dimensions of the water. (Authors' abstract)

CALAS, G. and TOURAY, J.-C., 1972, An upper limit for the crystallization temperature of "yellow" fluorite (with special reference to the thermal bleaching of samples from Valzergues, France): Modern Geology, v. 3, p. 209-210.

Primary fluid inclusions in fluorite from late Hercynian veins associated with barite, quartz, pyrite, and chalcopyrite, were studied. The freezing temperature ranged from -18 to -20°C, and homogenization temperatures of 100-135°C (calibration with benzil and acetanilid). Pressure corrections are estimated to be 10-20°C. Secondary inclusions were almost identical. Bleaching studies indicate that the maximum formation temperature was 220° ± 20°C. (ER)

CHAI, B.H.T., 1972, Experimental study of hydrothermal recrystallization of calcite, (abst.): Geological Society of America, Abstracts with Programs, v.4, no. 7, p. 467-468. Author at Department of Geology and Geophysics, Yale University, New Haven, Connecticut 06520.

The recrystallization of calcite has been investigated at 500°C and 650°C at 2 kilobars in the presence of: pure H_2O; 0.1 N NaCl solution, 2 N NaCl solution; 2 N $CaCl_2$ solution and each of the previously mentioned solutions with 0.1 mole fraction CO_2 added. The calcite starting material is nearly mono-dispersed with 90% of the grains falling in the size interval 3 to 5 microns. The recrystallization process involves growth of larger at the expense of smaller grains and a decrease in the total number of grains with time. At a given P, T and fluid composition

$$\bar{r} = kt^{1/3}$$

where r is the average radius of calcite grains, k is a growth rate constant strongly dependent on the experimental conditions and t is time. The grain size distribution tends to reach a steady state which is independent of time and experimental conditions. k is independent of the proportion of fluid in the system. Identical results are obtained when the volume ratio of fluid to calcite is 0.1 and 2. All other conditions being equal: k increases with increasing temperature; k increases with increasing concentration of a given salt; k is greater for $CaCl_2$ than NaCl; CO_2 greatly decreases k when mixed with pure H_2O but increases k when mixed with salt-bearing solutions. (Author's abstract).

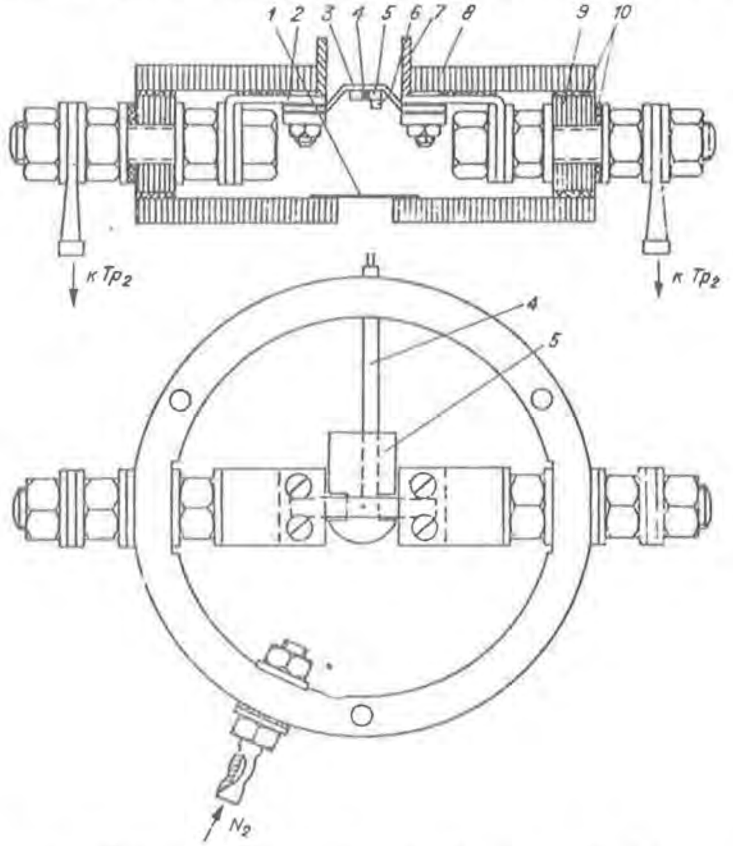
CHEN, Kuo-Hung and WILCOX, W.R., 1972, Boiling and convection during movement of solvent inclusions (abst.): Amer. Assocn. for Crystal Growth, 2nd National. Conf. on Crystal Growth. Princeton, N.J., 1972.

Boiling occurred in 0.5 mm diameter water and water-alcohol inclusions in NaCl, KCl and KI when the temperature was sufficiently high. Boiling points in a temperature gradient were 321°C for water in NaCl, 296°C for water - 50%v alcohol in NaCl, 249°C for water in KCl, 209°C for water - 50%v alcohol in KCl, and 137°C for water in KI. This boiling reduced the steady state rate of movement in a temperature gradient, although initial transients were often large. The rate of movement without boiling increased as the temperature increased and as the temperature gradient increased. It was generally higher with a horizontal temperature gradient than with a vertical gradient, indicating that free convection played a role in movement kinetics. Usually the hot side moved more rapidly than the cold side, causing the inclusion to lengthen and eventually break up. The presence of gas bubbles or boiling usually caused the cold side to move in the opposite direction. (Authors' abstract)

CHEPUROV, A.I. and POKHILENKO, N.P., 1972, Inert medium microchamber used for high-temperature study of inclusions in minerals: Acad. Sci. USSR, Sib. Div., Geol. and Geoph., 1972, no. 6, p. 139-141 (in Russian with English abstract).

An inert medium microchamber has been constructed for mineral-thermometric study of homogenization of inclusions. The contact method of heat transfer from the heating element permits one to obtain temperatures of about 1500°C and higher. Use of an inert medium provides a possibility of experimental study of minerals oxidized when exposed in air by heating them inside the microchamber. (Authors' abstract).

The authors' figure 2 shows the basic design features of the chamber (ER):



CHRISTOPHE MICHEL-LÉVY, M., 1972, Des inclusions fluides, peut-être aqueuses, dans un cristal de feldspath lunaire: Compt. Rend. Ser. D Sci. Natur., v. 274, no. 14, April 5, 1972, p. 1993-1994.

Reports a 6-μm liquid and gas inclusion in feldspar in lunar sample 14063,56, with a moving gas bubble (as evidenced by 2 photomicrographs). It does not consist of CO_2. (This is the only liquid inclusion found in all studies of the lunar samples. There remains a possibility that this could be from the trapping of liquids remaining during the solidification of epoxy embedding or mounting resins that had penetrated into a crack in the feldspar. (ER))

CLARK, N.A., LUNACEK, J.H. and BENEDEK, G.B., 1970, A study of Brownian motion using light scattering: American Jour. of Physics, v. 38, no. 5, p. 575-585. (Authors at Center for Materials Science and Engineering and Physics Department, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139)

A study of Brownian movement using laser light that provides an accurate determination of the diffusion constant. Of pertinence to measurements of the (apparent) Brownian movement of the bubbles in fluid inclusions (ER).

CLARK, T. and NALDRETT, A.J., 1972, The distribution of Fe and Ni between synthetic olivine and sulfide at 900°C: Economic Geology, v. 67, 1972, pp. 939-952.

Evacuated silica tube techniques have been used to investigate the partitioning of iron and nickel between coexisting iron-nickel olivine and mono-sulfide solid solution (Mss), $Fe_{1-x}S$-$Ni_{1-x}S$, in the presence of magnetite and tridymite. At 900°C and an oxygen fugacity close to that of the tridymite-fayalite-magnetite buffer, the distribution coefficient describing the partitioning is constant over a range of compositions of Mss from 0 to 19 wt % Ni, and has a value of $K_D = 33.2 \pm 3.4$ where

$$K_D = (N_{NiS}/N_{FeS})/(N_{NiSi_{\frac{1}{2}}O_2}/N_{FeSi_{\frac{1}{2}}O_2})$$

and N is the mole fraction. This is the result of four reversed experiments. Thermodynamic calculations indicate that temperature may have a pronounced effect on the distribution coefficient, the value decreasing with increase in temperature over the interval 700-1,100°C. Comparison of natural distribution coefficients with the experimental value suggests that equilibrium may have been reached in nature well above 900°C. (Authors' abstract). Of pertinence to understanding sulfide inclusions in magmatic silicates.

CLINE, H.E. and ANTHONY, T.R., 1972a, Effects of the magnitude and crystallographic direction of a thermal gradient on droplet migration in solids: Jour. Applied Physics, v. 43, no. 1, p. 10-15.

The migration behavior of saturated water inclusions in KCl was determined as a function of both the magnitude and the orientation of an applied thermal gradient. A flattening of the droplet perpendicular to the thermal gradient was observed to intensify with increasing thermal gradient. A nonlinear relation between the droplet migration rate and the applied thermal gradient was attributed to direct and indirect effects of interface kinetics. Below a critical thermal gradient dependent on droplet size, the migration velocity becomes zero. The crystallographic orientation of the thermal gradient had only a small effect on the shapes and velocities of small droplets. In contrast, the orientation of the thermal gradient significantly influenced the behavior of larger droplets, causing some of them to adopt chevronlike shapes (Authors' abstract)

CLINE, H.E., & ANTHONY, T.R., 1972b, The migration of liquid droplets in solids: Journ. of Crystal Growth 13/14 (1972), p. 790-794. Authors at General Electric Corporate Research, Schenectady, New York, U.S.A.

The migration of liquid H_2O droplets in transparent KCl crystals was directly observed under various driving forces including thermal gradients, accelerational fields, and grain boundary and solid-liquid surface tensions. In all cases, it was found that the kinetics of attachment and detachment of atoms at the solid-liquid interface of the droplet is the factor which determines the migration rate and shape change of the liquid droplets. For example, with thermal gradients and accelerational fields, no droplet motion was observed below a critical droplet driving force because of these interface kinetics.

The influence of interface kinetics was also demonstrated by examining changes of liquid droplets in KCl in two independent experiments. In the first experiment, it was shown that interface kinetics produce a flattening of the droplet perpendicular to its direction of motion. In the second experiment, already extended droplets were allowed to relax to their equilibrium shapes. Interface kinetics were found to retard the relaxation rate and to prevent large droplets from ever attaining an equiaxed shape.

Finally, droplets were migrated into grain boundaries in KCl. From the critical thermal gradient or acceleration field required to free the liquid droplets from the grain boundary, the grain boundary energy of KCl was determined. (Authors' abstract)

CURRIE, K.L., 1972, Control of peralkaline magma compositions by liquid immiscibility (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 14, Mineralogy, p. 415 (In English). Author at Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A OE8, Canada.

Melting experiments on ultrabasic alkaline rocks demonstrate that two or more immiscible fractions can form with compositions approximating carbonatite, melteigite and nepheline syenite. Field observations suggest that immiscibility occurs when olivine has finished crystallizing and crystallization of pyroxene has begun. If a significant carbonatite phase separates, it entrains with it large amounts of alkalies and titanium which eventually appear in the fenite aureoles surrounding carbonatites. The relatively soda-poor, alumina-rich residue crystallizes aegirine-augite and nepheline, producing ijolites and urtites, plus a later immiscible miaskitic syenite. If carbonate separation does not significantly affect the magma composition of the residue, large amounts of aluminous titanaugite are crystallized, greatly raising the Na/Al ratio, causing later separation of peralkaline syenites. Although both peralkaline and peraluminous alkaline rocks can be derived from nephelinitic parents by immiscibility, generation of large masses of syenite appears to require anatexis of pre-existing alkaline rocks, produced directly or indirectly by immiscibility. The ultimate source of alkaline rocks appears to be nephelinitic magma, which can be derived from alkali basalt by desilication processes due to volatiles. (Author's abstract).

DAVIDENKO, N.M., 1972, Conditions of formation of the gold-bearing veins of the Keperveemsk [junction (?)], western Chukotka (according to inclusions in minerals): in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 132-135 (in Russian).

DAVIS, J.B. and LINDSTROM, F., 1972, Spectrophotometric microdetermination of sulfate: Analytical Chemistry, v. 44, no. 3, p. 524-532. Authors at Department of Chemistry and Geology, Clemson University, Clemson, S.C. 29631.

A spectrophotometric method has been developed for the selective determination of sulfate in the 0-10 and 0-100 microgram ranges. The aqueous samples are treated with a mixture of hydriodic acid, acetic anhydride, and sodium hypophosphite and heated in a modified countercurrent reaction apparatus to evolve hydrogen sulfide. This gas is swept by nitrogen into a buffered solution of ferric ion and 1,10-phenanthroline, where it reduces ferric ion to ferrous ion. The bright orange tris (1,10-phenanthroline) iron(II) complex is formed and is measured spectrophotometrically at 510 nm. Of over 20 common ions, only nitrite and those ions capable of yielding hydrogen sulfide under the same conditions interfered. Sulfonated surfactants did not interfere.

(Authors' abstract) (Note: Sulfate is one of the most difficult inclusion microanalyses.)

DAVYDOVA, G.N., TEREMETSKAYA, A.G. and CHERNUKHA, F.P., 1972, Experimental evaluation of the formation temperature of rare-metal pegmatites in one of the regions of eastern Siberia: Vestn. Mosk. Univ., Geol. 1972, v. 27, no. 3, p. 40-46 (in Russian). Authors at Mosk. Gos. Univ., Moscow, USSR. CA 77 (10) 129022 c (1972)

Four paragenetic polymineral assemblages were recognized in the rare-metal pegmatites: (1) spodumene-quartz-albite, (2) spodumene-quartz-albite-microcline, (3) quartz-muscovite, and (4) quartz-albite. Decrepitometric detns. indicate that the 1st generation quartz crystd. at 540-490° and the 2nd at 440-420°. Compn., structural state, and degree of triclinicity of K feldspars and the amount of albite component in synthetic microclines were used to calc. the temp. of crystn, based on Barth's geothermometric curves. The pegmatites crystd. in 4 main stages commencing at 600° and culminating at 200°, with spodumene-quartz-albite assemblage at 600-490°, the spodumene-quartz-albite-microcline at 460-410°, the quartz-muscovite at 420-340°, and the quartz-albite assocn. 320-200°.

DAW, J.D., NICHOLSON, P.S., & EMBURY, J.D., 1972, Inhomogeneous dehydroxylation of talc: J. Amer. Ceramic Soc., v. 55, (1972), p. 149-151. Author at Department of Metallurgy and Materials Science, McMaster University, Hamilton, Ontario, Canada.

Dehydroxylation and enstatite development during the decomposition of talc were investigated by transmission electron microscopy using in situ heating. Bubbles and voids are produced during dehydroxylation, and enstatite then precipitates near the voids. Evidence of preferential bubble nucleation at dislocations was obtained. Enstatite crystallites of random orientation were observed initially but on further heating the product phase was formed topotactically. (Authors' abstract)

DEANS, T., SUKHESWALA, R.N., SETHNA, S.F., & VILADKAR, S.G., 1972, Metasomatic feldspar rocks (potash fenites) associated with the fluorite deposits and carbonatites of Amba Dongar, Gujarat, India: Inst. Mining and Metallur., Trans., Sect. B, v. 81, p. B-1-B-9. First author at Geochemical Division, Institute of Geological Sciences, London.

Rocks described as intrusive syenite or granite, occurring in the fluorspar mine at Amba Dongar, have been thought to indicate that these important fluorite deposits originated from acidic differentiates from the Deccan Traps, or even from granite. They consist largely of potash feldspar and are shown to be xenoliths of potash fenites of a type common in high-level carbonatite complexes, here developed by metasomatism of sandstones by intrusive alkaline carbonatites. Comparison is made with the similar association of large fluorite deposits with potash feldspar rocks and carbonatites at Okorusu in South West Africa, and attention is drawn to the possibilities of further discoveries of this type. The new information clarifies the relationships of the Amba Dongar carbonatite complex and fluorite deposits, the latter being low-temperature hydrothermal deposits from very dilute solutions. (Authors' abstract)

DEICHA, Georges, 1971, Granitic quartz microfissures and circulation of geochemical fluids of plutonic origin (abstr.): In E. Raguin Scientific Colloquium; Plutonic rocks in their relationships with ore deposits, Abstracts and short communications, p. 21-22: Paris, Ecole Nationale

Superieure des Mines.

DIMITRESCU, R. and BORCOŞ, M., 1972, Contribution to the study of paleogeothermometry of crystalline schists of the Fagaras and Ezer Mountains: Studii si Cercetari de Geol., Geof., Geog., Ser. Geol., v. 17, no. 2, p. 167-175 (in Roumanian with French abstract).

"Apparent" temperatures (of homogenization) of 255 to >>360°C are estimated to correspond to "real" metamorphic temperatures of 400 to >>665°C. (ER)

DMITRIEV, L.K., LYAKHOV, Yu. V., and EPOV, I.N., 1972, Stages and temperature regime of formation of the Darasun gold deposit (Eastern Transbaikal): in the Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 136-144 (in Russian).

The detailed thermometric regime is determined from fluids of primary and secondary two-phase inclusions occurring in the mineral assemblage of the deposits, by decrepitation and homogenization. The character of the relationships among the solutions is given, together with particular changes of the surrounding veins connected with them. Data on the change of the aggregate composition of the solutions with time and their chemical composition and temperature regime are also presented. The information obtained supports the thesis that the formation of the Darasunski ores resulted from a complex multistage endogenic physico-chemical process of the lithostatic hydrothermal type occurring in high-, intermediate-, and low-temperature environments. Early quartz-tourmaline-sulfide - 430°C, 275°C; later Pb-Zn-Cu sulfides, Au, sulfosalts, sulfates, carbonates and silica - 285-30°C. (Authors' abstract, translated by M.M. Hobson, courtesy Colin Barker, and expanded by ER).

DOLOMANOVA, E.I., BERSHOV, L.V., and GASOYAN, M.S., 1972. Minor elements in vein quartz of tin-bearing deposits of Transbaikalia and their genetic significance: Akad. Nauk SSSR, Izvestia, Ser. Geol., 1972, no. 6, p. 65-74 (in Russian).

A study of growth zonation revealed by cobalt-60 irradiation, and IR spectra of various quartz samples. (ER)

DOLOMANOVA, E.I., GASOYAN, M.S., KOROLEV, N.V., RUDNITSKAYA, E.S., TYUTNEVA, G.K. and ELINSON, M.M., 1972, Typomorphic features of hydrothermal vein quartz: in Typomorphism of Minerals and its Practical Significance, F.V. Chukhrov, ed.: Moscow, "Nedra" Press, p. 138-148. (In Russian).

DOLOMANOVA, E.I., GASOYAN, M.S., RUDINSHKAYA, E.S., TUTNEVA, G.K., and USPENSKAYA, A.B., 1972, Determination of the composition of minor elements and the temperatures of formation of vein and other quartz according to IR spectra: Mineralog. Muzeya Fersmana Trudy v. 21, p. 35-50. (in Russian).

Includes a short section on the effects of gas-liquid inclusions on IR absorption spectra. (ER).

DOLOMANOVA, E.I. and KVITKA, S.S., 1972, X-ray identification of β- and α-modifications of quartz in aggregates of compact vein quartz: Akad. Nauk SSSR, Doklady, v. 204, no. 4, p. 935-936. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 204, 1972, p. 127-129). Authors at M.V. Lomonosov State University, Moscow.

Paramorphism of the "alpha" after the "beta" quartz, once suggested for certain deposits of tin in Zabaykal'ye, and hence the very high temperatures at the beginning of the hydrothermal process (>573°C) are confirmed by X-ray analysis of massive quartz from 25 deposits in the area. The post-inversion honeycomb structures and the inversion twins (Fig. 1) and the practical absence of water in the post-inversion quartz are found to be diagnostic in the identifications. (Authors' abstract, translated in Internat. Geol. Review, v. 14, no. 12, 1972, p. 1377).

DONTSOVA, E.I., MILOVSKIY, A.V., and MEL'NIKOV, F.P., 1972, Fractionation of oxygen isotopes during formation of pegmatites: Geokhimiya, 1972, no. 5, p. 562-567 (in Russian; translated in Geochem. Internat. v. 9, no. 3, p. 351-355, 1972). Authors at Academy of Sciences USSR, Moscow and Moscow State University.

Fractionation of oxygen isotopes in minerals crystallized in a closed system during formation of crystal-bearing pegmatites of the chambered type (Volynia, Central Kazakhstan) has been investigated. It has been established that a gradual change takes place in the oxygen isotopic composition during formation of pegmatites in the quartz of enclosing granite, in the graphic pegmatite, in the quartz core, and in the large zoned quartz crystals grown on the core. This change is related to decrease in the temperature of crystallization of quartz as determined by homogenization of gas-liquid inclusions in quartz and topaz (120° to ∿900°C). The lower values of δO^{18} in phenacite, beryl, and topaz, which crystallized at the same temperature as quartz indicate that the distribution of oxygen isotopes in silicates during crystallization is influenced by their structure. (Authors' abstract)

DREVER, H.I., and JOHNSTON, R., 1972a, Metastable growth patterns in some terrestrial and lunar rocks (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 14, Mineralogy, p. 416 (In English). Authors at Dept. of Geology, University of St. Andrews, Fife, Scotland, United Kingdom.

Same as next entry.

DREVER, H.I. and JOHNSTON, R., 1972b, Metastable growth patterns in some terrestrial and lunar rocks: Meteoritics, v. 7, no. 3, p. 327-340. Authors at University of St. Andrews, Scotland.

With reference to new information on the textures in some terrestrial mafic and ultramafic igneous rocks of Tertiary age, textural patterns attributable to metastable crystallization are described, illustrated and reviewed. The igneous textural terminology, employed in the descriptive text, is reviewed and the use of certain new terms is advocated. Compared with these textural patterns are the skeletal crystal growth and intergrowth in igneous rock samples obtained, mainly by the Apollo 12 Mission, from the moon. Both orientated and unorientated metastable growth yield characteristic dendritic or skeletal olivine crystals, and a texture which has been termed "intrafasciculate" is also attributed to metastable crystallization of plagioclase and pyroxene. The three principal terrestrial textures defined and described are "Willow Lake'' texture, intrafasciculate texture and harrisitic texture. The term "thermotactic" is preferred to "Willow Lake" or "crescumulate" to define a texture with orientation of crystal growth in the direction of the thermal gradient.

Attention is drawn to the importance in petrogenesis of such metastable crystallization, as inferred from crystal growth and textural observations. It is apparent that analogous "metastable" textures occur through a remarkable range in geological context.

More detailed work is advocated on the pegmatitic eucrites and peridotites of Rhum. Since the evidence suggests that these rocks represent hydrous ultrabasic liquids, not cumulates, the conditions governing the growth of olivine in them must differ from those of any lunar analog.

(Authors' abstract) (Of pertinence to the study of silicate melt inclusions.)

DUBANSKY, A., 1972, Apparatus for chromatographic determination of gases in minerals: Geokhimiya, 1972, no. 4, 494-496 (in Russian; translated in Geochem. Internat. v. 9, no. 2, p. 297-298, 1972). Author at Geological Institute, Czechoslovak Academy of Sciences, Prague.

Apparatus is described for the recovery of gases and volatile substances from rocks and minerals.

DUBROVSKIY, M.I., 1972, Phase diagram of the granite system $NaAlSi_3O_8$-$CaAl_2Si_2O_8$-$KAlSi_3O_8$-SiO_2-H_2O and its petrologic significance: Akad. Nauk SSSR, Doklady, v. 203, no. 2, p. 446-449. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 203, 1972, p. 152-154). Author at S.M. Kirov Geological Institute, Kola Branch of the USSR Academy of Sciences, Apatity.

Poor legibility and graphic complexity of the known 5-component diagram of the system are minimized by simplifications ending with the original Pl-Or-Q-H_2O diagram of the phase equilibria (Fig. 2) for P_{H_2O} at 0 to 10,000 bar and P_{dry} at 1 to 10,000 bar, the range in which granitic magmas originate throughout the terrestrial crust. Another variant of this 4-phase cotectic plane (Fig. 3) is also derived for two extreme cases: $P_{total} = P_{dry}$, and $P_{total} = P_{H_2O}$. The phase equilibria so represented afford the following interpretations: a) "dry" granitic magmas may originate at any pressure, provided the temperature is 800-1000°C; b) water-saturated magmas may originate at $P_{total} = P_{H_2O} = 1500$ to 10,000 bar and 630-690°C, an easily attainable range in amphibolite facies of metamorphism; c) at one and the same pressure SiO_2 content of magma increases at increasing H_2O content. d) As T increases at P = const., potassium (orthoclase) increases in the magma, and so does the An:Ab ratio; the same enrichment (orthoclase) occurs when P increases and An:Ab = const. (higher than plagioclase No. 10); e) the maximum P_{total} to allow the least concentration (ca. 20%) of SiO_2, in the fluid phase, is 12-15 bar, i.e. granitic magmas originate only within the terrestrial crust; f) the "eutectic" granites may originate within a wide range of the magmatic compositions.(Author's abstract; translated in Internat. Geol. Review, v. 14, no. 8, 1972, p. 909-910).

ĎURIŠOVÁ, Jana, 1972, Data on the "temperature of formation" of cassiterite: p. 28-41 <u>in</u> Report of the first phase of the project "Metallization associated with acid magmatism" of the International Geological Correlation Program (mimeographed).

This is a compilation of all available data in the files of the Czech. Geol. Survey on geothermometry of inclusions in tin deposits. Copies (presumably) may be obtained from them. The remainder of the report is a summary of individual research activities in the project area, all over the world. (E.R.)

DUSIL, Josef; STRNAD, Zdenek; and HLAVAC, Jan, 1970, Study of volatile inclusions in rock quartz, III: Determination of gas and water content in rock quartz: Silikaty, v. 14, no. 4, p. 319-330 (In Czech, with English summary). First author at Research and Devel. Inst. of Technical Glass, Prague. (Bartuska) (Hlavac, et al.)

The present study is related to the previous papers I and II, and is concerned with the determination of water and permanent gases liberated from rock quartz from Czechoslovak localities.

The method employed was based on vacuum extraction. High temperature brings about destruction of inclusions, the liberated water is isolated by freezing, and the other gases are retained on silicagel in a liquid nitrogen cooled vessel. On desorption the water vapour volume is determined by measuring pressure in one part of the apparatus, the volume of the other gases is measured in the other part by means of McLeod's manometer (Fig. 1). The method was used for measuring the temperature dependence of four types of rock quartz. The individual types differed in their water content (Fig. 2), as well as that of permanent gases (Fig. 3), and differences were also exhibited in the course of the thermal liberation of the gases (Figs. 4 and 5). These differences are due above all to the different composition of the gases in the inclusions, and different structure of inclusions as regards their quantity and size.

Further measurements revealed a considerable relationship between the liberation of permanent gases and water, and the grain size of quartz. The amount of liberated water decreases with decreasing grain size (Fig. 6); more complex is the course of the temperature dependence of the liberated gas volume (Fig. 7).

Simultaneous effects of several factors affecting high-temperature liberation of gases are presumed.

The decrease of water liberated by quartz of finer grain size and the increase in the volume of permanent gases liberated at high temperatures is explained by the change in the original structure of inclusions due to grinding, and by the content of impurities in quartz (which increases with grain fineness) which can bring about reactions between water and the impurities.

The results of vacuum extraction measurements have been supplemented by gas chromatographic analysis of the gaseous mixture. The procedure is illustrated by Fig. 8; the results (Table 1) indicate that CO_2 and CO are liberated for the most part at lower temperatures, whereas H_2 and CH_4 at higher temperatures (Figs. 9 to 12).

More detailed information on the mechanism of liberation of water and gases from rock quartz inclusions would require further modified measurements carried out within wider temperature ranges and on narrower grain size fractions. (Authors' abstract)

DYMKIN, A.M., FEDOSEYEVA, M.M. and SHUGUROVA, N.A., 1972, Crystallization temperatures of scapolite and pyroxene from the Turgay magnetite deposits: Akad. Nauk SSSR, Doklady, v. 202, no. 1, p. 172-174 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 202, p. 109-111 (1973); abstract in Intern. Geol. Rev., v. 14, no. 5, p. 532). Authors at Institute of Geology and Geophysics, Siberian Division, USSR Academy of Sciences, Novosibirsk.

Homogenization temperatures of primary gas-liquid and gas-liquid-solid inclusions in scapolites are in the high-temperature class and are even higher in pyroxenites, but this trend does not seem to indicate a crystallizational heterochronism of the two minerals. (Authors' abstract).

Homogenization temperatures for inclusions in scapolite ranged from 180° to 700°C and for pyroxene from 340° to 720°C. The composition of the gas phase from pyroxene was found (by the volumetric procedure of Dolgov and Shugurova) to contain about 2/3 CO_2 and 1/3 N_2 + inert gases, with 5-8 percent acid gases; no hydrocarbons were detected. (ER)

EFIMOVA, M.I., GUSEV, M.S., VASILENKO, G.P., FILIPPOVA, T.G., and SHABANOV, V.N., 1972, Physical and chemical conditions of mineral formation of "productive" deposits in Upper Rudnikh: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 40-44 (in Russian).

A detailed study of inclusions in crystals of quartz, datolite, and calcite from drusy assemblages in vents of the Tetyukh skarn-polymetallic deposit permits the elucidation of some of the particulars of the formation of these assemblages. Parameters examined include the temperature and pressure regimes and some facets of the chemical processes involved in mineral-formation in the vents as compared with the physicochemical conditions during the formation of the skarn-sulfide bodies. Conclusions were drawn concerning the time of formation of the drusy assemblages and that of the skarn-polymetallic ore bodies. (Authors' abstract, translated by M.M. Hobson, courtesy Colin Barker).

ELINSON, M.M., POLYKOVSKII, V.S., and SHUVALOV, V.B., 1972, Physical and geochemical environment during the formation of greisens and quartz-wolframite veins in western Tien-Shan: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 74-87 (in Russian).

Results are presented from petrographic, geochemical and decrepitation studies, as well as determinations of the composition of the gas phase in gas-fluid inclusions in greisen and quartz-wolframite veins (22 analyses for CO_2, H_2 and N_2). The new data, together with information on previously described crystalline pegmatites, quartz-feldspar veins, and skarns are related to the endogeneous processes during the formation of the Maidantal'ski intrusion. Based on the results of this study, conclusions are presented concerning the conditions of formation of the Ayutorski ore fields and the specific distribution of different gases during this process. (Authors' abstract, translated by M.M. Hobson, courtesy Colin Barker).

ENJYOJI, Mamoru, 1972, Studies on fluid inclusions as the media of the ore formation (sic): Tokyo Kyoiku Daigaku, Science Reports, Sect. C, v. 11, no. 106, p 79-126 (in English).

1) The origin of most fluid inclusions used in the present study can be distinguished by their modes of occurrence and shape.

2) The number and the size of inclusions are commonly characteristic in individual ore deposits, suggesting the environment of mineral formation.

3) Leakage was observed in some fluid inclusions, especially in barite and sometimes even in quartz.

4) Fluid inclusions freeze(after supercooling to some extent) and melt at temperatures near or below 0°C. Fluid inclusions of this type are very common in samples from many ore deposits, but show different behavior:

a) Fluid inclusions freeze sometimes without leaving gas bubbles. The ice crystals in these fluid inclusions often do not disappear even up to some degrees above 0°C. In this case, an estimation of the salinity is impossible. Fluid inclusions of this type are found in the samples from some fluorite deposits such as the Hiraiwa, Kumi, and Chunchon-Sinpo mines.

b) When cooled, a hydrate of carbon dioxide and/or liquid carbon dioxide appears in some inclusions. The liquid carbon dioxide is always found around the gas bubble, and on heating homogenizes to the fluid phase at a temperature below +31°C, the critical temperature of carbon dioxide. Fluid inclusions rich in carbon dioxide are found especially in abundance in rhodochrosite from the Takatori mine.

c) Some fluid inclusions do not freeze even at the temperature of liquid nitrogen. In the case of fluid inclusions with several salt crystals, this phenomena seems to be caused by cleaning out the debris when this salt crystallized. In the case of very tiny ones, it seems to be very difficult to cause the nucleation of ice.

5) The following are suggested for the formation of the Takatori deposits:

a) The temperature was between 330°C and 270°C in the earlier stage, and between 280°C and 170°C in the later stage.

b) The salinity of the fluids was between 9 and nearly zero weight per cent NaCl equivalent.

c) In the No. 7 Vein of this mine, the ore fluids forming the main part (rich in ore minerals) were higher in both temperature and salinity than those forming the upper marginal part (poor in ore minerals).

d) The fluids were rich in Na and K constituents, and poor in Ca, Mg and Li constituents.

e) The fluids were rich in carbon dioxide.

f) The ore-forming fluids may essentially be of a magmatic origin.

6) Generally speaking, there are positive mutual relations between the formation temperature and the salinity of ore fluids:

a) Ore deposits of a contact metasomatic origin, such as the Chichibu, Kamaishi and Obira mines, were formed by the fluids with relatively higher temperature and higher salinity.

b) The plutonic vein type deposits, such as the Takatori, Nanetsu, Seikyu and Dalsung mines, were also formed by the fluids with comparatively higher temperature and higher salinity.

c) The subvolcanic vein type deposits, such as the Toyoha, Seigoshi Okuchi and Kushikino mines, were formed by the fluids with low temperature and low salinity. But some large deposits, such as the Hosokura and Osarizawa mines, were formed by fluids with slightly higher temperature and salinity, especially in their deeper parts.

d) Fluorite deposits were generally formed by the fluids with low temperature and low salinity, regardless of their types, except those of a connate water origin.

e) Kuroko type ore deposits might be formed by ascending fluids mixed with sea water. The paper includes 57 excellent photographs, mainly of inclusions, and extensive data tables. (Author's conclusions, modified by ER.)

ERMAKOV, N.P., 1969, Possible application of geologic thermometry and barometry to the solution of petrological problems (abst.): in Vses. Petrograf. Sovesh., Materialy, IV, p. 99-102: Baku, Akad. Nauk Azerb. SSR. (In Russian).

A review of the origin of inclusions and some of the data obtainable from them. (ER).

ERMAKOV, N.P., 1972a, Geocosmochemical classification of inclusions in minerals: Internat. Geol. Congress, 24th Session, Reports of Soviet Geologists, Problem 10, p. 145-153, Izdatelstvo "Nauka" (in Russian).

A discussion of each of the 21 individual classes in the scheme shown in the abstract published in Fluid Inclusion Research, Proc. of COFFI, v. 2, p. 18, 1969. (ER)

ERMAKOV, N.P., 1972b, Geochemical systems of inclusions in minerals: Moscow, Izdatelstvo 'Nedra', 375 pp. (including 27 plates). (In Russian). 3000 copies printed, price 3.86 R. See Translations Section Section.

ERMAKOV, N.P., 1972c, Prospecting-appraisal significance of gas-liquid inclusions and experiments on the combination of decrepitation and geochemical ore-prospecting methods on vein deposits of the Sadonsk group: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 5-14. (In Russian). CA 78 (12) 149667r (1973).

A combination of the special Pb, Zn, Bi, and Tl detns. with the decrepitation anal. (T is the decrepitation temp., N is the no. of decrepitations) gives a correlation between the mineral content of the ore and the ratio (E) of N at $T \leq 500°$ to N at $700° > T > 500°$. The title deposits are emplaced in Paleozoic granitic rocks contg. steeply dipping, ore-contg. quartz veins and covered with argillaceous schists and Jurassic sandstones. The E ratios are detd. by obtaining N of low (high-temp.) and upper (low-temp.) strata samples. The ore-rich veins and the enclosing country rocks have $E < 4$; the nonproductive veins have E 7-12. The country rocks which are leached by alk. liq. have lowered N. This occurs in the immediate vicinity of the quartz veins and it introduces a complicating factor in prospecting by means of the E ratios.

ERMAKOV, N.P., 1972d, Inclusions of mineral-forming solutions and melts in minerals, and their typomorphic significance: in Typomorphism of Minerals and its Practical Significance, F.V. Chukhrov, ed.: Moscow, "Nedra" Press, p. 33-39. (In Russian).

ERMAKOV, N.P., 1972e, Inclusions of solutions and melts in minerals, bibliography of Russian literature for 1970-1971: Moscow, Acad. Sci. USSR, 70 pp. (in Russian).

This small book, with a printing of only 300 copies, was issued in connection with the First International Geochemical Congress, in Moscow, in 1971. The first such compilation (Bogoyavlenskaya, et al., 1971; COFFI v. 4, p. 14) included all Russian publications up to 1970 (1170 entries). This volume contains 469 entries, arranged alphabetically, for 1970-71. The second part lists 66 papers from the non periodical literature since the previous bibliography, as well as 81 abstracts from the 2nd All-Union Conference at Novosibirsk, 20-25 Sept., 1965. The works of several foreign authors published in Russian in the USSR are also included. At the same time one monograph and 53 papers of Soviet researchers on inclusions, translated into English, German, Czech, and other languages abroad, as well as 106 published abstracts (of papers) read at various international conferences and congresses are not included. It should be noted that 25 papers from the collected papers of the 3rd All-Union Conference, which were published by "Nauka" in 1972 in the book "Ore-forming fluids from inclusions in minerals" and in the new monograph by Ermakov "Geochemical systems of inclusions in minerals", are not included in this bibliography.

After the Fourth All-Union Conference on Thermobarogeochemistry of Endogenetic Processes at Rostov-on-Don in the second half of September 1973, it is proposed to publish new bibliographic data for this branch of science. In this bibliography a single author index (pp. 58-71) has been made for the new work and the previously omitted publications (pp. 5-39). Starting on p. 55 is an additional group that has not been alphabetized. (Translated from the Editor's Preface by M. Fleischer and modified by ER).

ERMAKOV, V.A. and KOLOSKOV, A.V., 1969, Genesis of certain types of homogeneous inclusions in extrusive andesites, pp. 68-76 in Xenoliths and homogeneous inclusions: Moscow, Akad. Nauk SSSR, Sib. Otdel., Inst. Vulkanol. (in Russian).

Studies of mineral inclusions and olivine peridotite xenoliths; includes a discussion of the liquation (i.e., immiscibility) theory of inclusion origin. (ER)

ERNST, W.G., 1972, CO_2-poor composition of the fluid attending Franciscan and Sanbagawa low-grade metamorphism: GSA Abstracts with Program v. 4, 1972, p. 156. Author at Department of Geology and Institute of Geophysics, University of California, Los Angeles, California 90024.

Previous phase equilibrium and oxygen isotopic researches on the high-pressure, low-temperature metamorphic rocks of the Franciscan and Sanbagawa blueschist-type terranes have demonstrated the near ubiquity of a fluid at high (∿total) pressure and of its oxygen-rich nature during metamorphism. The coexistence of quartz with a $CaCO_3$ polymorph instead of wollastonite and of sphene rather that rutile + quartz + calcium carbonate in these rocks places narrow, rather low limits on the partial pressures of CO_2, as computed in this note; equilibrium calculations indicate that the mole fraction of carbon dioxide in the fluid must have been less than about 0.04 in the Sanbagawa terrane, less than 0.01 in the Franciscan terrane. The rocks are not sulfated or strongly oxidized, hence the only other likely component which could comprise the balance of this phase is H_2O. Evidently metamorphism in the Sanbagawa belt, and particularly in the Franciscan terrane, must have taken place in the presence of a highly aqueous fluid. (Author's abstract)

EUGSTER, H.P., 1972, Oxidation and reduction in metamorphism (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 5, Geochemistry, p. 303-304 (In English). Author at Department of Earth & Planetary Sciences, Johns Hopkins University, Baltimore, Maryland 21218, U.S.A.

Oxidation and reduction reactions in metamorphic rocks usually involve solid-gas reactions. Although solids and gases are rich in bound oxygen (42 to 53 wt% and 73 to 89 wt% oxygen respectively), free oxygen is exceedingly rare unless contact with the atmosphere is maintained. Therefore, most redox reactions are coupled to diffusion of gases such as H_2, CO, CH_4. Normally, solids define f_{O2} of the gas phase (internal buffering), and large f_{O2} gradients can be maintained over short distances. Such gradients commonly owe their existence to differences inherited from the sedimentary environment.

The oxygen fugacity of metamorphic rocks lies between quartz + fayalite + magnetite (QFM) and hematite + magnetite (HM) at low to moderate temperatures and between the graphite surface and HM at moderate to high temperatures; f_{O2} values higher than those of HM are preserved only under special circumstances, such as in manganese deposits. There are no large-scale sources of oxygen during metamorphism; hence oxidation is restricted to local phenomena. Reduction, on the other hand, is widespread because of the abundance of carbonaceous matter. Organic carbon and graphite may maintain f_{O2} levels in the lower part of the magnetic field. In the presence of water, methane is an important gas species at temperatures up to 400-500°C and reduction occurs through the reaction $CH_4 + O_2 \rightarrow CO_2 + 2H_2$.

The kinetics of redox reaction in metamorphism seem to be governed largely by the diffusion of the gas species involved in the particular reaction. (Authors' abstract).

FAIZIEV, A.R., ALIDODOV, B.A., ISCANDAROV, F.S., 1972, Some physical and chemical characteristic features of the formation of the Sasik gold-bearing deposit (the central Pamirs): Mineral. Sbor. L'vov, Gos. Univ., v. 26, no. 4, p. 378-387 (In Russian)

The study of gaseous-liquid inclusions showed that the mineral crystallization in the Sasik gold-bearing deposit originated from hydrothermal solutions of high concentration at a temperature range of 490-200°C and a pressure range of 1000-275 bars. (Authors' abstract)

FARN, A.E., 1972, Gemmological notes: The Jour. of Gemmology, v. 13, no. 4, October 1972, p. 121-124.

Implies (p. 122) that "three-phase inclusions" have never been synthesized (ER).

FAYZIYEV, A.R., 1972, Epitactic intergrowths of quartz and fluorite from the Akdzhilga deposit, Eastern Pamirs: Akad. Nauk SSSR, Doklady, v. 206, p. 702-704 (in Russian; text translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 206, p. 133-135, and abstract in Intern. Geol. Rev., v. 15, no. 5, p. 608 (1973). Author at the V.I. Lenin Tadzhik State University, Dushanbe.

Fluorite overgrows quartz, so that the rhombohedral and cubic faces of both minerals are parallel in prismatic crystals (fig. 1); a variety of scepter-shaped intergrowths also occur in the same deposit (fig. 2). Gas-liquid inclusions in quartz and fluorite invariably homogenize in the liquid phase. Two generations of quartz (355-335-310° and 285-245°C) and one of fluorite (250-220°C) are indicated (fig. 3). Curiously, both minerals were "healed" at about the same temperature (130-170°C). (Author's abstract).

FAYZIYEV, A.R. and MARKOV, A.B., 1971, Bituminoids in fluorite of some mineralized areas of Tadjikistan: Geokhimiya, 1971, no. 11, p. 1372-1375 (in Russian; translation in Geochem. Internat. v. 8, no. 6, p. 852-855.) Authors at Tadjik State University, Dushanbe.

Bituminoid contents of fluorites from various sources were determined by the luminescence-capillary technique. Most samples contained no more than 0.006 percent of bituminoids with others ranging up to 0.0125 percent. The content of bituminoids is not related to the nature of the surrounding rocks or the color of the fluorite; it is thought to be endogene in origin and to be related to a hydrothermal process. (I.A. Breger)

Samples from all 24 localities were examined for homogenization temperature of the fluid inclusions (aqueous?) but no correlation was found between temperature and the bitumen content. Temperature of homogenization ranged from 46 to 340°C. (ER).

FOLINSBEE, R.E., KIRKLAND, K., NEKOLAICHUK, A., & SMEJKAL, V., 1972 Chinkuashih-a gold-pyrite-enargite-barite hydrothermal deposit in Taiwan: Geological Soc. of America Memoir 135, p. 323-335. Authors at Departments of Geology and Physics, University of Alberta, Edmonton, Canada.

At Chinkuashih, an important Pleistocene copper-gold producing mine in Taiwan, the arsenical copper-gold ores are similar to those of Butte, Montana, in mineralogy, geochemistry, and temperature of formation. Electron microprobe analysis established the presence of antimony in the enargite (luzonite), as in the enargite at Butte. Octahedral pyrite crystals, characteristic of the ore zone, contain copper and arsenic in solid solution, producing anomalous areas of anisotropism. Sulfur isotopes for sulfides and sulf-arsenides yield values close to meteoritic and typical of magmatic hydrothermal deposits, but the equilibrium sulfate species barite is 25‰ heavier in S^{34}. Data on the barite-pyrite pairs suggest temperatures of formation in the range of 255°C to 305°C (using Sakai's 1968 geothermometric curve), a range compatible with fluid inclusion temperatures in barite (for the most part between 228°C and 305°C) and quite comparable to Meyer's (1950) figures of 275°C to 335°C for the Butte deposit. Extensive chloritic, argillic, and silicic alteration preceded mineralization and suggest that large amounts of water, perhaps meteoric, were involved in the hydrothermal processes. (Authors' abstract)

FORESTER, R.W. and TAYLOR, H.P., Jr., 1972, Oxygen and hydrogen isotope data on the interaction of meteoritic ground waters with a gabbro-diorite stock, San Juan Mountains, Colorado: Internat. Geol. Cong., 24th, 1972, Sect. 10, p. 254-263.

The mid-Tertiary Stony Mountain stock, about 1.3 km in diameter, intrudes horizontally bedded volcanic rocks 10 km NW of the Silverton caldera, in a zone of numerous radial and concentric fractures. The sequence of intrusion is (1) an outer, 150-m-thick, arcuate ring-dike of fine-grained diorite, (2) the main mass of medium-grained biotite gabbro and (3) a central plug, about 0.5 km across, of fine-grained diorite. These rocks are well-exposed over a vertical distance of more than 600 m. The range and average (in parentheses) of whole-rock δO^{18} values (SMOW) are: outer diorite, -1.1 to +5.8 per mil (+4.5); gabbro, +1.5 to +5.7 (+4.6) and central diorite, +1.3 to +2.7 (+2.3). The volcanic country rocks within 2 to 3 km of the stock are all highly depleted in O^{18}, with an average whole-rock δO^{18} of about +1.5. The δD values of biotites from the gabbro range from -135 to -145 per mil, in striking contrast to biotites in "normal" igneous rocks, which typically have $\delta D = -60$ to -80. Thus, during cooling and crystallization, the Stony Mountain pluton underwent varying degrees of exchange with hot, circulating waters of meteoric origin. The calculated water/rock ratios in the hydrothermal system range from about 0.1 to 0.8 (in atom % oxygen). Generally: (A) The δO^{18} values in the stock increase with increasing elevation, probably because the heated waters were moving upward here; the higher-level rocks thus reacted with water that already had undergone considerable O^{18} exchange. Further, the overlying volcanics were apparently less permeable to H_2O than the lowermost unit in the pile, the San Juan Tuff. (B) δO^{18} values are lowest near intrusive contacts, because the convecting ground waters are hottest here. (C) The finest-grained rocks tend to be most depleted in O^{18}. (D) The greater the abundance of propylitic alteration minerals (sericite, carbonate, chlorite, epidote, etc.) the lower is the whole-rock δO^{18} value. (E) Coexisting minerals typically exhibit disequilibrium O^{18} fractionations, indicating that the rock-forming minerals undergo O^{18} exchange to varying degrees, quartz being the most resistant and feldspar the least. (F) Quartz in the hydrothermal veins has $\delta O^{18} = -1.8$ to $+5.1$; thus it also was deposited from meteoric waters. (Authors' abstract)

FOURNIER, R.O., 1972, The importance of depth of crystallization on the character of magmatic fluids (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 5, Geochemistry, p. 306 (In English). Author at United States Geological Survey, 345 Middlefield Road, Menlo Park, California 94025, U.S.A.

If a rising magma can remain undersaturated with respect to a gas phase until it reaches a shallow depth, e.g., 2 to 3 km, two distinct hydrothermal fluids may evolve, each of which may be significant for ore formation and wall-rock alteration. Such undersaturation is compatible only with initial H_2O <3 wt. % (Burnham 1967); Otherwise separation of an aqueous phase containing most of the initial chloride and sulfur species would proceed at greater depth where simultaneous formation of dual hydrothermal fluids is impossible. At shallow depths, the transition from a lithostatic gradient (∿0.5 kb at 2 km) to a hydrostatic gradient (∿0.2 kb) would allow a rapid evolution of water from the magma at about 750°C. Under these T-P conditions, liquid water could exist only as a highly saline brine (>50 wt. % salt) rich in NaCl-KCl. If wt. % H_2O >wt. % salt in the magma, some (most?) water would separate as a gas (density ∿0.1 to 0.05) containing other volatiles, including appreciable HCl. If the gas moved out through many small openings in the overlying rock (as opposed to a few well-defined channels to the surface), most of it would condense in a short distance, forming a highly corrosive fluid of moderate salinity at boiling temperature (300° to 374°C). Within the intrusive and extending for a short distance into the country rock there would be a very steep temperature gradient and high heat flux. A hot (400° to 700°C), dense, relatively slowly convecting brine (residual brine augmented by evaporative concentration of descending solutions) would come to fill the open spaces there. Above the brine, separated by a relatively sharp interface, the cooler, less saline solution would become part of a large convecting hot spring system that would bring large quantities of meteoric water back into the hot rock. Ore formation might take place during any one or all of these stages. (Authors' abstract).

FOWKES, A.J., & PARKINSON, R.T., 1972, The analysis of gaseous inclusions in glass using a quadrupole mass spectrometer: Glass Technology v. 13, no. 4 p. 126-132. Author at Pilkington Brothers Ltd., Central Analytical Laboratories, St. Helens, Lancs., England.

A quadrupole mass spectrometer has been adapted to analyse bubbles in production and research glasses. It can handle sample sizes in the range 0.2 mm in diameter (1.4 nl of gas at s.t.p.) to 8 mm in diamter (90,000 nl of gas at s.t.p.), and has detected H_2, He, CH_4, N_2, CO, O_2, A, CO_2, COS, H_2S and SO_2 in bubbles from a variety of sources. The preparation of synthetic bubbles for use as laboratory exchange samples, or as reference samples is described. The mass spectrometer can be rapidly converted for general gas analysis when required. Some typical results are recorded and discussed. (Authors' abstract).

FRIDMAN, A.I., and MAKHLOVA, N.K., 1972, Certain aspects of origin and migration of carbon dioxide in mercury deposits, as in the Nikitovka, Donbass: Vyss. Ucheb. Zaved. Izv., Geol. i. Razvedka, 1972, no. 6, p. 92-98 (in Russian, translated in Internat. Geol. Rev., v. 14, no. 12, p. 1345-1350, 1972).

The relatively high concentrations of CO_2 in hydrothermally altered mineralized rocks, zones of fragmentation, and deeper levels of mines represent accessions of the gas from great depths, along fractures in the nearly impervious rocks. The gas may be regarded as a geochemical indicator of the ores, as shown by its connection with the mineralizing hydrothermalism and the isotopic composition of the C. (Authors' abstract).

GEGUZIN, J.E., DZIUBA, A.S. and OVCHARENKO, N.N., 1972, On the process of spontaneous facetting of cavities in crystals: Acad. Nauk SSSR, Doklady, (Technical Physics), v. 205, no. 3, p. 560-563 (in Russian).

A mathematical derivation of the process involved, and time-sequential photomicrographs of facetting. (ER).

GERASIMOVSKIY, V.I. and KUZNETSOVA, S.Ya., 1972, Forms of sulfur in extrusive rocks of the East African rift zone: Akad. Nauk SSSR, Doklady, v. 207, no. 2, p. 437-440. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 207, 1972, p. 202-204). Authors at V.I. Vernadskiy Institute of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR, Moscow.

In nephelinite and leucitite, the sulfur is sulfatic, sulfidic, pyritic, free, and organic (Table 1). The definitely quantitative subordination of sulfatic sulfur to the sulfidic total S contradicts the data reported by Ricke (Geochim. et Cosmochim. Acta, no. 1-2, 1960). This contradiction and the presence of organic and free sulfur in appreciable quantities in these magmatic rocks is further evidence of our still inadequate knowledge of the geochemistry of sulfur. (Authors' abstract, translated in Internat. Geol. Review, v. 15, no. 4, 1973, p. 483).

GERDEMANN, P.E. and MYERS, H.E., 1972, Relationships of carbonate facies patterns to ore distribution and to ore genesis in the Southeast Missouri lead district: Econ. Geol., v. 67, p. 426-433. Authors at St. Joe Minerals Corporation, Bonne Terre, Missouri.

The Southeast Missouri lead-zinc-copper district, one of the world's largest, has produced more than 11,000,000 short tons of lead. Recently discovered new mines will be at least as productive as those in the past.

Mineralization, in the Bonneterre Formation of late Cambrian age, is spatially related to a barrier reef and associated carbonate facies. Sedimentation and reef development was influenced by the St. Francois Mountains, an inlier composed of Precambrian igneous rocks. A portion of the Viburnum Trend is discussed and illustrated as representative of this model.

Evidence bearing on the origin of the mineralization is reviewed briefly, leading to the following conclusions:

a. An epigenetic origin is indicated.

b. The metals were transported by heated Na-Ca-Cl brines probably as chloride complexes.

c. Biogenically reduced sulfur related to algal reefs and/or other organic rich sediments precipitated the metals as sulfides. (Authors' abstract)

First publication of some inclusion data by Roedder on this deposit are given (p. 432): "Temperatures up to 125°C and salinities equivalent to 30% salts found in fluid inclusions." (ER)

GERMANOV, A.I., and BANNIKOVA, L.A., 1972, Alterations of organic substance in sedimentary rocks during the hydrothermal condensation of sulfides: Akad. Sci SSSR, Dok., v. 203, no. 5, p. 1180-1182 (in Russian; abstract translated in Int. Geol. Rev., v. 14, no. 10, p. 1149).

Quasilinear fluorescence spectra of the $CHCl_3$-soluble organic substance from Lower Cretaceous rocks, in a pyrite-cinnabar ore field, show accumulations of polycyclic aromatic hydrocarbons, even of coronen, in hydrothermally altered clays of the outer zone which contains veins and veinlets of calcite, but none of the sulfidic mineralization. The inner zone, hydrothermally mineralized, with Fe and Hg sulfides, shows no coronen and significantly lower quantities of the hydrocarbons (table 1). The alteration temperatures were 150-180°C in both of the zones. It appears that organic substances in bituminous hosts of the sulfides were subjected to thermal alterations and condensations, while the same substances, in the mineralized zone, were being oxidized concurrently with deposition and condensation of the sulfides, as the hydrothermal solutions functioned as donors of oxygen in the HS^-- and S^{2-}-yielding reaction. (Authors' abstract).

GERMANOV, A.I., BANNIKOVA, L.A., KORCHAGINA, Yu.I. and CHINENOV, V.A., 1972, Hydrothermal alteration of bitumens of sedimentary rocks: Akad. Nauk SSSR, Doklady, v. 206, no. 5, p. 1211-1214. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 206, 1972, p. 242-245).

Fracture-controlled deposition of cinnabar with pyrite in bituminous clayey-sand rocks, in a part of the Caucasian mega-anticlinorium, is accompanied by sulfuration and oxidation of the bitumens (except paraffins) and reduction of the hydrothermal sulfates. Sulfide generated in the process is the precipitating agent for both Hg and Fe. In the sulfide-free outer zone of the deposit, where calcite is the principal hydrothermal mineral, alterations of the bitumens, such as aromatization and condensation, are due almost entirely to the temperature, inasmuch as the hydrothermal sulfate was already spent. Elemental and group compositions of bitumens in unaltered and altered rocks and in the inner and outer zones of the alterations are reported in Tables 1 and 2. (Authors' abstract, translated in Internat. Geol. Review, v. 15, no. 7, 1973, p. 854).

GÖKE, GERHARD, 1972, A contribution to the microscopical investigation of inclusions in crystals: Der Aufschluss, v. 23, no. 1, p. 12-16. (In German).

The different methods of inclusion investigation on cut and uncut crystals in an immersion liquid under various types of microscopes are described. If a preparation of great durability is needed, the author proposes the following procedure: on a slide some "Lakeside thermoplastic cement 70c" is melted at 120°C; the crystal is placed on the resin, then embedded in a medium (with a refractive index close to the one of the crystal) and finally covered by a cover glass. The following embedding mediums which harden after evaporation of the solvent are proposed:

	Index of refraction (Na_D)	Available from:
Malinol	1.52	(Chroma, Stuttgart)
Caedax	1.55	(E. Merck, Darmstadt)
Epoxol	1.60	(Epoxidharzlösung, developed by the author)
Aroclor	1.665	(Monsanto, USA)
Naphrax	1.7	(N.B.S., Ipswich, England)

For UV-investigations the use of UV-inert (Serva, Heidelberg) or Entellan (Merck, Darmstadt) is mentioned.

In the summary of this paper the different types of mineral inclusions are given. The term "phase" is there used for the number of different states of aggregation in an inclusion; this corresponds to the normal use of this term in gemmology. (Abstract by H.A. Stalder)

GOLEVA, R.V., and MEL'NIKOV, F.P., 1972, Studies of gas-liquid inclusions in rocks and minerals for following the stages in metasomatic development: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 199-207 (in Russian).

In the area of ancient crystalline shield that was studied, unusual alkaline metasomatic rocks (albitites) formed as a result of metamorphism and granitization of the country rock. Three stages occurred during the alteration: first was the development of the outer, intermediate, and inner zones of metasomatic column; second, the separation of albite, riebeckite, titanite, apatite, and rutile; and third, manifestation of intense quartz crystallization.

The thermometric and decreptometric studies carried out on the gas-fluid inclusions permits the measurement of the maximum filling temperatures of inclusions in rocks of the inner zones of metasomatic rocks. Differences between quartz from stage I and stage II were shown. The temperature regime was determined for the quartz crystals of the later stages. Halos of distribution of gas-fluid inclusions in the country rock were established. A complex study of the metasomatic process by geological, mineralogical, and geochemical methods as applied to the study of gas-fluid inclusions permits a more complete description of its evolution. (Authors' abstract. translated by M.M. Hobson, courtesy Colin Barker).

GONCHAROV, V.I., NAIBORODIN, V.I. and SIDOROV, A.A., 1972, Temperature features of the formation of subvolcanic gold-silver deposits of northeastern USSR: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 124-131. (In Russian) CA 78 (12) 149674r (1973).

The homogenization temps (T) were detd. of minerals (mostly quartz and calcite) assocd. with the Ag-Au ore shoots of northwestern USSR. The samples were taken from the following ore deposits: (1) Khakandzhin, (2) Karamken, and (3) Agatov. The 1st deposit is emplaced under the Late Cretaceous liparite strata in the hydrothermal quartzite, kaolinite-hydromica facies; the T is 410-390° in the lower and 335-322° in the upper strata. The 2nd deposit is assocd. with the subvolcanic intrusives of plagiogranite-porphyry, liparites, and andesites; the Au-contg. strata have T = 176-206°. The 3rd deposit is emplaced in effusive andesites which were partly metasomatized by the carbonate-chlorite facies. It consists of quartz veins and various carbonates (predominantly calcite, dolomite, and ankerite). The deposit was formed in 5 hydrothermal stages; T ranges from 400° to 100°.

GORECKA, Ewa, 1972, Ore mineralization in Palaeozoic rocks of the Silesian-Cracow area: Acta Geologica Polonica, v. 22, no. 2, p. 275-326, plus 12 plates. (In Polish with English abstract and summary).

The paper deals with the genesis, mineralogical differentiation and occurrence of ore minerals in Paleozoic rocks of the NE part of the Silesian-Cracow area. Ore mineralization in these deposits belongs to the Hercynian and Alpine metallogenic epochs. Mineralization related to the Hercynian cycle is of polymetallic character and represents subvolcanic type, co-magmatic with acid magmatism of the Asturian phase. Ore mineralization of the Alpine cycle is represented by zinc and lead ores; it is of hydrothermal origin and forms the root parts of Silesian-Cracow Zn-Pb ores, occurring in Mesozoic, predominantly Triassic rocks. (Author's

GOVOROV, I.N., STEPANOV, G.N., FAT'YANOV, I.I., and FILIPPOVA, T.G., 1972, Geochemical types of ore hydrotherms of the Far East (from data on gas-fluid inclusions in minerals), in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 24-39 (in Russian).

The chemical composition and temperatures of ore-forming solutions in mineral inclusions were studied in different deposits of Dairen East (Anyuiski greisen, skarn-sulfide scheelite of West-2, Takurski gold-quartz, and the Lufudzinski tin ores). In the West-2 deposits, the evolution of the solution can be traced from the stages of mineralization; in the Lufudzinski deposit a change in the composition and mineralization of solutions is marked by the first tin-producing stage in the vertical profile. On the basis of generalizations from experimental data and the literature, five types of ore hydrotherms were recognized: 1) high-temperature (600-400°C) Na-K-Cl-HCO_3 solutions; 2) high- and intermediate-temperature (500-250°C) Na-Cl solutions; 3) intermediate-temperature (400-250°C) F-Na-K solution; 4) intermediate- and low-temperature Na-Ca-SO_4-HCO_3 solutions: and 5) low-temperature (250-150°C) Na-HCO_3 solutions. Each of these hydrotherms is characterized by particular types of endogeneous deposits. (Authors' abstract, translated by M.M. Hobson, courtesy Colin Barker).

GREEN, H.W. II, 1971, A CO_2-charged asthenosphere (abst.): Amer. Geop. Union, Transactions, v. 52, no. 11, p. 927. Author at Dept. of Geology, Univ. of Calif., Davis, Calif. 95616.

The solubility of non-reactive fluids in solids varies directly as pressure and inversely as temperature. In the Earth's interior this behavior suggests a solubility minimum in the upper mantle. In such a mantle, outgassing of the Earth by diffusion processes leads to concentration and ultimately to precipitation of a CO_2-rich fluid phase in a world-encircling zone. This zone lies where the local temperature makes its closest approach to the melting point, and results in a weak, low-density layer with low seismic velocities and high seismic attenuation, the asthenosphere. In this model the asthenosphere should be well-developed and shallow under oceans and less well-developed and deeper under shield areas. CO_2-rich fluid inclusions are abundant in ultramafic xenoliths from basalts, with greatest concentrations occurring in those xenoliths with metamorphic tectonite textures. Many of the bubbles are attached to dislocation arrays in subgrain boundaries and must have precipitated there during or after deformation. Consideration of the volume, shape,and distribution of inclusions in tectonite xenoliths suggests that they are sufficient to explain the seismic low velocity zones. (Author's abstract).

GROVES, D.I., MARTIN, E.L., MURCHIE, H., and WELLINGTON, H.K., 1972, A century of tin mining at Mount Bischoff, 1871-1971: Tasmania Dept. Mines Geol. Survey Bull. 54.

Includes a fairly detailed summary of geobarometric data (p. 214-215), geothermometry and zoning (p. 215-216), and composition of the fluid inclusions (p. 217-218), mainly from the work of Groves and Solomon (1969) (Fluid Inclusion Research--Proceedings of COFFI, v. 2, p. 43, 1969), and a 4-page summary of the origin and nature of the deposits (p. 255-258). (ER)

GROVES, D.I., and SOLOMON, M., 1972, Fluid inclusion studies at Mount Bischoff, Tasmania [A correction to paper of same title published in 1969 and abstracted in Fluid Inclusion Research-Proceedings of COFFI, v. 2, 1969, p. 43-44]: Inst. Mining and Metal. Trans., Sect. B, v. 81, no. 789, p. B181, 1972.

Determinations of the density of carbon dioxide in inclusions supposed to be originally coexisting with nearby aqueous inclusions lead us to indicate that the pressure of deposition of the host crystal was about 750 atm. We pointed out that very little aqueous solution appeared to have condensed out of the CO_2-rich phase in the CO_2 inclusions and ignored this in future calculations. The presence of any aqueous solution, however, means that the 750 atm should not be regarded as a total pressure.

Experimental evidence (Takenouchi and Kennedy, 1964) indicates that the CO_2 gas phase at 200°C and 750 atm in a CO_2-H_2O system should carry about 25 mole percent water (and only a slightly smaller amount of 6 percent NaCl solution; Takenouchi and Kennedy, 1965), considerably more than appears to be present in the Bischoff inclusions (Fig. 7, p. B4). The small number of inclusions available for the study means that they may not be truly representative of the original ore solution, and the lack of aqueous solution may reflect some local variation. A further problem is that the compositions of both the condensed CO_2 and the aqueous solution are not known with any degree of precision, and, hence, it is not possible to apply the available experimental evidence with certainty. It does indicate, however, that for a pure CO_2-H_2O system, where the partial pressure due to CO_2 is about 750 atm and the temperature about 200°C, the total pressure could be as high as 1000 atm. The actual pressure may well be somewhere between 750 and 1000 atm. (Authors' presentation, modified by ER)

GUNDLACH, H., STOPPEL, D., and STRÜBEL, G., 1972, On the hydrothermal solubility of barite: Neues Jahr. Mineral. Abh., v. 116, pt. 3, p. 321-338 (in German).

Experimental studies on the solubility of natural Sr-bearing barites in H_2O and 1.0*N* NaCl solutions between 20 and 350°C. Differing solubilities of Ba + Sr result in incongruent solubility. Reliable conclusions as to the genesis of barite deposits cannot yet be drawn. (ER) (More details are given, in English, in an abstract of same title in Intern. Geol. Cong., 24th, Abstracts, Section 10, Geochemistry, p. 309)

GUROV, Ye.P. and GUROVA, Ye.P., 1972, Pachnolite and thomsenolite from crystalline rocks of the Ukraine: Akad. Nauk SSSR, Doklady, v. 202, no. 5, p. 1168-1171. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 202, 1972, p. 143-145). Authors at Institute of Mineral Resources, Simferopol'.

These two rare dimorphic aluminofluorides were isolated from metasomatites of the Ukrainian shield. Their optical and crystallographic-crystallometric characteristics, interplanar distances (Table 1), infrared absorption spectra (Fig. 1), chemical composition (Table 2), are very much like known specimens from Greenland and Colorado. (Authors' abstract, translated in Internat. Geol. Review, v. 14, no. 7, July 1972, p. 784).

Previous studies had shown the presence of cryolite, weberite, prosopite, and gearksutite in these same rocks. They all occur as segregations and cavity linings in metasomatized granites, and verify the abundance of fluorine in these metasomatizing fluids. (ER)

GUTMANN, J.T., 1972, Giant phenocrysts from basaltic lavas at Crater Elegante: An argument for rapid growth of large crystals at shallow depth, (Abstr) : Geological Society of America, Abstracts with Programs, v.4, no.7, p. 522. Author at Department of Geology, Wesleyan University, Middletown, Connecticut 06457

Crater Elegante is a small collapse depression in the Pinacate volcanic field, Sonora, Mexico. Volcanic rocks exposed in and near the crater are porphyritic, vesicular, alkaline olivine basalts and' are typified by occurrences of exceptionally large crystals of labradorite, olivine, clinipyroxene, and magnetite, Labradorite crystals (An_{60}) attain at least four inches in maximum dimension and the other megacrysts attain comparable sizes.

Size distribution of the phenocrysts is seriate: crystals of all four types grade smoothly and continuously downward in size from giant individuals to groundmass crystals. The larger feldspar crystals are among the most calcic in a given volcanic unit but are compositionally indistinguishable from many small phenocrysts and groundmass crystals in the same rock. The phenocrysts of all types exhibit a remarkable array of textural features: amoeboid forms, "patchwork" crystals, and sieve and other inclusion textures are common. The outlines of numerous phenocrysts resemble the skeletal forms developed during rapid growth. Certain other crystals evidently have been partially resorbed.

It is here suggested that many phenocrysts of all sizes grew at shallow depths beneath the Elegante volcanic edifice. Rapid growth of crystals, imperfect in highly variable degree, may have been promoted by the exsolution and/or the presence of a water-rich phase derived from the basalt liquids as they passed through or paused in conduits or chambers perhaps no more than a few thousand feet beneath the surface. Caution is urged in applying the genetic term "resorbed" to the irregularly shaped phenocrysts common in volcanic rocks. (Author's abstract.)

HALL, W.E. and CZAMANSKE, G.K., 1972, Mineralogy and trace element content of the Wood River lead-silver deposits, Blaine County, Idaho: Economic Geol. v. 67, pp. 350-361.

The Wood River lead-silver deposits, near Bellevue in south-central Idaho, occur in veins in sheared zones in contact metamorphosed siliceous and limy argillites of Mississippian age near contacts with quartz diorite. Galena and sphalerite are the principal ore minerals, siderite the principal gangue mineral; the ore averages 1.25 ounces silver for each percent lead.

Seven purified mineral separates of galena contain 2,100 to 5,000 ppm silver and 3,100 to 4,700 ppm antimony; antimony and silver are in an atomic proportion of approximately 1:1. Electron microprobe analyses show that slightly less than one half of the antimony and silver is in solid solution in the galena. The rest is present in minute, high Ag-Sb inclusions of five distinct compositions, though principally as diaphorite ($Pb_2Sb_3Ag_3S_8$). Precise analyses of these inclusions were obtained by electron microprobe using a series of synthesized complex sulfosalts as standards. Some limitations on thermal stability of the mineral assemblages were obtained by these syntheses and by annealing natural materials at temperatures between 251° and 399°C.

Micron-size fluid inclusions in quartz in the hornfels indicate that the metamorphism was accompanied by highly concentrated, NaCl-rich brines poor in CO_2. The inclusions contain NaCl and hematite daughter minerals. The inclusions are too small to permit determination of homogenization temperatures on a heating stage, but the large size of the bubbles in the fluid inclusions suggests a temperature for the alteration of more than 350°C. Observed uniformity in bubble size indicates that the fluid was not boiling.

Some approximations of deposition temperatures can be made from individual minerals and mineral assemblages to indicate the ores were deposited over a range from above 350°C to less than 280°C. (Authors' abstract, extended by ER.)

HANF, N.W., and SOLE, M.J., 1972, High-temperature hydrolysis of sodium chloride in the presence of silica: Inst. Mining & Met. Trans., v. 81, Sect. C, Bull. 787, p. c97-c103. (Authors at Anglo American Research Laboratories, Anglo American Corporation of South Africa, Ltd., Crown Mines, Transvaal, South Africa)

The hydrolysis of sodium chloride in the presence of silica has been studied in the temperature range 600-1000°C. The equilibrium constant (K_p) for the reaction

$$2NaCl_{(s,l)} + ySiO_{2(s)} + H_2O_{(g)} = Na_2O.ySiO_{2(condensed)} + 2HCl_{(g)}$$

for $y = 2$ has been calculated as a function of temperature and compared with experimental values. It is shown that above a temperature of approximately 700°C the primary end-product of the reaction is a glass of approximate composition $Na_2O.2SiO_2$, which also contains some dissolved NaCl. Partial pressures of HCl generated during the initial stages of reaction are much higher than those predicted from K_p values unless the sodium silicate formed is assumed to be soluble in the quartz to a small extent. A theory is developed to show that this dissolution provides a reasonable explanation for the phenomena observed. It is further demonstrated that equilibrium is established extremely rapidly and that this has important implications for the TORCO process for the extraction of copper from refractory ores. (Authors' abstract) (Of pertinence to many inclusion studies).

HANOR, J.S., 1972, Regional control of Mississippi Valley type ore districts (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 4, Mineral Deposits, p. 127, (In English). Author at Department of Geology, Louisiana State University, Baton Rouge, Louisiana 70803, U.S.A.

The regional distriubtion and geochemical zoning of various mineral components of Mississippi Valley type ore districts provides considerable insight into the origin of these districts as a whole. In eastern North America, most major occurrences of barite were emplaced penecontemporaneously in areas of broad uplift and are secondarily localized within surficial structural features produced by uplift. Superimposed on this basic tectonic control is a regional geochemical zoning of strontian barite, celestite and associated fluorite, which parallels the basic tectonic grain of the continental basement rocks. This suggests a deep source for some components of these districts.

These and other constraints have led to the development of the following model for emplacement of some Mississippi Valley type districts: (a) development in platform areas of broad regions of heating and uplift originating in the upper mantle and lower crust; (b) development of such features as faults, fractures and karst structures in uplifted surface rocks; (c) heating and convective circulation of over-lying connate and meteoric waters; (d) partial degassing of upper mantle, with concomitant release of such large cations as barium; (e) reaction of deep, ascending fluids with rocks of the lower crust; (f) mixing of ascending fluids with circulating connate and meteoric water, or seawater; (g) precipitation by reaction and temperature decrease; (h) localization of precipitates in features produced in (b) (epigenetic deposits) or in contemporaneously deposited sediments (syngenetic deposits); (i) possible subsequent surficial mobilization and/or deformation of the deposits. (Authors' abstract).

HAUGHTON, D.R., and SKINNER, B.J., 1972, Chemistry of sulfur in melts (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 14, Mineralogy, p. 420 (In English). Authors at Dept. of Geology and Geophysics, Yale University, New Haven, Connecticut 06520, U.S.A.

Those factors defining the solubility of sulfur in mafic magmas and hence determining the spatial and temporal placement of immiscible sulfide melts are: temperature, fugacity of the gaseous species and chemical potentials of the melt components.

Experimental studies in that range of oxygen and sulfur fugacities where sulfide sulfur is the major species in solution, indicate that, in a melt of basaltic composition at 1100°C a temperature increase of 100°C can magnify the capacity of a melt to hold sulfur by a factor of five. A consideration of the "sulfide capacity" function indicates that the fugacity of oxygen and sulfur have opposing effects; i.e., increasing fo_2 decreases sulfur solubility and increasing fs_2 increases sulfur solubility. The complex interrelation between composition and the capacity of a melt to dissolve sulfur is clarified through the use of multivariate analysis. Sulfur in saturated silicate melts shows positive correlations with FeO, TiO_2, CaO and MgO, with FeO and TiO_2 having the highest correlation coefficients. SiO_2, Al_2O_3, Na_2O and K_2O show negative correlations with sulfur.

In nature all of these controlling variables change during differentiation and each or all of them may bring the magma to saturation, causing a sulfide phase to precipitate. The most important variable appear to be decreasing temperature, changing composition due to crystal differentiation and changes in fo_2 through the addition of aqueous fluids.

If the silicate melt becomes saturated, the immiscible sulfide oxide liquid which forms is essentially composed of iron, sulfur and oxygen. The content of the minor elements copper, nickel and the platinoids in this phase is also influenced by temperature, fo_2, fs_2 and the stage in the fractionation process at which the Fe-S-O melt develops. (Authors' abstract).

HAYNES, S.J., & CLARK, A.H., 1972a, Distribution of chlorine and fluorine in granitoid rocks and associated ore deposits, northern Chile (abstr): Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 531. Authors at Department of Geological Sciences, Queen's University, Kingston, Ontario.

The chlorine and fluorine contents of 63 whole-rock samples and 38 separated biotites from dated plutonic and sub-volcanic granitoids have been determined using new ion-selective electrode techniques.

Whole-rock values generally fall in the range (p.p.m.): 20 to 1080 Cl; 72 to 640 F. Halogen content does not vary systematically with:modal composition; depth of emplacement; age of intrusion; or degree of copper mineralization. However, high Cl values (>1090 p.p.m.) were found in Lower Cretaceous intrusions within a regional zone of metasomatic iron deposits. The granitoids are only slightly enriched in Cl and F relative to published values of average granitic rocks.

Magmatic biotites in the plutonic granitoids contain from; 188 to 7200 p.p.m. Cl; 164 to 4450 p.p.m. F. However, hydrothermal or deuteric biotites from ore deposits exhibit high halogen concentrations. Those from porphyry copper centers are enriched in F but not in Cl-El Salvador, 6000 p.p.m. F, 2800 p.p.m. Cl; Potrerillos, 8240 p.p.m. F, 3480 p.p.m. Cl; Rio Blanco, 6200 p.p.m., F, 2000 Cl; Los Pelambres, 9800 p.p.m., F, 3800 p.p.m. Cl; Biotite from the Boqueron Chañar metasomatic iron deposit analyzed 2.32 percent F and 1.12 percent Cl.

There was no change in chlorine and fluorine abundances in granitic magmas emplaced during the evolution of this part of the Andean orogen, except during the Lower Cretaceous. Fluorine, rather than chlorine, may influence post-magmatic copper transport while both halogens may play a vital role in post-magmatic iron transport. This has potential importance in mineral exploration for porphyry copper and metasomatic iron deposits. (Authors' abstract).

HAYNES, S.J., and CLARK, A.H., 1972b, A rapid method for the determination of chlorine in silicate rocks using ion-selective electrodes: Econ. Geology, v. 67, p. 378-382.

A fast, simple method that may be useful in reconnaissance studies of the chlorine in rocks from saline inclusions (ER).

HELGESON, H.C., 1972, Thermodynamic constraints on mass transfer in hydrothermal systems at high temperatures and pressures (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 10, Geochemistry, p. 310 (In English). Author at Department of Geology and Geophysics, University of California, Berkeley, California, U.S.A.

Thermodynamic prediction of the compositional variation of coexisting solid and aqueous solutions as a function of temperature and pressure, and calculation of the mass transfer attending reaction of hydrothermal solutions with sedimentary, igneous and metamorphic rocks defines constraints on (and consequences of) the chemical environment and composition of aqueous solutions responsible for the presence or absence of various hydrothermal mineral assemblages at high temperatures and pressures. The filtration and diffusion models of metasomatism, which in turn yield predictions of mass transfer in space/time coordinates. Theoretical calculations for idealized models can be used to predict directional rates of fluid flow and define compositional changes in the aqueous phase corresponding to those observed in rocks. Predicted changes in the mineral assemblages as a function of reaction progress can be compared with the spatial distribution, composition and relative mass of minerals in natural systems to define chemical and mineralogic requirements for hydrothermal ore deposition at supercritical temperatures and pressures. (Authors' abstract).

HENDERSON, B., 1972, Defects in crystalline solids: New York, Crane, Russak & Co., 203 pp.

Includes discussions of dislocations, etc., of pertinence to fluid inclusion occurrences & leakage. (E.R.)

HERRICK, D.C., ROSE, A.W., and DIENES, Peter, 1972, Mineralogical and isotopic studies of the Cornwall iron deposit, Pennsylvania, (abstr.): Geological Society of America, Abstracts with Programs, v. 4, no. 7, p. 534-535. Authors at The Pennsylvania State University, University Park, Pennsylvania 16802.

The Cornwall deposit is a contact metasomatic replacement of a Cambrian limestone intruded by a Triassic diabase sheet. The paragenesis includes early diopside followed by magnetite, actinolite, phlogopite, diopside, pyrite with minor garnet and K-feldspar and late chalcopyrite, Talc, serpentine and calcite are abundant only at the ore-limestone contact. Based on the mineral assemblages and on ΔO^{18} for calcite-magnetite, temperatures are estimated to have been about 450°C and the fS_2 and fO_2 about 10^{-3} to 10^{-6} and 10^{-20} to 10^{-22} respectively for most of the magmetite depositing period.

Isotopic measurements of calcites from unaltered limestones (δO^{18} = 20.9 °/oo vs SMOW), the ore-limestone contact (19.0 °/oo), and the ore 18.9 °/oo) show a small range in composition indicating only minor effects of the forming process. The isotopic compositions of magnetites from the contact zones of diabase-ore (9.7 °/oo) and limestones-ore (7.5 °/oo) are the heaviest yet reported for this mineral and indicate an isotopic gradient across the ore body.

The δO^{18} of water in equilibrium with the ore minerals is estimated to be 15 °/oo to 17 °/oo. In no other study has it been necessary to postulate the participation of such heavy waters in ore deposition processes. The possibilities of deriving such water from the diabase as well as the control of the O^{18} of the water by the replaced limestone are considered. The latter mechanism leads to the formation of the ore, suggesting that diffusion may have been an important transport mechanism here. (Authors' abstract.)

HEWITT, D.A., 1972, Stability of the assemblage muscovite-calcite-quartz (abst): Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 537. Author at Department of Geological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Reversed equilibrium data have been obtained for the reaction $KAl_3Si_3O_{10}(OH)_2 + CaCO_3 + 2SiO_2 \rightleftharpoons KAlSi_3O_8 + CaAl_2Si_2O_8 + CO_2 + H_2O$. Under the conditions fluid pressure equal to total pressure and $CO_2:H_2O$ ratio in the fluid equal to 1:1, the equilibrium temperatures are 606 ± 4°C at 7000 bars, 584 ± 5°C at 6000 bars, 557 ± 8°C at 5000 bars, 533 ± 6°C at 4000 bars, and 475 ± 20°C at 2000 bars. Using 1.20±.15cc/gm as the estimated specific volume for the fluid, the calculated enthalpy of reaction at 6000 bars and 584°C is 50,100 ± 8000 calories/mole.

The equilibrium curve at 6000 bars fluid pressure is nearly symmetrical about X_{CO_2} + .5 with points at 570°C, X_{CO_2} = .22 ± .08 and .75 ± .08 and 555°C, X_{CO_2} = .10 ± .05 and .87 ± .05. There is no evidence indicating any fluid immiscibility in the $CO_2 - H_2O$ system at the pressures and temperatures of the study. However, the suggestion of a slight asymmetry in the T-X curve indicates the fluid mixing may not be ideal.

The maximum stability of muscovite-calcite-quartz lies very near to or at slightly lower temperatures than the recently determined values for the aluminum silicate triple point. These data are consistent with the absence of the muscovite-calcite-quartz assemblage above the sillimanite isograd and the common occurrence of the assemblage within the kyanite zone. (Author's abstract).

HLAVAC, Jan; PICHA, Jaroslav; and VASKOVA, Ludmila, 1970, Study of volatile inclusions in rock quartz: II. Decrepitation of rock quartz: Silikaty, v. 14, no. 4., p. 309-317. (In Czech, with English summary). Authors at Dept. of Technol. of Silicates, Chem.-Tech. Univ., Prague.

A study by the decrepitation method (with the electrical layout indicated) of samples of quartz described in parts I (Bartuska) and III (Dusil, et al.), reported in this volume. (ER)

HOLLAND, H.D., 1972, Granites, solutions, and base metal deposits: Econ.

Geology, v. 67, p. 281-301.

The classical hypothesis for the derivation of postmagmatic hydrothermal ore deposits is based on three propositions: (1) magmas contain a fair amount of water, much of which is released as hydrothermal solutions during their crystallization; (2) hydrothermal solutions produced in this manner contain a sufficient concentration of ore metals to give rise to the observed base metal deposits; (3) the decrease in temperature and pressure, and the reactions of these solutions with wall rocks leads to the precipitation of the ore minerals.

The abundance of biotite and hornblende in most acid and intermediate igneous rocks indicates that such rocks crystallize from magmas containing several percent water. Their present water content is usually about 0.5 percent, and it is likely that some 1 to 5 weight percent of water are released during the crystallization of most acid to intermediate plutons.

Experiments on the composition of aqueous solutions in equilibrium with silicate melts of granitic composition have shown that zinc, manganese, and probably lead are strongly partitioned into the aqueous phase, and that the partition ratio is roughly proportional to the square of the chloride concentration of the aqueous phase. The extraction of these metals from granitic magmas into hydrothermal solutions depends on the initial chloride and water content of the magma, as well as on the time relationship between vapor phase separation and the crystallization of the melt. Under favorable circumstances zinc and manganese can be extracted virtually quantitatively from granitic magmas.

The quench pH of aqueous solutions equilibrated with granitic melts is typically between 1.4 and 2.2. Such solutions react with most wall rocks during cooling and move in the direction of supersaturation with respect to base metal sulfides.

These data strongly support the validity of the three propositions and of the classical hypothesis for the origin of postmagmatic hydrothermal ore deposits. They also suggest that water, chloride, the base metals and reduced sulfur are the most important ingredients in the production of such ore deposits, and that the criteria developed for assessing the availability of these ingredients in particular plutons, may turn out to be of use in large scale prospecting. (Author's abstract)

HURLE, D.T.J., 1972, Hydrodynamics, convection and crystal growth: Jour. of Crystal Growth, v. 13/14, p. 39-43. (Author at Royal Radar Establishment, Great Malvern, Worcestershire, U.K.)

Because the existing literature in this field is not well documented, the author has attempted to use the limited space available for this review to provide a bibliography (though by no means an exhaustive one) of the field rather than to treat one aspect of the subject in detail. The subjects reviewed are the effects of steady forced and natural convection on segregation in melt growth, the role of non-steady convection in forming striations and the effects of gas-phase convection on crystal growth. (Author's abstract)

IMAI, Hideki, KIM, M.S., & FUJIKI, Yoshinori, 1972, Geologic structure and mineralization of the hypothermal or pegmatitic tungsten vein-type deposits at the Ohtani and Kaneuchi mines, Kyoto Prefecture, Japan: Mining Geology (Japan) v. 22, p. 371-381, (in Jap., with Engl. abstr.)

The tungsten deposits of the Ohtani and Kaneuchi mines belong to the hypothermal or pegmatitic vein-type. These deposits are genetically related to the late Cretaceous or early Tertiary granitic activities. In the adjacent areas to these mines, the same granitic activities are also related to the deposits of the Ikuno, Akenobe and Tada mines, belonging to xenothermal type. The granitic activities and mineralizations in these districts would happen during 40 x 10^6 years ranging from Cretaceous to Tertiary Periods.

The ore deposit of the Ohtani mine filling the tension cracks and wrench faults occurs in the granodiorite stock intruded into the core part of the anticline of the folded Paleozoic formation. The vein fissures were formed by the lateral pressure causing the regional-scale folded structure accompanied by the upheaval pressure of the granitic magma. The ore deposit of the Kaneuchi mine exists in the hornfelsic rocks forming the dome structure due to the upheaval of the granitic cryptobatholith. The vein fissures of the Kaneuchi mine were also formed by the regional-scale folded structure accompanied by upheaval pressure due to the doming up of the cryptobatholith. These pressures correspond to two principal stresses, i.e., maximum principal stress ($\sigma 1$) and intermediate principal stress (σ_2). The leading vein fissures belong to the tension crack perpendicular to the boundary plane between the cryptobatholith of the granite and the surrounding Paleozoic formation. The tension cracks include the directions of the maximum and intermediate principal stresses, i.e., two kinds of pressure described above. Namely they are perpendicular to the minimum principal stress (σ_3). These fissures of both deposits were mineralized by the underlying granitic magma which would be perhaps rich in fluid containing high contents of salts.

The ore minerals of both deposits are scheelite, wolframite, cassiterite, chalcopyrite, cubanite, pyrrhotite, stannite, sphalerite, mackinawite and others in accessory amounts, accompanied by quartz, muscovite, tourmaline, fluorite, etc. In the Ohtani mine, the exsolution texture of cubanite, chalcopyrite, pyrrhotite and mackinawite are observed under the microscope.

Though the country rock of the Ohtani mine is granodiorite, the tungsten mineral in this deposit is only scheelite. The source of the ore-forming fluid in this area would exist in the deeper part underneath the present country rock, i.e., granodiorite which would be formed by the contamination of the granitic magma with the calcareous rock at the time of intrusion. Scheelite would be formed by the effect of the calcareous rock through which the ore-forming fluid flowed upwards. This fact has the relation with the problem of fluid inclusion in the constituents quartz of the granodiorite discussed in the other paper [See Kim et al., 1972, this issue].

In the Kaneuchi mine, the zonal distribution of ore minerals is recognized according to the distance from the cryptobatholith of the granite, which reflects the decrepitation temperatures discussed in the other paper.

It is noticed in these districts that in the hypothermal tungsten and tin veins primary bornite, primary chalcocite, mawsonite and stannoidite are lacking, which are found in the xenothermal tin and tungsten veins. While, cubanite, pyrrhotite, and mackinawite are not recognized in the xenothermal type, which exist in the hypothermal type. (Authors' abstract)

IRVING, J.A. and GREEN, D.H., 1972, Experimental study of phase relationships in a high-pressure mugearitic basalt as a function of water content, (Abstr.): Geological Society of America, Abstracts with Programs, v. 4, no. 7, p. 550-551. Author at Department of Geophysical Sciences, University of Chicago, Chicago, Illinois 60637.

Phase relationships have been determined for a lherzolite-

bearing nepheline mugearite lava from the Newer Basalts of Victoria (SiO_2 48.9 %, Al_2O_3 15.4 %, Na_2O 5.7 %, K_2O 2.9 %, 100 $Mg/Mg + Fe^{2+}$ = 65, ne 14.5 %):

wt. % H_2O	**coordinates of liquidus (kb, °C)**	**liquidus phases (kb)**
"dry"	(2,1215), (15,1275), (25,1385)	Ol(0-9), Cpx(13.5-22.5)
2 %	(2,1140), (15,1185), (25,1280)	Ol(2.7-13.5), Cpx(13.5-27)
5 %	(3,1105), (15,1135), (25,1220)	Ol(3-15.9), Cpx(13.5-27)
10 %	(9,1065), (15,1090), (25,1170)	Ol(12), Phlog(16), Cpx+Phlog(20)
30 %	(10^{-3},1220) (3,1105), (3,1070), (13,1055), (20,1090)	Ol(2.7-15), Ol+Phlog(20) Phlog(25)

For 5 % H_2O, amphibole-out passes through (3,1040), (18,1115), (22,1065), (21.7,900), (20.5,800), and the reversed high pressure portion has a +ve dP/dT; mica-out passes through (3,1040), (12,1095), (20,1160), (27,1195). The curves for 2 % H_2O are almost identical in position, with amphibole-out 1 kb higher at 900°C and 1000°C. Calculations based on microprobe analyses of synthetic phases suggest that the nepheline mugearite (and spatially associated nepheline hawaiites) may be derived from Victorian basanite magmas containing 7-8 % H_2O by fractionation at mantle pressures (15-20 kb) of minor olivine + cpx followed by major Ti-amphibole ± mica. (Authors' abstract).

ISAKOVICH, I.Z., and GIBSHER, N.A., 1972, Temperature conditions of formation of complex ores in some deposits of Rudnyi Altai: Geol. Geofiz. 1972, no. 10, p. 79-85 (in Russian). CA 78 (13) 162072n (1973). (Authors at Inst. Geol. Geophys., Novosibirsk, USSR)

The pyrite-complex ore deposits of the Tishinsk, Leninogorsk, and Zmeinogorsk regions are localized in the Middle Devonian effusive-sedimentary rocks. The ore minerals include pyrite, chalcopyrite, sphalerite, quartz, and barite indicating that these deposits were formed under mesothermal (120-350°) conditions. The gas phase occurring as inclusions in sphalerite contains H_2S, SO_2, HCl, NH_3, CO_2, O, CO, N, and rare gases.

JESSBERGER, E., & GENTNER, W., 1972, Mass spectrometric analysis of gas inclusions in Muong Nong glass and Libyan Desert glass: Earth and Planetary Science Letters v. 14, p. 221-225. Authors at Max-Planck-Institut für Kernphysik, Heidelberg, Germany.

Noble and non-noble gases in bubbles of Muong Nong- and Libyan Desert glass were released by vacuum crushing at room temperature and measured by high sensitivity mass spectrometry. The N_2:Ar:Kr:Xe ratio as well as the rare gas isotope ratios were found to be atmospheric, indicating the terrestrial origin of these glasses. The concentrations of the active gases O_2, CO_2, CO and SO_2 vary highly between adjacent bubbles. Total gas pressure in the bubbles of the glasses is in the 100 mm range, much higher than that found for other types of tektites. (Authors' abstract)

JOHNSON, A.M., 1972, Metal-bearing brines from reef complexes (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 553. Author at Institute of Mineral Research, Michigan Technological University, Houghton Michigan 49931.

Diagenetic mechanisms best explain distributions of trace elements Fe, Mn, Na, K, Sr, Cu, and Zn in limestones and dolostones of the west Texas-New Mexico Permian Reef Complex. Much higher concentrations of organics and metals, including zinc, reported from Recent carbonate sediments contrast with those observed in the Permian rocks. The model developed to explain these differences provides a source of metal-bearing brines which may be important for Mississippi Valley-type deposits.

The writer proposes that diagenetic processes, contemporaneous with sedimentation, operating in prograding shelf-margins of reef systems provide the mechanism for metal and organic release. Residual, Mg-rich chloride brines, generated in the evaporite zone of the shelf, dolomitize buried skeletal carbonate debris thereby releasing metals and organics. These warm (50°C), dense (1.2 g/cc) brines pass into basin sediments carrying metals and organics stripped from the reef mass. It is not clear whether metals are transported as chloride or organometallic complexes, or both.

Brine generation, dolomitization and metal-organic release are envisioned as continuous processes which need not be simultaneous with mineralization; metalliferous brines may remain "on tap" in the basin sediments. Similarities between reported analyses of sabkha, oil field and fluid inclusion brines are interpreted as supportive evidence.

Huge volumes of carbonates preserved in ancient reef systems attest to the very long time spans of reef growth. Through time, large amounts of metals and organics could be generated suggesting reef systems to be an important link in the geochemical cycle of ore and oil formation. (Author's abstract).

JONES, D.R.H., 1972, The determination of the kinetics of ice-brine interfaces from data on temperature-gradient zone migration: Phil. Magazine, v. 25, no. 1, p. 97-103, 1972. Author at Department of Metallurgy, University of Cambridge, Cambridge, England.

An analysis is made of existing experimental data for the temperature-gradient migration of droplets, containing either NaCl or KCl solution, through ice. In contrast with earlier treatments the present analysis employs properly calculated values for the diffusivities of NaCl and KCl in saturated aqueous solution. In the present study droplet motion is shown to be controlled partly by the reactions at the ice-solution interfaces. Since the data are consistent with the operation of interfacial mechanisms either involving "normal growth", or requiring the presence of screw dislocations or "two-dimensional" nuclei, the mechanism of the interfacial reaction cannot be decided. However, the choice of the "normal growth" or dislocation mechanisms requires a dependence of the appropriate kinetic coefficients on salt concentration, whereas no such dependence is required if a nucleation mechanism is assumed. It is not possible to determine the kinetic coefficients for the nucleation mechanisms; but values are obtained for the coefficients of the "normal growth" and screw-dislocation mechanisms; for both the NaCl and KCl systems, for liquidus (droplet) temperatures between 260 and 266°K(K). The dependence of the latter coefficients on concentration was much more pronounced in the NaCl system than in the KCl system. For the case of "normal growth", for example, the kinetic coefficient was about 3×10^{-3} mm s^{-1} $°K^{-1}$ (3 μm s^{-1} K^{-1}) for a concentration of NaCl equivalent to a liquidus temperature of 263°K(K); for a similar concentration of KCl, the coefficient was about 30×10^{-3} mm $s^{-1}$$°K^{-1}$ (30 μm s^{-1} K^{-1}). (Author's abstract)

JONES, M.B., ALLEN, J.M., and FIELD, C.W., 1972, Hydrothermal alteration and mineralization, Valley copper deposit, British Columbia (abst): Geol. Soc. America Abstracts with programs, v. 4, no. 7, p. 557. First author at Department of Geology, Oregon State University, Corvallis, Oregon 97331.

Valley Copper is a large (1000 m.t.; 0.48% Cu) porphyry Cu-Mo deposit in the Highland Valley District, British Columbia. Host rock is the Bethsaida Granodiorite; the youngest, most silicic, and centrally located major phase of the 198 + 8 m.y. (Northcote, 1969) composite Guichon Creek Batholith. Hydrothermal effects were structurally controlled by faults and fractures. Gangue minerals include quartz, sericite, potassium feldspar, kaolinite, and sparse anhydrite as pervasive replacements, selvages, and vein fillings. Potassic alteration is largely characterized by addition of K_2O and depletion of Na_2O and CaO. The ore minerals (bornite, chalcopyrite, and minor molybdenite) were deposited in quartz and quartz-sericite veinlets that cross-cut the previously altered host. Sulfide-bearing veinlets form three arcuate zones that are nested around an earlier barren quartz stockwork core. Stable isotope abundance data for hypogene sulfides (-4.1 to +1.5 δS34°/oo), sulfates (+11.8 to +15.2 δS34°/oo) quartz (+8.7 to +12.5 δO18°/oo), potassium feldspar (+7.7 to +8.7 δO18°/oo), and sericite (+6.5 to +7.6 δO18°/oo and -65 to -53 δD°/oo) suggest a deep sub-crustal source of sulfur and little contamination of the hydrothermal system by meteoric water. Age determinations for a pre-ore porphyry dike (204 ± 4 m.y.), vein sericite (198 and 202 ± 4 m.y.), and a post-ore lamprophyre dike (132 ± 3 m.y.) were obtained by the K-Ar method. Geologic evidence, stable isotope data, and radiometric dates indicate a close space-time genetic relationship between late magmatic processes of Bethsaida phase plutonism and the hydrothermal event. (Authors' abstract)

JOSHI, M.S., and TAKU, R.K., 1971, Inclusions in natural topaz crystals: Jour. Gemmology, v. 12, no. 8, p. 346-353.

A short but important paper. Matched opposing cleavage surfaces, and opposite surfaces of thin (001) flakes of topaz (locality unstated) were examined with the microscope, etched in KOH at 440°C for 10 to 40 seconds and reexamined. Rows of densely-spaced diamond-shaped etch pits formed where curving planes of (probably secondary, ER) fluid inclusions intersected the cleavage surfaces. Etching on opposing cleavage surfaces yielded mirror-image arrays of etch pits. Etching from opposite sides of a 500μm plate, originally having what appear (to ER) to be tubular holes with square outlines (termed "square inclusions" by the authors), yielded symmetrically-arranged etch pits. The authors interpret these as the result of etching of dislocations through the plates, and the original square inclusions as the result of trapping on dislocations. Different sizes of etch pits arise from different original inclusion sizes, different etch times, and different strain energies around dislocations. (ER).

JOWETT, E.C., 1972, The nature of the ore-forming fluids of the Polaris lead-zinc deposit, Little Cornwallis Island, N.W.T., from fluid inclusion studies: Batchelor's Thesis, Univ. of Toronto, 35 pp. (submitted for publication in Canadian Inst. Min. and Metal.).

The deposit is very similar to that at Pine Point. Primary two-phase inclusions (86) in sphalerite homogenized at 52-105°C (with one at 131°). Inclusions in late calcite are one-phase (liquid). No inclusion in sphalerite froze at -19.5°C. (ER)

KADIK, A.A., 1972a, Physical-chemical conditions of water separation from magmas at their uprising ot the earth's surface (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 2, Petrology, p. 46 (In English). Author at Institute of Geochemistry, Academy of Sciences of the USSR, Moscow, V-334, Vorobyevskoe shosse, 47-a, U.S.S.R.

On the basis of experimental and thermodynamic data, the physical-chemical conditions of radial transfer of water in magmas and boiling of melts with water loss are considered.

Under the conditions of crust and upper mantle, the solubility of water in basic, acid and ultrabasic melts increases with the water pressure. At these depths, pressure decrease during the upward movement of magma must favour establishment of a saturated state in the magma, leading to boiling. In the high-pressure region, maximum solubility of the water may be expected, followed by a decrease of the H_2O solubility with further increase in pressure.

The process of boiling with H_2O loss can only arise at the top of a magma body under the gravitation field and convective instability of magmatic liquids. With convective fluid movement, the boiling of magmas leads to intensive radial transfer of water and of other volatiles by melt flow from the deep part of the magma to the location of the boiling (10^{-6} -10^{-9} g/cm^2 sec). The boiling of basic and ultrabasic magmas during the upward movement results from zone melting or tectonic reasons, and takes place most probably at depths corresponding to the continental crust.

Using this hypothesis, peculiarites of magmatic differentiation in the crust and the source of volatiles in processes of melt interaction with roof rocks, and during autometamorphic transformation of the top part of the intrusion, are explained. (Authors' abstract).

KADIK, A.A., 1972b, Separation of water from magmas during its rise to the surface of the earth, pp. 135-141 in Progress in Modern Geochemistry and Analytical Chemistry: Moscow, Izdatel. "Nauka" (and Vernadski Institute) (in Russian).

A survey of the problem, with 20 references. (ER)

KALYUZHNYI, V.A., & GIGASHVILI, G.M., 1972, Physical-chemical properties of the formation of cavity pegmatites of the Ukraine: Mineral. Sbornik L'vov. Gos. Univ., v. 26, no. 3, p. 247-256.

A diagrammatic representation is given of the stages and acid-alkaline periods of minerogenesis in pegmatites of the cavity type. The periods are connected with the evolution of the acid-alkaline ascending flow of the volatiles in the cooling mother intrusion. (Authors' abstract)

KARAMYAN, K.A. and MADANYAN, O.G., 1972, Temperature conditions of formation of Cu-Mo deposits of the Zangezurskii ore region: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 170-177. (In Russian)

KARWOWSKI, L., & KOZLOWSKI, A., 1972a, Thermogravimetric method of determination of decrepitation temperature: Bulletin de L'Academie Polonaise des Sciences, v. 20, no. 1, p. 11-17 (in English with Russian abstract).

The paper concerns the thermogravimetric determination of decrepitation temperatures of minerals. The authors applied the derivatograph which has not hitherto been used for such investigations. The beginning decrepitation temperatures were determined by means of the loss of weight effect during heating, recorded on the DTG and TG lines. It appears that the thermogravimetric method is just as efficient as the thermoacoustic one. The phenomenon of decrepitation of inclusions in minerals is the result of transgressing the host-mineral's break resistance by the pressure inside the inclusion, which increases during heating [8,11]. The breaking of inclusions gives an acoustic effect; besides, the effect of weight decrease is connected with decrepitation being a result of the escape of inclusion filling [11]. During decrepitation the single grains of mineral move sometimes with great energy. (Authors' abstract).

KARWOWSKI, Lukasz, & KOZLOWSKI, Andrzej, 1972b, Ball pegmatite from Czarne in the Karkonosze Mts.: Acta Geologica Polonica, v. 22, no. 1, p. 93-108, (in Polish with English abstract). Authors at Institute of Geochemistry, Mineralogy and Petrography of the Warsaw University, Warszawa 22, Al. Zwirki i Wigury 93, Warsaw, Poland

Ball pegmatite has probably developed from the aplite melt, as shown by the same composition of both rocks. The crystallization centers of the balls were potash feldspars and feldspar, quartz and biotite aggregates, which had relatively high-temperature beginnings. The temperature of their crystallization was determined by thermogravimetric decrepitation method (Karwowski & Kozlowski 1972) as ∿ 640°C. The slightly triclinic structure of central potash feldspar, strongly cracked automorphic grains of quartz (during inversion α-β) and a large amount of gaseous phase in the primary inclusions without Brownian movements are additional arguments of the discussed high-temperature origin.

A quick growth of feldspar interwoven with quartz was caused by temperature drop. The equable influx of the material and the identical speed of growth in all directions caused the spherical shape of the bodies. The mean value of crystallization temperature was 500°C. Inclusions of minerals in this sphere of balls are gaseous-liquid with a considerable amount of gaseous phase.

Fine pegmatite of the envelope as well as of that infilling the fissures between the balls and joining them, formed in the temperature ∿ 320°C.

Besides ball pegmatite, also drusy pegmatite formed during the later stages, as it is evidenced by the character of the inclusions. Li, Na, K, Cl and Br were analyzed in 7 extracts from quartz. (From authors' two-page summary.)

KAZANSKIY, Yu.P., KATAYEVA, V.N., and SHUGUROVA, N.A., 1969, Gas and liquid phases in inclusions as relicts of former atmospheres and hydrospheres: Geologiya i Geofizika, 1969, no. 11, p. 39-43 (in Russian; translated in Internat. Geol. Rev., v. 12, no. 9, 1970, p. 1150-1153; abstract on p. iv.).

Liquid inclusions in authigenic minerals from ancient marine siliceous rocks may represent the saline constituents of the ancient marine waters in which Mg appears to have exceeded the alkalies; as a rule, SO_4 was absent and F was found in only one sample. Presence of appreciable quantities of O_2 in the Late Precambrian, essentially CO_2-N_2, atmosphere (table 1) is definitely indicated by interpretations of the gas or gaseous phase of the inclusions. (V.P. Sokoloff).

KESLER, S. E. and ASCARRUNZ-K., R. E., 1972, Guatemalan lead-zinc mineralization: magmatic-hydrothermal or Mississippi Valley type? (abst.): Geol. Soc. America Abstracts with Programs, v. 4, no. 7, p. 561; also Econ. Geol., v. 67, p. 1007. Authors at Dept. of Geology, University of Toronto, Toronto 5, Ontario, Canada.

Lead-zinc mineralization is widespread in carbonate rocks of the Permian Chochal and Cretaceous Cobán-Ixcoy formations in a 400 x 30 km zone that extends (E-W) across central Guatemala. This zone forms the southern erosional edge of an evaporite-bearing sedimentary basin that extends northward toward its Precambrian-early Paleozoic provenance in Oaxaca and Yucatán. Massive galena-sphalerite-pyrite mineralization is concentrated along bedding and fault surfaces in areas up to 1500 x 100 m. Minor barite, chalcopyrite and pyrargyrite are present locally and the silver content of galena increases southward across the mineralized zone. Most mineralization is near the base of the lowest carbonate unit in the local stratigraphic section and shows no observable relation (in surface outcrop) to the depositional and collapse breccias that are widespread throughout the mineralized carbonate rocks. Although the mineralization is "Laramide", no igneous rocks of this age are known in the entire mineralized zone. Limited fluid inclusion and S isotope data suggest depositional temperatures of 50° to 150°C for the sulfides. δS^{34} values for sulfides have a range of over 20 per mil and are largely positive. Pb isotope values for galenas are slightly radiogenic and do not fit a simple two-stage model.

These observations suggest that the Guatemalan lead-zinc mineralization is similar to that of the Appalachian Valley and some areas of Europe and is transitional in character between typical magmatic-hydrothermal and Mississippi Valley deposit types. Application of newly acquired regional geologic data to stratigraphically oriented exploration in Guatemala could be rewarding (Authors' abstract).

KESLER, S.E., STOIBER, R.E., and BILLINGS, G.K., 1971, Direction of flow of mineralizing solutions at Pine Point, N.W.T.: Economic Geology, v. 67, no. 1, p. 19-24. (First author at Univ. of Toronto, Ontario).

The horizontal asymmetry of single crystals and crystal aggregates in flat-floored vugs at Pine Point, N.W.T., indicates that solution movement during sulfide deposition took place in both directions along a path trending N50°E (parallel to the Presqu'ile barrier complex) and along paths southeast of that trend. This solution movement was controlled in part by the local joint system. The abundance of paragenetically early botryoidal sphalerite aggregates and skeletal galena in high-grade ore "plums" suggests that sulfide precipitation took place when the moving solutions contacted isolated sulfur-rich areas or patches of sulfate-reducing bacteria. (Authors' abstract).

KHETCHIKOV, L.N., DOROGOVIN, B.A., and SHATAGIN, N.N., 1970, Application of multidimensional regression analysis in determination of pressure during mineralogenesis: Akad. Nauk SSSR Geol. Rudnykh. Mestor., 1970, no. 6, p. 112-114. In Russian; trans. in Intern. Geol. Rev., v. 14, no. 9, p. 971-973; abstract on p. iii.

Reliable estimations of the crystallization pressure, P_c, are shown to be possible by means of simplified equations which involve 7 or 5 independent variables (tables 1,2), in the case of synthetic quartz. (Authors' abstract)

KHITAROV, N.I., and KADIK, A.A., 1972, The role of water and carbon dioxide in the melting of the substances of the earth (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 14, Mineralogy, p. 421-422 (In English). Authors at V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Academy of Sciences of the USSR, Moscow, U.S.S.R.

1. The solubility of water in acid, basic and ultrabasic magmas, from emperimental data at pressures up to 10 kb, increases with increasing of P_{H_2}. At pressures which apparently correspond to those of the upper mantle, maximum of solubility should be expected. Further increase of pressure decreases the concentration of water in the melt; the ratio of water to its components will be determined by the degree of its dissociation and by reactions with the magma.

2. At pressures up to 5 kb, the solubility of carbon dioxide in magmas of the same composition is considerably less than that of water. The solubility of CO_2 rises with increasing pressure at temperatures above 1000°C. The separation of a fluid phase from magmas during their movement to the earth's surface must be characterized by diminution of part of the CO_2 in the vapor along with decreasing pressure. The solubility of CO_2 at pressures of more than 10-20 kb is expected to be significant and possibly to approach that of the solubility of water.

3. In the absence of water-containing phases (amphiboles, biotites), silicate mass fusion starts at lower temperatures when water pressure increases, independent of the quantity of water. At pressures over 10-20 kb, which correspond to the upper mantle regions, the temperature of melting silicates, in the presence of water, must increase.

4. When water-bearing phases are forming, independent of the primary content of water, the melting can take place in the presence of a free vapor phase in intergranular space, or in the field where this vapor phase is absent. The temperature of beginning of the melting in the latter case is greater than in the former case and increases with pressure.

5. The gradual accumulation of water in zones of melting in the mantle as well as in the earth's crust, under the influence of the diffusion of gases from the deep part of the mantle or surroundings, must lead to a relatively sharp fall in the temperature of the beginning of melting when water concentration reaches some definite value. This process must lead to a break in the mechanical stability of partly-melted masses and to the intermixing and active interaction with surrounding substances.

6. In the field of the low pressures, the influence of CO_2 on the temperature of melting of silicates is significantly less than that of water. As a consequence, the ratio of CO_2 to H_2O in pore fluids of rocks must control the temperature of their melting. Increase of CO_2 concentration in the fluid phase with depth determines the rise of temperature minimum on the curve of rock melting. This may be connected with the appearance of processes of local melting. (Authors' abstract).

KILINC, I.A., 1972, Experimental study of partial melting of crustal rocks and formation of migmatites (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 2, p. 47-48 (In English). Author at Department of Geology, University of Cincinnati, Cincinnati, Ohio 45221, U.S.A.

Partial melting of shales and graywackes in the presence of $CaCl_2$-NaCl and KCl-NaCl solutions were experimentally investigated at 700° and 750°, in the pressure range of 2 to 8 kilobars.

Partial melting of shales resulted in the production of potassium-rich melts ranging in composition from granite to quartz monzonite and granodiorite which were in equilibrium with biotite, cordierite and aluminum silicates. Partial melting of graywackes resulted in the formation of sodium-rich melts (trondhjemite) in equilibrium with biotite and amphiboles.

As the amounts of early-formed melts are small, the liquid may not free itself from the crystalline material and, upon crystallization of such melts, migmatites may form. The results suggest that crystallization of melts forming by partial melting of shales or their metamorphic equivalents may result in the formation of migmatites having potassium-rich veins and biotite, cordierite and aluminum silicate selvages. On the other hand, partial melting of graywackes or their metamorphic equivalents may be responsible for sodium-rich migmatites with biotite-amphibole selvages. (Author's abstract.)

KILINC, I.A., & BURNHAM, C.W., 1972, Partitioning of chloride between a silicate melt and coexisting aqueous phase from 2 to 8 kilobars: Econ. Geology, v. 67, p. 231-235.

Chloride bearing solutions were equilibrated with partially melted silicate rocks under two to eight kilobars fluid pressure, near the 700° and 750°C isotherms. Glasses, ranging in composition from granite to granodiorite and trondhjemite, were separated from the charges and were analyzed colorimetrically for their chloride content. The molal partition coefficient of chloride,

$$K_p^{Cl-} = m_{Cl^-}\text{ in melt}/m_{Cl^-}\text{ in aqueous phase}$$

decreases from 0.023 at two kilobars to 0.012 at six kilobars and then increases sharply to 0.077 at eight kilobars. This strong preference of Cl^- for the aqueous phase suggests that highly concentrated Cl-brines can be produced during separation of H_2O from a crystallizaing magma. (Authors' abstract)

KIM, M.S., FUJIKI, Yoshinori, TAKENOUCHI, Sukune, & IMAI, Hideki, 1972, Studies on the fluid inclusions in the minerals from the Ohtani and Kaneuchi mines: Mining Geology (Japan), v. 22, p. 449-455.

The writers studied fluid inclusions in minerals from the Ohtani and Kaneuchi mines, which belong to the hypothermal or pegmatitic tungsten vein-type deposit, by means of the heating stage- and cooling stage-microscope and decrepitation methods.

(1) By the heating-stage microscope, the filling temperatures of inclusions are measured as follows (Figs. 3,4): Ohtani mine: quartz 375°~225°C, scheelite 337°~262°C, cassiterite 345°~297°C. The maximum filling temperature of quartz is 375°C, which is exceptional as shown in Fig. 3. Most of the filling temperatures of quartz are below 300°C. Kaneuchi mine: quartz 308°~231°C, scheelite 318°~276°C, wolframite 337°~286°C. The filling temperatures of the inclusions in scheelite, cassiterite and wolframite are somewhat higher than those in quartz. This would be due to the fact that the quartz crystals studied were deposited at the later stage of mineralization. The earlier stage quartz is white and milky in colour, so it is difficult to observe the inclusions of the earlier stage quartz under the microscope.

(2) By the cooling-stage microscope, the NaCl equivalent concentrations in inclusions are determined as follows (Figs. 5,6); Ohtani mine: quartz 7.4~4.0 wt.%, scheelite 8.2~6.1 wt.%, cassiterite 8.7~6.1 wt.%. Kaneuchi mine: quartz 8.2~3.7 wt.%, scheelite 8.6~6.4 wt.%, wolframite 8.4~8.1 wt.%. The NaCl equivalent concentrations in scheelite, cassiterite and wolframite are higher than those of quartz. This would be due to the same reason as for the filling temperatures stated above.

(3) The filling temperature increases with the increase of the NaCl equivalent concentration (Figs. 7,8). This would be due to the dilution of the ascending ore-forming fluid by the underground water.

(4) In the Ohtani mine, the fluid inclusions in quartz from greisen and granodiorite adjacent to the greisen envelope are nearly the same as those in the vein materials. The ore-forming fluid would be concentrated in the granitic magma existing in the deeper part underneath the present country rock, i.e., granodiorite.

(5) The decrepitation temperatures of quartz samples in both deposits are as follows: Ohtani mine 382°~280°C, Kaneuchi mine 334°~255°C. It is inferred that the formation temperatures of the Ohtani mine are higher than those of the Kaneuchi mine.

(6) It is generally said that the decrepitation temperatures are higher than the filling temperatures because of the overshoot effect. The samples of quartz which were used in the decrepitation method of the present study belong to an earlier stage of mineralization than those in the heating-stage microscope method. Therefore, it is probable that the temperature differences between the heating-stage microscope method and the decrepitation method are due to both overshoot effect and difference of the stage of quartz deposition. But, it is also probable that there exist other factors which make the difference between the filling temperatures and decrepitation temperatures. (Authors' abstract)

KLYAKHIN, V.A., and LEBEDEV, A.S., 1972, Beryllium behavior in boron-fluorine-carbonate solutions: in Experimental investigations in mineralogy, 1970-1971, A.A. Godovikov and V.S. Sobolev, eds.: Novosibirsk, Acad. Sci. USSR, Sib. Division, Inst. Geol. & Geophys., p. 87-92 (in Russian).

Formation of various solid phases including chiolite and cryolite, etc. (ER)

KNIZKOVA, JIRINA, and ZALUDOVA, VLASTIMILA, 1972, Selected bibliography of Czech economic geologists: Prague, Czech Geol. Survey, 55 pp. (in English).

This lists 278 titles (original Czech, and English translations) of geological publications on various fields of interest to ore deposit research. (ER)

KOGARKO, L.N., 1972, The role of compounds of oxygen, sulphur and carbon in the magmatic gas of alkaline rocks (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 10, Geochemistry, p. 312 (In English). Author at Institute of Geochemistry, Academy of Sciences, Vorobiovskoje shossee 47a, Moscow V-334, U.S.S.R.

Experimental investigations of phase equilibria during the melting of nepheline syenites from the Lovozero Alkaline Massif at elevated water vapour pressures and under controlled fugacity of oxygen revealed that these rocks crystallized at relatively low oxygen fugacities corresponding to the buffer QFM (Kogarko, Hamilton, Nolan, in press). Low oxygen fugacity of the magmatic gas phase of alkaline rocks leads to a shift of equilibria toward the formation of reduced forms of sulphur and carbon.

Estimating the fugacity of sulphur in alkaline rocks from the monovariant equilibrium, pyrite-pyrrhotite, and that of water from the reaction, nepheline + albite + $H_2O \rightarrow$ analcime, and assuming the activity of carbon equal to unity, because graphite is present in the rock oversaturated with respect to alkalies (Zezin, 1968), we have calculated the composition of a magmatic gas phase.

The comparison of the results of calculations with the known facts concerning the concentrations of certain components in gases extracted from alkaline rocks (Petersilie, 1964) has shown that this gaseous phase is the expected product of the evolution of rocks oversaturated with respect to alkalies. Hydrocarbons (CH_4, C_2H_6, C_3H_8, etc.) were formed at relatively low temperatures and pressures. Rise in temperature, all other conditions being equal, leads to concentrations of the oxidized forms of sulphur and oxygen. (Author's abstract).

KOKORIN, A.M. and KOKORIN, D.K., 1972, Quartz-cassiterite paragenesis and temperature conditions of formation of the tin-bearing zone of the Komsomol region: *in* The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 88-96. (In Russian)

KOLTUN, L.I., 1972, The stages of the mineralization of the Akatuj deposit on the basis of gas-liquid inclusions in minerals: Mineral. Sbor. L'vov. Gos. Univ., v. 26, no. 4, p. 355-359. (In Russian)

The process of ore forming at the Akatuj deposit proceeded from hydrothermal solutions. The temperature changed from 380°C (the formation of the early quartz, pyrite and arsenopyrite) to 60-70°C (the formation of fluorite, calcite etc.). Inside of the process of ore forming there are two temperature spasms (?) which were 40-50°C and 30-40°C and which agree with the stages of development of the deposits. (Authors' abstract)

KOMOV, I.L. and KOMOVA, V.V., 1972, Distribution of mercury in metasedimentary rocks and quartz veins of the Pamirs and Polar Urals: Geokhimiya, 1972, no. 7, p. 817-823 (in Russian; translated in Geochem. Internat. v. 9, no. 4, p. 552-557, 1972). Authors at All-Union Institute of Synthesis of Mineral Raw Materials, Aleksandrov.

Mercury content depends on the lithological characteristics of rocks and on hydrothermal activity, causing its redistribution. The dependence of mercury content on the degree of metamorphism, age, and structural environment of rocks is discussed. It is shown that mercury content increases sharply with decrease in the degree of hydrothermal alteration of rocks, i.e., with approach to the productive zones. Mercury content in quartz veins is higher in veins formed at lower temperatures, as evidenced by samples with homogenization temperatures of 180° to 500°C. (Author's abstract).

KONEV, P.N. and CHALOV, B.Ya., 1972, Study of detrital quartz of the Takatin suite in the Kolva-Vishera region for paleogeographic reconstruction: Litologiya i Polez. Isko., v. 7, no. 5, p. 21-25. (In Russian; translated in Lithology and Mineral Resources, v. 7, no. 5, 1973, p. 557-561.) Authors at Kamsk affiliate, All-Union Petroleum Scientific-Research Institute of Geological Exploration, Perm.

The work is devoted to a study of the density of detrital quartz from the middle Devonian Takatin sandstones, as well as of the ratio of moisture to gas in liquid-gas inclusions in quartz pebbles from the same suite and underlying beds. Conclusions are presented concerning the proposed location of the sources of the Takatin diamonds, based on the density and the H_2O/CO_2 ratio (determined by a "closed tube" method). The temperature of formation is obtained from the expression 560-280°·log H_2O/CO_2. (Authors' abstract, modified by ER)

KONOVALOV, I.V., 1972, Stages of minerogenesis in a deposit of the Lena gold field (as revealed by analysis of gas-liquid inclusions): Akad. Nauk SSSR, Doklady, v. 204, no. 3, p. 674-676. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 204, 1972, p. 66-68). Author at Institute of the Earth's Crust, Siberian Division, Academy of Sciences, USSR, Irkutsk.

Quartz veinlets and veins in the Konstantinovskiy granitic massif, 6 km NW of the gold deposit, were examined by decrepitation, in order to ascertain the relative age of the veinlet-phenocryst and vein types of the ore in the Bodaybo synclinorium (Table 1). Temperatures were found to be 560, 545, 475, 530°C, on the average, for beginnings of the crystallization of quartz in the granites. Breakdown of the results (Fig. 1) indicates that the "Bodaybo" type of lenses, veinlets, and veins represents one and the same stage of the mineralization and that the veins which accompany the massif represent a much later stage which has nothing to do with the deposition of gold. (Author's abstract, translated in Internat. Geol. Review, v. 14, no. 11, 1972, p. 1275).

KOSTYLEVA, E.E., 1968, Improvement in thermal-acoustic analysis: Mineralog. Thermometry and Barometry, v. 2, p. 46-49, Ed. by N.P. Ermakov: Moscow, Izd. "Nauka," (in Russian; see Translation Section).

KOZLOWSKI, A., & KARWOWSKI, L., 1972a, Physico-chemical conditions of the drusy mineral crystallization from Alam Kuh (Iran): Bull. de L'Academie Polonaise des Sciences, v. 20, no. 4, p. 249-255 (in Engl. with Russ. abst).

An attempt at the reconstruction of physico-chemical conditions of the drusy mineral formation from the Tacht-e Soleiman massif (Iran), is dealt with in the present paper. The samples of gray and smoky quartz, rock crystal, colourless and violet fluorite were investigated. Most of the discussed data are based on a study of fluid inclusions in these minerals and in feldspar. The sequence of formation of fluid inclusion generations, evidenced by the phenomena of inclusion refilling, was ascertained. Primary inclusions of gray quartz yield the highest temperatures, 880 ±10°C; the inclusions of rock crystal homogenize at temperatures of 730 ±10°C, those of smoky quartz at 600 ±2°C and of fluorite at 380 ±2°C. The determined salinity of brines in fluid inclusions was as high as 70 wt% of NaCl equivalent in quartz and up to 31 wt% of NaCl equivalent in fluorite. The high salinity induces relatively low pressures during homogenization, (from 70 to 390 bars). (Authors' abstract)

KOZLOWSKI, A., & KARWOWSKI, L., 1972b, Hydrothermal origin of quartz from Jeglowa (Lower Silesia): Bulletin de L'Academie Polonaise des Sciences v. 20, no. 2, p. 91-96 (in English with Russian abstract)

The paper attempts to explain the origin of the rock crystal occurring in kaolinite rock at Jeglowa, lower Silesia. Temperatures at which the rock crystal had originated were established by the methods of homogenization of gaseous-liquid inclusions and thermogravimetric and thermoacoustic decrepitation. It was found that the rock crystal crystallized at temperatures in the interval between 350 and 200°C. Partial composition concentrations of mineral-forming solutions and trace elements occuring in the quartz were determined. (Authors' abstract)

KULLERUD, G and MOH, G. H., 1972, Das Problem "Erz-Nebengestein" erläutert an ausgewählten Beispielen im Experiment: Mineral. Deposita (Berl.), v. 7, p. 271-279. (In German)

Pronounced correlations exist between many ores and the rock types in which they occur. For instance, iron-nickel-copper sulfide ores are almost exclusively located in mafic rocks, such as norites and molybdenum sulfide deposits and vein-type lead-zinc sulfide deposits occur in silicic rocks, such as granites and monzonites. Experimental investigations of pertinent systems containing sulfide as well as silicate components have demonstrated the presence of wide fields of liquid immiscibility. The solubilities of sulfides in liquid silicates are low (<1000 ppm) even at low oxygen fugacities and diminish further with increase in f_{O_2}. Addition of sulfur to homogeneous "noritic-type" liquid which contains small amounts of nickel and copper produces a sulfide-oxide liquid which coexists with the silicate liquid. The silicate liquid buffers the composition of the sulfide-oxide liquid. The latter crystallizes on cooling to a mixture of magnetite and a $(Fe, Ni, Cu)_{1-x}S$ solid solution which in turn decomposes to the pyrrhotite, chalcopyrite, pentlandite assemblages characteristic of Sudbury-type deposits. Liquid immiscibility fields containing coexisting silicate and sulfide-oxide liquids exist also in systems containing granitic or monzonitic as well as the sulfide components. Reactions between sulfur vapor and silicate minerals produce sulfides and oxides commonly observed in metamorphosed rocks. (Authors' abstract)

KUO,V.H.S., and WILCOX, W.R., 1972, Influence of crystal dimensions on the interfacial temperature gradient: Jour. of Crystal Growth, v. 12, p. 191-194. (Authors at Chemical Engineering and Material Science Departments, University of Southern California, Los Angeles, California 90007, U.S.A.)

The influence of the length and radius of a crystal on the interfacial temperature gradient was estimated by use of a one-dimensional heat transfer calculation. It was found that the temperature gradient is substantially independent of crystal length only when the Biot number hR/k is large (where h is the heat transfer coefficient from the crystal surface, R is crystal radius, and k is thermal conductivity). (Authors' abstract)

KUROVETS, M.I., 1972, Regime of formation of granitic pegmatites of the Southern Urals, from data of thermometric studies: in The Ore-Forming Envirment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 67-73 (in Russian).

LAHIRI, Dipankar, 1971, Geology of the area around Kajlidongri, Jhabua District, Madhya Pradesh: Geol. Soc. India, J., v. 12, no. 4, p. 328-341.

In a study of metamorphic manganese silicate rocks and manganese oxide ores in the district, L. found a greater abundance of fluid inclusions in quartz of the metamorphic rocks near granite contacts. Carbonate bodies up to 600m long (also on or near the contact) are believed to have formed by replacement, from fluids from the granite. (ER).

LAMARCHE, R.Y., 1972, Role of liquid immiscibility in the differentiation of ophiolitic complexes (abst.): Internat. Geol. Cong., 24th, Abstracts, section 2, p. 48 (In English). Author at Department of Natural Resources, Quebec 6, Quebec, Canada.

Results of a systematic field study recently conducted by the writer on ophiolitic complexes of the Appalachians of southern Quebec indicate close spatial, temporal and genetic associations of the ultramafites (peridotite, pyroxenite and dunite) with one another and with other coarse-grained igneous rocks (phanerites) of gabbroic, dioritic, syenitic and granitic compositions, as well as with fragmental, pillowed and massive, spilitic volcanics. All these igneous rocks are interpreted as being part of so-called alpine-type ultramafic complexes, herein referred to as ophiolitic complexes.

Field evidence indicates that these ophiolitic complexes were extruded as huge submarine flows on a eugeosynclinal ocean floor through a major zone of distensional fractures, during the Lower Ordovician epoch.

Natural features strongly suggest that liquid immiscibility is the sole process responsible for the magmatic differentiation that took place under a self-formed roof of mafic volcanics in the submarine ophiolitic complexes of southern Quebec.

Podiform, nodular and orbicular features in chromite deposits, universally associated with ophiolitic complexes, are interpreted as primary features resulting from the coalescent growth of chromite-rich immiscible liquid droplets in an ultramafic melt.

Because of their great number of similarities with the ophiolites of southern Quebec, other ophiolitic complexes such as those of western Newfoundland, Canyon Mountain in Oregon, New Caledonia, Oman, Sesia Lanzon zone of the Western Alps, Troodos of Cyprus, and Vourinos of Northern Greece, regardless of their respective ages and sizes, are also believed to have been extruded as huge submarine ophiolite flows on ocean floors and to have undergone differentiation through liquid immiscibility in this relatively fast cooling submarine environment. (Authors' abstract).

LANDIS, G.P., 1972, Geologic, fluid inclusion, and stable isotope studies of a tungsten - base metal ore deposit: Pasto Bueno, Northern Peru: Ph.D. dissertation, Univ. of Minn., 195 pp. (Also available from Univ. Microfilms, Ann Arbor, Mich., no. 73-1035).

The Pasto Bueno tungsten - base metal ore deposit is situated at an elevation of ~ 4000 meters in the north central Andes of Peru. Ore mineralization occurs in near-vertical quartz vein systems spanning several hundred meters either side of the upper intrusive contact of a 9.5 m.y. old quartz monzonite stock emplaced in a Jurassic-Cretaceous shale and quartzite sequence. The stock exhibits three pervasive, and roughly zoned alteration assemblages: 1) alkalic, 2) argillic, and 3) propylitic. Greisen assemblages of zinnwaldite, fluorite, pyrite, and minor topaz and tourmaline occur within the argillic zone.

The principle vein mineralogy is wolframite, tetrahedrite/tennantite, sphalerite, galena, and pyrite in a gangue mineral assemblage of quartz, fluorite, sericite, and carbonate. Detailed studies of the hydrothermal mineral paragenesis and quartz crystal zones established three major recognizable divisions: Greisen (60-70% of deposition), Vein (25-35% of deposition), and Vug (<5% of deposition).

Fluid inclusion studies suggest that Greisen and Early Vein stage fluids were very saline (>40 equiv. wt. % NaCl) high temperature (400°-500°C) solutions of magmatic derivation. Boiling of these ore solutions is indicated only for the Greisen and Early Vein stages of hydrothermal activity. The subsequent main Vein stage ore fluids attained temperatures of 290°-175°C and a salinity range of 17-2 equiv. wt. % NaCl.

The results of stable isotope studies on inclusion fluids trapped in vein minerals indicate that the δ D of the ore fluids varied in a range of -28.8 ‰ to -87.6 ‰ (SMOW). Analyses of water contained in secondary inclusions indicate the deuterium content of the fluids may have attained values as depleted as -145 ‰ prior to the cessation of hydrothermal activity. The oxygen-18 composition of the hydrothermal fluids, calculated from the δ 0^{18} quartz and carbonate data, ranges from +7.8 ‰ to +0.0 ‰ (SMOW). [The isotopic composition of present day meteoric water is: δ D = -95.6‰; δ 0^{18} = -13.3 ‰.]

The isotopic patterns for δ D and δ 0^{18} of the hydrothermal fluids indicate that mixing of a meteoric water component with water of magmatic derivation occurred during Vein stage deposition. Major variations in the deuterium content of the ore solutions were not reflected by fluctuations in the oxygen-18 composition. Interpretation of these data indicate that meteoric water circulation patterns extended deep into the hydrothermal plumbing system. Wolframite deposition was associated with episodes of meteoric water influx that are reflected in the temperature, salinity, and δ D values of the inclusion fluids. Sulfide mineralization, on the other hand, was associated with water of magmatic derivation.

The carbon-13 data for hydrothermal CO_2 range from -4.11‰ to -11.92‰ (PDB) and are interpreted to indicate that the carbon in the ore fluids was derived both from sedimentary limestone and from deep-seated sources. Sulfide $\delta\ S^{34}_{pyrite}$ data exhibit a narrow range of values (-2.50‰ to +3.92‰) with an average of +0.59‰ ($\delta\ S^{34}$). These data indicate an isotopic composition for hydrothermal sulfur close to the meteoritic standard, and are comparable to sulfur of known deep-seated or mantle origin.

Most, if not all, of the components present in Pasto Bueno ore deposits appear to be of magmatic origin. However, it is clear that significant volumes of meteoric water [20-50%] must have been involved in some stages of the ore deposition process (Author's abstract).

LANDIS, G.P., RYE, R.O., and SAWKINS, F.J., 1972, Geologic, fluid inclusion and stable isotope studies of the Pasto Bueno tungsten-base metal deposit, northern Peru (abst): Econ. Geol., v. 67, p. 1007 - 1008. First author now at Dept. Geology, Univ. of N. Mexico, Albuquerque, N. Mexico.

The Pasto Bueno tungsten-base metal deposit occurs in near-vertical quartz vein systems at the upper intrusive contact of a 9.5-m.y.-old quartz monzonite stock. The stock exhibits well-defined alkalic, argillic, and propylitic alteration zones. Greisen assemblages are common in the argillic zone. The mineral paragenesis is divisible into greisen (60-70%), vein (25-35%), and vug (< 5%) stages. Principal ore minerals are wolframite, tetrahedrite, sphalerite, galena, and pyrite. The gangue is quartz, fluorite, sericite, and carbonate. Fluid inclusion studies indicate high salinity (> 40 equiv wt % NaCl), high temperature (400-500°C), and sporadic boiling in the greisen and early vein stage fluids. No evidence of boiling was noted for later main vein and vug stage ore fluids which attained temperatures of 290-175° C and a salinity range of 17-2 equiv wt % NaCl.

The δD and δO^{18} indicate that magmatic fluids were responsible for greisen stage mineralization but that mixing of meteoric water with magmatic water occurred during vein and vug stage deposition. Major variations in the δD of the ore solutions with only minor variations in δO^{18} indicate that meteoric water circulated deep into the hydrothermal plumbing system. Wolframite deposition was associated with episodes of meteoric water influx, whereas only magmatic water was present during sulfide mineralization. The δC^{13} values for hydrothermal CO_2 range from -4.1 to -11.9‰ and indicate that carbon was derived from both sedimentary and deep-seated sources. Sulfide δS^{34} values range from -2.5 to 3.9‰ and indicate a deep-seated or mantle origin for the hydrothermal sulfur. (Authors' abstract).

LAWRENCE, J.R., and TAYLOR, H.P., JR., 1972, Hydrogen and oxygen isotope systematics in weathering profiles: Geochim. et Cosmo. Acta, v. 36,, p. 1377-1393. (Authors at Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91109)

Deuterium and oxygen studies undertaken in detail on seven different soil profiles developed on both igneous and sedimentary parent rocks indicate that the parent rock minerals in these soils do not undergo appreciable oxygen or hydrogen isotopic exchange with meteoric waters in the weathering environment. Clay minerals and hydroxides produced during weathering may attain drastically different isotopic compositions than those of the parent rocks, and these weathering products form essentially in isotopic equilibrium with their local meteoric waters. (Authors' abstract, abbreviated)

LAZ'KO, E.M., DOROSHENKO, Yu. P., KOLTUN, L.I., LYAKHOV, Yu.V., MYAZ', N.I., and PINZYUR, A.V., 1972, Temperature and other physico-chemical conditions of formation of postmagmatic formations of eastern Transbaikal: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 15-23. (In Russian) CA 78 (12) 149668s (1973).

A study of the postmagmatic paragenesis conditions of Au-Mo, W, fluorite, and complex ore formations in eastern Transbaikalia showed that the gradual decrease of the postmagmatic fluids Mg-Ca-bicarbonate, and fluoride mineral formation stages (sic). The transport of Au, Mo, W, and other elements was closely related to the migration of alk. elements, esp. Na. The transport and deposition of Pb and Zn depended largely on the concn. of H_2CO_3. The temp. zonality , i.e., the sequence of ore types formed at progressively decreasing temps., corresponds to the geog. and geol. distribution of these ores in eastern Transbaikalia.

LEACH, D.L., JR., 1971, Investigation of fluid inclusions in Missouri barites; M.A. thesis, Univ. of Missouri, Columbia, Mo.

The barite deposits of central and southeast Missouri are stratiform in nature, formed at relatively shallow depths, and are believed to be part of the general Mississippi Valley type mineralization. The mineralogy of the deposits is relatively simple with barite, galena, sphalerite, pyrite, marcasite, chalcopyrite, and calcite being the most abundant minerals.

Sphalerite mineralization in central Missouri was by strongly saline brines, approximately 23 equivalent NaCl weight per cent, in the temperature range 108°C to 115°C. The uniform homogenization and freezing temperatures of the sphalerite and the ubiquitous organic dolomite suggest rather uniform conditions throughout the Central Barite District during sphalerite mineralization. Clear barite crystals from the Central and Southeast Barite Districts formed at temperatures less than 50°C by brines in the concentration range 5 to 10 equivalent NaCl weight per cent. Major barite mineralization must represent the period of cooling and dilution of the strongly saline brines after sphalerite mineralization. Calcite from central Missouri formed at temperatures less than 50°C by brines in concentration range 5 to 10 equivalent NaCl weight per cent. Gross supercooling of the fluid inclusions in clear barite indicates they are clean and free from suitable nuclei for formation of ice, suggesting slow movement of the mineralizing fluids. A varvelike banding in blue barite from Texas County, similar to celestite from Clay Center, Ohio, indicates annual compositional zoning. Approximately 500 years would be required for the growth of a 1 cm crystal of blue barite from Texas County. (Author's abstract)

LEBEDEV, L.M., 1970, Modern growth of sphalerite in Cheleken peninsula: Akad. Nauk SSSR Geol. Rudnykh Mestor., 1970, no. 4, p. 84-92. (in Russian; translation in Intern. Geol. Rev., v. 14, no. 9, p. 959-965; abstract on p.ii). Author at Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, AN SSSR, Moscow.

Data on modern hydrothermal mineralogenesis, particularly of sphalerite, as in the Cheleken peninsula, are reported here, with characterization of its composition(analyses show ZnS + Fe, Cd, Pb, As, & Tl), morphology, structures, and physicochemical conditions of the process. The brines from which these sphalerites form contain up to nearly 4 ppm each of Pb & Zn. (Author's abstract, modified by ER)

LEBEDEV, L.M., 1972, Minerals of contemporary hydrotherms of Cheleken: Trudy Mineralog Muzeya Akad Nauk SSSR, 1972, v. 21, p. 90-108 (in Russian; translated in Geochem. Internat. v. 9, no. 3, p. 485-504, 1972)

The Cheleken thermal brines are contemporary ore-carrying hydrotherms. The average amount of material brought to the surface each year amounts to 300-350 tons of Pb, 48-50 tons of Zn, 24-34 tons of Cu, 18-24 tons of Cd, and 6-8 tons of As. Data on the minerals and chemical composition of these waters are discussed.

LEFAUCHEUX, F., 1972, Observations de dislocations dans des calcites synthétiques: Journal of Crystal Growth v. 13/14, p. 272-275. Author at Laboratoire de Minéralogie-Cristallographie, Université Paris VI, 9 quai St. Bernard, Paris V°, France .

Hydrothermally grown single crystals of calcite have been examined. They are of two types: crystals grown from a rhombohedral seed and spontaneously nucleated plates. Lattice defects have been studied by X-ray Lang topography. The dislocation densities, their distribution and preferred orientations are described. An interpretation is proposed for the origin of the many dislocation bundles observed. (Author's abstract)

LETNIKOV, F.A., KASHCHEYEVA, T.V. and MINTSIS, A.Sh., 1972, The metastable state of water and aqueous solutions upon heating to high temperatures and pressures: Akad. Nauk SSSR, Doklady, v. 206, p. 964-966. (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 206, p. 232-233, 1972). Authors at Institute of the Earth's Crust, Siberian Branch of the USSR Academy of Sciences, Irkutsk.

The authors report that water and aqueous solutions, after heating to high T & P under "standard conditions", remain in a metastable "activated" state for a period of time. The activated water is a better solvent for various compounds such as carbonates and quartz. (ER).

LEVINSON, A.A., 1972, Introduction to exploration geochemistry: Calgary, Applied Pub., Ltd.

Includes a short section (pp. 341-343) on some of the possible applications of fluid inclusions to exploration. (ER)

LIOU, J.G. and YEN, T.P., 1972, Field-microprobe investigations on the coastal range ophiolites, Taiwan, (abstr.): Geological Society of America, Abstracts with Programs, v.4, no.7, p. 578. First author at Department of Geology, Stanford University, CA 94305

The Coastal Range ophiolites of Taiwan are sporadically exposed as allochthons within a sequence which includes Miocene chaotic turbidities and Mio-Pliocene andesitic agglomerates. The ophiolitic ultramafics, mainly harzburgite, are highly serpentinized. Spatially related gabbros, ranged from norite, hornblende gabbro to anorthosite, occur as injected dikes and also form isolated blocks which grade into peridotites. Similar relationship exists between diabase and glassy basalt. Unmetamorphosed pillow lavas lie directly on peridotite-gabbro masses and some pillows contain xenoliths of serpentinite. Glassy parts of pillows may contain as much as 95% glass enclosing microlites and microphenocrysts of olivine, plagioclase (An68-72) and minor chromian spinel (Sp55Chr30-Mg14Uv1). Delicate textures, such as spherulitic and dendritic overgrowths around olivine and plagioclase are well preserved. The glass may contain palagonite along small cracks and veins. Where it is fresh it is extremely low in K_2O (0.03-0.06%) and TiO_2 (0.7 -1.0%), and markedly high in CaO (11-12%) and MgO/FeO*, and is thus similar to average oceanic tholeiite. Olivine is typically Fo89-93 in harzburgite and Fo 83-87 in diabase and glassy basalt. Orthopyroxene is En86-90 in harzburgite and En64-68 in gabbro. Field relations and petrochemical data suggest that the various rocks of the ophiolites are genetically related.

The allochthonous fragments are intimately associated with an andesitic sequence in the Coastal Range. The Allochthons are interpreted as fragments of the Philippine Sea Plate which were emplaced by overthrust during the complex interaction of that plate with Eurasian continent. (Authors' abstract.)

LITVINOV, V.L., 1970, Zonation of ancient temperatures in a Karian deposit of gold, Eastern Zabaykal'ye: Akad. Nauk SSSR, Geol. Rudnykh Mestorozh., 1970, no. 5, p. 96-101 (in Russian; translated in Internat. Geol. Review, v. 14, no. 9, p. 966-970, 1972. Abstract on p.iii).

Two deposits of gold in one and the same field (fig. 1), products of one and the same pneumatolytic-hydrothermal process, were formed at different temperatures and pressures, judging by the homogenization temperatures of gas-liquid inclusions in their auriferous quartz (table). Variations in the temperature for one of them (fig. 2) and the physical state of the mineralizing solutions (fig. 3) are explainable by the depth factor and by the character of the migration paths (Author's abstract).

LIU, Chia-tsun, & LINDSAY, W.T., Jr., 1972, Thermodynamics of sodium chloride solutions at high temperatures: Journal of Solution Chemistry, v. 1, no. 1, p. 45-69. First author at Westinghouse Research Labs., Pittsburgh, Pa.

Osmotic coefficients are reported from vapor-pressure-lowering measurements on sodium chloride solutions at concentrations from approximately 4 m to saturation and at temperatures from 75°C to 300°C. In combination with previously reported measurements at lower concentrations these results allow a correlation of free energies for the system $NaCl-H_2O$ over a range of concentrations and temperatures that is unprecedented for any aqueous electrolyte. Activity coefficients and other thermodynamic quantities for both salt and water have been calculated for the complete range of concentrations and temperatures. Calculated heats of solution and standard partial molal entropies agree well with calorimetric determinations where comparison is possible. The excess partial molal entropy of the salt is informative concerning structural effects and their changes with temperature and concentration. (Authors' abstract)

LOFOLI, P., 1972, Endoscopie des grains de sable de la Côte Francaise de la Manche: Mem. B.R.G.M. no. 79, p 263-267 (in French with English abstract). Author at Lab. de Geologie I, 9 quai Saint-Bernard (Tour 14-15), Univ. Paris-VI (France - 75).

The microscopic and ultramicroscopic study of gaseous, liquid and solid inclusions of detrital quartz yields a complement of sedimentologic information; using a simple preparation technic, this study permits: 1) a better understanding of the morphology of grains and 2) appreciation of the origin of detrital elements.

This method, worked out on sediments from Congo, has been applied in France to various loose sediments, in particular to actual beaches sands. First, we can quote Mediterranean beaches: the example of the bay of Agay is already classical. There, the presence of magmatic reliquates (i.e., silicate melt; Ed.) inclusions is a constant fact, confirmed by many observations realised chiefly by the E.R. n° 45 C.N.R.S. (R. Clocchiatti), the mineralogy and petrology laboratory of the Faculty of Sciences, Nice (Prof. Turco, Director).

On the coasts of the Channel, the study of inclusions in grains of quartz has been made up only on the French beaches. This communication gives some preliminary results of the endoscopic study of Channel sands south of the Seine (Houlgate and Mont-Saint-Michel). (Author's abstract)

LUFKIN, J.L., 1972, Tin mineralization within rhyolite flow-domes, Black Range, New Mexico (abst): Geol. Soc. America Abstracts with Programs, v. 4, no. 7, p. 581. Author at Rt. 1, Box 117H, Snoqualmie, Washington 98065.

The tin-bearing Taylor Creek Rhyolite forms several flow-domes in the Tertiary volcanic section of the Black Range, southwestern New Mexico. The flow-layered, porphyritic rhyolite is pale red to gray, with phenocrysts of microperthitic sanidine, quartz, and minor plagioclase and biotite enclosed in a devitrified groundmass of alkali feldspar and quartz. Accessory igneous minerals include titaniferous magnetite, sphene, fayalite (?), and zircon. Rhyolite facies vary from miarolitic, lithophysal types near the tops of the domes to more dense, spherulitic types that comprise the bulk of the rhyolite masses. Pyroclastic rocks are interbedded with and marginal to the rhyolite domes. Rhyolite flow structure in the dome interiors is gentle to moderately inclined, but near some of the dome margins it is steeply inclined and locally expresses recumbent flow-folds.

Tin mineralization appears to be cogenetic with the rhyolite. Lode tin occurs as cassiterite, both in miarolitic cavities and in hematite-rich veinlets; it also appears as finely crystalline "wood-tin" in local placer accumulations. Cassiterite is commonly associated with hematite and quartz, and locally with bixbyite, pseudobrookite, alkali feldspar, topaz, and monazite.

Rhyolite alteration includes widespread bleaching and disseminated weak argillization; silicification and sericitization of alkali feldspar are noted locally. Mineral associations of cassiterite suggest that some of the tin was deposited at temperatures of 500° to 600°C, from a gas phase derived from the cooling rhyolite flows. (Author's abstract)

MAKAGON, V.M., 1971, Temperatures of formation and postmagmatic changes of mica-bearing pegmatites in the Mama region, based on data obtained from various geologic thermometers, pp. 48-71 in Geochemistry of pegmatites of Eastern Sibera: Moscow, Akad. Nauk SSSR, Sib. Otdel., Inst. Geokhim. (in Russian)

A review and comparison of the various geologic thermometers that have been applied to these pegmatites and the enclosing metamorphic rocks, with a 5-page section on liquid inclusions. (ER)

MAKOGON, Yu.F., TSAREV, V.I. and CHERSKIY, N.V., 1972, Formation of large natural gas fields in zones of permanently low temperatures: Akad. Nauk SSSR, Doklady, v. 205, no. 3, p. 700-703 (in Russian; text translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 205, p. 215-218; abstract in Intern. Geol. Review, v. 15, no. 2, p. 227 (1973)). First author at I.M. Gubkin Institute of Petrochemical and Gas Industry, Moscow.

Diagrams of the heterogenous state of the methane-water-gas hydrate (clathrate) system (fig. I), experimental work, and interpretations of evidence in the field (as in Western Siberia, Krasnoyarsk, Yakutia) suggest that the known modern accumulations of gas may have developed by decomposition of the gas hydrate, caused by contraction of the zone of the hydratogenesis, in turn caused by the known retreat of the permafrost. (Authors' abstract; included here because of pertinence to low temperature studies of fluid inclusions. ER.)

MALININ, S.D. and SAVELYEVA, N.I., 1972, The solubility of CO_2 in NaCl and $CaCl_2$ solutions at 25, 50, and 75° under elevated CO_2 pressures: Geokhimiya, 1972, no. 6, p. 643-653 (in Russian; translated in Geochem. Internat. v. 9, no. 3, p. 410-418, 1972). Authors at Vernadskiy Institute of Geochemistry and Analytical Chemistry, Academy of Sciences of the USSR, Moscow.

NaCl and $CaCl_2$ have been used alone or together over the range 0.4 up to 3-4 M with CO_2 at 50 kg/cm^2 and 25, 50, and 75°C. The salting-out factors agree with the most reliable published values for NaCl at 25°, and they increase linearly with the electrolyte concentration in the range 0-3 M. A formula is given for this salting-out. The mixed solutions show additivity in the salting-out effects. (Authors' abstract)

MALYSHEVA, T.V., ROMANCHEV, B.P. and SHVAGEREV, V.D., 1972, Determination of the temperature of olivine formation by methods of the Mössbauer spectroscopy and the thermometry of inclusions: Geokhimiya, 1972, no. 4, p. 496-497 (in Russian; translation in Geochem. Internat., v. 9, no. 2, 1972, p. 299-300). Authors at Vernadsky Inst., Acad. Sci. USSR, Moscow.

Mössbauer spectrometry on Mg-Fe ordering in olivine in a sample of lherzolite from Tanzania, after quenching from various temperatures, showed an "equilibrium state" of $\leqslant$ 1150°C. Solid phases in primary, spherical melt inclusions 10-40μm in diameter melted at 1100-1130°, giving a minimum temperature of formation. (ER)

MARCHENKO, Ye. Ya., 1972, Fluorine-rich metasomatites in subalkalic granitoids: Akad. Nauk SSSR, Doklady, v. 203, no. 5, p. 1170-1172. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 203, 1972, p. 134-136). Author at Institute of Mineral Resources, Simferopol'.

Metasomatic quartz-cryolite veinlets in albititized biotite granites and feldspathic metasomatites were found on periphery of a Precambrian shield, in European USSR, and also larger accumulations of fluorides, the Greenland type, in intensively metasomatized granites. Such accumulations are recognizable by their fluorine halos in the rocks and the mineralogical evidence. The accumulations are localized in zones of contacts between cryolitized granites and the metamorphics and also the intersections of sublatitudinally striking structures with the zones of tectonic disturbances. (Author's abstract, translated in Internat. Geol. Review, v. 14, no. 10, 1972, p. 1148-1149).

MARKOV, V.K., NASEDKIN, V.V. and RYABININ, Yu.N., 1972, Liquation in ultramafic alkalic magma at high pressures: Akad. Nauk SSSR, Doklady, v. 207, no. 2, p. 428-429. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 207, 1972, p. 154-155). First author at O.Yu. Shmidt Institute of Earth Physics, Academy of Sciences, USSR, Moscow.

Liquation (i.e., immiscibility) of natural nephelinite (Table 1) and stratification of ultrabasic alkalic melt were attained experimentally at 3-18 kbar and 800-1200°C. The vitreous phases developed at different pressures (Table 2) and 9% H_2O differ from each other physically and chemically. It was found also that liquation occurs at 1050°C and 5% H_2O. Consequently pressure is definitely a factor in the liquation, and environments modeled here should be quite realistic in abyssal zones of the earth. (Authors' abstract, translated in Internat. Geol. Review, v. 15, no. 4, 1973, p. 482-483).

MARSHALL, W.L., 1972, Predictions of the geochemical behavior of aqueous electrolytes at high temperatures and pressures: Chemical Geology, v. 10, no. 1, p. 59-68. (Author at Reactor Chemistry Division, Oak Ridge National Laboratory, Oak Ridge, Tenn., U.S.A.)

Applications of ionization and solubility constants, of interest to geochemistry, obtained from electrical conductance and solubility measurements over wide ranges of temperature (0-800°C) and pressure (1-4000 bars) are described. The ionization constants have been correlated with solvent concentration as a variable in deriving complete constants that are experimentally independent of pressure. In some examples where complete constants are used to predict thermodynamic behavior, methods are given for estimating partial molar volumes and standard volume changes of electrolytes. Although solubilities adhere well to extended Debye-Hückel theory to moderately high ionic strengths at high temperatures, a difficulty that arises in predicting solubilities in mixed electrolytes is discussed. (Author's abstract)

MARTIN, R.F., & DONNAY, Gabrielle, 1972, Hydroxyl in the mantle: Amer. Mineralogist, v. 57, p. 554-570. Authors at Department of Geological Sciences, McGill University, Montreal, Quebec, Canada.

Four lines of evidence are presented to support the claim that hydroxyl substitutes in limited amounts in certain oxygen point-positions in nominally anhydrous minerals: a) H_2O^+ is present in analyses of these minerals; b) structural formulae are improved in a crystallochemical sense if cation considerations are made the basis for the conversion from weight percent to formula and if OH + O are used to balance the sum of cationic charges and to fill the anion positions in the structure; c) valence-sum calculations indicate some substitution of OH for O in pyroxenes, for example; d) infrared absorption spectra show the presence of hydroxyl in pyroxenes and olivines. The OH-for-O model implies a near-uniform distribution of small amounts of water throughout the mantle and thus eliminates the need for postulating new kinds of high-pressure hydrous phases. (Authors' abstract)

MARTIN, R.J., III, 1972, Time-dependent crack growth in quartz and its application to the creep of rocks: J. Geophys. Research, v. 77, p. 1406-1419.

The time-dependent growth of an axial crack in single-crystal quartz tested in uniaxial compression with a constant load was studied as a function of temperature, stress, and partial pressure of water. Although this study involved propagation of a crack from a bored hole, it is pertinent to the problems of the mechanical properties of inclusion-bearing minerals under stress from metamorphism or laboratory experiments. (E.R.)

MART'YANOVA, R.M., 1971, The characteristics of the form of inclusions in gypsum, pp. 99-107 in Mineralogy and geochemistry of central Kazakhstan and Altai: Akad. Nauk Kaz. SSR Inst. Geol. Nauk, Trudy v. 31 (in Russian).

The shape, orientation, and position of inclusions in crystals of gypsum varies with various crystal and growth parameters. (ER).

MASURENKOV, Yu.P., and SELYANGIN, O.B., 1969, The role of gas phases and easily soluble compounds in the formation of peridotite and pyroxenite xenoliths of the Avacha Volcano, pp. 21-29 in Xenoliths and homogeneous inclusions: Moscow, Akad. Nauk SSSR, Sib. Otdel., Inst. Vulkanol. (in Russian).

A discussion of the various types of liquid inclusions to be found in the pyroxene and olivine of these xenoliths, with 13 photomicrographs and chemical analyses (6) of water extracts for Na, K, NH_4, Mg, Ca, Cl, Br, I, F, SO_4, and HCO_3. (ER).

MAZOR, E., 1972, Paleotemperatures and other hydrological parameters deduced from noble gases dissolved in groundwaters; Jordan Rift Valley, Israel: Geochim. Cosmochim. Acta, v. 36, p. 1321-1336. Author at The Israel Atomic Energy Commission and the Weizmann Institute of Science, Rehovot, Israel.

One cm^3 samples of thermal waters were analyzed mass spectrometrically for their dissolved He, Ne, Ar, Kr and Xe. The isotopic abundances of the four heavier gases are atmospheric and their concentrations equal those of air-equilibrated waters at 15-22°C. The waters contain up to 2700×10^{-8} cm^3 STP radiogenic He/cm^3 STP water.

The data showed: (a) the thermal waters studied originated from meteoric waters that entered the ground. (b) While they entered the ground (in periods up to 30,000 years ago according to C-14 dating) the average temperature in the region was rather close to the present one, i.e. around 19 ± 4°C. (c) The dissolved noble gases were not lost in the ground although the waters had been heated in some cases up to 63°C for thousands of years.

The present data support the reliability of the noble gas method for determining original surface paleotemperatures of ancient meteoric waters.

Radiogenic He excess is potential indicator for ancient waters along with Ra excess and low C-14 contents. (Author's abstract)

MEL'NIK, Yu.P., 1972, Thermodynamic parameters of compressed gases and metamorphic reactions involving water and carbon dioxide: Geokhimiya, 1972, no. 6, p. 654-662 (in Russian; translated in Geochem. Internat. v. 9, no. 3, p. 419-426, 1972). Author at Institute of Geochemistry and Mineral Physics, Academy of Sciences of the Ukrainian SSR, Kiev.

Based on information gained from experimental and theoretical data on the compressibility of gases, a new method of approximate calculation of thermodynamic properties of the natural fluid components under high T and P is suggested. As example we give the calculation of carbon dioxide properties (fugacity and free energy) up to 10 kbar and 1500°K. For the first time P-T curves of some reactions of decarbonization under high pressures are calculated. In conclusion the peculiarities of the metamorphic processes with H_2O and CO_2 participation are discussed. (Author's abstract)

MELSON, W. G., JAROSEWICH, Eugene, SWITZER, George, and THOMPSON, Geoffrey, 1972, Basaltic nuées ardentes of the 1970 eruption of Ulawun Volçano, New Britian: Smithsonian Contrib. to the Earth Sciences, No. 9, Mineral Science Investigations, 1969-1971, p. 15-32.

The ejecta of the 1970 eruption are plagioclase phyric high-alumina basalts, which are compositionally like previous eruptive rocks. Three new analyses, petrographic features, and electron probe analyses are given. Of special interest are the compositions of glass inclusions in phenocrysts, which give evidence for the existence of high-alumina basaltic liquids, and may indicate mixing of basaltic and dacitic magmas prior to eruptions. (From authors' abstract).

MELTON, C.E., SALOTTI, C.A., and GIARDINI, A.A., 1972, The observation of nitrogen, water, carbon dioxide, methane and argon as impurities in natural diamonds: American Mineralogist, v. 57, pp. 1518-1523.

A unique method of destructive analysis has been developed for the study of gaseous impurities in diamonds and other minerals. Crystals are crushed at room temperature in a high vacuum sample inlet system of a research mass spectrometer. This is done by means of a suitably designed crusher which is incorporated in the inlet system of the spectrometer. Crusher elements are constructed from tungsten carbide. The spectrometer used for the analysis has a detection sensitivity of about 10^{-10} cc at STP. In a preliminary study of diamonds, the gases N_2, H_2O, CO_2, CH_4, and Ar have been identified. The most abundant is N_2. (Authors' abstract)

MERLICH, B.V., and DATSENKO, N.M., 1972, The composition of aqueous extracts of liquid inclusions in sulphur and authigenic minerals of sulphur deposits of the Precarpathians: L'vov. Gos. Univ. Min Sbornik, v. 26, no. 1, p. 73-88 (in Russian with English abstract). (Authors at L'vov. Gos. Univ., L'vov, U.S.S.R.)

The results of analyses of the water extracts of solutions of mineral inclusions of sulphur deposits of the Little Carpathians are as follows: solutions of inclusions of primary cryptocrystalline sulphur are characterized by a chlorine-sodium composition, which is similar to that of sea-water. The composition of solutions of inclusions in secondary phanerocrystalline sulphur and authigenic calcite, barite and celestite is similar to that of contemporary underground waters of sulphur deposits. (Authors' abstract)

MILLER, R.E., BROBST, D.A., & BECK, P.C., 1972, Fatty acids as a key to the genesis and economic potential of black bedded barites in Arkansas and Nevada: Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 596. Authors at U.S. Geological Survey, Denver, Colorado 80225.

Samples of black finely crystalline laminated barite ranging from 95 to 97 percent $BaSO_4$ were selected from bedded deposits in siliceous rocks of mid-Paleozoic age in Arkansas and Nevada for geo-lipid extraction by a chloroform: methanol azeotrope (constant boiling point mixture) using the Soxhlet method. Fatty acids were isolated from the crude geo-lipid extract and analyzed in their methyl ester form by gas chromatography. The most abundant acids are $C_{16:0}$, $C_{18:0}$ and $C_{18:1}$. These same fatty acids are found in the lipid cells of living sulfate reducing bacteria, and are interpreted as "biological markers" for such bacteria. The presence of these acids suggests that anaerobic bacteria were trapped in the finely crystalline barite during sedimentation. It is proposed that these microorganisms were responsible for producing hydrogen sulfide by decomposing and reducing associated organic matter and $BaSO_4$ at the sediment-saline water interface. The resulting hydrogen sulfide gives the fetid odor so universal in these barite deposits. The presence of these acids in the barite, together with the field relations, petrography, and trace-element content of the barite, supports a proposed model of a primary sedimentary origin for the bedded deposits. Exploration for high-grade barite deposits should especially include the examination of sedimentary sequences of siliceous rocks of mid-Paleozoic age. (Authors' abstract)

MILLHOLLEN, G.L., 1971, Melting of nepheline syenite with H_2O and H_2O + CO_2, and the effect of dilution of the aqueous phase on the beginning of melting: Amer. Jour. Sci., v. 270, p. 244-254. Author at Department of Geochemistry and Mineralogy, The Pennsylvania State University, University Park, Pennsylvania 16802.

The addition of 50 mole percent CO_2 to the aqueous phase raises the solidus of the Blue Mountain nepheline syenite about 80° at 1 kb and 100° at 2 to 6 kb total pressure. By use of f_{H_2O}-T and Pe_{H_2O}-T projections of the solidus curves with nearly pure H_2O and 0.5 H_2O + 0.5 CO_2, the beginning of melting is contoured at constant f_{H_2O} or constant Pe_{H_2O} in P(total)-T projection. These contours show that as the fluid phase is diluted from X_{H_2O} equals 1.0 to 0.5, the solidus at constant f_{H_2O} or Pe_{H_2O} is raised to higher temperature and higher pressure. Contours of the solidus at constant Pe_{H_2O} are used to construct T-X_{H_2O} (fluid) projections at constant total pressure. These T-X_{H_2O} (fluid) projections are then used to construct P(total)-T projections of the solidus at constant X_{H_2O} (fluid) like the experimentally-determined curves but for additional values of X_{H_2O}. These projections show that at 5 kb total pressure, for example, the solidus is raised about 85°, if Pe_{H_2O} is reduced from 5 kb to 3 kb. If Pe_{H_2O} is only 1 kb at 5 kb total pressure, the solidus is about 225° higher than the solidus with nearly pure H_2O. If X_{H_2O} (fluid) is reduced from 1.0 to 0.1 at 5 kb total pressure, the solidus is raised about 430°. These results indicate that the composition of aqueous fluids has a major effect on temperatures of anatexis and of magmatic crystallization. (Author's abstract)

MIYAZAWA, Toshiya, and ENJOJI, Mamoru, 1972, Studies of fluid inclusions and origin of hydrothermal fluids: Journal of Japan Geothermal Energy Association, no. 34, p. 59-76. (In Japanese with English abstract). Authors at Tokyo University of Education.

Primary inclusions in the minerals are undoubtedly the most important geologic material to the study of the genesis of ore deposits, because they are the only remaining samples of the original solution that formed the ore deposits.

Short descriptions of the nature of fluid inclusions and their modes of occurrence in the minerals are given. Historical development of fluid inclusion studies are also briefly described. Data on the homogenization temperatures, states and chemical compositions of ore-forming fluids are presented.

Studies on the origin of ore-forming fluids responsible for the formation of four ore deposits including that of the Takatori tungsten-copper mine, Japan, are briefly reviewed: 1.) The Cave-in-Rock fluids were formed by the mixing of connate and magmatic waters; that is, a combination of the connate-hydrothermal and magmatic hypothesis is suggested. 2.) The Providencia fluids had evolved either as a late-stage differentiate of a cooling intrusion, or as juvenile water migrating from the mantle. 3.) The Bluebell fluids are best explained by the mixing of two meteoric waters. 4.) The Takatori fluids may be formed by the mixing of magmatic and meteoric waters. (Authors' abstract)

MIZUTANI, Yoshihiko, & HAMASUNA, Takemasa, 1972, Origin of the Shimogamo geothermal brine, Izu: Bull. of the Volcanological Society of Japan, v. 17, no. 3, p. 123-134. Authors at Department of Earth Sciences, Faculty of Science, Nagoya University, (in Jap., Engl. abst..)

The geothermal brines (surface temp. =100°C) discharged from drillholes (52 ∿ 250 m in depth) at Shimogamo, Shizuoka, Japan, have been analyzed for stable isotopes of hydrogen , oxygen, and sulphur, together with chemical analyses. The chemical and isotopic evidences indicate that the geothermal brines are the mixture of local superficial water and the deep geothermal brine supplied by a single source. The estimated chemical and isotopic composition of the deep geothermal brine are interpreted by a mechanism, in which sea water penetrates into the deep geothermal brine reservoir and changes into Na-Ca-Cl brine through hydrothermal reactions with surrounding rocks. The underground temperature of the deep geothermal brine has been estimated as 221° ∿ 335°C from the oxygen isotopic fractionation between sulphate ion and water in the brine. (Authors' abstract)

MODRESKI, P.J. , 1972, Partial melting of phlogopite-bearing mantle assemblages in the system K_2O-MgO-CaO- Al_2O_3-SiO_2-H_2O, (Abstr.): Geological Society of America, Abstracts with Programs, v.4, no.7, p. 598. Author at Department of Geosciences, The Pennsylvania State University, University Park. Pennsylvania 16802.

Microprobe analyses of liquids in equilibrium with forsterite at 20°-80°C above the beginning of melting of phlogopite + pyroxene assemblages provide a model for partial melting in the mantle. Liquid formed by melting of Ph (phlogopite) + En (enstatite) contains 66 wt. % SiO_2, 16.5% Al_2O_3, 2.2% MgO, and 15% K_2O (5% normative Q) at 10 kb, 1100°C; 65.5% SiO_2 (5% normative Q) at 15 kb, 1200°C; 62.9% SiO_2 (normative en + fo) at 20 kb, 1250°C; and 58.8% SiO_2, 20.6% Al_2O_3 2.3% MgO, and 18.3% K_2O (47% normative lc) at 30 kb, 1350°C. Melting of Ph + En + vapor (water-rich) produces liquids that average 71.7% SiO_2, 15.8% Al_2O_3 , 0.9% MgO, and 11.6% K_2O (26% normative Q) independent of pressure between 7.5 and 25 kb, 1050° to 1210°C. The high SiO_2 contents are related to the incongruent melting of En + water. At 10 kb and 1118°C Ph_{ss} ($KMg_{2.75}$ - $Al_{1.5}Si_{2.75}O_{10}(OH)_2$) + En_{ss} ($Mg_{1.85}Al_{0.3}Si_{1.85}O_6$) + vapor melt to form liquid containing 64.4% SiO_2, 21.3% Al_2O_3, 4 1% MgO, and 10.1% K_2O (19% normative Q). Ph + Di (diopside) produces liquid containing 53.9% SiO_2, 17.7% Al_2O_3, 3,3% MgO, 5.0% CaO, and 20.2% K_2O (76% normative lc) at 15 kb, 1250°C. At 10 kb, Ph + En + Di produces liquid with 6% normative Q (65.8% SiO_2, 15.8 Al_2O_3, 2.8% MgO, 1.8% CaO, and 13.8% K_2O) at 1150°C; the vapor-saturated liquid contains 25% normative Q (72.0% SiO_2, 15.5% Al_2O_3, 0.1% MgO, 0.4% CaO, and 12.0% K_2O) at 1125°C. At these pressures, Di makes only a minor contriubtion to the beginning of melting. It is inferred that partial melting of mica-bearing peridotite may produce quartz-normative magma down to 60 km. In the presence of water-rich vapor, highly silicic magmas may be formed down to depths of at least 80 km. (Author's abstract.)

MOGAROVSKII, V.V., 1969, Celestite-quartz secretions (concretions?) of the Dzhet-tau Range, S. Tadzhik basin: Akad. Nauk Tadzhik SSR Doklady, v. 12, no. 9, p. 53-55 (in Russian).

Temperatures of homogenization of inclusions in quartz range from 65°-210°C (avg. 100-150°C). (ER).

MOORE, P.B., 1972, Phosphate paragenesis in granitic pegmatites, (Abstr.): Geological Society of America, Abstracts with Programs, v.4, no.7, p. 601. Author at Department of the Geophysical Sciences, University of Chicago, Chicago, Illinois 60637.

Paragenetic classification is as follows: (1) Primary giant crystal phases. Euhedral crystals often of large dimension (meters) embedded in bull quartz, perthite, muscovite toward or in the core. Included are triphylite-lithiophilite, high temperature sarcopside-graftonite solid solution with triphylite structure, arrojadite (in some instances), triplite, mangan-apatite, amblygonite-montebrasite, new species ($Na_2Fe_2Al(PO_4)_3$). Iron in the Fe^{2+} state. (2) Metasomatic products (replacement). Ghost-like outlines of pre-existing primary phases, nodular forms, phosphate-albite rhythmic growths, siderite replacement, brecciated crystals healed with quartz; removal of Li^+, addition of Na^+, Ca^{2+}, presence of $(OH)^-$; extensive oxidation of iron; Fe/Mn + Fe ratios sames as parent primary phase, zonation in $Fe^{3+}/Fe^{2+}+Fe^{3+}$. Examples include alluaudites, sicklerites, heterosites, triploidite, griphite, natrophilite, apatites, lazulite-scorzalite. (3) Early hydrothermal products. Hydroxylated minerals replacing (1) and (2) as druses. Mostly beryllium and aluminum phosphates. (4) Late hydrothermal products. Mixed valence basic phosphate hydrates; alkalies nearly completely removed; bulk composition of Fe/Fe + Mn similar to (1) and (2): well-defined and repeated parageneses based on degree of octahedral condensation. $(PO_4)^{3-}$, $(OH)^-$ and $(H_2O)^o$ ligands. Oxidation of iron is believed to be the controlling mechanism in removal of alkalies. It is proposed that auto-oxidation-reduction reactions $Fe^{2+}(H_2O) \rightarrow Fe^{3+}(OH) + H^+$ are thermally dependent and operate in the presence of an aqueous medium at low temperature where $(H_2O)^o$ bond to metals as ligands. (Author's abstract.)

MOVILEANU, Aurelia, and POMÂRLEANU, V., 1972, Contributions to the geochemistry of pegmatites with spodumene of the Sadu Valley (Southern Carpathians, Romania): Rev. Roum. Geol., Geophys. Geogr., Ser. Geol., v. 16, no. 1, p. 11-16. (in English).

Includes a brief resume of the earlier studies of inclusions in spodumene and quartz, formed by several stages of pneumatolytic and then hydrothermal action, and reported by Pomârleanu and Movileanu, 1968 & 1971, and Pomârleanu, 1971b. (all abstracted in previous volumes of Fluid Inclusion Research - Proceedings of COFFI.) (ER).

MUELLER, G., 1972, Organic microspheres from the Procambrian of South-West Africa: Nature, v. 235, no. 5333, p. 90-95. Author is at Inst. Molecular Evolution, Univ. Miami, Coral Gables, Fla.

Quartz crystals from cross fissures in calcite veins in a diabase dike contain inclusions of a variety of types, including organic liquids and solids and emulsions in aqueous solutions. Spherical droplets in the presumably abiogenic emulsions are viewed as possibly significant in the problems of the origin of life. (ER)

MYSEN, B.O., and BOETTCHER, A.L., 1972, Melting in a hydrous mantle: phase relationships in peridotite-H_2O-CO_2 systems (abst): Geol. Soc. America Abstracts with Programs, v. 4, no. 7, p. 608. Authors at Department of Geosciences, The Pennsylvania State University, University Park, Pennsylvania 16802.

Phase relations were determined in piston-cylinder apparatus for a hornblende-biotite-, garnet-lherzolite from Oahu, Hawaii (rock *a*) and of a garnet-lherzolite inclusion from the Wesselton Mine, South Africa (rock *b*).

Rock *a* has $Mg/Mg+Fe^{++}=0.88$ and $Al_2O_3=4.0\%$ (wt), $CaO=3.5\%$, $Na_2O=.38\%$ and $K_2O=.01\%$. Rock *b* has $Mg/Mg+Fe^{++}=.93$, $Al_2O_3=1.6\%$, $CaO=.7\%$, $Na_2O=.09\%$ and $K_2O=.04\%$.

In the presence of vapor of nearly pure H_2O ($X^V_{H_2O}\sim1.0$) rock *b* begins to melt at 940°C/10kb and at 880°C/30kb, with a temperature minimum at 860°C/25kb. The crystalline assemblage at the solidus below 20kb is ol+opx+cpx+amph. Amphibole is replaced by garnet at higher pressures and melts at 1030°C/25kb and 1060°C/10kb, with a temperature maximum at 1070°C/15kb. With $X^V_{H_2O}\sim1.0$ rock *a* begins to melt about 50°C lower than rock *b*, and the assemblage ol+opx+cpx+sp+amph is stable on the solidus below 17kb. Garnet and spinel coexist at higher pressures. Amphibole persits to slightly higher temperatures than in rock *b*, with a maximum temperature at 1080°C/17kb. In another series of runs $X^V_{H_2O}$ was controlled by using various proportions of H_2O and CO_2, the latter generated by $Ag_2C_2O_4=2Ag+2CO_2$ in the Ag/Pd capsule. Concomitantly f_{H_2} was controlled with the magnetite-hematite buffer in a surrounding Pt capsule. In a vapor with $X^V_{H_2O}=.5$ ($f_{O_2} = 10^{-4.5}$ to $10^{-6.5}$ atm) and .25 ($f_{O_2} = 10^{-5.0}$ to $10^{-7.0}$ atm), the solidus of rock *a* is at 1050°C/10kb and 1010°C/30kb with $X^V_{H_2O}=.5$ and about 75°C higher with $X^V_{H_2O}=.25$. Amphibole is stable on the solidus with the .5 mix, but not with the .25 mix. (Authors' abstract).

NADEAU, J.E., 1967, Temperatures of fluorite mineralization by fluid inclusion thermometry, Sweetwater barite district, East Tennessee (abst): Geol. Soc. Amer. Spec. Paper 115, Abstracts for 1967, p. 490 (pub. in 1968). Author now at Rider College, Trenton, N. J. 08602

Mineralization in the Sweetwater barite district is present in three belts of early Paleozoic rock separated from each other by parallel thrust faults. Thirty-one samples for the visual study of fluid inclusions were taken from two mines in the eastern belt and one mine in the western belt. Primary mineralization consists of pyrite, sphalerite, barite, and fluorite which fill cavities in a breccia of the Kingsport Formation. In the eastern belt three stages of fluorite mineralization are evidenced with green fluorite being earliest, purple fluorite next (coincident with barite deposition), and clear fluorite latest and present within vugs in earlier formed minerals. Green and purple fluorite are not present in samples from the western belt.

Temperatures were measured by means of an iron-constantan thermocouple inserted through the observation port of the heating stage and placed in contact with the specimen near the inclusion being observed. Uncorrected temperatures of vapor bubble disappearance from inclusions in fluorite ranged from 170°C to 195°C for specimens from the eastern belt and from 115°C to 145°C for specimens from the western belt. Assuming a similar temperature correction for the effects of pressure is required for both the eastern and western mineralized belts, a temperature zonation for fluorite crystallization is indicated (Author's abstract; missed in previous literature coverage).

NASH, J.T., 1972, Fluid-inclusion studies of some gold deposits in Nevada: U.S. Geol. Survey Prof. Paper 800-C, p. C15-C19. Author at U.S. Geol. Survey, Denver, Colo.

Fluid inclusions were studied in samples from nine gold-producing districts in Nevada. The ore fluids are characterized by low salinities, commonly below 2.1 wt percent NaCl equivalent. These salinities are less than those of most base-metal deposits but still higher than those of hot-spring systems, which provide an excellent model for the gold deposits. Fluid-inclusion homogenization temperatures range from 200° to 330°C for the gold-adularia veins; this large range suggests that temperature is not a prime factor in the formation of these deposits. Disseminated fine-gold deposits at Carlin, Cortez, and Gold Acres appear to have formed at about 200°C from solutions of about 6 percent salinity. Fluid density and pressure played major roles in the genesis of these deposits and are considered to be useful parameters in conceptual exploration models. (Author's abstract)

NATIONAL BUREAU OF STANDARDS, 1972, Microbubble basis for gas standards: Bureau Standards Technical News Bull., v. 56, no. 8, p. 181.

A method is described that consists of encapsulating, measuring, and storing very small quantities of pure gas as microbubbles in capillary tubes, after dilution with a clean, inert gas (ER).

NAUCHITEL', M.A., LUGOV, S.F., MAKEEV, B.V., and POTAPOVA, T.M., 1972, Temperature conditions of formation of the tin-ore deposits of cassiterite-quartz formations of northeastern USSR: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 97-106 (in Russian): CA 78(12) 149671n(1973).

The cassiterite ores of northeastern USSR are assocd. with quartz, feldspar, wolframite, and, in places arsenophyrite or Bi sulfide. Their thickness depends on the country rock type and the temp. at which they were formed from the ascending hydrothermal fluids. The ores emplaced in quartz or sedimentary strata are much thicker (<5km) than the ores emplaced in feldspars. The economically-significant ores of Tariel' and Chantal' were formed at 360-245° and, judging from the thermosonic data, are not very thick, because of the extensive surface erosion.

NAUMOV, V.B. and IVANOVA, G.F., 1971, The pressure and temperature conditions for formation of wolframite deposits: Geokhimiya, 1971, no. 6, p. 627-641. (In Russian; translated in Geochem. Internat., v. 8, no. 3, 1971, p. 381-394). First author at Vernadskiy Institute of Geochemistry and Analytical Chemistry, Academy of Sciences of the USSR, Moscow.

Fluid inclusions have been used to determine the temperature range for wolframite mineralization (250-450°C, usually 280-350°C) in deposits of various types. The corresponding pressures are 550-1650 atm. The mineralizing solutions sometimes contain up to 27 percent CO_2. (Authors' abstract).

Includes fairly extensive comparisons of decrepitation temperatures and homogenization temperatures, and 41 references. (ER)

NAUMOV, V.B., KOVALENKO, V.I., KUZ'MIN, M.I., VLAD'KIN, N.V., and IVANOV, G.F., 1971, Thermometric studies of melt inclusions in topaz from topaz-bearing quartz keratophyre: Akad. Nauk SSSR, Doklady, v. 199, no. 3, p. 681-683. (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 199, p. 104-106, 1972).

Studies of 5-30 μm, partly crystallized inclusions in topaz from unusual topaz-bearing quartz keratophyres("ongonite") from Mongolia, were made with visual observations to 800°C and by the quenching method to 1020°C. Melting started at the surprisingly low temperature of 520°C and homogenization occurred at 920-1020°C, in runs of 0.5 to 6 hours. Other primary crystalline inclusions in topaz, from a pegmatite in Mongolia, homogenized at 640-720°C. Crystalline inclusions in diopside from a skarn in the Aldan Shield homogenized at 770-850°C. (ER).

NAUMOV, V.B., POLYAKOV, A.I., and ROMANCHEV, B.P., 1972, Crystallization conditions of volcanic rocks of Eastern Africa rift zones according to data of thermobarometric investigations: Geokhimiya, 1972, no. 6, p. 663-668 (in Russian with English abstract). (Authors at V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Moscow)

Thermometric investigations have been carried out of primary melt inclusions from mineral phenocrysts of rocks of three large magmatic series developed within the rift zones of Eastern Africa. The following ranges of homogenization temperatures have been determined: 1) 1260-930°C for the series olivine basalt--phonolite; 2) 1320-880°C for the series of olivine melanephelinite--phonolite; 3) more than 1400-1080°C for the series olivine melaleucitite--leucitic basanite. The pressure values estimated according to primary inclusions of high-denisty carbon dioxide (0.47-0.83 g/cm^3) make up 1900-2000 bars for minerals of the first series, 2800-3000 bars for the second series and 4800-6000 bars for the third series. A conclusion about the independent development of each separate rock series has been drawn. (Authors' abstract)

NAYDENOV, B.M., BOGOLEPOV, V.G., POLYVYANNYY, E.YA., and ZAKHARCHENKO A.I., 1972, Behavior of argon isotopes in pegmatite mineralizing solutions: Geolhimiya, 1972, no. 6, p. 734-737. (in Russian; translation in Geochem. Internat., v. 9, no. 3, 1972, p. 471-473).

The relative amounts of radiogenic and atmospheric argon in fluid inclusions of pegmatite quartz is an indication of the proportion of juvenile and meteoric waters present in the mineralizing solutions. The proportion of juvenile water is thereby seen to increase with the age of the deposit, the depth of emplacement, and the tightness of the crystallizing pegmatite chamber. R.E. Zartman.

NICHOLS, F.A., 1972, On the diffusional mobilities of particles, pores and loops: Acta Metallurgica, v. 20, p. 207-214. Author at Westinghouse Electric Corporation, Bettis Atomic Power Laboratory, Box 79, West Mifflin, Pennsylvania 15122.

The movement of macroscopic defects (usually pores or particles) through solids, has been analyzed by various authors. These analyses typically deal with only one specific combination of type of particle or pore, transport mechanism and driving force; furthermore they are usually restricted to spherical shapes, and involve the solution of sometimes rather complicated atomic diffusion fields. A unified treatment is developed here, for arbitrary shape, transport mechanism and driving force using the concept of a macroscopic defect mobility, which avoids the solution of the atomic diffusional field (which represents in some instances an intractable problem). Specific cases are treated for illustrative purposes including (1) the movement of lenticular-shaped voids along thermal gradients in nuclear fuels (2) the thermal-gradient driven motion of dislocation loops by pipe-diffusion and (3) the rate of sliding of a grain boundary containing discrete particles. (Author's abstract)

NIKOGOSOVA, L.R., 1971, Structural controls of accumulations of lead-zinc ores in El'brus ore field: Akad. Nauk SSSR, Izvest., Ser. Geol., 1971, no. 3, p. 85-94. (In Russian; translated in Intern. Geol. Review, v. 14, no. 10, 1972, p. 1051-1059; abstract on p. ii). Author at "Sevkavtsvetmetrazvedka" Trust, Ordzhonikidze, USSR.

The ore-controlling function of regional fractures (table) and important details in positions of the known sphalerite-galena ore bodies (as in figs. 2-4) were ascertained by detailed studies in the field and a potentially economic extension of the Daut deposit was discovered in the Lower Paleozoic schists (figs. 5-6).

Thermometric investigations by G.V. Khetagurov using the method of decrepitation and homogenization have shown that deposition of the rock-forming minerals took place in the temperature range of 60-280°. At relatively high temperatures, early quartz was precipitated, and at relatively low temperatures, late carbonates and barite. (Author's abstract, extended by ER)

NIKOLAYEVA, O.V. and GERMANOV, A.I., 1972, Thermodynamic equilibria in the system $C\text{-}H_2O$ under hydrothermal conditions: Akad. Nauk SSSR, Doklady, v. 207, no. 4, p. 958-961. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 207, 1972, p. 212-215). First author at M.V. Lomonosov State University, Moscow.

The 3-member equilibrium system, $C_{solid}\text{-}HCO_{3\,soln.}\text{-}H_2S_{soln.}$, is entirely realistic, at the beginning of hydrothermal mineralogenesis (Fig. 1a-1d). Calculated equilibria in the system, which consists of solid graphite and dissolved CH_4, CO_3^{2-}, HCO_3^-, + H_2CO_3 at 25 to 300°C (Table 1) harmonize quite well with situations observed in nature. Graphite proves to be indeed one of the earliest hydrothermal minerals, with sulfides next to it. Gas-liquid inclusions in the early quartz are high in oxidized carbon, as a rule. Inasmuch as the equilibria involve oxidized C and reduced S, it would be reasonable to regard these two elements as functioning as an active oxidizing-reducing pair, in the hydrothermal process, by way of accounting for the associations here ascertained. (Authors' abstract, translated in Internat. Geol. Review, v. 15, no. 7, 1973, p. 861-862).

NORTON, D.L., 1972, Concepts relating anhydrite deposition to solution flow in hydrothermal systems (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 10, Geochemistry, p. 316-317 (In English). Author at Kennecott Exploration, Inc., 2300 West 1700 South, Salt Lake City, Utah 84104, U.S.A.

The reactions between hydrothermal solution and host rocks that lead to formation of the biotite-potassium feldspar-anhydrite-muscovite alteration zone, typically found in porphyry deposits, depend on the fluid flow path and the initial solution composition. This particular alteration-mineralization process is discussed within the context of a convecting hydrothermal fluid in which the relative permeabilities of host and stock rocks and the permeabilities of various mineralization-alteration zones control the fluid flow patterns.

The distribution of anhydrite in porphyry-related sulfide systems can be attributed to: (1) the interaction of calcium-poor acid-sulfate hydrothermal solutions with igneous rocks typical of these deposits, (2) the response of hydrothermal solutions to increasing temperatures and (3) the boiling (evaporative concentration) of hydrothermal solution caused by a change from lithostatic to hydrostatic pressures attendant on breccia pipe formation.

The solution-rock interactions that lead to the deposition of anhydrite and commonly associated mineral phases are predicted from thermodynamic computations. The resulting theoretical models are resonably consistent with the "average" anhydrite assemblage found in the igneous stocks of sulfide systems. The agreement between theoretical models and geologic observations allows constraints to be placed on the nature of hydrothermal solutions responsible for ore deposition in porphyry systems.

This study indicates that acid-chloride hydrothermal solutions characterized by pH = 3.0, Na^+ = 4 wt.%, K^+ = 1-2 wt.%, $SO_4^=$ = .5-1 wt.%, Ca^{++} = 2-10 ppm and Cu^+ = .5-50 ppm are responsible for the formation of the biotite-anhydrite-potassium feldspar-muscovite alteration zones. (Author's abstract).

NORTON, D.L., + CATHLES, L.M., 1972, Breccia pipes - products of exsolved vapor from magmas: Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 615. First author at Kennecott Exploration, Inc., 2300 West 1700 South, Salt Lake City, Utah 84104.

The fundamental problem any proposed model of breccia pipe formation must answer is how the void, necessary to accommodate the breccia, was created. Once a void of sufficient size is produced, the major aspects of breccia pipes (fragment character and distribution, sheet fracture boundaries, and dimensions) follow naturally and in analogy to the collapse of underground workings.

We propose that the prebreccia void was formed by magmatic water which exsolved as the pluton rose to shallower depths and lower pressures and was trapped for a time beneath the cooled rim in the apical region of the pluton. Eventual piercement of the rim by this hydrous bubble would lead to: 1) a drop in P_{H_2O} in the bubble, 2) pinching of the lower portion of the vapor void by viscous magma, 3) crystallization of magma as P_{H_2O} drops, 4) buckling of void walls and onset of stope caving, 5) continued stope cave filling of void, and 6) invasion of the breccia pipe by groundwater not in chemical equilibrium with fragments. Mass balance calculations indicate the proposed void generating mechanism is feasible for the Santa Rita, N.M. porphyry system. The porphyry stock mass, 1.6 $\times 10^{13}$ kg, could have exsolved 9.6×10^{11} kg of H_2O during its cooling history. At 800°C and 0.5 kb, $V_{H_2O} = 9.6 \times 10^9 m^3$, the exsolved water volume is more than adequate to account for the prebreccia void volume, $V_{void} \approx 5 \times 10^7 m^3$, of the two pipes associated with the Santa Rita stock. (Authors' abstract)

ORVILLE, P.M., 1972a, Plagioclase cation exchange equilibria with aqueous solution: Results at 700°C and 2000 bars in the presence of quartz: Am. Jour. Science, V. 272, p. 234-272. (Author at Yale University, Department of Geology and Geophysics, Yale University, New Haven, Conn. 06520)

Equilibrium conditions for the reaction between synthetic plagioclase solid solution and aqueous chloride solution represented by

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

have been determined in the presence of excess quartz at 700°C, 2000 bars, and total chloride concentrations 0.2 to 2.0 normal. Reaction proceeds rapidly in the right-hand, quartz-producing direction and closely approaches equilibrium within 1 day. Reaction proceeds much more slowly in the left-hand, quartz-consuming direction, and equilibrium is not approached within 30 days.

For a solution in equilibrium with a given plagioclase composition, the function $M_{NaCl}{}^2/M_{CaCl_2}$ is a constant which indicates ideal solution behavior of the aqueous chloride solution.

The plagioclase solid solution is continuous and, taken as a whole, shows positive deviations from ideality. This behavior can be interpreted, however, in terms of: an ideal solution of disordered high albite structure over the composition range An_0 to An_{50-55} with constant activity coefficients, $\gamma_{Ab} = 1.00$ and $\gamma_{An} = 1.28$; an ideal solution of ordered anorthite structure over the composition range An_{85-90} to An_{100} with constant activity coefficients, $\gamma_{Ab} = 1.89$ and $\gamma_{An} = 1.00$; a non-ideal solution ranging from a disordered high albite structure at An_{50-55} to an ordered anorthite structure at An_{85-90}.

An upper limit of about 1 weight percent is set on the amount of excess silica that may be contained in plagioclase as Schwankte's component ($Ca_{0.5}AlSi_3O_8$) under the conditions of these experiments, and reasonable corrections for solubility of SiO_2 in the aqueous fluid reduce the probable limit to near zero. Experiments of Wyart and Sabatier (1965), which seem to show very high solubilities of excess SiO_2 in plagioclase, are given an alternative interpretation. (Author's abstract)

ORVILLE, P.M., 1972b, The role of fluid composition in regional metamorphism (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 2, Petrology, p. 51, (In English). Author at Dept. of Geology and Geophysics, Yale University, New Haven, Connecticut 06520, U.S.A.
The composition of the fluid phase can be of equal or greater importance than temperature and pressure in determining the relative stabilities of mineral assemblages which involve change in volatile-content. For example, all reactions so far proposed which relate the anorthite-content of plagioclase to metamorphic grade (temperature and pressure) are also sensitive to composition of the fluid phase.

In a divariant equilibrium mineral assemblage that contains plagioclase and a fluid phase of variable composition, the compositions of both the plagioclase and vapor phases are fixed at a given temperature and pressure and the compositions of these phases are "buffered" independent of the bulk rock composition. In such an equilibrium assemblage, the composition of plagioclase can be regarded as an indicator of metamorphic grade. In trivarient assemblages at constant temperature and pressure, the composition of plagioclase can be used as an indicator of the composition of the fluid phase present at the time the assemblage formed.

This approach to studying the history of the now-missing fluid phase is illustrated by examples from the Swiss Alps where Bündnerschieffer rocks commonly contain low-variance assemblages which can be represented in the seven-component system K_2O-Na_2O-CaO-Al_2O_3-SiO_2-H_2O-CO_2. The divariant assemblage (assuming vapor to be present as well) is calcite-muscovite-quartz-plagioclase-K-feldspar-zoisite; trivariant assemblages lack one of these phases. Assemblages indicating constant and variable fluid compositions are found. (Authors' abstract).

PAL'MOVA, L.G., 1972, Correlation of formation and decrepitation temperatures of synthetic quartz, calcite, and pyrite: Izv. Vyssh. Ucheb. Zaved., Geol. Razved., v. 15, no. 3, p. 46-49. (in Russian).

A comparison of the decrepitation temperatures (T_D) of synthetic quartz, calcite and pyrite with formation temperatures (T_F). The tensile strength of the mineral causes large deviations, so that T_D-T_F ranged from -170 to +60°C. (ER).

PANINA, L.I., 1972a, Ultrabasic rocks of Kiysky alkaline massif and their genesis: Acad. Sci. USSR, Sib. Div., Geol. and Geoph., 1972, no. 6, p. 142-144. (in Russian with English summary).

Until recently, no ultrabasic rocks were known in the Kyisky alkaline massif. The spinel-forsterite specimens collected by V.P. Belov were handed over to the author for mineral-thermometric study. The results of the study have shown that these rocks are of magmatic origin, and crystallized from a melt at a temperature higher than 1370°C. These conclusions are based on the presence of glassy inclusions and gaseous-fluid inclusions in olivine. On examining the mineralogical and chemical composition of the rock and magma-genesis, the author concludes that V.P. Belov (1969) was mistaken in regarding the latter as Mg--skarns. They must belong to ultrabasic rocks, perhaps to dunite series. (Author's abstract).

PANINA, L.I., 1972b, Mineralogic and genetic characteristics of some alkalic massifs of the Baikal region: Akad. Nauk SSSR, Sib. Otd., Inst. Geol. Geofiz. Tr., No. 94, 127p. (In Russian)

Contains a section (Chapt. 6) on use of melt(?) and fluid inclusions in nepheline, pyroxene, sodalite, wollastonite, scapolite, quartz, alkali feldspar, and cancrinite for thermometry. Homogenization temperatures ranged from 80° to 1100°C. (ER).

PERSIKOV, Z.S., 1972, The viscosity of granitic melts up to 800-1200°C and 2000 bars water pressure: in Experimental investigations in mineralogy 1970-1971, A.A. Godovikov and V.S. Sobolev, eds.: Novosibirsk, Acad. Sci. USSR, Sib. Division, Inst. Geol. & Geophys., p. 93-97 (in Russian).

Experimental technique and results.

PHILPOTTS, A.R., 1972, Density, surface tension and viscosity of the immiscible phase in a basic, alkaline magma: Lithos, v. 5, p. 1-18. Author at Department of Geology and Institute of Materials Science, University of Connecticut, Storrs, Connecticut 06268.

A 5.5 meter thick sill of fourchite near Montreal, Quebec, has several cumulate layers of titanaugite phenocrysts in its lower half and a corresponding number of zones of ocelli, small rounded bodies of feldspathic rock, in its upper half. Many of these ocelli coalesced to form thin, continuous sheets which, being composed of less dense material than the surrounding fourchite, became unstable and developed small diapiric structures. From the distribution and shapes of the ocelli, and the spacing of the diapiric domes, it is calculated that the initial ocellar phase had a density of 2.1 gm/cm^3, an interfacial tension with respect to the fourchite magma of less than 9 dynes/cm and a viscosity considerably greater than 3 poises. These properties indicate that these ocelli originated as droplets of immiscible feldspathic liquid that separated from a basic, alkaline magma, and rule out the other prevalent hypothesis that they are formed by the filling of gas cavities with residual magma. (Author's abstract)

PINCKNEY, D.M., 1972, Electrolytic cells for cleaning crystals before fluid inclusion analysis: U.S. Geol. Survey Professional Paper 800-B, p. B141-B145. (Author at U.S. Geol. Survey, Denver, Colo.)

A set of electrolytic cells has been designed and built for cleaning the crystal surfaces as part of the sample preparation for the chemical analysis of fluid inclusions. The parts are readily obtainable and inexpensive, and can be assembled in the laboratory. Cleaning is accomplished by immersing the specimens in water and passing a direct current through the water. The cells are specially constructed U-tubes designed for thorough flushing of both crystals and tubes. The amount of current flowing through each cell can be determined by switching the current from each cell through a meter. Details of the electrical circuit and operation of the cells are described. The cells may be useful also for other purposes such as removing mineral coatings from the surface of sand grains. (Author's abstract)

PINCKNEY, D.M. and RAFTER, T.A., 1972, Fractionation of sulfur isotopes during ore deposition in the Upper Mississippi Valley zinc-lead district: Economic Geology, v. 67, p. 315-328.

Fractionation of sulfur isotopes during ore deposition was studied by analyzing samples of coprecipitated sphalerite, galena, and marcasite from four deposits in the Upper Mississippi Valley zinc-lead district. This district was chosen because (1) the ore was deposited at low temperature, (2) the banded character of the ore provides the basis for a precise paragenetic sequence, (3) textural evidence indicates that two or more sulfide minerals were deposited together and therefore they are coprecipitates, and (4) the ore has not been recrystallized or metamorphosed.

The δ values of S^{34} for nearly all of the sulfides (main stage of the ore) range from 6.3‰ (per mil, or parts per thousand) to 15.9‰ relative to the Canyon Diablo standard. The δ values for galena (6.3‰ to 11.4‰) are lower than the δ values for sphalerite (11.4‰ to 15.9‰). The δ values for marcasite, in ore of the main stage, are nearly the same as those for sphalerite. Fractionation factors for coprecipitated sphalerite and galena range from 1.0030 to 1.0073. Fractionation factors for sphalerite and galena from the early part of the ore are smaller than those from the later part of the ore.

The fractionation factors for sphalerite and galena when compared to the theoretical fractionation curve of J.R. Hulston give temperatures for sulfide deposition of 150°C to 260°C for the early part of the ore and 100°C or less for the later part of the ore. These temperatures for the later ore are close to temperatures previously determined from fluid inclusions. The temperature and the isotopic composition of sulfur in both the hydrothermal fluid and the minerals appear to have changed at about the same time.

The variation found in the isotopic composition of the sulfur from the main stage of ore deposition is almost 10‰. More than 7‰ of this variation is due to fractionation of the isotopes of sulfur in the sulfide minerals, sphalerite and galena. The remainder could be due to differences in Eh and pH in the hydrothermal solution. (Authors' abstract).

PINCKNEY, D.M., & RYE, R.O., 1972, Variation of O^{18}/O^{16}, C^{13}/C^{12}, texture and mineralogy in altered limestone in the Hill mine, Cave-in-Rock District, Illinois: Econ. Geology, v. 67, p. 1-18. (Misprint in original title) (Authors at U.S. Geological Survey, Denver, Colo.)

Mississippian limestone wallrocks surrounding a low-temperature ore body in the Hicks dome area of southern Illinois were dolomitized, recrystallized, and silicified, and their δO^{18} and δC^{13} values were lowered during ore deposition.

The rocks studied are adjacent either to a major body of slump breccia or to fissures and vugs. The effects of hydrothermal alteration are megascopically inconspicuous, even though the rocks were greatly modified. Alteration occurred during two episodes of hydrothermal activity, each of which is correlated with structural events and with ore deposition. The earlier alteration is associated with a late stage of slumping that was due to dissolution of limestone and with the earliest stage of ore deposition; and during this time limestone was converted to dolomite, and the δO^{18} values of the rocks were uniformly reduced from about 26‰ to about 21‰ (SMOW), while δC^{18} values remained constant at 2‰ (PDB).

The later alteration is associated with a later stage of ore deposition during which additional limestone was recrystallized and silicified and the δO^{18} and δC^{13} values of the rock were reduced to values as low as 18‰ and -4‰ respectively. The degree of recrystallization and silicification and the amount of isotopic exchange increase toward fissures or other channelways that were conduits for hydrothermal solutions. In one section of the ore body the δO^{18} values of gently dipping beds of limestone, adjacent to fissures, decrease along the probably direction of movement of the hydrothermal fluids through the ore body.

Isotopic exchange between limestone and the altering fluid probably occurred during recrystallization. The extent of the isotope halo appears to have been limited by the extent of recrystallization. The minimum amount of water required to produce the observed changes in the δO^{18} values in a prism with a cross-sectional area of 1 cm^2 extending through the alteration halo in a selected bed is 46 moles or 830 grams, corresponding to a volumetric water-to-rock ratio of about 0.8. However, considerations based on the amount of introduced quartz and the amount of C^{13} exchanged in the wall-rock indicate that a much larger amount of fluid actually passed through the wallrocks. The temperature of the hydrothermal fluid during alteration is estimated to have been 130°C, as indicated by filling temperature measurements of fluid inclusions in associated fluorite. The δO^{18} of the hydrothermal pore fluid in calculated at 4.7, 2.9, and 1.4‰ from δO^{18} values for calcite, dolomite, and quartz, respectively, in the most altered parts of the wallrock.

O^{18} halos in limestone could be the result of (1) a temperature gradient, or (2) a gradient in the isotopic composition of the pore fluid in the wallrock, or (3) partial exchange between the pre fluid and the wallrocks. Gradients of temperature and isotopic composition may have had some effect on the formation of the isotopic patterns in the Hill mine, but the dominant effect was related to partial exchange. (Authors' abstract)

PIZNYUR, A.V. and PLATONOVA, E.L., 1972, Thermodynamic regime of solutions that formed barite-polymetallic ores of the Began'skii deposits (Transcarpathia): in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 145-149. (In Russian) CA 78 (10) 126791n (1973).

The Begana complex ore deposit is localized in the fracture zones of the Lower Sarmatian rhyolite tuffs and xenotuffs in contact with argillites, mudstones, and sandstones. The deposit is characterized by 2 sets of mineral assemblages forming 3 types of ores: complex ore, barite-complex ore, and barite. The decrepitation and homogenization studies of liq. inclusions indicate that the complex ore stage was formed at 230-65°, the barite-complex ores at 190-220°, and the barite ores at 140-80°. The 2nd zone (~200-275 m) is an intermediate stratum contg. the minerals of the 1st zone in concns. decreasing in the upward direction and increasing concns. of barite. The 3rd zone is a barite-quartz layer cemented with alunite and kaolinite impregnated with Fe oxides.

POLYKOVSKII, V.S., and MORGENSHTERN, L.E., 1971, Empirical formula for computing probable homogenization temperatures of inclusions in fluorite. Vses. Mineral. Obshch., Zap., v. 100, no. 2, p. 228-232 (in Russian).

This gives the details of work published under same title and authors in a book, referenced in Fluid Inclusion Research--Proceedings of COFFI v. 4, p. 58. Apparently the empirical curve, and the equation that is derived to describe it, is valid only for a given composition fluid. (ER)

POTTER, R.W., 1970, Geochemical, geothermetric (sic) and petrographic investigation of the Rush Creek mining district, Arkansas: M.S. thesis Univ. Arkansas, Fayetteville, Ark., 115 pp.

This Mississippi Valley-type district consists of 13 zinc mines associated with faults in Paleozoic sediments. The faults acted as conduits to introduce the ore fluids into an ancient collapse and breccia pipe system. Contours of Cd (0.34-0.94%) and Fe (0.07-0.13%) content of sphalerite and homogenization temperatures of fluid inclusions in sphalerite (169-114°C) yield similar map patterns suggesting ore fluid movement directions. Late calcite and quartz yielded lower temperatures. (Calibration of the stage at a later date showed that all these temperatures are approximately 30°C too high - personal communication, R.W. Potter, 1974). (ER)

POTY, B., HOLLAND, H.D. and BORCSIK, M., 1972, Solution-mineral equilibria in the system $MgO-SiO_2-H_2O-MgCl_2$ at 500°C and 1 kbar: Geochim. Cosmochim. Acta, v. 36, p. 1101-1113. First author at Centre de Recherches Pétrographiques et Géochimiques, C.O. N°1, 54-Vandoeuvre, France.

The quench pH of $MgCl_2$ solutions equilibrated at 500°C and 1 kbar pressure with talc + quartz is between 0·9 and 1·6, that of solutions equilibrated with forsterite + talc 4·2 to 7·7, and that of solutions equilibrated with brucite + forsterite between 6 and 9. The addition of NaCl and $CaCl_2$ does not affect the quench pH measurably. The low quench pH of solutions equilibrated with talc + quartz is due to the ionization of HCl° during the quench. The quench pH of solutions equilibrated with forsterite + talc is apparently controlled by the reaction of Mg-OH complexes with HCl° during cooling, that of brucite + forsterite solutions by the precipitation of magnesium hydroxychlorides and/or brucite during cooling. At 500°C and 1 kbar the solutions are neutral to slightly acid.

The low quench pH of solutions equilibrated with talc + quartz shows that these can give rise to extensive proton metasomatism with wall rocks during cooling. This is not the case for solutions equilibrated at 500°C and 1 kbar with forsterite + talc or brucite + forsterite, and explains the lack of proton metasomatism around ultrabasic bodies. The SiO_2 concentration in solutions equilibrated with forsterite + talc is sufficient to lead to the precipitation of quartz on cooling. This may explain the occurrence of quartz with some ultramafic bodies. $Mg(OH)_3Cl$ appears to be a stable phase in equilibrium with brucite + forsterite in runs containing more than 0·1 mole $MgCl_2$/kg of solution. Much of the chlorine in altered ultramafic bodies may be present as a component of this and/or other magnesium hydroxychlorides. (Authors' abstract)

PRASOLOV, E.M. and TOLSTIKKIN, I.N., 1972, Origin of ^3He in microinclusions in Volyn honeycomb quartz: Geokhimiya, 1972, no. 6, p. 727-730 (in Russian; translated in Geochem. Internat. v. 9, no. 3, p. 506, 1972).

Data from experimental neutron irradiation of quartz and from calculation of the existent neutron flux in the country rock are consistent with the production of observed high $^3He/^4He$ ratios in quartz by the reaction:

$$^{6}Li = n \rightarrow \alpha + {}^{3}H \xrightarrow{\beta^-} {}^{3}He.$$

PREISINGER, A., 1969, Mass spectroscopic analysis of gases in minerals (abst.): Tschermaks Mineral. Petrogr. Mitt., v. 13, no. 3-4, p. 341 (in German).

A very brief statement of the establishment of a cycloidal mass spectrometer at the Min. Inst. Univ. Wien, for use on K/Ar, O16/O18, and gas inclusion studies. (ER)

PRICE, L.C., 1972, Solubility of petroleum forming hydrocarbons in aqueous solutions as applied to primary petroleum migration (abst): Geol. Soc. America Abstracts with Programs, v. 4, p. 220. Author now at U.S. Geological Survey, Denver, Colorado.

Solubility data have been gathered for the thirty-five most common hydrocarbons found in petroleum as a function of temperature, salinity, and the effect of different hydrocarbons upon each other in the same solution. Aqueous solutions at high temperatures carrying large amounts of hydrocarbons have been subjected to sudden changes such as large increases in salinity or cooling to room temperatures and the exsolution rates of these solutions have been monitored as a function of time.

The variables of the systems studied and the exsolution experiments were constructed in a manner closely approaching natural conditions. The previously unreported data show that aqueous solutions are more than capable of accounting for primary migration of petroleum by true solution, and that conditions found in natural systems provide adequate exsolution mechanisms to account for primary petroleum accumulations.

The direct aqueous injection gas chromatographic analytical technique developed for this study has direct applications to water pollution studies, studying effects of oil spills and characterizing any organic-aqueous system, because of its sensitivity (.005 ppm), speed, and simplicity, and large sample sizes possible (greater than 1 ml). (Author's abstract). (Of considerable pertinence to the interpretation of fluid inclusion studies on Mississippi Valley ore transportation and deposition. ER.)

PUPIN, JEAN-PIERRE, and TURCO, GUY, Le zircon accessoire en geothermometrie: Comptes Rendus, vol. 274, no. 15, April 10, 1972, p. 2121.

PUZANOV, L.S., 1972, Temperatures of formation of ratofkite from the Sylva River basin in the Perm' part of the Ural region: Akad. Nauk SSSR, Doklady, v. 207, no. 5, p. 1204-1207. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 207, 1972, p. 135-138). Author at All-Union Research Institute of Mineral Products, Moscow.

The mineral, a powdery variety of fluorite, has been generally regarded as sedimentary, authigenic, etc., but proves to be hydrothermal, at least in some of its accumulations and ores examined here in detail. The evidence includes geological positions and textures-structures of the ores, mineralogical analyses, and homogenization temperatures of gas-liquid and multiphase primary inclusions in the gangue (dolomite, calcite) and the fluorite itself. Inclusions in "fluorite II" homogenize generally at 150-190°C, occasionally at 250°C. (Author's abstract, translated in Internat. Geol. Review, v. 15, no. 7, 1973, p. 863).

PUZANOV, L.S., KOPLUS, A.V. and KORYTOV, F.Ya., 1972, Reverse vertical temperature zoning in fluorite deposits: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 150-155 (in Russian): CA78(10) 126792p(1973).

Three examples are cited of the inverted vertical zoning (e.g. zoning in which minerals formed from colder hydrothermal solns, are at a lower level than the minerals formed from the hotter and younger solns.). The ore deposits belonged to the mesothermal-epithermal vein type controlled by the fault tectonics; (1) the Gornyi Altai fluorite deposit localized in Middle Devonian volcanic rocks, (2) Transbaikalian fluorite deposit related to the Mesozoic magmatic activity, and (3) the Central Asian deposit confined to center facies of the Middle-Upper Carboniferous acid effusives. In all 3 areas, for tectonic reasons, the downward magmatic flow caused the zone inversion. At Gornyi Altai the average formation temp. of fluorite I (0-100m below the surface) was 237.5°, while fluorite IV 300-400 m depth) was formed at 120°. In the Transbaikalian deposits the upper fluorite strata were formed at 140-200°, while the lower pyrite-marcasite strata contg. 30-40% Fe sulfide were formed at 140-70°. At Agata-Chibargata (Central Asia) the upper strata contained barite and the lower strata contained fluorite, although the latter has a lower crystn. temp. than the former.

RADKEVICH, R.O, 1972, Temperature conditions of formation of polymetallic deposits of the Sadonsk group (northern Caucasus): in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 116-123 (in Russian): CA78(12) 149673q(1973).

The title ores are emplaced in Caledonian granitic rocks, rejuvenated by later tectonic activity, and also in the effusive-sedimentary strata. The ores were formed by hydrothermal processes about 140 million yr ago; the main minerals are: sphalerite, galena, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, marcasite, magnetite, and hematite. The formation of sulfide ore was preceeded by the quartz-pyrite stage and followed by the carbonate-sulfide stage. The temps. of homogenization and decrepitation of inclusions in the minerals found in these ores show that there were 4 stages of the hydrothermal activity corresponding to 370°, 300°, 200°, and 100°.

RADKEVICH, E.A., 1971, Geology, mineralogy, and geochemistry of the Komsomol region: Moscow, Akad. Nauk, SSSR, Sib. Otdel., Dal'nevost. Fil., Dal'nevost Geol. Inst.-Minist. Geol. RSFSR, Dal'nevost. Geol. Upr., 335pp. (in Russian).

Includes a long chapter (p.211-268) dealing with the temperatures of formation of minerals in this tin province. Many decrepitation and homogenization data (up to 411°C) and their changes with mineralization stage, from many deposits. Includes 6 photomicrographs of multiphase inclusions. (ER).

RAKHMANOV, A. M. and KHITAROV, D. N., 1972, Physico-chamical features of processes of hypogene mineralization of fluorite-polymetallic deposit of Takob (southern Gissar) in The Ore-Forming Environment as Determined from Inclusions in Minerals, V. I. Smirnov, ed.,: Moscow, "Nauka" Press, p. 156-163 (in Russian).

The Takob ore deposit in the southern slope of the Gissar ridge is localized in subparallel veins of northwest-trending tectonic fractures in the south Darzovsk granitic batholith. The hypogene minerals include fluorite (4 generations) quartz (5 generations), calcite, barite, galena, sphalerite, chalcopyrite, pyrite, arsenopyrite, bournonite, tetrahedrite, and tennantite. Results of decrepitation and homogenization detns. of the gas-liq. inclusions in the hypogene minerals are presented. The following mineralization stages are distinguished: carbonatic-fluoritic, fluoritic-sulfide, silicic, quartz-galena-sphaleritic-fluorite, carbonatic, fluorite-calcite-complex ore, and baritic stage. The pH of the ore-bearing soln. is 6.0-7.5. Some data are also given on the compn. of liq. inclusions and water-sol. inclusions in these minerals.

RASHID, M.A., 1972, Amino acids associated with marine sediments and humic compounds and their role in chelation and solubility of different metals (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 10, Geochemistry, p. 319 (In English). Author at Atlantic Oceanographic Laboratory, Bedford Institute, Dartmouth, Nova Scotia, Canada.

Seventeen different amino acids of acidic, basic, neutral and aromatic nature were identified in the acid-hydrolysates of marine sediments collected from the Scotian Shelf and humic compounds associated with these sediments. The quantities of these amino acids ranged from 6.2 to 6.7 mg/g in dry sediments and 76.5 to 99.9 mg/g in humic compounds. Glycine, alanine, glutamic acid and serine, which are believed to be stable under low temperature conditions over millions of years, constituted 30 to 35% of the total amino acid content. Another 10-15% of these amino acids consisted of valine, proline and leucine, which are also known for their thermal stability.

The amino and carboxyl groups present in amino acids enable them to enter into reactions with various metals leading to their chelation or formation of organo-metallic complexes. The chelation reactions that increase the solubility of various metals may also influence their transportation and redistribution.

The acid-hydrolysate of humic acid containing different amino compounds and reagent-grade glycine, aspartic acid and phenylalanine were found effective in solubilizing varying quantites of copper, cobalt, nickel and zinc from their insoluble carbonate salts. Each gram of different reagent-grade amino acids solubilized 11.4 to 440.0 mg of various metals as compared with less than 1 mg of metals in control treatments consisting of distilled water. On a weight-to-weight basis, the metal solubilizing capacity of acid-hydrolysate of humic compound was very similar to pure amino acids.

The usual stability of amino compounds together with their metal chelation and metal solubilizing properties may play a leading role in the migration, redistribution and concentration of various metals in the zone of sedimentation. (Authors' abstract).

RAYMAHASHAY, B.C., and HOLLAND, H.D., 1968, Composition of aqueous solutions in equilibrium with sulfides and oxides of iron at 350°C: Science, v. 162, no. 3856, p. 895-896.

Ed.'s note: Included here even though old as it contains a description of a method of analysis for small amounts of oxidized and reduced sulfur in solution, using radiotracer techniques, that may also be useful in the difficult problem of analysis of sulfur species in fluid inclusions. See also next item.

RAYMAHASHAY, BIKASH C., and HOLLAND, HEINRICH D., 1969, Redox reactions accompanying hydrothermal wall rock alteration: Economic Geology, v. 64, pp. 291-305.

Wall rock alteration processes often include redox reactions involving iron and sulfur. The effect of these reactions on the composition of hydrothermal solutions can be represented conveniently on log f_{S_2}—log f_{O_2} diagrams. Contours of total dissolved sulfur concentration at 250°C and 350°C, calculated on the basis of the available thermochemical data and partially checked by direct experiment, were superimposed on the mineralogical boundaries of the Fe-S-O system in log F_{S_2}—log f_{O_2} diagrams. During the replacement of iron oxides or silicates by pyrite, solutions containing a higher concentration of reduced than oxidized sulfur species move toward lower f_{O_2} values, whereas solutions containing a higher concentration of oxidized than reduced sulfur species move toward higher f_{O_2} values. The sequence of iron sulfide-iron oxide minerals in wall rock alteration zones depends both on the trend of these reaction paths and on the initial total dissolved sulfur concentration in the hydrothermal solutions.

The observed sequences of minerals in alteration zones at Butte, in the northern part of the Boulder Batholith, and at Ely, Nevada, can be interpreted readily in terms of the proposed scheme. The concentration of total dissolved sulfur in the solutions in these three areas was probably less than 10^{-2} moles/kg of solution. In the northern part of the Boulder Batholith the chemistry of the hydrothermal solutions was affected strongly both by cation metasomatism and by redox reactions. (Authors' abstract.)

REH, Herbert, 1968, Flüssigkeitseinschlüsse als Hinweis auf die Beschaffenheit mineralbildender Lösungen: Zeit. Angewandte Geol. v. 14, heft 11, p. 595-601 (in German with German, English and Russian summaries).

A review with 31 references. (ER)

REMESHILO, B.G., 1972, Inclusions in accessory beryl in metasomatically altered rocks (the Zanorysh pegmatites of the Volynia): Mineral. Sborn. L'vov Gos. Univ., v. 26, no. 3, p. 318-321. (In Russian).

A description is given of inclusions in beryl crystals from metasomatic altered rocks of pegmatites. The temperatures of homogenization of primary inclusions are 480-510°C (in the gaseous phase), secondary--250-300°C (in the liquid phase); pH=7.2-7.5. The temperature of freezing of primary inclusions is -2°-3.5°C. Analysis of gas from the inclusions shows major CO_2, lesser N_2 and CH_4, and minor H_2. (Author's abstract)

RIFE, D.L., 1972, Barite fluid inclusion geothermometry, Cartersville mining district, northwest Georgia, a reply: Econ. Geol. v. 67, p. 822-824.

A reply to criticism by Roedder (1972f, this volume).

ROEDDER, Edwin, 1970, Laboratory studies on inclusions in the minerals of Ascension Island granitic blocks, and their petrologic significance: in Problems of petrology and genetic mineralogy, Sobolev's volume II, p. 247-258 (in Russian with English abstract). See Translations Section.

ROEDDER, Edwin, 1972a, The Composition of Fluid Inclusions: Chapter JJ in Data of Geochemistry, Sixth Edition, M. Fleischer, Ed., U.S. Geol. Survey Professional Paper, 440 JJ, 164 pp., 12 plates, color frontispiece.

(This extensive review of the world literature (1600 references) places particular emphasis on the methodology and significance of studies on composition; it is for sale by Supt. of Documents, U.S. Govt. Printing

Office, \$2.75 (paper covers), as Stock no. 2401-1211)

Fluid inclusions in minerals and rocks preserve for us tiny samples of the fluids that have been present during, and that have in part caused, a number of geological processes, including ore deposition. Although the original material trapped in them was generally a homogeneous fluid at the time of trapping, most inclusions have undergone changes on cooling to surface temperatures, resulting in the formation of new phases such as a gas bubble, immiscible liquids, or daughter minerals. This report is mainly a compilation of the world literature on the methods and results of study of their composition, but it also includes various unpublished data by the author.

Most inclusions are extremely small and may average less than 10 micrometers in diameter. A single inclusion of this size contains a total of only 10^{-10} gram of material; hence it cannot be analysed by ordinary chemical techniques. But a surprising amount of useful qualitative and semiquantitative compositional data on the nature of solid, liquid, and gaseous phases present can be obtained by a series of relatively simple, nondestructive microscope procedures. These procedures, and their limitations, are discussed in detail and are illustrated with a series of photomicrographs. Additional methods that yield qualitative data, but require destruction of the samples, are also described.

These various procedures have shown that although inclusions of organic liquids and gases are common in some localities, most fluid inclusions consist of a liquid water solution. At room temperature, the gas bubble usually contains only water vapor at 0.03 atmosphere pressure, but it may consist of CO_2 at pressures up to 70 atmospheres. Where a second immiscible liquid phase is present, it is generally found to be liquid CO_2. The daughter minerals that form in some inclusions after trapping have been studied intensively, as they are compounds that were sufficiently concentrated in the original fluid that they were precipitated when saturation was reached on cooling. Small, isotropic cubes are by far the most common daughter minerals, as they are found in samples from many environments; they have been identified as halite by several procedures. Many other daughter minerals have been recognized, including particularly sylvite, calcite, and hematite, a number of rare carbonates, fluorides, and fluoborates, and many as yet unidentified species. Large amounts of such daughter minerals are found in inclusions from certain types of pegmatites, from porphyry copper deposits, and from several other environments.

Many igneous rocks and meteorites also contain fluid inclusions, but the "fluid" now consists of silicate crystals or glass, representing a former silicate melt. Such melt inclusions are not covered in this report, although their study involves many of the same techniques.

Quantitative analyses of single, large (~1 millimeter) inclusions have been made by semimicro-, micro-, or ultramicrochemical methods. More commonly, the fluid from a large number of smaller inclusions is extracted by crushing and leaching to provide enough material for analysis by more conventional methods. More than 2,400 partial to relatively complete quantitative analyses of fluid inclusions have been reported in the literature and are summarized here in tables. Many of these are for gaseous constituents only. The significance of most of these data is seriously limited by problems of sample selection and extraction procedure. In addition, analytical procedures adequate to provide quantitative data on the very small samples of fluid usually obtained require considerable care to avoid major contamination, and loss, from a variety of sources. Some of the procedures reported (for example, for pH) cannot fail to give grossly erroneous results except under very limited conditions. There is no known panacea for these problems, and as a result of the many variables involved, it is unlikely that a standardized analytical procedure, suitable for most samples, will be developed. Many of the newer analytical tools have been or soon will be applied to inclusion analysis and considerable progress can be expected, but the nature of the samples and extraction procedures used are the prime considerations in evaluating the precision, the accuracy, and most important, the significance of any measurements obtained.

Representative analyses are given from a number of published papers, and some unpublished data, along with a discussion of their limitations and geological significance. The different types of geologic environment show grossly different compositional ranges.

The many analyses that have been made of the "organic" gases and liquids present as inclusions in the minerals of some igneous rocks show appreciable amounts of a variety of compounds of high molecular weight, in addition to major amounts of H_2, CO, CH_4 and C_2H_6, but the question of inorganic versus organic origin is still open.

Aqueous inclusions have been analyzed by a variety of methods. The concentration of salts in the inclusion fluid as trapped is generally less than 10 percent by weight, but may range from more than 50 to practically 0 percent. The salts consist of major amounts of Na^{+1}, K^{+1}, Ca^{+2}, Mg^{+2}, Cl^{-1}, and $SO_4{}^{-2}$, with lesser amounts of Li^{+1}, Al^{+3}, $BO_3{}^{-3}$, $PO_4{}^{-3}$, $HSiO_3{}^{-1}$, $HCO_3{}^{-1}$, $CO_3{}^{-2}$, and many other ions. Many individual ions in this list may predominate, although Na^{+1} and Cl^{-1} are generally the most abundant. Free carbon dioxide, both as liquid and gas, is not uncommon and may be dominant.

The references include those papers concerned directly with various aspects of the composition of inclusions. As many of the methods for inclusion geothermometry are inextricably connected with considerations of inclusion composition, those papers that present geothermometric data also are included and are annotated briefly in a table. (Author's abstract.)

ROEDDER, E., 1972b, Results and significance of recent fluid inclusion studies in ore deposits (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 10, Geochemistry, p. 322 (In English). Author at United States Geological Survey, 959 National Center, Reston, Va., 22092, U.S.A.

There has been a tremendous increase recently in the publication of fluid inclusion data pertinent to problems of ore deposition, and interpretation. The percentage of papers in languages other than Russian (particularly English) has also increased, although the largest percentage by far is still in Russian.

Fluid inclusions provide a surprising amount of data on the processes of ore deposition, much of which is otherwise unobtainable. This review paper will briefly summarize recent data obtained by the many inclusion methods (for example, homogenization, decrepitation, freezing, and isotopic and chemical analysis), their accuracy, significance and relationship to other field and laboratory data on the nature of the process of ore deposition, and the prospects for future work. (Author's abstract).

ROEDDER, E., 1972c, Fluid inclusions, in Encyclopedia of Geochemistry and Environmental Sciences, v. IVA of Encyclopedia of Earth Sciences Series, ed. Rhodes W. Fairbridge: New York, Van Nostrand Reinhold Co., 1972, p. 373-377. An elementary review. E.R.

ROEDDER, Edwin, 1972d, (Formation of the enigmatic east Tennessee zinc ores): U.S. Geol. Survey Prof. Paper 800A, Geological Survey Research, 1972, p. A1-2.

An abstract of material presented previously (see Roedder, 1971a, Fluid Inclusion Research, v. 4, 1971, p. 64-65).

ROEDDER, Edwin, 1972e, (Fluid inclusions at Bingham, Utah): U.S. Geol. Survey Prof. Paper 800A, Geological Survey Research, 1972, p. A-3.

An abstract of material presented previously (see Roedder, 1971d, Fluid Inclusion Research, v. 4, 1971, p. 65).

ROEDDER, Edwin, 1972f, Barite fluid inclusion geothermometry, Cartersville mining district, northwest Georgia, a discussion: Econ. Geol., v. 67, p. 821-822.

A discussion of internally contradictory evidence in an earlier paper by D.L. Rife (See Fluid Inclusion Research, v. 4, p. 63-64, and Reply, D.L. Rife, this volume). (ER)

ROEDDER, E. and WEIBLEN, P.W., 1972a, Petrographic and petrologic features of Apollo 14, 15 and Luna 16 samples, in Lunar Science III (ed. C. Watkins), pp. 657-659: Lunar Science Institute Contr. no. 88.

A three-page abstract of material given in more detail in the following three citations (1972b, 1972c, and 1972d).

ROEDDER, E., and WEIBLEN, P. W., 1972b, Petrographic features and petrologic significance of melt inclusions in Apollo 14 and 15 rocks: Proceedings of the Third Lunar Science Conference (Supplement 3, Geochim. et Cosmoch. Acta) vol. 1, p. 251-279, Cambridge, Mass., The MIT Press.

The occurrence and significance of silicate melt inclusions in a series of Apollo 14 and 15 igneous rocks, breccias, and soils are described. Electron microprobe analyses (114) are reported, giving the bulk composition of representative inclusions as well as their daughter and host minerals and other phases associated with the inclusions. Although many of the features seen are similar to those previously described, some novel ones were found.

Silicate melt inclusions in olivine are abundant and occasionally large (400μm). Nucleation and growth (epitaxial or random) of daughter phases varies with inclusion size, bulk composition, and probably with cooling history. Solid inclusions in olivine consist of relatively large Cr-spinel euhedra (20-40μm); the olivines in thermally metamorphosed rocks have, in addition, rows of very minute Cr-rich crystals ($\sim$1μm) that have decorated what apparently are otherwise invisible dislocations. Tiny melt inclusions in fractures in plagioclase of 15415 indicate the presence of at least a small amount of melt at the time of fracturing.

Melt inclusions related to the onset of immiscibility are common in all the samples, particularly 14310, and are like those in Apollo 11 and 12 and Luna 16 samples - potassic granite and ferropyroxenite in composition. There is an inverse relationship between the K_2O/Na_2O ratio in the bulk rock and its residual high-silica melt. A summary of all our melt inclusion data in the form of a single silica variation diagram suggests grossly similar liquid lines of descent for the various igneous rock types sampled at the five landing sites. All these lines appear to end at the same high-silica melt composition.

Numerous areas and fragments of glass of potassic granite composition (partly crystallized to K-feldspar) were found in the Apollo 14 breccias. The residual glass in these fragments is very similar in composition to that of the high-silica immiscible melt and could represent a phase of granitic composition from this process that occurs in the crust of the moon and was concentrated in the Apollo 14 source materials. (Authors' abstract)

ROEDDER, Edwin and WEIBLEN, P.W., 1972c, Silicate melt inclusions and glasses in lunar soil fragments from the Luna 16 core sample: Earth Planet. Sci. Letters, v. 13, p. 272-285.

More than 2000 fragments were studied microscopically, and electron microprobe analyses were made of 39 selected areas, from a few square mm of polished surface, through 75- to 425-μm fragments of lunar soil from two samples of the Luna 16 core. The silicate melt inclusions and glasses differ in important details from those observed earlier in the Apollo samples. Melt inclusions in olivine contain epitaxially oriented daughter crystals, but also show a similar epitaxy around the outside of the crystals not observed in previous lunar samples. Melt inclusions in ilmenite suggest trapping at successive stages in a differentiation sequence. There is abundant evidence for late-stage silicate liquid immiscibility, with melt compositions similar but not identical to those from Apollo 11 and 12. A comparison of the alkali ratio of any given bulk rock analysis with that of its late-stage, high-silica melt shows gross differences for different rocks. This is pertinent to understanding late-stage differentiation processes. Glass fragments and spherules exhibit a wide range of crystallization textures, reflecting their wide range of compositions and cooling histories. No significant differences were found between the two portions of core examined (Zones A and D). (Authors' abstract.)

ROEDDER, E. and WEIBLEN, P.W., 1972d, Occurrence of chromian, hercynitic spinel ("pleonaste") in Apollo-14 samples and its petrologic implications: Earth Plan. Sci. Letters, v. 15, p. 376-402.

Primary inclusions of nickel-rich sulfide were found in hercynitic spinel crystals, possibly from the mafic cumulate counterpart of the lunar anorthositic crust. Secondary planes of glass and gas inclusions occur in associated olivine. (ER)

ROEDDER, Edwin, and WEIBLEN, P.W., 1972e, (Luna 16 samples). U.S. Geol. Survey Prof. Paper 800A, Geological Survey Research, 1972, p. A-182.

An abstract of material presented previously (see Roedder and Weiblen, 1972c, Fluid Inclusion Research, v. 4, 1971, p. 67).

ROEDDER, Edwin, and WEIBLEN, P.W., 1972f, (Glass inclusions in olivine crystals): U.S. Geol. Survey Prof. Paper 800A, Geological Survey Research, 1972, p. A-108.

An abstract of material presented previously (see Roedder and Weiblen, 1971a, Fluid Inclusion Research, v. 4, 1971, p. 67).

ROEGGE, John, BARR, H.B., BORCSIK, Maria, and HOLLAND, Heinrich, 1972, Halogens in apatites from the Providencia area, Mexico (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 641-642 (First author at Princeton Univ., Princeton, N.J., 08540).

Important copper, lead, zinc, and silver mineralization is closely associated in time and space with the shallow, lower Tertiary, granodioritic stocks at Concepcion del Oro, Providencia, and Noche Buena in north central Mexico. Apatites were separated from 30 samples taken along traverses across the stocks. The apatite concentrates contained between 0.3 and 1.6 weight percent chlorine and between 0.8 and 2.8 weight percent fluorine. Individual apatite crystals were rarely zoned, but different crystals from the same hand specimen usually contained widely different quantities of fluorine and chlorine. Typically, the chlorine concentration either remained nearly constant or decreased with increasing fluorine content. The composition of individual crystals ranged from nearly pure fluorapatite to apatites containing 50 mol percent chlorapatite. The Cl/OH ratio in most of the apatites was between 0.1 and 1.0. Apatites from intrusives in the Odenwald (Taborszky, 1962) have Cl/OH ratios close to 0.1. Those from Shonkin Sag (Nash, 1972) between ca. 0.1 and 0.3. Apatites from Lassen dacites (Stormer and Carmichael, 1971) have Cl/OH ratios close to 0.5.

The Cl/OH ratio in our apatites ranges from quite average to abnormally high. The large compositional range of apatites from single hand specimens suggests that apatite has a much better memory for magmatic events than biotite; the high Cl/OH ratio of some of our apatites may be related to the evolution of highly saline hydrothermal solutions from these stocks. (Authors' abstract).

ROMANCHEV, B.P., 1972, Inclusion thermometry and the formation conditions of some carbonatite complexes in East Africa: Geokhimiya, 1972, no. 2, p. 172-179 (in Russian; translated in Geochem. Internat. v. 9, no. 1, p. 115-120). Author at Vernadskiy Institute of Geochemistry and Analytical Chemistry, Academy of Sciences of the USSR, Moscow.

Inclusion homogenization has been used to deduce minimum formation temperatures for minerals in East African carbonatite complexes: 1000 - 1020°C for olivine in picrites, 870-930°C for nepheline and pyroxene in nephelinites, 780°C for nepheline in ijolites, and 640-700°C for apatite and calcite in carbonatites. Nepheline in lavas contains inclusions where glass accompanies calcite. The carbonatite magma appears to have been derived from an alkali silicate melt. (Author's abstract)

ROMANCHEV, B.P., KOGARKO, L.N. and KRIGMAN, L.D., 1972, A study of liquation-type inclusions in minerals: Geokhimiya, 1972, no. 10, p. 1307-1311 (in Russian; translated in Geochem. Internat., v. 9, no. 5, p. 876-879, dated 1972 on cover but published in 1973). Authors at Vernadskiy Institute of Geochemistry and Analytical Chemistry, Academy of Sciences of the USSR, Moscow.

Experiments in the nepheline-NaF system show that inclusions of liquation type (i.e. exhibiting immiscibility) can be produced in a mineral deposited from a heterogeneous melt and that these can be used to define temperature and medium of crystallization. (L.P. Greenland).

ROMBERGER, S.B., 1972, The hydrothermal synthesis of copper, zinc, and lead sulfides, (Abstr.): Geological Society of America, Abstracts with Programs, v. 4, no.7, p. 643-644. Author at Department of Geology and Geophysics, University of Wisconsin, Madison, Wisconsin 53706.

Copper, lead, and zinc sulfides were synthesized together in a 3 molal sodium chloride, 0.14 molal calcium chloride, solution between 20° and 200°C under the vapor pressure of water. Metal carbonates were

used as starting materials along with elemental sulfur and calcium carbonate. The mole ratio of Cu:Zn:Pb added was 3.3:3:1.0. The amount of sulfur was in slight excess of that necessary to react with all metal. The products were covellite, sphalerite, galena, anhydrite, and a second generation of calcite. Morphology of the composite metallic sulfide grains suggests reaction occurred above the melting temperature of sulfur. Nonequilibrium is indicated by the presence of unreacted sulfur in the cores of the grains. No metal carbonates remained in the run products. The sulfides showed a regular zonation, with covellite next to sulfur, followed outward by galena and sphalerite, with calcite on top. The sequence is equated to paragenesis.

The aqueous solution was analyzed for copper, lead, and zinc. The mole ratio of Cu:Zn:Pb in solution at 200°C was 1:935:30, and at 20°C, 1:4680:550. The concentration of all metals increased with temperature; copper rose from 0.5 ppm at 20° to 4.5 ppm at 200°C. Because equilibrium was not established the only significance of these data is to demonstrate relative tendencies for metal sulfides to precipitate under the conditions of the experiment.

These results may be applied to natural systems where metal-bearing sulfur deficient saline solutions invade sulfur-containing environments to help explain paragenesis and zoning. (Author's abstract.)

ROSENBERG, P.E., 1972, Paragenesis of the topaz-bearing portion of the Brown Derby No. 1 pegmatite, Gunnison County, Colorado: Amer. Mineralogist v. 57, p. 571-583. Author at Department of Geology, Washington State University, Pullman, Washington 99163.

The paragenesis of the asymmetrically zoned, Li-rich, topaz-bearing portion of the Brown Derby No. 1 pegmatite, Gunnison County, Colorado, has been reconstructed on the basis of observed textural relationships in the light of the recent model for pegmatite genesis by Jahns and Burnham (1969).

The coarse-grained, K-rich "hood" formed in the presence of an aqueous fluid phase during the crystallization of the wall zones; topaz was originally abundant in the hood assemblage. The finer-grained texture of the footwall unit suggests crystallization directly from the silicate melt. Large topaz crystals concentrated at the base of the core unit imply gravitationaly settling of topaz in the melt. Lepidolite and cleavelandite crystallized later from the aqueous fluid phase, replacing pre-existing assemblages and forming the observed core unit. Topaz was armoured and preserved by the residual melt trapped largely at the base of the core unit which crystallized to form multiple quartz pods. (Author's abstract)

ROWE, J.J., MOREY, G.W., and ZEN, C.S., 1972, The quinary reciprocal salt system Na,K,Mg,Ca/Cl,SO_4-A review of the literature with new data: U.S. Geol. Survey Prof. Paper 741, 37 pp. (Authors at U.S. Geol. Survey, Reston, Va.).

Data from the literature, supplemented by new experimental results, are presented for 28 binary systems, 13 ternary systems, six ternary reciprocal salt systems, and four quaternary reciprocal salt systems that make up the quinary reciprocal salt system Na,K,Mg,Ca/Cl,SO_4. The data were extrapolated to the pseudoquaternary system $NaCl-K_2SO_4-MgSO_4-CaSO_4$ to develop a theory for the crystallization-differentiation of the salt melted by the Gnome underground nuclear explosion in the Salado Formation near Carlsbad, N. Mex. (Authors' abstract) (Of considerable pertinence to understanding the equilibria in multiphase, highly saline inclusions (ER).

ROZHKOV, I.S. and ANDRUSENKO, N.I., 1972, Problems of studies of gold ore deposits according to inclusions in minerals: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 208-213 (in Russian).

A brief review of inclusion data, mainly from the literature, of 20 deposits in the USSR. (ER).

RUB, M.G., 1972, The role of the gaseous phase during the formation of ore-bearing magmatic complexes: Chem. Geol., v. 10, p. 89-98. (Author at Department of Geology, Institute for Geology of Ore Deposits, Moscow, U.S.S.R.)

It is shown that there is a direct relationship between the fluorine content of acid igneous rocks and associated mineralization with particular reference to tin and tungsten. The fluorine may be bound in minerals such as micas and apatite but may also be enriched in fluid inclusions in quartz. Particular emphasis is placed on fluorite-bearing magmatic rocks. Volatile phases enriched in boron are considered to be related to association of the magmas with arenaceous sediments. (Author's abstract)

RUCHKIN, G.V. AND DIOMIN, Y.I., 1969, Some genetic questions of the Bliava ore field copper-kies deposits (southern Urals): Sovets. Geol., 1969, no. 1, p. 45-60 (in Russian).

Includes an extensive study by decrepitation. (ER)

RYE, D.M. & RYE, R.O., 1972, The origin of the Homestake gold deposit, South Dakota, in the light of stable isotope studies: Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 649. First author at Department of Geology, Yale University.(Abstract also in Econ. Geol., v. 67, p. 1010).

The Homestake mine, South Dakota, is the largest producing gold mine in North America. The ore occurs as nearly conformable replacement bodies in dilatant zones of deformed Precambrian Homestake Formation and is associated with arsenopyrite, pyrrhotite, and quartz in chloritized regions of sideroplesite or cummingtonite schist. The δS^{34} values of arsenopyrite and pyrrhotite in the mine are 5.6-9.8‰ in the Homestake, 2.7-5.1‰ in the underlying Poorman Formation, and 4.1-29.8‰ in the overlying Ellison Formation. The formational dependence of δS^{34} values indicates a sedimentary origin for the sulfur in the deposit. Consideration of the influence of pH, f_{O_2}, temperature, and biogenetic activity on the δS^{34} values of sedimentary sulfides indicates that most of the sulfur was ultimatly derived from sea-water sulfate. The δS^{34} values of sulfides in individual ore bodies vary systematically with local structure and suggest that the original sedimentary sulfur migrated into dilatant zones during Precambrian metamorphism but not across formational boundaries. The δO^{18} values of quartz in the mine and regional segregation quartz veins show a strong dependence on the wallrock and indicate that the quartz in the mine was a normal part of the metamorphic sequence. Data on the δD of water and δC^{13} of CO_2 and CH_4/CO_2 in fluid inclusions are consistent with a metamorphic origin for the ore body and differ markedly from data on Tertiary ore deposits in the surrounding area. The isotopic and geologic data suggest that the gold and other constituents of the ore deposit were indigenous to the Homestake Formation, were probably of syngenetic exhalative origin, and were concentrated in dilatant zones during metamorphism. (Authors' abstract)

SABOURAUD-ROSSET, Christiane, 1972, Microscopy of liquid inclusions in gypsum and the salinity of their generating environments: Revue de Géographie Physique et de Géologie Dynamique, v. 14, pt. 2, p. 133-144 (in French with English abstract). (Author at Centre des inclusions gazeuses et liquides (E.R. n° 45 du C.N.R.S.), Laboratoire de Géologie de l'Ecole normale supérieure, 46, run d'Ulm, Paris 5^e, France.)

During crystal growth, small drops of mother solution are trapped in intracrystalline cavities. Their study gives significant indications about paleotemperatures and paleosalinities. Present day and fossil gypsum samples contain inclusion fluids whose salinity has (or has not) been altered during diagenesis. Microscopy is a simple application of the phase diagram $NaCl-H_2O$; any inclusion is parallelized to the pure $NaCl-H_2O$ system having the same "last melting point". Eventual presence of other salts (e.g. $CaCl_2$ or $MgCl_2$) may be detected by the value of the "first melting point" - 21.1°C for pure $NaCl-H_2O$.

Present day samples of known origin are studied in the first part (crystals from continental or coastal sabkhas or marine environments). Such origins may be distinguished by the value of the first and last melting points. Synthetic and natural crystals grown from marine (environments) exhibit a wide range of salinities (at least about 3 times the "normal oceanic" concentration). Old samples of marine origin exhibit high salinities apparently altered by diagenesis waters. Fossil samples of challenged origin (Cenozoic samples from France) contain abundant secondary inclusions filled with nearly pure water and primary inclusions whose salinity pattern is similar to that of old marine crystals. Fluid inclusions in gypsum apparently reflect syngenetic and diagenetic environments (Author's abstract).

SAMBLES, J.R., 1971, An electron microscope study of evaporating gold particles: the Kelvin equation for liquid gold and the lowering of the melting point of solid gold particles: Proc. Royal Soc. Lond. A. v. 324, p. 339-351. Author at Department of Physics, Imperial College of Science and Technology, London, S.W.7.

Of pertinence to fluid inclusion work only in that it shows that although the effect of small particle size causes very significant lowering of the melting points of Au, Sn, and Pb, (down to 0.9 bulk melting point), the effect becomes significant below about 20 nm (0.02 μm). (ER)

SANS, J.R., 1972, Glass inclusions in olivines from Holocene Cinder Cones. Medicine Lake (ML) Calif.: Amer. Geophys, Union Trans (EOS) v. 53, p. 547.

On variation diagrams the data generally fit within the scope of the High Cascades as an andesite-rhyolite province, Some typical analyses:

Cone	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	P_2O_5	TiO_2	Total
M39	64.1	16.2	5.6	2.2	4.4	1.7	2.41	0.38	1.39	98.4
Hippo	51.8	20.2	8.3	4.6	8.7	3.7	1.20	0.47	1.60	100.6
B.Crater	48.4	18.0	8.0	7.2	12.4	2.6	0.16	0.11	0.96	97.8

On a NaKCa plot the analyses break into two distinct groups, perhaps indicative of mixing of two magmas with independent histories, to form the whole rock. Several of the localities exhibit Dickinson K_{60} values (%K_2O for 60% SiO_2) which are much higher (2.5) than the value for ML (2.0) as a whole. These variations may represent scatter of K_2O values due to alternate paths of differentiation. (Author's abstract)

SASSANO, G.P., FRITZ, P., and MORTON, R.D., 1972, Paragenesis and isotopic composition of some gangue minerals from the uranium deposits of Eldorado, Saskatchewan: Canad. Jour. Earth Sciences, v. 9, p. 141-157. Authors at Department of Geology, University of Alberta, Edmonton, Alberta.

A paragenetic sequence of the common mineral constituents of the uraniferous vein deposits of the Fay Mine and Bolger open pit of Eldorado Nuclear Ltd., in northwestern Saskatchewan, is presented.

Pitchblende associated with hematite, pyrite, chalcopyrite, bornite, galena, and clausthalite in quartz ± calcite ± dolomite gangues is found in veins cutting folded Tazin metamorphics, adjacent to the St. Louis Fault. Fluid inclusion studies reveal a cooling sequence from the initial phase of mineralization at 440 ± 30°C down to the final stages at around 80 ± 10°C. Stable isotope studies, augmented by petrographic data, serve to distinguish at least five generations of carbonate in the ore veins. Early generations of dolomite have apparently not undergone any significant recrystallization or isotopic readjustment and exhibit original restricted $\delta^{18}O$ (SMOW) values of 9.5 to 11.0‰ and $\delta^{13}C$ (PDB) values of -0.60 to 0.55‰. Isotopic evolution via equilibration with wall rocks has resulted in the deposition of late-stage calcites characterized by $\delta^{18}O$ (SMOW) values of +13.2 to +14.5‰ and $\delta^{13}C$ (PDB) values of -15.9 to -16.8‰. The strong decrease in $\delta^{13}C$ may possibly be explained by a decrease in the amount of CH_4 present in the system. It is felt that the deposits were generated by metamorphic hydrothermal fluids with initial $\delta^{18}O$ (SMOW) values of +6 to +8‰ which during cooling underwent isotopic exchange with the host metamorphic rocks and became depleted in ^{18}O. The final stages of mineralization were possibly effected by some influx of isotopically lighter surface waters into an otherwise essentially 'closed' system. Present day waters from the Fay Mine have $\delta^{18}O$(SMOW) values of -16.0 to -16.2‰ and could represent products of a continuing evolution of the hydrothermal fluids. (Authors' abstract).

SCHEEL, H.J., 1972, Accelerated crucible rotation: A novel stirring technique in high-temperature solution growth: Jour. of Crystal Growth, v. 13/14, p. 560-565. (Author at IBM Zurich Research Laboratory, 8803 Rüschlikon, Switzerland)

The role of diffusion and convection in conventional flux growth is compared with the strong stirring effect of the accelerated crucible rotation technique (ACRT). ACRT allows fast solution flow rates at the growing crystal faces. By this and by homogenization of the solution many problems in flux growth are solved. Control of nucleation in a closed crucible is achieved by combination of ACRT with localized cooling. Large inclusion-free crystals with applications in solid state physics and technology have been grown. (Author's abstract)

SCHEEL, H.J., and ELWELL, D., 1972, Stable growth rates and temperature programming in flux growth: Jour. of Crystal Growth, v. 12, p. 153-161. (Authors at IBM Zurich Research Laboratory, 8803 Rüschlikon, Switzerland)

Theoretical and experimental evidence is presented to demonstrate that the maximum stable growth rate of crystals growing from slowly cooled solutions must decrease as the crystal size increases and the solute concentration decreases. Temperature programs derived for a constant linear growth rate are therefore unlikely to result in the growth of high-quality crystals. A cooling program based on the theoretical maximum stable growth rate is calculated, and it is shown that a constant cooling rate should give stable growth except in the early stage following spontaneous nucleation. Practical procedures are suggested for the growth of large crystals of good quality by slow cooling of high-temperature solutions. (Authors' abstract)

SCHOLANDER, P.F., 1972, Tensile water: American Scientist, v. 60, p. 584-590.

An excellent review (18 refs.) of the various phenomena involving metastable stretched water under negative pressure. (ER)

SCHUBNEL, H.-J., 1972, Pierres précieuses dans le monde: Paris, Horizons, 192 pp. (in French).

A general book on gemstones and their mining, fashioning, and identification, and including 32 color plates, some of solid and liquid inclusions with CO_2, NaCl, and other phases, in gems. (ER)

SCOTT, S.D., and BARNES, H.L., 1971, Sphalerite geothermometry and geobarometry: Econ. Geol., v. 66, p. 653-669 (First author at Dept. Geology, Univ. Toronto, Toronto 5, Canada).

An experimental and theoretical consideration of the significance of the FeS content in ZnS. A comparison is made with the fluid inclusion homogenization data of Kelly and Turneaure (1970) on samples from the Bolivian tin province. (ER)

SCOTT, S.D., & O'CONNOR, T.P., 1972, Fluid inclusions in vein quartz, Silverfields mine, Cobalt, Ontario: Canadian Mineral. v. 11, pt. 1, p. 263-271. Authors at Department of Geology, Univeristy of Toronto, Toronto 5, Ontario.

A reconnaissance study of primary (?) fluid inclusions in quartz from the principal ore veins of the Silverfields mine near Cobalt, Ontario has revealed four types of inclusions containing various combinations of vapour, liquid, and a halite crystal as follows: I (liquid only), II (liquid + halite crystal), III (liquid + vapour), and IV (liquid + vapour + halite crystal). Repeated chilling and thawing induced nucleation of the vapour phase in types I and II, but did not precipitate a halite crystal in types I and III. The anomalous behaviour of types I, II and III is thought to be due to metastability caused by the very small size of the inclusions (<10 microns).

Heating experiments show that the included brines contain > 30 wt% NaCl. There are two distinct populations of filling temperatures with median values of 165°C and 250°C, but only one population is found in a sample. Depositional temperatures of the two quartz populations, corrected for confining pressures of 400 to 1200 atm as estimated from geological evidence, range from 195° to 260°C and 285° to 360°C. (Authors' abstract)

SEDLETSKIY, V.I., TRUFANOV, V.N., and MEL'NIKOVA, Ye.M., 1971, Origins of authigenic quartz in salt basins: Akad. Nauk SSSR, Sibir. Otdel., Geologiya i Geofiz., 1971, no. 5, p. 72-77 (in Russian; translated in Inter. Geol. Rev., v. 14, no. 9, p. 1008-1012, 1972). Authors at State Univ. Rostov.

The quartz crystals (<1 mm) are sharp and bright, and contain solid inclusions of hematite, anhydrite, and carbonates outlining growth zones. They contain inclusions of CO_2 homogenizing into the gas phase at 25-28°C, and liquid (aqueous?) inclusions homogenizing between 40 and 110°C. Quoting Lemmlein and Klevtsov (1956) and Kalyuzhnyi (1960), the authors assume that these latter data are 15-20° too high due to the 25-30% salinity (sic); and hence the maximum formation temperature was 80°C. (ER)

SHAFRANOVSKIY, I.I., 1972, Shapes of crystals as indices of the mineral-forming medium: in Typomorphism of Minerals and its Practical Significance, F.V. Chukhrov, ed.: Moscow, "Nedra" Press, p. 64-67. (In Russian).

SHCHEGLOV, A.D., 1972, Fluorite deposits and tectonics (abst.): Internat. Geol. Cong, 24th, Abstracts, Section 4, Mineral Deposits, p. 148 (In English). Author at Ministry of Geology of the USSR, Moscow M242, U.S.S.R.

1. Fluorite and less commonly barite-fluorite and sulphide-fluorite (vein and stratiform) deposits are characterized by a close relation to tectonic processes at all stages of their formation.

2. Fluorite deposits mainly appear within regions of tectonic-magmatic activization, which arise on the consolidated structures of platforms, folded zones, and median masses. In many regions fluorite deposits are localized in activated zones (of various orders) occurring along the margins of tectonic blocks, composed of Precambrian formations.

3. Fluorite deposits are related to the separate group of "tectonogenic" deposits, the prinicpal features of which depend upon the character, time and scale of the manifestation of disjunctive tectonic displacements.

4. According to morphological features, fluorite deposits may be divided into two distinct groups: a - veins and fractured zones; b - conformable orebodies, in places of strata-bound type. The position of the latter is always controlled by faults, and the deposits occur at the intersection of ore-bearing tectonic displacement zones with formations favourable for ore deposition (carbonate rocks).

5. A peculiar feature of these "tectonogenic" fluorite deposits is the presence of liquid and solid bitumens in ores, marking a relation between endogenic ore deposits and petroleum deposits, which appears at present to be of rather illusory nature.

6. Fluorite deposits occur in regions characterized by peculiar structure of the tectonosphere and above all by small depths to the upper mantle. (Authors' abstract).

SHEVKALENKO, V.L., and TSOI, A.V., 1972, Use of the decrepitogram of quartz for the study of zoning in gold-silver deposits of Shkolnoe (northern Tadzhikstan): Zap. Uzb. Otd. Vses. Mineral. Obshchest. 1972, no. 25, p. 139-142 (in Russian). CA 78 (3) 32549n (1973).

The Skolnoe deposit consists of quartz-carbonate veins with Au-Ag mineralization (electrum and kuestelite). Several modifications of quartz, which form a zoning structure in individual ore bodies, were detd., based on their structural characteristics. The study of quartz decrepitation revealed the presence of a thermal zoning. The difference in temp. of deposition of early and final quartz is 50-70° for the ore parts of the vein and 20-40° for the vein zones below and above the ore part. The temp. of deposit formation was 170-240° from decrepitation and homogenization temps. of inclusions in quartz.

SHIRONOSOVA, G.P., and KOLONIN, G.R., 1972, On calculation of component activities and pH of solutions at elevated temperatures: in Experimental investigations in mineralogy, 1970-1971, A.A. Godovikov and V.S. Sobolev, eds.: Novosibirsk, Acad. Sci. USSR, Sib. Division, Inst. Geol. & Geophys., p. 114-120 (in Russian).

SHVEDENKOV, G., 1972, Influence of carbon dioxide on andradite synthesis in hydrothermal conditions: in Experimental investigations in mineralogy, 1970-1971, A.A. Godovikov and V.S. Sobolev, eds.: Novosibirsk, Acad. Sci. USSR, Sib. Division, Inst. Geol. & Geophys., p. 59-62 (in Russian).

Discussion of P_{CO_2}, CO_2/H_2O ratio, and state of oxidation of iron. (ER)

SILLITOE, R.H., 1972, A model for porphyry copper systems (abst): Geol. Soc. America Abstracts with Programs, v. 4, no. 7, p. 665. Author at Department of Mining Geology, Royal School of Mines, Imperial College, London, S.W. 7, England.

Typical porphyry copper deposits are accepted as 3-km high, upright cylinders of zoned alteration-mineralization centered on felsic stocks. The largely non-economic extremities of porphyry copper systems, both above and below the deposits, have not been described.

At Chuquicamata and Domeyko, Chile, post-mineralization, high-angle faults cut the porphyry deposits and resulted in erosion of the portions of the deposits on the upthrown blocks. The bilateral symmetry of the alteration patterns was disrupted. Unaltered, phaneritic granodiorite outcrops on the upthrown blocks and represents the roots of the systems. Zones of biotite-poor potassic alteration in phaneritic intrusives may represent the lower parts of porphyry deposits.

Whereas most porphyry copper deposits were emplaced in sub-volcanic basement, several small deposits at Farallón Negro, Argentina occur in the infrastructure of a calc-alkaline volcano. Furthermore, many heavily-dissected stratovolcanoes in the Andes exhibit centrally-located, pyritic alteration zones consisting of propylitic and silicified andesitic volcanics, that are considered to overlie porphyry deposits. High-temperature fumaroles and deposits of native sulfur are interpreted as the surficial manifestations of porphyry copper formation in depth.

Available evidence suggests that the tops of typical porphyry copper deposits were formed 2 - 3 km beneath the summits of volcanic edifices, and that complete porphyry copper systems possess vertical extents of 6 - 9 km (Author's abstract).

SIMANOVICH, I.M., and IVENSEN, G.V., 1972, Inclusions of minerals and mineral-forming medium in clastic quartz: Litologiya i Polez. Isko., v. 7, no. 5, p. 34-50. (in Russian; translated in Lithology and Mineral Resources, v. 7, no. 5, p. 568-581, 1973.) Authors at Institute of Geology, Yakutsk Branch, Siberian Division of the Academy of Sciences of the USSR, Yakutsk.

On the basis of a statistical study of quartz in rocks of a standard collection (granites, metamorphic rocks, vein quartz), conclusions have been reached on the genetic importance of mineral inclusions in clarifying the primary nature of clastic quartz. A statistical study has been made of the various features of the inclusions of the mineral-forming medium: dimensions, shapes, phase composition, and the saturation of the grains by them. On the basis of an analysis of the data obtained, it has been shown that there is a change in the frequency of occurrence of the various features of the inclusions of the mineral-forming medium according to the series: metamorphic rocks--"ancient" granites--"young" granites--vein quartz, and several other patterns have also been identified, on the basis of which we may proceed to a qualitative interpretation of the composition of clastic quartz in sandy rocks, which is illustrated by examples. A study of the origin of clastic quartz on the basis of mineral inclusions and inclusions of the mineral-forming medium may give important additional information for identifying the sources of supply and the correlation of unfossiliferous sequences. (Authors' abstract, abbreviated).

SINCLAIR, W.D., 1972, The solubility of copper and chalcocite in aqueous chloride solutions from 25° to 250°C (abst): Geol. Soc. America Abstracts with Programs, v. 4, no. 7, p. 667. Author at Department of Geology and Geophysics, Science Hall, University of Wisconsin, Madison, Wisconsin 53706.

The solubility of copper and chalcocite, Cu_2S, was measured in sulfur-deficient, aqueous chloride solutions as a function of temperature, pH, and chloride concentration. The copper-chalcocite pair was chosen to buffer the sulfur fugacity. The chloride concentrations of the solutions were varied from 0.1 to 3.0 molal. Calcite was included in the runs to buffer the pH.

Chloride concentration and pH were the most important factors in the solubility of copper and chalcocite in aqueous chloride systems. At 150°C the 0.1 m chloride solutions contained less than 1 ppm copper, whereas the 3.0 m solutions contained 30 ppm. Also at 150°C, a decrease of approximately two pH units in the 3.0 m solutions increased the copper concentration from 30 to 60 ppm. Increasing the temperature had little effect on the solubility.

The high chloride content of natural hydrothermal systems suggests that many metals, including copper, may be transported as chloride complexes in ore-forming solutions. The results of these experiments are most directly applicable to deposits such as the native copper deposits of Upper Michigan in which chalcocite is common, though minor. The results indicate that the amounts of copper and chalcocite soluble in chloride-rich, sulfur-deficient solutions are adequate for the transport of copper. Deposition would occur with an increase in pH, or by dilution of the ore fluid, whereas temperature may have little importance below 250°C (Author's abstract).

SKINNER, B.J., FERNANDEZ, L.A., and ALTHAUS, E., 1972, Primary sulphide phases precipitated from magmas: Their nature and causes of precipitation (abst.): Canadian Mineralogist, v. 11, pt. 2, p. 580-581. (Authors at Department of Geology and Geophysics, Yale University, New Haven, Conn.)

Ore minerals preserved as isolated solid inclusions in silicate minerals provide unchanged samples of primary phases precipitated from magmas. In rocks of the granodiorite-monzonite-granite suite, magnetite is ubiquitous, and pyrite almost ubiquitous, as primary inclusions in quartz and feldspar. Evidence of the time of their precipitation is not conclusive, but their distribution suggest both are early phases to appear on the liquidus and that they remain there throughout the crystallization interval.

The presence of pyrite limits the crystallization temperatures of most salic igneous rocks below 743°C, the invariant temperature for the assemblage pyrite+pyrrhotite+sulphur liquid+sulphur vapor. The appearance of both pyrite and magnetite on the liquidus requires that any hydrothermal fluids evolved must be saturated with respect to both phases, placing close restraints on the activities of sulphur (a_{S_2}) and oxygen (a_{O_2}) in the fluids and thereby controlling their potentials as ore forming fluids.

Other primary sulphide phases, in decreasing frequency of occurrence, are chalcopyrite, the breakdown products of a digenite-bornite solid solution, pyrrhotite, (in some granodiorites from the Sierra Nevada, and in feldspar phenocrysts of ash-flow tuffs from the Jemez Mountains, New Mexico) and molybdenite.

Experimental determination of sulphide solubility in magmas demonstrates that the controlling variables are bulk composition of the magma, temperature and the partial pressures of oxygen and sulphur. Pressure is apparently not an important variable throughout the crustal pressure range except in-so-far as it affects the H_2O-contents and thereby the bulk compositions of magmas. Increasing the H_2O-content decreases the sulphide solubility. Changing H2O pressures and falling temperatures appear to act with equal efficacy in controlling sulphide precipitation during crystallization of hydrous magmas. (Authors' abstract).

SMITH, R.C., II, and ROSE, A.W., Jr., 1972, Major and trace elements in differentiates of Triassic diabase and their relationship to Cornwall-type magnetite ores (abst): Geol. Soc. America Abstracts with Programs, v. 4, no. 7, p. 671. Authors at Mineral Conservation Section, Mineral Sciences Building, Pennsylvania State University, University Park, Pennsylvania 16802

Mineral, major, and trace-element distribution in Triassic diabase sheets from southeastern Pennsylvania reveals crystallization fractionation effects, especially early bronzite crystal settling which depleted the magma in Mg, Cr, and Ni. Lack of chemical balance between chilled borders and the main portion of sheets indicated that crystal settling accompanied residual magma flow and possibly down-dip slumping or flow of settled crystals and interstitial magma. Segregation into diabase pegmatite and granophyre, and loss of hydrothermal fluid have also occurred.

The residual magma from the crystal settling process was best developed near Reeser's Summit and is enriched in K, Fe, Cl, Cu, S, and other elements. A magnetite-rich "quartz gabbro" formed by the above process contains quartz, magnetite, fayalite, Fe-rich biotite, K-feldspar, ilmenite, plagioclase, altered pyroxenes, amphibole, and copper-iron sulfides. The mineral assemblage and microprobe analyses of selected minerals, allow estimates of temperature (780°C), f_{O_2} ($10^{-15.65}$ bars), f_{H_2} (50 bars), f_{H_2O}(1900 bars) and other parameters at the time of final consolidation of the magma. Fluid inclusions and f_{H_2O} suggest that the magma was near saturation with water at this stage. The observed differentiation followed by separation of a hydrothermal fluid constitute a concentration mechanism for formation of contact metasomatic magnetite-chalcopyrite ores adjacent to diabase at Cornwall, Morgantown and about 45 smaller but similar occurrences in southeastern Pennsylvania (Authors' abstract).

SNOW, D.B., 1972, Dopant observations in thin foils of annealed tungsten wire: Metallurgical Transactions, v. 3, p. 2553-2554.

Electron microscopy of tungsten wires revealed "rapidly oscillating fluid" in partly fluid-filled inclusions in the size range of 50-1200 Å (0.005-0.12 μm). These inclusions were aligned in rows parallel to the axis of the wire, presumably by the drawing process. The original dopants (in ppm) were: K-82, Al-12, and Si-4; after drawing, the wires were annealed in H at 3020°C for 6 minutes. The inclusions are believed to represent holes formed by the volatilization of dopants and diffusion of the resulting vacancies, and the liquid is probably residual metallic K, which melts (64°C) in the electron beam. (The liquid movement may be caused by the same variable surface tension forces in thermal gradients noted in normal liquid inclusions in a size ∿ 3 orders of magnitude larger. E.R.)

SOBOLEV, V.S., BAZAROVA, T. Yu. and BAKUMENKO, I.T., 1972, Crystallization temperature and gas phase composition of alkaline effusives as indicated by primary melt inclusions in the phenocrysts: Bull. Volcanologique, v. 35, part 2, p. 479-496 (in English). Authors at Institute of Geology and Geophysics, Siberian Branch of the USSR Academy of Sciences, Novosibirsk.

Minerals formed during magma crystallization trap droplets of melt that are preserved as primary or secondary inclusions. Depending on the rate of cooling, the droplets may solidify as glass, or crystallize. Inclusions may contain one or more bubbles, or none. When inclusions are heated the glass or crystalline materials melt and the inclusion expands, the size of bubbles diminishes, and homogenizations of the inclusion occurs. It is possible to observe these transformations by means of high-temperature stages which permit visual observations to 1600°C and above. The possibility of using the homogenization of inclusions to determine the temperature of formation of the host mineral has been demonstrated experimentally, using inclusions in artificial diopside formed at 1300 ± 10°.

Melt inclusions in phenocrysts from nepheline basalt, fergusite porphyry, and tephrite were investigated. In the leucite-bearing rocks leucite crystallized at 1600° or above, and clinopyroxene in the range 1380-1250°. The central part of olivines in nepheline formed at 1290-1270° and the peripheral zones at 1160-1120°; nepheline formed at 1290-1250°; the central part of pyroxenes at 1280-1250° and the peripheral zones at 1160-1120°. These temperatures suggest almost dry magma.

Gas from the bubbles of individual inclusions has been analyzed. The predominant gaseous component of the early crystallization stage of the nepheline basalt and fergusite porphyry was CO_2. H_2S, SO_2, NH_3, HCl, HF, and H_2 comprise less than 5 volume percent except in olivine of olivine basalt in which the total content of these gases was on average 6.22 volume percent, and in leucite of fergusite porphyry in which H_2 was on average 12.7 volume percent. The main gas components in the crystallization of the leucite tephrite were nitrogen and rare gases. Liquid hydrocarbons in the secondary inclusions in pyroxene from nepheline basalt can be accounted for by their assimilation by the magma from enclosing rocks during its rise (Authors' abstract).

SOBOLEV, V.S., PANINA, L.I. and CHEPUROV, A.I., 1972, Crystallization temperatures of minerals in meymechite as revealed by the homogenization of rock inclusions: Akad. Nauk SSSR, Doklady, v. 205, no. 1, p. 201-204 (in Russian; translated in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 205, p. 159-162; abstract in Intern. Geol. Rev., v. 14, no. 12, p. 1384, 1972). Authors at Institute of Geology and Geophysics, Siberian Division, USSR Academy of Sciences, Novosibirsk.

The inclusions in olivine (fig. 2, 3a) consist of transparent glass, dark brown crystalline phases, and a jet-black ore mineral; gas bubble is rarely seen; their smelting begins at 1150-1200°C and the homogenization in the melt occurs at 1450 ± 30°C. The corresponding ranges for the inclusions in monoclinic pyroxene (fig. 3b) are 1000-1050°C and 1170-1230°C, respectively. Upon consideration of several possible explanations of this difference, plausible or improbable as they are shown to be, the crystallization range of the meimechites is taken here as 1170-1450°C (much higher than the Hungarian nepheline basalts), pending further investigations. (Authors' abstract)

SOTNIKOV, V.I., PROSKURYAKOV, A.A., and NIKITINA, Ye.I., 1972, Temperatures of formation of explosion breccia in the Shakhtama deposit: Akad.

Nauk SSSR, Doklady, v. 204, no. 1, p. 185-188. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 204, 1972, p. 35-38). Authors at Institute of Geology and Geophysics, Siberian Division, USSR Academy of Sciences, Novosibirsk.

Brecciation, on the whole, may have occurred at high temperatures, judging by homogenization of the gas-liquid inclusions in the accessory apatite and others (Table 1), at a favorable water-content, in the presence of volatile constituents, and in an active current of heat, hot enough to melt the rocks and particularly the cementing substance in the breccias (250-610°C). The "zone of boiling" in the breccia bodies must have lain somewhat below the modern erosion plane, judging by the phase state of the fluid in the cement and the breccia fragments, as well as in the gas-liquid inclusions in the apatite. (Authors' abstract, translated in Internat. Geol. Review, v. 14, no. 11, 1972, p. 1271).

STANTON, R.L., 1972, Ore Petrology: New York, McGraw-Hill, 713pp.

Includes several references to published data from fluid inclusions, and a 3-page summary of inclusion studies (p. 166-168). Unfortunately the data on ore metal concentrations found (by neutron activation) in inclusions by Czamanske, Roedder, and Burns (1963) are misquoted in the author's table 6-6. Since the Greek "mμ" was omitted from in front of the symbol "g" for gram, all concentrations given there are one million times too high! (ER).

STRÜBEL, Günter, 1968, Experimental studies of synthetic hydrothermal solutions at 600°C and 2000 bars: Geol. Rundschau, v. 58, p. 259-273 (in German with English and Russian summaries).

An extensive study of the solubilities of CaF_2, $BaSO_4$, $SrSO_4$, and $PbSO_4$, with and without added NaCl (ER).

STUPAKOV, G.P., and ANUFRIYEV, Yu.N., 1971, Genesis of crystal quartz at Kochkar gold deposit: Akad. Nauk SSSR, Izvestiya, Ser. Geol., 1971, no. 6, p. 79-87 (in Russian; translated in Internat. Geol. Review, v. 14, no. 6, p. 559-565, 1972).

The crystal-filled pocket described here resembles the metamorphogenic Uralian type of such accumulations. Comprehensive analysis of this crystal quartz, vein quartz, and others, including the absolute age of the paragenesis, liquid-vapor ratios determined using the method of Vertushkov, et al., (1969), decrepigrams, three analyses of water extracts for K, Na, Mg, Ca, Li, NH_4^- (sic.), Cl, F, SO_4, HCO_3, and SiO_2, and mineralogical studies do not sustain the once assumed genetic connection of ores with the Late Hercynian microcline granites. (Authors' abstract, extended).

SWITZER, George, MELSON, William G., and THOMPSON, Geoffrey, 1972, Olivine crystals from the floor of the Mid-Atlantic Ridge near 22°N latitude: Smithsonian Contrib. to the Earth Science, no. 9, Mineral Science Investigations, 1969-1971, p. 43-46

Some excellent scanning electron micrographs show development of inclusions on various faces of olivine phenocrysts. (E.R.)

TAKENOUCHI, S., 1972, Glass inclusions in quartz of volcanic rocks from mining areas (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 10, Geochemistry, p. 325 (In English). Author at Department Mineral Develop. Eng., Univ. of Tokyo, Tokyo-113, Japan

Microscopic observations, heating experiments and chemical analyses of glass inclusions in quartz of acidic volcanic rocks from several mining areas were carried out to investigate the relation between the mineralization and the igneous activity. Glass inclusions in quartz are classified into 4 types, e.g. inclusions of (1) glass (monophase), (2) glass + bubble, (3) glass + bubble + microcrystals, and (4) devitrified glass + bubble. The homogenization temperatures of glass inclusions that were determined by the heating stage and by the microscopic observation of inclusions quenched from high temperatures varied from 900° to 1,300°C. Clusters of acicular crystals grew in some glass inclusions when they were kept at 700° ∿ 800°C for 24 hours. Chemical analysis of major elements in glass inclusions were made by an electron probe microanalysis. The compositions are generally rich in silica and alumina. Quantitative analysis of metals in some inclusions by LASER probe microanalysis recognized the presence of Ag, Zn, and Mn. The various states of glass inclusions would reflect the thermal history of host minerals in cooling. Transparent monophase and bubble-bearing glass inclusions indicate relatively rapid cooling from the temperatures at which the glass inclusions were trapped. Microcrystal-bearing glass inclusions would suggest their slow cooling and retention of high temperatures for a certain period. (Author's abstract). (A similar but shorter abstract will be found in the 24th Internat. Geol. Cong., Abstracts, p. 545, 1972)

THACKRAY, MALCOLM, 1970, Melting point intervals of sulfur allotropes: Jour. of Chem. & Eng. Data, v. 15, no. 4, p. 495-497. (Author at Australian Atomic Research Establishment, Lucas Heights, New South Wales, Australia, 2232)

The intervals between the melting points of the four allotropes of cyclooctasulfur (designated α, β, γ, and δ) were measured by a microtechnique in sealed capillaries. New melting point values resulting from this work were β 120.14°, α 115.11°, γ 108.60°, and δ 106.0°C, all appreciably higher than currently accepted values. (Author's abstract)

THURM, R.E., 1972, The Lake-Manyara-emeralds of Tanzania: J. Gemmol., v. 13, no. 3, p. 98-99.

These emeralds contain "three-phase inclusions" (liquid, vapor, and a cubic or rectangular crystal). (ER).

TOLSTIKHIN, I.N., MAMYRIN, B.A., KHABARIN, L.V., 1972, Anomalous helium isotopic composition in some xenoliths: Geokhimiya, 1972, no. 5, p. 629-631 (in Russian; translated in Geochem. Internat. v. 9, no. 3, p. 407-410, 1972). Authors at Institute of Precambrian Geology and Geochronology, Academy of Sciences USSR, Leningrad.

The isotopic composition of He in xenoliths from Kamchatka and from Antarctica is reported. The He^3/He^4 ratio is higher than in natural gases or granites, implying that primordial He is present in the lower crust and/or mantle.

TOURET, J. and POTY, B., 1972, Origin of CO_2 rich fluids in metamorphic rocks (Abst.): Fortschr. Mineral., v. 50, no. 1, p. 110 (in English).

Quartz crystals of medium and high grade metamorphic rocks contain very often CO_2 rich fluids which become predominant in granulite facies. Two regional distributions of this CO_2 have been investigated, mostly by microthermometrical techniques (freezing and heating stage).

1) In the Alps, fluids related to the metamorphism of sediments usually contain CO_2. It melts under the freezing stage at -57°C which is the triple point of the pure component system.

2) In granulite facies rocks from Southern Norway and other Pre-

cambrian domains so far investigated (Grenville, Greenland, Madagascar, Brazil, India, etc.) the fluid phase in fluid inclusions is almost devoid of water and made of a CO_2 rich fluid phase of high density which melts between -75 and -57°C. This phase is consequently not pure CO_2, but a mixture which has been qualitatively analyzed. CH_4 and other hydrocarbons are the main fellow components of CO_2. This duality of composition is discussed and several possible origins are presented for the fluid phase in granulite facies rocks. (Authors' abstract).

TREIVUS, E.B., 1970, Formation of solution inclusions in crystals growing by free convection: Kristallografiya, v. 5, p. 1087-1089, (in Russian; translated in Soviet Physics-Crystallography, v. 15, no. 5, 1971, p. 950-951). Author at Leningrad State Univ.

An experimental and theoretical study of growing KNO_3 crystals. Inclusions form after a face reaches a certain critical size and becomes instable, yielding nonuniform growth. T attempts to use the experiments to obtain data on the numerical values for parameters in the appropriate diffusion equations. (ER)

TRUFANOV, V.N., 1972, Thermodynamics of post-magmatic processes of mineral formation of northern Caucasus: in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 107-115. (In Russian) CA 78 (12) 149672p (1973).

The decrepitation anal. (thermosonic and thermovacuum methods), electron microscopy, and homogenization under pressure were used to study the hydrothermal temps. and pressures at which the following ore types were formed in northern Caucasus: (1) rare metals in skarns (2) copper pyrites, (3) complex ores, and (4) Sb-Hg ores. The max. and the min. temps. of the ore-forming processes were 650° and 60° resp. Each ore type was formed in a relatively narrow temp. and pressure ranges (ore type, temp., pressure given): 1, 570-120°, 700-150 atm; 2, 320-120°, 300-150 atm; 3, 280-100°, 600-250 atm; 4, 170-50°, 200-50 atm. The inclusions of minerals contained gases, liqs., and solids (including colloids and bituminous materials). In some instances 2 homogenization temps. were obsd.; the inclusion contents homogenized, sepd. into 2 phases, and homogenized again when the temp. was increased. This was esp. characteristic of inclusion from the tele-thermal minerals.

TUGARINOV, A.I., and NAUMOV, V.B., 1972, Physico-chemical parameters of hydrothermal mineral formation: Geokhimiya, 1972, no. 3, p. 259-265 (in Russian with English abstract). (Authors at V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Moscow)

The analysis of more than 3000 determinations obtained on gaseous-liquid inclusions in minerals of almost 1000 deposits of the world bears witness of the wide temperature range of hydrothermal mineral formation - from less than 50°C to 800-850°C, although for many minerals a relatively narrow range of most favourable formation temperatures exists. Hydrothermal fluids - prevailingly liquid ones of sufficiently high density (usually 0.7-1.0 g/cm^3) are under high pressure - from a few hundreds to 1500-2000 and more bars, which often considerably exceeds the magnitude not only of hydrostatic, but even of lithostatic pressures. An extremely typical component of hydrothermal solutions is carbon dioxide, the concentration of which in a number of cases is by 2-3 orders greater than in mineral waters of the "narzan" type. (Authors' abstract)

ULRICH, William, 1971, Rock crystal inclusions of Herkimer County, New

York: Rocks and Minerals, v. 46, no. 9, p. 507-509.
A review.

VAKHRUSHEV, V.A., 1969, Petrographic indications of parting of magmatic melt into silicate and sulfide fractions: Akad. Nauk SSSR, Geolog. Rudnykh. Mestor., 1969, no. 1, p. 15-26 (In Russian; translated in Intern. Geol. Review, v. 13, no. 4, p. 453-462, 1971; abstract on p. i). Author at IGiG-SO-AN-SSSR, Novosibirsk.

Many examples of globular inclusions of sulfides in silicate minerals are shown and indicated to stem from separation of an immiscible sulfide melt. (ER)

VAKHRUSHEV, V.A. and PROKOPTSEV, N.G., 1969, Primary magmatic formations in basalts from oceanic crust and inclusions of ultrabasic rocks in basalts: Akad. Nauk SSSR, Geol. Rudnykh Mestor., 1969, no. 6, p. 14-26 (in Russian; translated in Intern. Geol. Review, v. 14, no. 2, p. 125-135; abstract on p.i). First author at IGiG, SO AN SSSR, Novosibirsk.

The results presented here were obtained by mineragraphic studies of primary magmatic sulfides in basalts collected from the Indian and Pacific Ocean floors by dragging and from modern flows of lava in the Hawaiian Islands, as well as from inclusions in ultrabasic rocks. Distribution specificities of the sulfides were ascertained in the inclusions, indicative of the original disequilibria between constituents of the inclusions and the basaltic melts. The meaning of these data is discussed in reference to nature of inclusions of ultrabasic rocks in basalts and also to certain problems of the magmatogenic formation of ores. (Authors' abstract).

VEITCH, J.D., & McLEROY, D.F., 1972, Organic mobilization of ore metals in low temperature carbonate environments: Geol. Soc. Amer. Abstracts with Programs, v. 4, no. 7, p. 110-111. Authors at Department of Geological Sciences, Lehigh University, Bethlehem, Pennsylvania 18015.

Experiments show that naturally-occurring amino acids in solid-$CaCO_3$-H_2O and solid-$CaCO_3$ - $S^=$ - H_2O systems greatly increase the aqueous-phase concentration of Cu, Zn, Pb, and Cd. Such amino acids have been found in most low-temperature natural environments and form stable, soluble chelates with many metals which occur as concentrations in these environments.

Cu in the aqueous phase, which remained below 1 ppm in organic-free systems, increased at a 1:1 ratio with increasing amino acid content until 70% of the Cu was in the aqueous phase throughout the 0 to 126 ppm Cu range evaluated. Inclusion of $S^=$ reduced the Cu level of the aqueous phase in proportion to the $S^=$ content. At 50 ppm $S^=$ the Cu level was reduced by 50%. Zn showed similar results except that the aqueous-phase Zn:amino acid ratio was about 10:1. Pb and Cd showed similar correlations but at much smaller absolute levels. Changes in pH between 6.5 and 8.0, NaCl contents of 0 to 10%, and the temperature from 25°C to 100°C had no significant effect. In percolation tests of solutions containing 50 ppm of Cu and Zn through $CaCO_3$ - FeS beds, the addition of 800 ppm of amino acids reduced Cu loss from 80% to 0 and Zn loss from 40% to 10%.

The experimental results suggest that the mobilization and fractionation of these metals in $S^=$ -bearing carbonate environments may be significantly influenced by the presence of organic materials. (Authors' abstract)

VOLOSOV, A.G., KHODAKOVSKIY, I.L., and RYZHENKO, B.N., 1972, Equilibria in the system SiO_2 - H_2O at elevated temperatures along the lower three-phase curve: Geokhimiya, 1972, no. 5, p. 575-591 (in Russian; translated in Geochem. Internat. v. 9, no. 3, p. 362-377, 1972). Authors at Department of Geochemistry, Moscow State University, Moscow, and V.I. Vernadskiy Institute of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR.

A critical review is presented of the published experimental material on the solubility and modes of occurrence of silica in aqueous solutions. Equations of the temperature dependence of solubility of quartz, dissociation and polymerization constants of orthosilicic acid are derived, and the thermodynamic properties of substances formed in the system $SiO_2 - H_2O$ are calculated. (Authors' abstract)

VOLYNETS, V.F., and SUSHCHEVSKAYA, T.I., 1972, Nitrogen in the hydrothermal process (ammonium in inclusion solutions): Geokhimiya, 1972, no. 1, p. 58-63 (in Russian with English abstract). Translated in Geochem. Internat., v. 9, no. 1, p. 42-46. (Authors at V.I. Vernadsky Institute of Geochemistry and Analytical Chemistry, USSR Academy of Sciences, Moscow)

A systematic investigation of the content of chemically bound nitrogen (NH_4+) in solutions of inclusions, in samples of quartz and fluorite from different hydrothermal ore deposits has been carried out. It has been established that ammonium concentration in hydrothermal solutions makes up 10^{-2} mol/l and is by 1-2 orders lower than the Na and K content. (Authors' abstract)

VOSKRESENSKII, S.S., KOLOSOVA, G.N., and NAUMOV, V.B., 1972, Thermobaric formation characteristics of vein quartz in the basin of the upper reaches of the Kolyma River and the denudational section: Izv. Vyssh. Ucheb. Zaved., Geol. Razved. 1972, v. 15, no. 10, p. 42-45 (in Russian). CA 78 (5) 60657q (1973). (Authors at Mosk. Gos. Univ. im. Lomonosova, Moscow, USSR)

The temp.-pressure conditions of vein quartz formation in the area of the Kolyma River upper flow were detd. from the homogenization temp. of liq. inclusions and the decrepitation temp. of minerals contg. inclusions. The silky white massive quartz in veins cutting granodiorite dikes was formed at 275-290°, at a calcd. pressure of 1100 ± 1010 atm (sic). The quartz veins cutting sedimentary complexes were formed at 270-280° under ∿2000 atm pressure. The av. denudation rate, caused by neotectonic movement, was evaluated as 0.016-0.036 mm/year, from the av. values of denudation of the section (300-400 m) during activation lasting 12-18 million yr. At the present time, the av. rate of denudation calcd. from solid discharge of the Kolyma River is 0.22 mm/year.

VOYTOV, G.I., SHIROKOVA, I.Ya., DINISENKO, V.Ye., KATSONIS, A.N. and SPEKTOR, T.L., 1972, Gas composition in quartz veins of the Krivoy Rog amphibolites series: Akad. Nauk SSSR, Doklady, v. 207, no. 6, p. 1449-1452. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 207, 1972, p. 233-236). Authors at All-Union Research Institute of Nuclear Geophysics and Geochemistry, Moscow.

Chemical analyses (Tables 1, 2), distribution curves of gaseous hydrocarbons and H_2 in the quartz and amphibolites (Fig. 1), quartz structures and positions of gas-liquid inclusions therein (Fig. 2), and permeability histograms (Fig. 3) demonstrate: a) enrichment of the volatiles in the quartz veins; b) chemical reactions, in gaseous phase, as factors in the distrubution of H_2, CH_4, heavier hydrocarbons, depending on composition of the exocontacts, mobilities of the constituents, heterogeneities in the media, flow of the heat, and other variables; c) the function of the quartz veins, as migration paths of the gases, during late tectonic movements, because the veins prove to be more permeable than the amphiboles. (Authors' abstract, translated in Internat. Geol. Review, v. 15, no. 7, 1973, p. 866).

WELLMAN, T.R., 1970, Fugacities and activity coefficients of NaCl in NaCl-H_2O fluids at elevated temperatures and pressures: Amer. Jour. Sci., v. 269, p. 402-413. Author at Department of Geology and Geophysics, Yale University, New Haven, Connecticut 06520.

Experimental data for coexisting synthetic nepheline, sodalite, and aqueous fluid have been used to calculate the fugacities and activity coefficients of NaCl in aqueous fluid as a function of temperature, pressure, and NaCl mole fraction in the range 500° to 700°C and 600 to 2000 bars fluid pressure. (Author's abstract)

WENNER, D.B., and TAYLOR, H.P., 1972, D/H and O^{18}/O^{16} data on the origin of the H_2O and the temperature involved in serpentinization of ultramafic rocks (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 2, Petrology, p. 58 (In English) Authors at Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91109, U.S.A.

Examination of the D/H and O^{18}/O^{16} ratios of minerals in a large number of alpine serpentinites from the eugeosynclinal terranes of North America and the Caribbean area reveal that the D/H ratios of most lizardite-chrysotile serpentines exhibit a good correlation with the geographic pattern shown by the D/H ratios of present-day meteoric waters; their O^{18}/O^{16} ratios show a similar but less well-defined correlation. In contrast, the antigorite serpentines, talcs and actinolites show no such isotopic correlation whatsoever, exhibiting uniform δD and δO^{18} values of -40 to -75 per mil and +6.0 to +9.2 per mil, respectively (SMOW scale). These values are similar to those found in chlorites from regionally metamorphosed schits. The O^{18}/O^{16} fractionations (Δ-values) between coexisting serpentine and magnetite in a few representative samples indicate that Δ-values in the lizardite-chrysotiles are a great deal larger (15.1 to 12.9) than in the antigorites (8.6 to 4.8). These Δ-values, together with an empirically determined serpentine-magnetite O^{18} geothermometer curve, suggest approximate equilibrium temperatures of about 85° to 115°C for the formation of lizardite-chrysotiles and around 220° to 460°C for antigorites. All of the isotope data are thus consistent with the concept that a large fraction of the lizardite-chrysotile-type serpentinization in these terranes occurred in the presence of heated meteoric ground waters and/or saline formation waters at relatively low temperatures and shallow depths ($P < 4$ kb). The antigorites apparently formed at considerably higher temperatures and pressures in the presence of deep-seated (metamorphic?) waters. Except for certain "deweylite" serpentines which have $\delta O^{18} = +12$ to $+15$, the isotope data are, however, totally incompatible with the idea that serpentinization is a surface or near-surface weathering process. All of the above-described continental and island-arc serpentines are isotopically clearly distinct from the serpentines dredged from the midocean ridges; the latter have $\delta D = -31$ to -68 and $\delta O^{18} = +0.8$ to $+6.7$, suggesting that the aqueous fluids responsible for submarine serpentinization are dominantly heated ocean waters. (Authors' abstract).

WICKMAN, F.E., & KHATTAB, K.M., 1972, Non-destructive activation analysis of fluid inclusions in fluorite: Econ. Geol. v. 67, p. 236-239.

The Na/Cl, Na/Br and Cl/Br ratios in some fluorites (sample weight 20-30 mg) have been studied by non-destructive activation analysis. Some experiments are described which show that the analyses refer to the liquid inclusions.

One specimen studied in detail showed a Na/Cl ratio corresponding to a NaCl solution. Its Cl/Br weight ratio of 63 contrasts to the ratios of sea water as well as most surface and subsurface waters, but is similar to some brines. Some possible explanations are mentioned. The method seems useful in the study of liquid inclusions, especially since it can be used for several other elements and other minerals. (Authors' abstract)

WILCOX, W.R., 1972a, Crystallization flow: Journ. of Crystal Growth v. 12, p. 93-96. Author at Chemical Engineering and Materials Science Departments, University of Southern California, Los Angeles, California 90007.

If one regards the crystal surface as stationary, then crystal growth generates a flow through the crystal-fluid interface. The flow velocity in the crystal is V_C, the physically measureable growth rate. The corresponding velocity in the fluid at the interface is called here the crystallization flow, which is <u>not</u> equal to the crystal growth rate. The exact relationship between growth rate and crystallization flow depends on whether the diffusion flux is referred to the mass average velocity, the mole average velocity, or the volume average velocity. Application of the results to growth rate, segregation , and constitutional supercooling calculations are discussed. With the proper relationships for crystallization flow these calculations are valid for crystal growth from solutions and vapors as well as from high purity melts. (Author's abstract)

WILCOX, W.R., 1972b, Movement of liquid inclusions by centrifugation: Journal of Crystal Growth v. 13/14, p. 787-789. Author at Chemical Engineering and Materials Sciences Departments, University of Southern California, Los Angeles, California 90007, U.S.A.

A theory is developed for movement of solvent inclusions in crystals by a centrifugal field. It is necessary to account for the electric field generated by the differential migration rates of the different ions. The theory predicts a centripetal movement rate which increases as the solubility increases, which usually means as the operating temperature increases. Experimentally, the rate of movement of aqueous inclusions in potassium iodide decreases with increasing temperature and becomes centrifugal above about 30°C. The origin of this discrepancy between experiment and theory is presently unknown. (Author's abstract)

WILCOX, W.R., & SHLICHTA, P.J., 1972, A survey of movies on crystal growth: Journal of Crystal Growth v. 15, p. 61-72. Authors at School of Engineering, University of Southern California, Los Angeles, California 90007.

Movies provide a uniquely accurate and complete means of recording and communicating crystal growth research data. Unfortunately, there is at present no means of including such movies in the scientific literature or of making their existence known to the scientific community as a whole. The present survey describes 78 movies, most of which contain original observations of crystal growth phenomenology. In addition, recommendations are made for improving the effectiveness of such movies and for publishing abstracts of future movies or of those inadvertantly omitted from the present survey. (Authors' abstract)

WINKLER, E.M., 1972, Strength and fire resistance of granites and quartz sandstones in the light of the P-V-T diagram of quartz (abst); Geol. Soc. America Abstracts with Programs, v. 4, no. 7, p. 708. Author at Department of Geology, University of Notre Dame, Notre Dame, Indiana 46556.

Fire resistance and uniaxial compressive strength of fresh granitic rocks is about 25% less than of quartz-free igneous rocks despite 25,000 kg/cm^2 compressive strength for pure quartz. The rapid drop of strength of Missouri granites after exposure to high temperatures up to 1000°C was already known to Tarr in 1915. The spalling and collapse of sandstone columns in conflagrations is ascribed to the anomalous behavior of quartz to high temperatures which is readily explained with the P-V-T diagram. The contraction of quartz and associated minerals in granites during cooling from the melt is determined by the loss of temperature from near 950° to ambient, and pressure loss from about 3500 atm to 1 atm as the overburden disappears with time. The total volume loss of quartz is 4.83%, but is 1.35% crossing from high-quartz to low-quartz. The conversion point lies near 700°C at 3500 atm, 573°C at 1 atm. The rate of contraction diminished with continued cooling. The internal stresses are enhanced by only 2% maximum contraction of mineral components other than quartz. Thus, a ready explanation is found for micro-cracking and micro-porosity in granitic rocks.

Heating of granites and other quartzose rocks can exert 1000 to 1500 atm as tensile strength leading to disruption, even at temperatures well below 500°C (Author's abstract). (Of possible pertinence to the formation of chamber pegmatites and the "reticulate" quartz of pegmatites. Ed.)

YAKOVLEVA, M.E. and POTAPOVA, L.I., 1972, Inclusions of bituminous matter in obsidian: Mineralog. Muzeya Fersmana Trudy, v. 21, p. 205-209. (In Russian).

YPMA, P.J.M., 1972, The multi-stage emplacement of the Ni-Co-Bi-Ag deposits of the Chalanches, France - remobilization, rejuvenation or repetition (abst.): Internat. Geol. Cong., 24th, Abstracts, Section 4, Mineral Deposits, p. 157-158 (in English). Author at Dept. Econ. Geol., Univ. Adelaide.

The base metal Ni-Co-Ag-Bi ores of Chalances have been formed in at least two major hydrothermal stages. The early Fe carbonate-Pb-Zn-Ag deposits are of pre-Triassic age and are part of a widespread siderite-base metal mineralization in the Belledonne. The Ni-Co-Ag-Bi minerals are of late Mesozoic age and present a special facies of the more common carbonate (inner zone) and siderite-quartz (outer zone) veins throughout the Belledonne. Their occurrence together in a vein system results from reactivation of the same wrench fault system and concomittant tension fractures in late-Hercynian and Alpine orogenies. The mineral-rich ore shoots at Chalanches are controlled by intersections of the late Mesozoic veins with pyrite-pyrrhotite-chalcopyrite fahlbands. The Alpine carbonate veins have been formed from solutions of intermediate temperature (250° - 300°C), intermediate (5-10 wt. % NaCl) to occasionally high (close to Chalanches 20% NaCl) salinity, low sulfur fugacity (log $fS_2 = 10^{-13}$) and varying CO_2 pressure (up to 300 bars, depending upon salinity). Both the Hercynian and Alpine mineralization took place well after consolidation and erosion of the Belledone central granites. The source of the metals should be sought in the country rock, as is suggested by lead isotopes, sulfur isotopes (equal for both cycles), and a very systematic district- and country rock-controlled variation in siderite composition. The geological conditions of deposition have been very similar for both the old and young mineralization; namely, close to the interface of the crystalline massif and its sedimentary cover (measuring in the case of the young mineralization at least 4000 m thick). Similarities between Chalanches and Freiberg, E. German, are striking: both have the same paragenesis, age and identical ore control of the Ni-Co-Ag-Bi veins by earlier sulfides.

The absence of contemporaneous magmatic events is significant. However, the model of remobilization of pre-existing mineral deposits has been rejected and substituted for by one of multiple injection of hydrothermal fluids generating their own heavy metal content by interaction with country rock. In the case of Freiberg, the long time period (over 100 m.y.) in which hydrothermal activity took place is considered to be significant in explaining both the multitude, and the inversions, of mineral parageneses. (Authors' abstract).

ZAKHARCHENKO, A.I., 1972, Phase state and composition of sequentially evolved magmatogenic fluids associated with granite, and their role in mineral-and ore-formation (on the basis of studies of solidified and gas-liquid inclusions): in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 45-66 (in Russian): CA78(12)14976y(1973).

The compn. and the phys. state of granitic rock inclusions were correlated with their texture, lithol. characteristics, and paragenesis. The flow of magmatic fluids from the high pressure to the low pressure zones caused the sepn. of gas bubbles. The size and compn. of these bubbles provides information on the age and the paragenetic history of the rocks. Many examples, taken from the literature, are cited.

ZAKRZHEVSKAYA, N.G., 1972a, Classification of inclusions of mineral-forming media in magmatic rocks of the Khibina apatite deposits: in The Ore-Forming Environment Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 192-198. (In Russian)

ZAKRZHEVSKAYA, N.G., 1972b, Inclusions of the mineral-forming medium in foyaite of the Khibiny pluton: Akad. Nauk SSSR, Doklady, v. 202, no. 4, pp. 919-922. (In Russian; translation of text in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 202, 1972, pp. 136-139). Author at S. Ordzhonikidze Geological Prospecting Research Institute, Moscow.

Gaseous and liquid hydrocarbons are identified in certain primary inclusions in nepheline of the rocks, alongside other types of inclusions: solid (poikilitic ingrowths of aegirine, others), gas, gas-liquid, liquid. The combined (compositionally heterogenous; xenogenic solid phase common; gas up to 10% by volume) and the solidified type are more abundant than the others. Gas and liquid inclusions are characteristically missing in cancrinite, but the poikilitic ingrowths are still there, inherited from nepheline as they are. The evidence as a whole indicates a magmatic origin of the hydrocarbons. (Author's abstract, translated in Internat. Geol. Review, v. 14, no. 7, 1972, p. 781).

ZATSIKHA, B.V., 1972, Post-magmatic mineralization of granite of Kamennykh Mogila (near-Azov): in The Ore-Forming Environment as Determined from Inclusions in Minerals, V.I. Smirnov, ed.: Moscow, "Nauka" Press, p. 178-184 (in Russian): CA78(10) 126795s(1973).

The postmagmatic mineralization of the granites proceeded in 5 stages: (1) microclinization at 500-600°, (2) albitization at 430°, (3) greisenization at 320-430°, (4) late albitization at 200-420°, and (5) heterogenization of solns involving the crystn. of xenotime, colorless quartz, and fluorite at 200° and 650 atm. The 1st and 2nd stages (high-temp. alk. metasomatism) produced microcline, biotite II, albite II, muscovite, and also tantalite-columbite (accessory mineral). The 3rd stage gave quartz, fluorite, pyrite, and probably molybdenite. Albite III, muscovite III, and quartz constitute the 4th stage. The 5th stage gave, besides the above-mentioned minerals, calcite, parisite and bastnaesite. The foregoing postmagmatic mineralization sequence is based on the anal. and decrepitation studies of gas-liq. inclusions in minerals as well as the petrochem. data from Kamennye Mogily massif.

ZATSIKHA, B.V., TARASKO, V.I., ZHILENKO, L.A., and NOVIKO, E.S., 1972, Genesis and geochemical characteristics of mercury mineralization in the southern part of the Donets Basin: Geol. Zh. (Russ. Ed.). v. 32, no. 2. p. 102-109.

Includes 8 chemical analyses of water extracts for Na, K, Ca, Cl, SO_4, HCO_3, BO_3, F, & pH, and homogenization temperatures. (ER).

ZHIROV, K.K., KRAVSHENKO, E.V., KRAVCHENKO, M.P. and RYUNGENEN, G.I., 1972, Geochemistry of the gaseous component in the sulfide mineralization process: Geokhimiya, 1972 no. 4, p. 447-459 (in Russian; translated in Geochem. Internat. v. 9, no. 2, p. 302, 1972).

Fourteen analyses for helium and argon from sulfides from Moncha Tundra and Pechenga (Kola peninsula), Sudbury, Talnakh, Broken Hill, and Pyshma (Urals) show 4 to 80 ppb He and 2 to 350 ppb Ar. The weight He/Ar ratio varies from 0.5 to 4 with a single exception of 106. Analyses for uranium and potassium prove that the great bulk of the gases are primary constituents of the ores. Nitrogen was also detected qualitatively in the same materials.

ZIMMERMANN, J.L., 1972a, Petrogenetic application of the study of water and carbon dioxide release from cordierites: C.R. Acad. Sci., Ser. D 1972, v. 275, no. 4, p. 519-522 (in French). (Author at Cent. Rech. Petrogr. Goechim., CNRS, Vandoeuvre-les-Nancy, Fr.)

Water and CO_2 were obtained by heating to 450° (inclusions) and 1200°C (total). (ER)

ZIMMERMANN, J.L., 1972b, Water and gases in the principal families of silicates. Contribution to the study of their distribution. Application to geochronological and petrogenetic problems: Sci. de la Terre, Mem. no. 22, 188 pp., 64 figs., 58 tables (in French with English, German, and Russian abstracts) (PhD dissertation, Univ. of Nancy, 1972).

The aim of this work is to study the relationships which exist between water, gases and the silicate structures in view of their application to geochronological and petrogenetic problems.

The relationships existing between the minerals and gases are studied in the light of our present knowledge in physical-chemistry and geology.

The gases are extracted by vacuum heating; after a selective separation, the gases are analysed with a mass spectrometer. The author shows their nature and positions in the structures, he shows also that their liberation depends on that of water and of the dilatation of the lattice. Using Horowitz and Metzger's method and its variation by Piloyan and Novikov, he calculates the activation energies of dehydration. As far as the argon contained in potassic minerals is concerned, the results obtained permit not only to distinguish atmospheric argon, adsorbed or inherited but also to locate the radiogenic argon and to evaluate its diffusion characteristics. As a practical consequence, it has lead to a better way of extracting and analysing the gas.

The last part is devoted to petrogenetic problems and the author undertakes the analysis of fluids of crystallization or of evolution. For three examples studied - fluids from the clefts in Mont-Banc Massif, fluids in quartz from tin-wolfram deposits of Montbelleux and Villeray (Illeet-Vilaine, France), fluids in cordierites at the boundary amphibolite facies-granulite facies in the province of Bamble (Southern Norway) - the results are complementary to more important geological and petrographical works carried out by other investigators in the Earth Sciences Division at Nancy. (Authors' abstract).

ZOOK, T.F., 1972, Usual and unusual inclusions in a peridot specimen: Jour. Gemmology, v. 13, no. 4, p. 133-138.

Melt inclusions and presumed daughter crystals are described. (ER)

ZSHUZE, N.G., 1969, On the question of types of bitumens in carbonate rocks: Sovets. Geol., 1969, no. 1, p. 73-86. (in Russian).

Includes numerous analyses for various fractions. (ER).

ZUBKOV, V.A., BRYZGALOVA, G.S., DEMIN, Yu.I. and DOROGOVIN, B.A., 1972, Genesis of magmatic rocks of the Leninogorsk district, Rudnyy Altai, as shown by their mineral inclusions: Akad. Nauk SSSR, Doklady, v. 207, no. 6, p. 1427-1429. (In Russian; translation of text in Doklady Acad. Aci. USSR, Earth Sci. Sect., v. 207, 1972, p. 163-165). Authors at M.V. Lomonosov State University, Moscow.

Significant differences in crystallization temperatures of the heterochronous granitic massifs are indicated by homogenization temperatures of the inclusions in the rock-forming minerals. Volatiles were definitely present in granitic magma at the time of the crystallization, in quantities sufficient to lower the crystallization temperature from 1000°-780°C (the Zmeyinogorsk intrusive complex) to 650°-720°C (the Permian intrusive complex). (Authors' abstract, translated in Internat. Geol. Review, v. 15, no. 7, 1972, p. 865).

TRANSLATIONS SECTION

The three items presented here were selected on the basis of 1) availability of translation, 2) significance to inclusion research, and 3) lack of publication elsewhere. Photographs do not reproduce well and are not included, but the photo caption translations are given; the interested reader can examine the photographs in the original publications.

ERMAKOV, N.P., 1972b, Geochemical systems of inclusions in minerals: Moscow, Izdatelstvo 'Nedra', 375 pp. (including 27 plates). (In Russian) 3000 copies printed, price R-3.86. Translation by M. Fleischer.

CONTENTS

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Section I

Elements of methodology and significance of media in the knowledge of endogenic mineral formation.

Section II

Classification of Inclusions and the Genetic Information contained in them.

Section III

Captions to plates

(Ed.'s note: The following is a translation, by Dr. Dorothy Vitaliano, of the captions of the 27 full page composite plates in the book. The plates include some exceptionally fine photomicrographs, and although they should, of course, accompany a translation of the full 340-page text, the captions were all that could be obtained. A few of the items in the captions are obscure (marked sic). The English sequence abcdef is used for the Russian sequence абвгде in the individual photo designations on the plates.)

PLATE I.* Heteroorganic compounds of abiogenic synthesis in inclusions in eudialytes in alkalic intrusive rocks of the Khibiny massif (according to S. V. Ikorskiy) and petroleum and gas extracts (according to Yu. F. Levitskiy).

a - Crystals of grayish bituminous matter on the walls of inclusions in transmitted light (left) and under crossed nicols (right). x440.

b - Gaseous inclusion of synthetic hydrocarbons; right -- luminescence in ultra-violet rays. x980.

c - Inclusions with liquid bitumen in hydrothermal fluorite.

PLATE II. Amorphous inclusions of melt in the phenocrysts of rapidly cooled volcanic and intrusive rocks.

a - Negative-crystal inclusion of glass in a quartz phenocryst from the Georgian S.S.R. x380.

b - Inclusion of glass in orthoclase from North Caucasus granites, partially crystallized on the periphery. x300.

c - Glass inclusion with gas bubble and sulfide crystal in olivine from the Noril'sk ore-bearing gabbro-dolerites. x1800.

d - Inclusions of glass in plagioclase from Armenian basalts. x200.

PLATE III. Crystalline inclusions in minerals of alkalic, mafic, and silicic intrusives.

a - Solidified inclusion of alkalic melt in the nepheline of Khibiny urtites. Gas bubble at top; a number of anisotropic (and ore) mineral crystalline phases in the low-index isotropic mass. x880.

b - Solidified inclusion in nepheline pegmatites in Khibiny rischorrites. A euhedral parallelipeped of villiaumite, aegirine crystals, and a deformed gas bubble in an isotropic substance. x500.

c - Crystalline inclusion of mafic melt in olivine I of the Noril'sk ore-bearing gabbro-dolerites. At left, olivine (light) with interstitial segregations of gases; at right, sulfides (black), plagioclase, and pyroxene. x1800.

d - Completely crystalline polymineralic inclusion of a melt of ordinary granitic magma in quartz from granite porphyries. + nicols. x1200.

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*Twenty-two of the 27 plates of photomicrographs illustrating the various chapters of the book consist of photomicrographs of inclusions taken by the author and F. P. Mel'nikov in the Microthermobarometric Laboratory of the Department of Economic Geology of Moscow University, of materials collected personally.
Five photomicrographs of inclusions in calcite by N. I. Andrusenko, 3 in topaz by I. V. Banshchikova, 4 in magmatic rocks by A. V. Gromov, and 6 photomicrographs of inclusions in quartz and topaz by Yu. A. Dolgov were used.
Several individual photomicrographs by V. B. Anikin, D. K. Vosnyak, B. V. Zatshikha, S. V. Ikorskiy, V. A. Kalyuzhniy, A. Ye. Lisitsyn, M. M. Slivko, and others were also included in various plates.

e - Crystalline inclusion of ultrasilicic magma in quartz from the Kent granites (subsidiary intrusion of marginal type). In the vacuole, which is filled mainly with quartz, plagioclase, a large gas bubble, and an ore mineral (?) have separated. Plain light, x1800.

PLATE IV. Crystalline-fluid inclusions of melts-mother liquors (a and b) in topaz from Volyn pegmatites and in quartz from Central Kazakhstan pegmatites (c, d, e).

a - Segregation of fluid part into two flattened gas bubbles, in equilibrium with the solid phases and with the condensate of the fluid mother liquor. x500.

b - Doubly - terminated quartz growing out of a drop of silicic melt-mother liquor is observed in an inclusion in topaz, as indicated by the absence of the tip of the termination leaning against the wall of the vacuole (lower right).

c - Vacuole of an inclusion crowded with daughter minerals of haloids, silicates, and ore-minerals. The large crystal of cubic habit on the left is halite, down below it sylvite. Separation of the liquids during crystallization caused the formation of large-scale segregation of gas and fluid in the interstices. x1200.

d - The amount of liquid condensate in a dipyramidal inclusion is high compared to the inclusion in c. x550.

e - Negative-crystal gas-fluid inclusion, transitional to hydrothermal brine, occupying a relatively large volume in the system. x700.

PLATE V. Essentially gaseous inclusions in negative crystals from Volyn pegmatites.

a,b - Saturation of pneumatolytic quartz with inclusions of "dry" gases;. a - x35, b - x150.

c,d - Essentially gaseous two-phase equant hexagonal and rounded dihexagonal inclusions in quartz. x300.

e - Large subhedral inclusion in topaz, photographed against a background of numerous gas inclusions of the same kind, but tiny (x500).

PLATE VI. Phase diversity of gaseous inclusions in minerals from Volyn. (Subscripts unidentified)

a - Equant inclusion of dry gases. x230.

b - Flattened inclusion -- $G >>_x L$. x230.

c - Euhedral negative two-phase essentially gaseous flat inclusion $(G_x >> L)$ in quartz. x300.

d - Two-phase essentially gaseous flat inclusion in topaz -- $G >> L$. x300.

e - Flattened multiphase gas-water inclusion in topaz, of $G > L \geq$ variety [sic; probably $\geq C$]. x150.

f - Gas-water multiphase flat inclusion in topaz, of $G >> L > C$ variety. x300.

PLATE VII. Genetic diversity of gaseous inclusions.

a - Inclusions of hydrocarbon gases in nepheline urtites from the Khibiny, controlled by (1010) cleavage plane. x380.

b - Gaseous inclusion combined with crystallites of aegirine, in eudialyte from alkalic pegmatites from the Khibiny. x450.

c - Inclusion of dry gases in quartz from Volyn pegmatites, with a microdruse of associated minerals. x800.

d - Gas-water inclusion of $G \geq L > C$ variety with microdruse of daughter crystals. x860.

PLATE VIII. Syneresis phenomena in a gel film deposited on the walls of vacuoles of gaseous inclusions (aerosols) in morions from Volyn pegmatites.

a - Detail of upper part of wall of gaseous inclusion (black rim). The polygonal syneresis pattern of the gel film, conforming to the quartz host mineral substrate, is clearly discerned in its clearance(sic). x220.

b - Ditto, in another crystal, with no distinct influence of the substrate. At left, near the gas rim, a blob of silica gel. x220.

c - "Demarcation snakes" of contraction formed in cracks in the gel film upon dehydration, and a micronodular "shagreen" of this film in the polygons. x450.

d - Detail of the "shagreen" (gel film). x900.

PLATE IX. Fluid inclusions of true aqueous solutions.

a - Single-phase cold-water fluid inclusions in gypsum from the Shiretskoye deposit. x90.

b - Ditto, in halite from the Wieliczka deposit (Poland). x160.

c - Two-phase fluid inclusion with a small amount of gas (water vapor) in hot-water hydrothermal calcite from Vilyuy. x35.

d - Two-phase fluid inclusion in low-temperature fluorite from Central Kazakhstan pegmatites. x300.

e - Ditto, from rock crystal from Dagestan quartz veins. x330.

f - Ordinary two-phase fluid inclusions in medium-temperature quartz. x135.

PLATE X. Multiphase fluid inclusions of concentrated hydrothermal mineralizing solutions. (Most subscripts unidentified in caption).

a - Three-phase aqueous fluid inclusion in quartz from the Pamirs -- $L_V \geqslant (G_P + C_L)$. x300.

b - Multiphase aqueous fluid inclusion in quartz from Central Kazakhstan pegmatites, $L_V > (G_P + C_L + C_T)$. x136.

c - Multiphase inclusion of aqueous ore-bearing solution in Kent fluorite. $L_V \geqslant (G_P + C_L + C_T + C_P)$. x135. Everywhere the cubic C_L is halite.

PLATE XI. Multiphase fluid inclusions of concentrated and very concentrated hydrothermal ore-bearing brine -- L_V $(G_P + C_L + C_T + C_P)$.

a,b - In Central Kazakhstan fluorite. x135.

c - In Volyn morion. x300.

PLATE XII. Mixed and compound water-CO_2 inclusions of saline hydrothermal solutions.

a - Typical "cockscomb" inclusions in quartz from the hydrothermal veins of the South Urals. x220.

b - Ditto, from Central Kazakhstan. x300. Four-phase CO_2-water inclusions.

c - In topaz from Volyn pegmatites. x300.

d - In rock crystal from the Pamirs (daughter mineral is halite everywhere). x200.

PLATE XIII. Colloidal inclusions in chalcedony incrustations of druse filling from the Iceland spar deposits of West Siberia.

a - Inclusion of syneretic aqueous solution, the result of centripetal diffusion of silica gel separated from the surrounding spherical part, rimmed by iron hydroxide at the right (dark). In the center, a gas bubble from contraction of the fluid of the inclusion. The walls of the vacuole have a characteristic squamose pattern, like the faces. x220.

b - Same kind of spherical inclusion, around which a spherical rhythmicity is observed in the structure of the silica. The walls of the vacuole have a "бляшечный" microrelief. x220.

c - Analogous spherical inclusion of fluid with a gas bubble from contraction. Microrelief similar to "shagreen" relief on the walls of the vacuole (cf. Plate VIII, b and c). x220.

PLATE XIV. Genetic diversity of primary zonal inclusions.

a - Stepped surface of artificial fluor-phlogopite, caused by discrete growth layers overlapping zonal inclusions. x35.

b - Zonal distribution of gas-fluid inclusions on rhombohedral faces of a crystal of rock crystal. Natural size.

c,d - Clavate and discoid forms of vacuoles of inclusions found in places of spiral growth of crystals of Iceland spar. x56.

e - Corrugated sculpture of the surface of a negative rhombohedron of artificial quartz, favorable for the formation of tubular inclusions of the crystallizing solutions. x35.

f - Formation of inclusions in the case of a "serrated" front of tangential growth of a discrete microlayer in artificial fluor-phlogopite. x35.

PLATE XV. Azonal primary inclusions of solutions.

a - Large solitary fluid inclusions in Volyn morion. Natural size.

b - Formation of a three-phase fluid inclusion on top of an accessory mineral (halite) which shields a growth face in quartz (the face grew upward from below). x220.

c - Formation of obelisk-like fluid inclusion in Iceland spar from the Lower Tunguska on top of particles of foreign substances which shield the growth face of the crystal. x35.

d - Ultramicroscopic inclusion of liquid solution in daughter mineral (halite) -- an inclusion within an inclusion in quartz from the Pamirs. x550.

PLATE XVI. Pseudosecondary (primary-secondary) inclusions of solutions and melts in syngenetic microcracks.

a - Inclusions of "dry" gases healing polygonal cracks from rapid α-β transformation of quartz in the core part of crystals of Volyn morion. These inclusions are epigenetic with respect to the α-quartz honeycomb but syngenetic with respect to the zone of transparent pneumatolytic quartz (left). Divergent cracks, with fluid inclusions trapped at the time of hydrothermal formation of the late-stage zone of the morion, are seen. x2.

b - Inclusions in cracks in quartz which were healed at the very beginning of formation of the light outer zone of the crystal (left). x35.

c - Intersection of healed cracks in euhedral hydrothermal quartz from the South Urals; the diagonal (cross-cutting) crack with tubular inclusions is the younger. x120.

d - Pseudosecondary inclusions of late-stage melts in pyrogenetic plagioclase from the Noril'sk dolerites. x220.

PLATE XVII. Pseudosecondary regenerated fluid inclusions in artificial quartz (according to G. M. Sofronov) (sic).

a - Healing of a microcrack in a seed plate of natural quartz (left) by liquid solutions growing a layer of artificial quartz (right). The layers are separated by solid and fluid inclusions on the interface. x35.

b - Fluid inclusions generated in places where the seed plate (left) is leached at the intersection with the layer of growing quartz (right). x35.

c - Fusiform inclusion in an open etch channel of the seed plate. The bubble of water vapor grew after the crystal cooled and was located only in the upper part of the inclusion. x56.

d - Larger fluid inclusion beginning to form in an etch depression of the plate (from below). A family of small inclusions arose on its prolongation in the layer of growing quartz. x120.

e - Group of tubular inclusions in a healed etch pit (above) and a large inclusion at its mouth, related to a solution depression. x120.

PLATE XVIII. Secondary and pseudosecondary inclusions in healed and half-healed cracks in artificial and natural quartz.

- a - Late-stage crack emerging at the surface of an artificial crystal. The incomplete skeletal growth, photographed in the plane of the crack, took place after the end of the crystallization cycle, with formation of often united single-phase secondary inclusions. x35.
- b - Typical cellular framework of nonequilibrium forms from incomplete healing of cracks in artificial quartz, with late-stage single-phase secondary fluid inclusions. x90.
- c - Zones of silex quartz (below), smoky quartz, and morion in a crystal from Volyn are intersected by healed cracks with small secondary gaseous and fluid inclusions epigenetic for these zones, with the formation of so-called "banded" quartz. Reduced by 1.5 times.
- d - Fragment of structure of "banded" quartz interrupted by healed cracks of different orientation and time of formation. x2.

PLATE XIX. Formation of anomalous necked down ("unstrung") fluid inclusions.

- a - Almost complete necking down of an inclusion in artificial quartz into two parts: a two-phase part with a gas bubble and a single-phase part, left with no contraction bubble due to maintenance of a connecting capillary channel during the whole time of cooling of the enclosing mineral. x120.
- b - Multiphase inclusion in fluorite from Kazakhstan pegmatites, trapped on an interface of complete separation (sic) by means of a capillary channel. A gas bubble "grew" in the right-hand part as it cooled, and the main mass of daughter minerals crystallized in the left-hand part. x220.
- c - Separation of low-temperature hydrothermal solution upon rapid recrystallization of a cleavage crack in calcite from the Lower Tunguska, with the formation of a large two-phase and many small single-phase fluid inclusions. x45.
- d - Necking down ("unstringing") of the liquid of inclusions in a late-stage microcrack in artificial quartz upon cooling of the crystal. x120.

PLATE XX. Healed fracture aureoles around anomalous inclusions in topaz, fluorite, and calcite.

- a - Fluid inclusion in topaz from Volyn, artificially exploded by heating and transformed into a "gaseous" one due to injection of the liquid solution into a microcrack (along the cleavage), forming numerous daughter inclusions. x220.
- b - Naturally exploded, not completely disrupted fluid inclusion in fluorite from the Azov area, with an aureole of daughter inclusions formed by dendritic growth on a crack. x300.
- c - Turret-like primary inclusion from spiral growth disrupted along the cleavage in optical calcite from the Lower Tunguska. x56.

PLATE XXI. Flat and tubular inclusions of mineralizing media, suitable for measuring phase relations by areal and linear methods.

- a - Highly flattened fluid inclusion in fluorite from Central Kazakhstan. x230.
- b - Tubular fluid inclusion in quartz. X90
- c - Equant-flattened (sic) tubular and flat gaseous inclusions in topaz (against the background of a micrometer scale). x100.
- d - Flattened-tubular multiphase inclusion of concentrated mineralizing solution in topaz. Liquid phase with gas bubble above and solid phases below. Middle part is occupied by daughter minerals with mother liquor in the interstices. x180.

PLATE XXII. Internal micromorphology of vacuoles of inclusions of liquid and gaseous solutions.

- a - Primary fluid inclusion in high-temperature hydrothermal tourmaline from a pegmatite in the Mamsk area. Internal striation is exactly oriented along the long axis of the crystal. x230.
- b - Pseudosecondary fluid inclusion in Volyn topaz. Below, cones of closure of a microcrack as the continuation of the striation of the walls of the vacuole. x230.
- c - Large gaseous inclusion in quartz from Volyn pegmatites. Complex "icicle" relief of the walls of the vacuole is related to very rapid segregation of related substance (i.e., quartz in solution? Ed.) as a result of a sudden drop in pressure and temperature. x70.
- d - Formation of very complex skeletal relief on the lower wall of an open fluid inclusion in fluorite from Central Kazakhstan. x70.

PLATE XXIII. Electron photomicrographs of vacuoles and daughter minerals of inclusions (from S. V. Kurshev, V. B. Trufanov, and V. I. Vasil'yev).

- a - Pseudosecondary ultramicroscopic inclusions in honeycomb quartz, controlled by the intersections of healed cracks from shrinkage of the mineral upon its α-β transformation; size of inclusions is 1μ.
- b - Tubular inclusions in fluorite with stepwise-spiral growth of matter on the walls of the vacuoles; diameter of the"spiral" is 0.2μ.
- c - Stepwise-layered relief of the faces of a daughter microcrystal from gaseous-fluid inclusions; size is 9μ in diameter.
- d - Ultramicroscopic relief of vacuole of pseudosecondary gaseous inclusion in quartz, not conformable with the growth layers of the host mineral; size of inclusion is 8μ along the long axis.

PLATE XXIV. Electron probe examination of solid inclusions in Khibiny apatites (KAMEKA type probe) (from V. M. Valyashko and L. M. Kogarko).

- a - In transmitted light.
- b - In absorbed (backscattered? Ed.) electrons.
- c - Distribution of Cl.
- d - Distribution of K.
- e - Distribution of Fe.
- f - Distribution of Al.

PLATE XXV. Study of the element composition of ultramicroscopic daughter minerals of gaseous-fluid inclusions in morion from Sherlova Gora [Schorl Mountain] (1) and in smoky topaz from the Spokoynoye deposit (2) (from Ye. I. Dolmanova and M. M. Elinson).

- a - In transmitted light.
- b - Zinc.
- c - Copper.
- d - Iron.
- e - Chromium.

PLATE XXVI. Primary multiphase fluid inclusions of concentrated hydrothermal solutions in a slightly turbid growth zone in fluorite from Bektauat at different magnifications.

- a - x90.
- b - x880.
- c - x1300.

PLATE XXVII. Primary-secondary inclusions of residual melt-mother liquor in the Volyn blue topaz.

- a - Family of multiphase fluid inclusions. x70.
- b - Isometric inclusion of this group. x280.

KOSTYLEVA, E.E., 1968, Improvement in thermal-acoustic analysis: Mineralog. Thermometry and Barometry, v. 2, p. 46-49, Ed. by N.P. Ermakov: Moscow, Izd. "Nauka". (In Russian, translated by Mary Michael Hobson, courtesy Colin Barker).

The application of thermal acoustic analysis to anhydrous minerals can be broadened if in the course of heating the sample, observations are made on the evolution of volatiles which either form a film on the walls - sulfur gases - or condense at the cold end of the sample tube - vapor or droplets of water. These volatile compounds - water and gases - represent remnants of the mineral-forming environment, and are contained not only in inclusions but also in all kinds of lattice defects present in real crystals (in pores, linear fractures, and cavities). Correlation of the out-gassing of volatiles with the corresponding temperature intervals of decrepitation helps to define the decrepitation effect and gives complementary criteria for the genesis of the studied minerals.

To make these simultaneous observations we constructed a new system. In this sytem (Figure 1) two samples are simultaneously heated in an electric furnace (E).

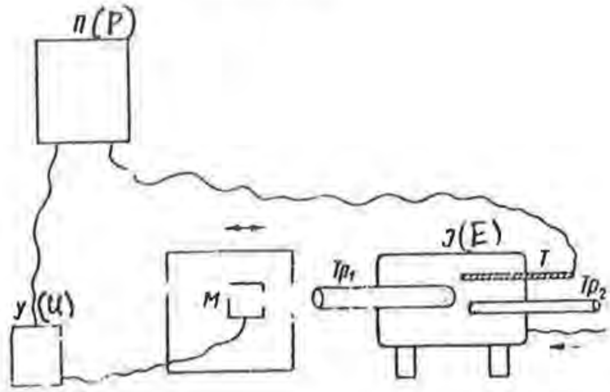

Figure 1. Diagram of the system for recording the decrepitation of minerals.

A large sample for the decrepitation analysis is placed in a quartz glass tube (Tp_1), the closed end of which in inserted into a port in the electric furnace; the open end of the tube is connected to an electrodynamic? microphone (M), placed in a box and covered with asbestos to screen the microphone from extraneous interference. The box is set near the furnace during a run. The other, smaller sample is placed in the narrower pyrex tube which is inserted into the electric heater via another port. The free end of this tube (Tp_2), exposed to the atmosphere, allows a visual observation of the separation process of heating the volatile material during the actual heating. A thermocouple (T), inserted in the electric heater, is connected with a potentiometer (P) to control the furnace temperature, such that the heating is controlled automatically and is practically linear. The noise of the decrepatation is picked up by the microphone, transmitted to the amplifier (U) and then to a new type of recorder which plots the decrepitation on multichannels.[1]

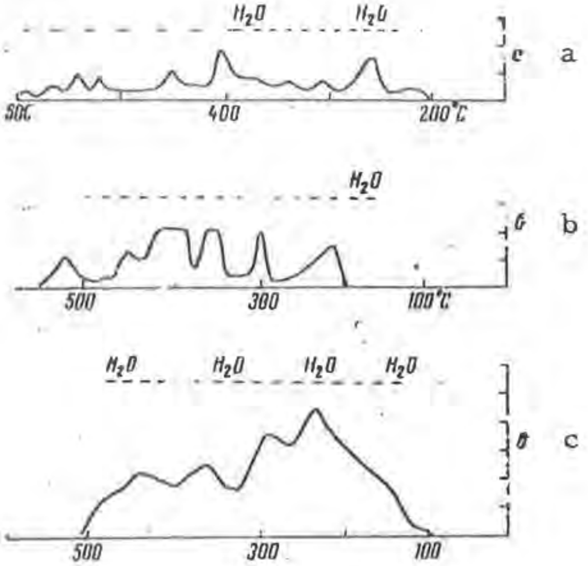

Figure 2. Decrepitation curves of tungstates from the Spokoy deposit in Zabay'kal'e:
a - from the greisen zone;
b - from a sharply dipping vein; and
c - from a sloping vein.

At the output of the amplifier, the decrepitation impulses are integrated, and the signal, proportional to the level of decrepitation, is then sent to a three-terminal potentiometer. Thus, plots are made of the change in the temperature of the sample during heating versus the level of decrepitation.

Visual observations of the evolution of water or gas from the sample (or lack thereof) are recorded on the strip-chart decrepitation curve at the end of the run.

This apparatus makes it possible to follow simultaneously the decrepitation and the evolution (or the lack thereof) of water and gases.

The absence of observable evolution of volatiles simultaneous with intense decrepitation may indicate the out-gassing of CO_2, i.e., the decrepitation of inclusions with liquid or gaseous CO_2. Heating the samples in independent chambers, in this case not connected to the microphone as was our previous assembly (Kostyleva and Labuntsov, 1958; and Kostyleva, 1964, 1965), permits heating to over 1000°C;

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[1] The system was developed by N. Privezentsov and Yu. Morozov, Fourth-year students at the Moscow Energetics Institute with the help of a professional electrician, V. A. Labuntsov.

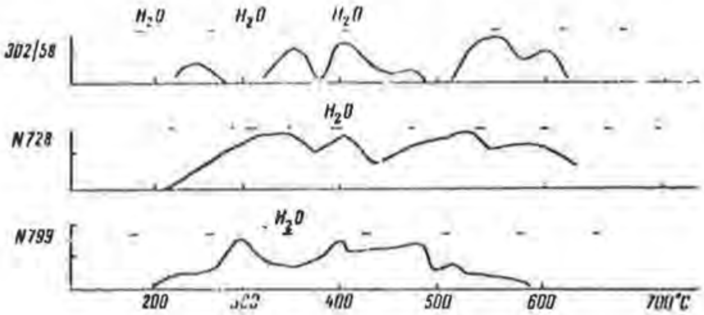

Figure 3. Decrepitation curves of metasomatic apatite from the Khibini tundra.

799 - fine-grained apatite from the mottled Rasvumchorr;
728 - apatite from apatite rocks in the breccia of the Kuel'por deposit; and
302/58 - apatite from the apatite-nepheline rocks of the Poachvumchorr deposits.

and in addition, it allows a subsequent transfer from a visual determination to a more precise quantitative determination of water and CO_2 by automatic recording of their generation over the temperature intervals at which the volatiles are out-gassed. Such combined observations strongly enhance the value of the thermal acoustic analysis. The decrepitation curves obtained are essentially curves of the types of mineral formations or their typomorphs. This may be shown by several examples.

1. Wolframite from the greisen zone (Spokoinoye (translit) deposit in Zabaykal (translit)), and in ore-bearing quartz from the greisen zone (Koskyleva, 1964) are characterized by a weak decrepitation, plotted as a long curve with small decrepitation peaks accompanying the release of H_2O. On this basis, the tungstate of this deposit from steeply dipping veins must be related to the formation of the process of greisenization (Figure 2). Minerals, which, from geologic and optical evidence, are related to the metasomatism of the formation, are characterized by low-intensity decrepitation and long curves having soft broad peaks. This pattern of decrepitation is consistent with rock metasomatism accompanied by a gradual infiltration through the micropores of the rock of solutions whose composition changes. Relics of these are contained as inclusions in minerals resulting in the minerals' "popping." Such decrepitation occurs in some apatites of the Khibini tundra, the genesis of which is regarded as probable metasomatism, although it is equivocal. The curves obtained by the present authors for the decrepitation confirm metasomatic formation of these rocks. (Figure 3)

2. Minerals of hydrothermal genesis (and possibly those generated by infiltration metasomatism) formed from solutions located in fractured or chambered cavities or circulated through coarse, porous spaces show

an intense decrepitation resulting in curves whose decrepitation shows a sharp rise, a maximum, and then a rapid decrease. The temperature at the beginning of both the rapid rise and sharp reduction in decrepitation determines the approximate temperature interval according to the genetic types of their formation. For example, apatite from the pegmatite vein in hibinite (?) (from the Chasnachorr Mountaines in Khibini) from its characteristic decrepitation curve formed in a temperature interval 300-400°C., apparently was formed from high temperature solutions. (Figure 4).

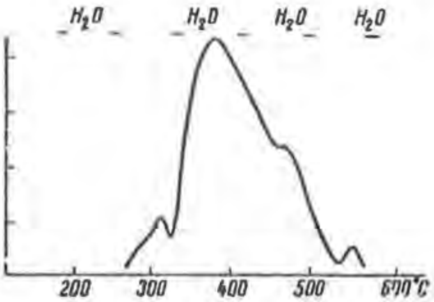

Figure 4. Decrepitation curve for apatite from a pegmatite vein in the Chasnachorr Mountains.

3. Minerals formed in an environment with liquid or gaseous CO_2 (for example, carbonatites) are always characterized by an intense decrepitation curve having a sharp rise (usually beginning at around 100°C or somewhat lower) which does not fall until 600 - 700°C and is not associated with an observed release of water and gases. (Inclusions containing CO_2 are visible in sections under the microscope.) Apatite from the carbonatite deposits (Figure 5) and fluorite from the pegmatite vein of the Khibini tundra have decrepitation curves similar in paragenesis to those of aegirine and the rare earth carbonates from the ancylite(?) group (Figure 6).

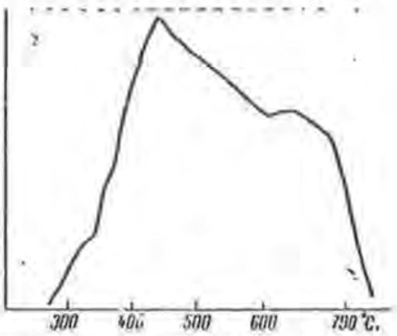

Figure 5. Curve for the decrepitation of apatite from the carbonatites of the Kobdor deposit.

The patterns observed during the simultaneous monitoring of decrepitation and the release of volatiles also aided in observing the homogeneous inclusion and considering the paragenesis of materials, in order to more fully describe the initial conditions of these minerals and determine their genetic characteristics.

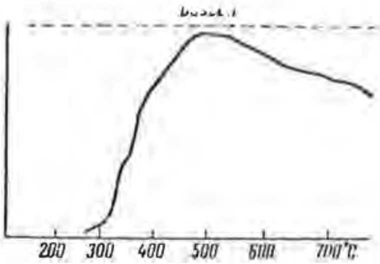

Figure 6. Curve for the decrepitation of fluorite from the pegmatite vein in Khivinite

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ROEDDER, Edwin, 1970, Laboratory studies on inclusions in the minerals of Ascension Island granitic blocks, and their petrologic significance: in Problems of petrology and genetic mineralogy, Sobolev's volume II, p. 247-258 (in Russian with English abstract). Note: This title and abstract are given here as orginally submitted for publication. The English title and abstract in the published version (p. 258) were erroneous. The English text is reproduced here because interest has been expressed in seeing the new data here that have not appeared in English previously. (Editor)

Quartz and alkali feldspar from vuggy ejected granitic blocks found in trachytic breccias at Ascension contain large numbers of fluid inclusions of three main compositional types, I, II, and III, presumably the homogeneous fluids. These fluids were I--silicate melt; II--dense aqueous-saline fluid with 50-70 weight percent NaCl; and III--dense water-rich steam or vapor, with CO_2. In addition, a number of mixed type I-II inclusions were trapped, providing verification of the existence, at depth, of immiscible droplets of aqueous-saline fluid in the silicate magma from which the granite crystallized.

Homogenization temperatures and devitrification experiments on the inclusions indicate that the solid granite was hot at the time it was broken and erupted as blocks, and place some limits on the possible rates of cooling of the blocks. The inclusion studies also have bearing on the problems of the validity of the decrepitation method, the pressure during crystallization of the granites, the change in shape of inclusions after trapping, and the possibility of leakage of inclusions in nature. (Author's abstract).

Introduction

In view of Prof. Sobolev's extensive studies in mineralogy and petrology, it seems appropriate to review here the petrologic significance that may be attached to some laboratory studies made on inclusions, both aqueous and glassy, in the minerals of some granitic rocks from Ascension Island. Although most of this work is part of a larger study of the inclusions in these rocks (Roedder and Coombs, 1967), the present paper includes new data and extends the discussion in some areas. The reader is referred to the earlier paper for a fuller account of the geologic setting, the mineralogy and petrography of the rocks (particularly the feldspars), other types of inclusions, and a more extensive bibliography.

Geologic setting

Although the dominant lavas on Ascension Island are basaltic, there are some trachytic breccias, as well as numerous other rock types. The granitic blocks used in the present study are angular fragments, generally less than 30 cm in size, lying loose at the surface, among a litter of trachytic breccia fragments, particularly on the slopes immediately below the Five Mile Post on the road up Green Mountain. There is no evidence that these blocks were ever embedded in liquid trachyte, as no lava has been found coating them; they are evidently accidental blocks torn from the walls of the volcanic conduit by an explosive blast.

Petrography

Individual granitic blocks vary rather widely in mineralogy and texture, but all are irregularly miarolitic, porous and friable, quartz-alkali feldspar rocks. Most of the mineral grains are in the range of one to five mm, and only a few of the blocks are porphyritic. The miarolitic cavities are generally small and exceedingly irregular in shape, and grade into intergranular porosity throughout the rocks. This characteristic indicates that a volatile phase was present during crystallization, as the miarolitic cavities require the former existence of a fluid phase (gas or liquid) of a composition sufficiently soluble or volatile that all traces of it are subsequently lost to the atmosphere or groundwater, leaving the crystal lining exposed. Such cavities thus represent "fluid inclusions" that have leaked and have been flushed of all readily soluble minerals. Smaller fluid inclusions, trapped in strong and presumably impermeable single crystals rather than polycrystalline, permeable rocks, give us samples of these previously existing fluids and provide evidence for the environment of formation as discussed below.

The feldspars vary widely from one block to another, from an irregular, patchy perthite (monoclinic potassic phase of about Or_{67} to Or_{74}, and twinned, low-albite of approximately Or_{3-5}) to essentially single-feldspar sanidine rocks (Or_{35}-Or_{55}) showing only slight traces of heterogeneity optically or by X-ray.

Some of the blocks contain the rare potassium zirconium silicate, dalyite (van Tassel, 1952), and most show peralkaline affinities, as seen by the presence of aegirine, arfvedsonite, and aenigmatite (totalling five-ten percent), as prisms and needles as much as 4 mm long. In addition to dalyite, the most common accessory minerals are zircon and pyrochlore. The rocks are high in Cl, F, and Zr, low in Ca, and have several percent acmite in the norm.

The inclusions and their behavior in the laboratory

Sections made from the granite blocks show very large numbers of inclusions in all minerals. In particular, much of the feldspar is crowded with as many as 10^{10} inclusions per cubic centimeter._/ Although some of these could be called primary, many are of the indeterminate origin. A number of different types of inclusions are found in the samples, indicating a very complex history, but the great bulk of the inclusions fall into three groups. Inclusions from all these groups have been found coexisting in single grains of both quartz and feldspar from every granite block studied, regardless of the degree of exsolution of the feldspar phases. All the inclusions in quartz are in the form of rounded to sharply faceted negative crystals, but those in the feldspar are much more irregular in shape. The samples contain few of the very flat inclusions and none of the long tubular inclusions so useful in precise phase-ratio measurements.

Type I - Glass plus small, low-pressure gas bubble

Such inclusions are common in any igneous rock that has been cooled rapidly, and represent merely parts of the silicate melt or magma. In the Ascension blocks they are rare in the feldspar, but common in the quartz. The glass has an index of refraction of 1.500 ±.002 and occasionally shows a slight granularity in strongly collimated lighting, presumably indicating slight devitrification. Examination on a crushing stage (modified from that of Deicha, 1950) proves the bubble to be nearly a complete vacuum. A number of the larger type I inclusions have a small isotropic daughter crystal tentatively identified as fluorite (also present in the glass of mixed type I-II inclusions, see Figs. 1 and 2). The bubble (formed by shrinkage) amounts to only a few volume percent (Fig. 1). A variety of heat treatments were tried on such glass inclusions. Fluorite daughter crystals formed when the inclusions were held at 710°C for 32 days, and dissolved when held at 800°C for 43 hours._/ A sample with clear glass inclusions was given a sequence of heat treatments: the inclusions showed no change after 19 hours at 250°C, but 25 hours at 415°C resulted in a mat of birefringent needles (unidentified) in all but the smallest glass inclusions. Following this, 96 hours at 650°C caused visible coarsening of the needles, and after 32 days at 710°C most of the needles had dissolved in the glass. An additional 43 hours at 800°C eliminated most the remainder. Separate samples, each reheated for 24 hours, showed devitrification and growth of crystals at 400°, at 500°, and at 600°C, but none at 700°C. Heating (for two hours) at 1050°C apparently was adequate to cause homogenization of these glass inclusions, as might be expected. This is based on the fact that many

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_/ Estimated by counting the inclusions in minute volumes of the feldspar in apparently typical areas.

_/ In each of the experiments of this type reported here, the time given represents the arbitrarily chosen length of the experiment, before reexamination of the sample. Shorter time might yield identical results.

of the smaller glass inclusions contain no bubble after such a heat treatment if it is followed by rapid quenching (approximately one second). By contrast, type I inclusions as small as 4μ in diameter had (or developed ?) shrinkage bubbles after quenching in four seconds from 995°C.

Type II - Large halite crystal plus saturated water solution plus gas bubble ± minor phases.

The gas bubbles in these inclusions range from about 20 to a maximum of about 50 volume percent. The halite crystal may occupy more than 30 volume percent of the inclusion, corresponding to original homogeneous fluids with as much as 70 weight percent NaCl (see inclusions marked II in Fig. 2). The identification as halite was based on its index of refraction _/ and on observations of its reaction with the liquid to form the birefringent compound $NaCl \cdot 2H_2O$ on cooling below +0.1°C. On subsequent heating, this hydrate melts incongruently to form liquid plus NaCl crystal (Roedder and Coombs, 1967, Plate 1, Figs. G-J). Many of the larger type II inclusions also contain a second isotropic cube (probably KCl), small amounts of liquid CO_2, a small, highly birefringent grain (possibly calcite), and an opaque grain.

The homogenization temperature of type II inclusions, both primary and secondary, was determined to be generally between 590° and 612°C, and occurred in the liquid phase (type I homogenization of Ermakov (1950)). Solution of the last of the halite crystal occurred slightly below the temperature of elimination of the vapor bubble. Although the platinum/platinum-10 percent rhodium thermocouple of the heating stage (Richter and Abell, 1953) was calibrated, simultaneously with the actual runs, at the melting points of very pure tellurium (449.5°C) and antimony (630.5°C) _/, no great precision can be claimed for these homogenization temperatures, as severe thermal gradients were evident. The experimental uncertainty is thus at least ±25°C.

Crushed grains of quartz and of feldspar were heated to determine the decrepitation characteristics of type II inclusions. Grains of quartz of 0.1 - 0.5 mm diameter showed no loss of fluid from their inclusions after 24 hours at 700° C. Some quartz grains as small as 0.1 mm retained their type II inclusions during two hours at 1050°C and even two hours at 1200°C. Most type II inclusions in grains of feldspar of similar size were unaffected by 16 hours at 600°C, but were emptied during 16 hours at 710°C or two minutes at 865°C. As the samples were mostly < 1 mg. in minute platinum foil capsules, the time to reach furnace temperature was only a few seconds. To obtain fast air quenching, the capsules were jerked out of the horizontal tube furnace by a thin platinum wire.

_/ Type II inclusions are so abundant in some of the feldspar that single crystal X-ray diffraction photographs of these crystals show diffraction lines for the three strongest reflections from halite.

_/ Minute slivers of these elements were sealed, in vacuum, in individual short sections of fused silica capillary tube, <1 mm in diameter, and placed beside the sample grain.

Type III - Dilute water solution plus very large gas bubble containing some CO_2.

This type normally contains about equal amounts of gas and liquid (see Fig. 2 inset). Under ordinary lighting these may seem to be opaque, or empty. As the liquid forms a thin layer around the large bubble, it is difficult to observe with the collimated lighting of a heating stage, and hence the homogenization temperatures (probably in the gas phase) are undetermined. The conditions for leakage or decrepitation for type III were about as for type II. Examination on the crushing stage verified the presence of gas under pressure; examination on the cooling stage showed the formation of the clathrate compound $CO_2.5\frac{3}{4}H_2O$ and little evidence of salts in solution. Type II and type III inclusions of apparently primary origin occur in close proximity but randomly distributed with respect to each other, and are frequently only a few microns apart. A number of curving healed fractures were also found, however, outlined by dozens of obviously secondary or pseudosecondary inclusions of sharply faceted negative crystal shape. These consisted of both types II and III, in random array relative to each other.

Type I-II, an uncommon but particularly significant mixed type.

In addition to the three main types, there were a number of examples of inclusions containing silicate glass, and saline liquid, with a halite crystal and vapor bubble. Figs. 2-6 show several of these, and Roedder and Coombs (1967, Plate 2) show six others. These are difficult to photograph _/, but show generally a large "bubble" in a glass inclusion, too large to have formed by normal shrinkage on cooling. Each such bubble" contains crystals, liquid, and vapor. The inside of the "bubble" is either lined with a layer of wet salt crystals surrounding the vapor phase, or has a single large isotropic cube and other smaller isotropic and birefringent crystals, a liquid, and a vapor bubble. The ratio of (gas + liquid) to glass varies widely. After rapid quenching in the experimental runs, the lining of tiny wet crystals on the surface of the bubble (for example, Fig. 4a) might be easy to confuse with the rather common feature of solid daughter crystals in some glass inclusions giving the appearance of sticking to the bubble (presumably due to preferential nucleation on the interface). However, when the mixed type I-II inclusions are given a moderate heat treatment, such as two hours at 60°C, the tiny salt crystals recrystallize through the liquid to form a few larger ones (Fig. 4b).

A number of these mixed inclusions were examined on the heating stage. The salt crystals, vapor, and liquid in them homogenized to a single fluid at about 600°C, similtaneously with the homogenization of adjacent type II inclusions, but no effect was seen on the glass phase or the occasional daughter crystals found in the glass. Higher temperatures, up to 1050°C, showed no permanent effects. For example, the inclusion in Fig. 3 is only 16μ below the surface of the grain, and has been held at 1050°C for two hours, with no evidence of leakage. A small grain of quartz, less than 0.3 mm thick and containing a number of mixed

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_/ Many other similar inclusions were found which were unsuited for photography, but showed the same phases quite adequately when several different settings of lighting and focus were used.

type I-II inclusions (mostly less than 30μ from the surface), was given the following sequence of heat treatments, with quenching and optical examination after each: 710°C for 32 days; 800°C for 72 hours; and 990° C for 17 hours. There was no change in any of the inclusions; all showed a layer of wet salt crystals lining the bubble. The photomicrographs shown in Figs. 1, 4a, and 6a happen to have been taken after this sequence of heat treatments, but the inclusions looked the same before and after. The grain was then heated to 1105°C for 42 hours and quenched in approximately two seconds. Now each mixed type inclusion showed three phases (Figs. 5 and 6b): silicate glass (unaffected except for some increase in volume by solution of the walls); a clean, clear vapor bubble, and a round, solid globule of mainly istropic salt crystals with a granular surface and interior. Within each such salt globule another vapor bubble is now visible.

From this evidence it is presumed that at 1105°C, the salt was present as fused globules, immiscible with the hydrous silicate melt, and all the water was in solution in the melt. On cooling the melt shrank and formed new vapor bubbles, essentially free of salt. The salt globules crystallized while the glass was still soft, and shrank to form another vapor bubble in the interior of each. A second heating to 1105°, followed by slow cooling, caused most of the inclusions to return to their original appearance, with a single "bubble."

Significance of data and conclusions

Although the results of this work apply strictly to only the materials studied, some petrologically significant conclusions may be drawn from them.

A. Overheating of inclusions (above their homogenization temperatures) and geologic thermometry by decrepitation.

As the bulk of the inclusions of types II and III in quartz grains even as small as 0.1 mm could be taken to 100°C above their homogenization temperature for a month without decrepitation or leakage, and some could be taken as much as 600°C higher for hours, decrepigrams made of such samples could be very misleading. This is perhaps expectable, as inclusions with a high temperature of homogenization exhibit a much smaller change in the rate of pressure increase with temperature rise at the point of homogenization than do lower temperature inclusions of the same composition.

B. Silicate melt-hydrous saline fluid immiscibility in granitic magmas.

The common occurrence of individual inclusions of both types I and II in any sample would merely indicate the existence, at unspecified times, of each of these types of fluid. Many crystals of quartz, and a very few of feldspar, contain apparently primary inclusions of both types, implying simultaneous existence of the two immiscible fluids: silicate melt, and dense hydrous saline fluid or "melt" (density about 1.4 g/cm^3). Far more convincing evidence of immiscibility is found in the mixed type I-II inclusions. These indicate the existence, and trapping, of globules of dense hydrous saline fluid immersed in a silicate melt.

One alternative possibility that might be considered is that a homogeneous silicate melt was originally trapped, and that the salts and water have exsolved from it on cooling to form the mixed type I-II inclusions. Although this possibility in itself would indicate immiscibility, at lower temperatures and pressures, several facts preclude it. One of the strongest points of evidence is the fact that the ratio of (gas + liquid) to glass varies widely, and cannot be explained by simple necking down and compartmentalization of elongated multiphase inclusions, yielding a variety of ratios (the "beading" described by Lemmlein, (1929)). Another is that most of the glass inclusions (even in the same grain) have only the normal, small size bubble, with no evidence of exsolved salts or water. Lastly, the behavior of the mixed inclusions on heating is not explicable in terms of a homogeneous, hydrous, silicate-saline fluid. This is seen in the fact that on heating to 1105°C an obviously immiscible droplet of fused salts formed in the silicate melt. As this is well above the probable formation temperature of the rock, this behavior indicates that a homogeneous silicate melt, containing salt and water in solution, could not be responsible for the mixed type I-II inclusions.

The trememdous concentration of type II inclusions in the feldspar is believed to be merely a result of preferential wetting; although the feldspar grew essentially from the silicate melt, the globules of saline fluid in this melt apparently adhered preferentially to the growing feldspar surface and thus were enclosed in large numbers, even though they were not the fluid from which the crystal was actually growing. Such a pheonomenon could also lead to differentiation by flotation of the crystals.

C. Boiling of the saline fluid.

The simultaneous presence of apparently primary inclusions of both types II and III in the same sample is permissive evidence of boiling, particularly as the distributions of salts and of CO_2 between the two types of inclusions are as expected for "liquid" and "vapor" phases in the system H_2O-CO_2-NaCl_/ (Sourirajan and Kennedy, 1962; Takenouchi and Kennedy, 1965).

_/ Only rare examples of mixed type II-III were found.

The common occurrence of these two types of inclusions outlining the <u>same</u> healed fracture is difficult to explain except by the trapping of a boiling solution, perhaps early in the eruption of the blocks, and the pressures involved are geologically reasonable. The relative abundances and distributions of the two types preclude necking down of elongated inclusions as an explanation. Such boiling places some limitations on the pressure, and hence depth, at which type III inclusions were trapped. Sourirajan and Kennedy (1962) have shown that the vapor phase in equilibrium with a saturated solution of NaCl at 600°C (the homogenization temperature of the inclusions) has a pressure of only 392 bars, and contains only 0.04 percent NaCl. Thus it is feasible that these granites crystallized at rather shallow depths.

D. Nucleation and crystallization of glass inclusions and the cooling rate in nature.

Except for the possibility of some at present unknown hysteresis effects, the fact that 24 hours heating at 400°, 500°, or 600°C caused crystallization of formerly clear glass inclusions requires that in nature these blocks were cooled from about 600° to under 400°C in less than 24 hours. Data on the exsolution rate and composition of coexisting feldspar phases (Roedder and Coombs, 1967) seem to be in conflict with this conclusion, but may still be explicable. The evidence seems to point to original crystallization of the minerals of the blocks at or above about 650°C, relatively rapid quenching (less than one day) to just below 400°C, presumably by eruption, maintenance of temperatures just below 400°C for a period, and subsequent quenching, or at least cooling into a range where further reaction was insignificant.

E. Decrepitation of inclusions in feldspar and the temperature of eruption.

The fact that the type II inclusions in feldspar (also type III, probably) are emptied by two minutes heating at 865°C, and by 16 hours (or less?) at 710°C, requires that these blocks were erupted at temperatures under 865°C, and probably under 710°C. (As the blocks are friable they are assumed to have no significant tensile strength.) Such temperatures are not unreasonable for accidental blocks in a trachytic volcanic breccia with no lava.

F. Recrystallization and the change in shape of inclusions.

Most of the inclusions in these samples, including many obviously secondary inclusions outlining healed fractures, are equant, faceted negative crystals. As it is almost impossible for secondary inclusions to have this shape at the time of trapping, it must be assumed that they have changed shape after trapping. Such changes in inclusions shape, as first described by Lemmlein (1929), probably occur in all cases where (1) the host mineral has a finite solubility in the trapped fluid; (2) the shape at the time of trapping does not represent the lowest energy configuration, i.e., the minimum surface energy; and (3) there has been adequate time for recrystallization to occur. It is thus surprising to see inclusion shapes in general, and negative crystal shapes in particular, used so commonly in the literature as criteria for a primary origin for inclusions. The difference between two groups of inclusions in a given sample, one irregular and the other negative crystals, may be *empirically* related to secondary vs. primary origin in some given locality, but such a relationship is far from regular, and in fact it is frequently found to be reversed.

G. Leakage of fluid inclusions in quartz.

If fluid inclusions have commonly leaked under natural pressure gradients, letting material in or out, their usefulness in geologic studies would be greatly reduced. Although a more extensive laboratory study minimizing the general problem of leakage in fluid inclusions is to be reported in a separate paper, it should be noted here that many of the heating experiments show that quartz is relatively immune to leakage of aqueous fluids, even at elevated temperatures. _/ Heating to the homogenization temperature of 600°C develops pressures in the inclusions up to 392 bars along the three-phase curve (Sourirajan and Kennedy, 1962), and lower salinities or higher temperatures would result in still higher pressures. Yet 32 days at 710°C, plus 11 more days at temperatures of 800° to 1105°C, failed to produce any visible evidence of leakage of a large number of mixed type I-II inclusions (and a few plain type II inclusions), even though many were less than 30μ below the surface of the grain. Similarly, some type II and type III inclusions within 20μ of the surface showed no evidence of leakage after two hours at 1200°C.

_/ Although the Ascension Island samples have probably cooled through the α-β quartz inversion temperature rapidly, other quartz samples have cooled through this range at extremely slow rates. This would be very difficult to duplicate in experimental runs, but the possibility that much more rapid leakage might take place *during* the transition should be considered (oral communication, P.B. Barton, Jr., 1967).

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Captions for figures

Fig. 1 Group of mixed type I-II inclusions in quartz. Each contains a thin layer of salt crystals and water inside the bubble, in an amount that is a function of the bubble size. Although the two inclusions marked I' look in this illumination like normal type I inclusions, with small bubbles, heat treatment showed that they were actually mixed type I-II (see Fig. 5). The inset shows a type I inclusion, with vapor bubble (v) and fluorite daughter crystal (f) in glass (g). Sample As 51.3.

Fig. 2 Grain of quartz from sample As 51.14 showing several probably primary type II inclusions, and one large mixed type I-II inclusion. The latter is a sharply faceted negative crystal cavity filled with glass (g), containing a small daughter crystal presumed to be fluorite (f), and a large "bubble" containing a single cube of halite (h) and a wet mass of smaller crystals of soluble salts, plus a vapor bubble (v). The inset shows two type III inclusions in quartz from the same sample, each with liquid (l) and a large vapor bubble (v).

Fig. 3 Mixed type I-II inclusion in quartz showing two isotropic cubes (presumably halite, h, and sylvite, s), in a liquid film (l) lining "bubble" in glass (g).

Fig. 4 Mixed type I-II inclusion, showing wet mass of small salt crystals lining "bubble" in glass, from rapid quenching of sample (a); and the results of recrystallization to a small number of larger crystals after holding for two hours at 60°C (b). Sample As 51.3.

Fig. 5 Same area as Fig. 1, after heating for 42 hours at 1105°C and rapid quenching. Each mixed type I-II inclusion now consists of a granular globule (h) of salt crystals (an immiscible liquid droplet at 1105°C) and a separate vapor bubble (v), in the glass (g).

Fig. 6 Enlargements of another inclusion in same grain as Fig. 5, before (a) and after (b) heating to 1105°C. Letter identifications as in Fig. 5. The globule of salt crystals is seen to contain a small shrinkage cavity (V').

INDICES TO VOLUME V

The user should keep in mind the following features of these indices. The indexing procedures and entries are evolving and hence are not completely uniform from one volume of COFFI to the next, and absolute consistency even within a given volume cannot be claimed (caveat emptor). Where several different items in the given category occur on the same page, either the number of such items or "m" (for multiple) 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 both possible spellings, e.g., Ye and E., ...iy and ...ii, etc.

AUTHOR INDEX

Notes: Only first authors are listed. See general note above.

SUBJECT INDEX

Notes: See page 138. 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 known to the Editor 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 possibly 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 decrepitation studies. Entries that would include too many page references (such as Homogenization, Quartz) are omitted. Some entries with broad and diffuse applicability (e.g. "Geobarometry, methods and comparisons" or "Homogenization of inclusions, factors affecting") have only a few of the most appropriate page references.

DEPOSIT INDEX

Notes: See page 138. 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. Only a very few of the many localities referred to by Ermakov (1972b, p. 34 and 116-124 here) and by Roedder (1972a, p. 89-91 here) are indexed here.

VOLUNTEERS NEEDED

The Editor would appreciate very much 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 covering various segments of the literature, preparing abstracts, indexing, and translation (particularly from the Russian). These jobs can be partitioned into as small units as desired, and every little bit of help helps.