FLUID INCLUSION RESEARCH

PROCEEDINGS OF COFFI

VOL. 3, 1970

(Including Indexes for Vols. 1-3)

(REPRINT)

NOTICES TO SUBSCRIBERS

This is a yearly volume to provide communication between workers in various fields of research on fluid inclusions, using the term in its broadest sense to embrace inclusions of any fluid, gas, liquid, or melt, and in any natural material, terrestrial or extraterrestrial. Privately published each year, starting with 1968, at Washington, D.C. Subscriptions U.S. $3.00 per year. A very limited number of press overruns of the previous volumes are still available at $3.00. Standing orders are gratefully received. Make checks payable to COFFI and address all correspondence to:

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Publication of this issue of Fluid Inclusion Research - Proceedings of COFFI, as with the previous issues, has been unfortunately delayed by a series of circumstances. Most of the material for the issues for 1971 and 1972 has already been collected and it is hoped that they can follow this one in close succession, to bring the Proceedings up to date and hence more useful. As this is essentially a one-man, non-profit, after-hours operation, the Editor would very much appreciate assistance, particularly in covering specific journals and in the translation of abstracts. All subscribers can help by requesting standing orders and by paying for each volume as received (or in advance), without waiting for separate billing. This will give the Editor more time for such operations as bibliographical searching and selecting, cross-checking, transcription, editing, proofing, pasting printers copy, indexing, recording subscriptions, banking, addressing, and mailing, etc., that now occupy his spare time.

FLUID INCLUSION RESEARCH-PROCEEDINGS OF COFFI, Vol. 3, 1970

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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 of the Genesis of Ore Deposits (IAGOD). Although closely connected with COFFI and IAGOD, the publication of the Proceedings is an independently arranged, nonprofit operation, and was separately financed with a loan from the International Union of Geological Sciences. The original plan for these Proceedings was that they would provide three main types of material to inclusion workers:

1. Abstracts or annotated bibliographic notes of papers published during the volume year that either contain inclusion data or are pertinent to inclusion workers.
2. English translations of inclusion papers from foreign languages, where available and not otherwise published.
3. Notices and programs of forthcoming meetings and symposia.

Originally a Board of Associate Editors was established, each member of which was to cover a specific segment of the literature. With this issue, however, each contributor is credited individually for each abstract he has made, and the Editor hopes that these individual acknowledgements will suffice to express his appreciation. The Editor wishes to acknowledge, in particular, the help of Dr. M. Fleischer, who provided translations of many Russian titles, and most of the translations of complete articles given here, as indicated at the end of each. Chemical Abstracts, of Columbus, Ohio, has most graciously permitted the use of a limited number of their copyrighted abstracts (indicated by "C.A.", or the full abstract citation). Translations of several abstracts from the Russian original by Asoke Lahiry are also gratefully acknowledged, as well as individual abstracts translated by others, as indicated. Many other 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. 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. Some of the Russian articles listed in the previous issues by title only have since been obtained as translated abstracts, and hence are given again here, as abstracts. 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, photocopies of the originals can be provided at $.25 per page.

NOTICE OF FOURTH SOVIET ALL-UNION CONFERENCE ON THERMOBAROMETRY

The following announcement has been received from Prof. Ermakov: The Fourth All-Union Conference on Thermobarometry will meet in the second half of September, 1973, in Rostov-on-Don, USSR. The areas in which papers are specifically requested are as follows:

1. Thermodynamic factors in mineral formation in terrestrial and extraterrestrial conditions.
2. Geochemistry and cosmochemistry of mineral-forming media in inclusions.
3. Application of inclusion study to petrology.
4. New methods of research in study of inclusions.
5. Use of inclusions as a tool in exploration of mineral deposits.

Registration fee for individuals who are not members of the Soviet Section of COFFI will be 10 rubles. Excursions are planned, before the Congress, by steamer on the Don and Sea of Azov to historic sites and mariupolites (2 days), and after the Congress to ore deposits of the northern Caucasus, with examination of the laccoliths at Pyatigorsk and Mt. Elbrus (5 days). The deadline for abstracts has already passed. Those interested in attending should contact Prof. N.P. Ermakov, Geological Faculty, Moscow State Univ., Moscow 117234, U.S.S.R.

(It should be noted that prior to the above, a meeting on "Volcanism and associated metallogenesis" is to be held at Bucharest, Romania, on 3-8 September, 1973, under the auspices of the International Association of Volcanology and Chemistry of the Earth's Interior. It also will have pre- and post-session field excursions of 7 days each. All correspondence should be addressed to the Secretary General, Prof. Dan Radulescu, Faculty Geology and Geography, Bul. Balcescu 1, Bucharest, Romania.)

ABSTRACTS, TRANSLATED ABSTRACTS, OR ANNOTATED CITATIONS TO WORLD LITERATURE

Editor's notes:

Although most of the references that follow are dated 1970, a few earlier ones are included which were missed in earlier issues of COFFI 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).

The Editor acknowledges that his lack of adequate time has resulted in gross inconsistencies in the methods of citation, transliteration, abstracting, and indexing. This lack of time (and a modicum of personal bias) has also resulted in giving rather short shrift to articles based on decrepitation. There may also be shortcomings in some author's English abstracts (to foreign language publications), but these in general are presented as given.

ALYEKHIN, Yu.V., PASHKOV, Yu.N. and DISTLER, V.V., 1970, Characteristics of greisenization, as indicated by gas-liquid inclusions in minerals: Geolog. Rudnykh. Mestorozh., 1970, no. 3, p. 33-40 (in Russian); translated in Internat. Geol. Rev., v.14, p. 639-644, 1972.

Conditions of origin of metasomatic rocks, in a greisen ore deposit in eastern Transbaikal 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. CO_2 varies from low to >16 mole %. Homogenization and decrepitation data are given. (Authors' abstract, extended).

ANDRUSENKO, N.I., 1970, Geological (and) structural features of deposits of Iceland spar of dike-type of the Siberian platform: VNIISIMS, Geology and Experimental Studies, v. 12, p. 3-13 ("Nedra" Press, Moscow; in Russian)

(These are the deposits from which were obtained the specimens for many Soviet inclusion studies. E.R.)

ANDRUSENKO, N.I., and KIEVLENKO, J.E., 1970, Thermobarogeochemistry of hydrothermal solutions connected with paleovolcanism of central part of Siberian Platform (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 250.

During the basaltic stage of the earth development (late Pz, Mz, Tr era) in certain parts of the world (Indo-China, India, South Africa, Siberia) gigantic effusion of basic lava took place. Paleovolcanic hydrothermal activity of the basaltic magma resulted in mineralisation of traps of the platforms of Siberia, Deccan, Karroo, etc., which may be explained by enriching the base magma with volatiles, Cl, CO_2, H_2O, etc., high percentage of calcium in basaltoids, and favourable structural-tectonics.

Specific features of trap mineralization of the central part of Siberian platform are due to subvolcanic character of hydrothermal activity going on under comparatively low temperature, and pressure dropping very fast. This resulted in many deposits such as iron ore, polymetals, accumulation of Ba- and Sr-minerals-zeolites and especially Iceland spar (optical calcite), which deposits are the largest in the world.

The authors managed to settle successfully the problem of genesis thanks to a great many investigations of gas-liquid inclusions in calcite (the main mineral of the traps), analcime, apophyllite, quartz, barite, celestite, garnet, viluite (sic.) etc.

Thermometrics of gas-liquid inclusions in paragenetic minerals, except zeolites with nonhermetic inclusions, made it possible to find out the evolution of hydrothermal solutions and the ranges of temperature for the stages of mineral formation. There are two main mineral phases: subvolcanic ferro-carbonate, and a near surface zeolite-calcite one. Mineralization went on in three stages corresponding to thermodynamic phases of the solutions: 1) garnet-magnetite stage corresponds to the phase of high temperature (520-400°) solutions; 2) silica-carbonate stage corresponds to the zone of boiling (300-200.°) solutions; 3) zeolite-calcite stage corresponds to cold (200-50°) solutions. Their chemical composition evolved from complex-component sulfate-chloride-carbonate weakly acidic-weakly alkalic solutions to simple bicarbonate-chloride calcium-sodium or sodium-calcium weakly alkalic or weakly acidic (pH=4,5-5,5) solutions, the concentration of which was constanly dropping from 250- to 100 g/l. The range temperature (according to the inclusions) of productive calcite formation is 180-50°. The presence of oxygen in gas-phase inclusions points to the oxidizing conditions of crystallization of Iceland spar. Together with the (chemical) evolution and dropping of the main thermodynamic parameters of the mineral-forming medium, fluctuations took place, i.e., sudden changes in the density, temperature and concentration of the solutions as a result of discovering fractures and increase of volume of cavities. (Authors' abstract.) (Editor's note: this abstract may contain typographical errors, as the original printing was partly illegible.)

ANGRELL, C.A. and SARE, E.J., 1970, Vitreous water: Identification and characterization: Science, v. 168, p. 280-281.

Of pertinence to inclusion cryometry. (ER).

ANTHONY, T. R., and CLINE, H.E., 1970, The kinetics of droplet migration in solids in an accelerational field: Philos. Mag., v. 22, p. 893-901.

Careful experimental study of migration of liquid inclusions in KCl crystals in fields up to 50,000 G. Some study of movement in thermal gradients as well. Of pertinence to possibility of movement of inclusions in soluble salts in nature. (E.R.)

APFEL, R.E., 1970, Vapor cavity formation in liquids: Harvard Univ., Acoustics Research Laboratory, Tech. Memorandum 62, 207 pp.

This work is devoted to the experimental and theoretical study of vapor cavity formation in pure and impure liquids. A novel experimental technique has been developed for studying the properties of liquids under conditions that are not ordinarily accessible. This technique involves the use of an acoustic standing wave field established in a column of one liquid in order to trap an immiscible droplet of another liquid. In this experiment an ether droplet suspended in glycerine was superheated and acoustically stressed until the combination produced an explosive liquid-to-vapor phase transition. The measured trade-off between tensile stress and superheat as causes of this vapor cavity formation is in gratifying agreement with the theory of homogeneous nucleation in liquids. The theoretical efforts go beyond this study of nucleation in pure liquids to consider the nucleation of vapor cavities from imperfectly wetted solid impurities (motes) in liquids. The qualitative conclusions of this theory bring some semblance of order to a wide variety of observations of statically-induced cavitation and low-frequency acoustic cavitation reported in the literature. A theory for the frequency dependence of the acoustic cavitation threshold, based on numerical solutions for the motion of a vapor cavity in a viscous, incompressible liquid subjected to an acoustic field, also yields results consistent with the available experimental data. (Author's abstract. This work has considerable pertinence to many aspects of metastability in fluid inclusions, both under natural and laboratory conditions. E.R.)

ARKHIPCHUK, R.Z., 1970, Formation conditions of western Transbaikalia fluorite mineralization: Akad. Nauk SSSR, Otd. Geol. Buryat. Filial, Sib. Otd., 1970, No. 2, 83-89 (in Russian). CA 75 (9) 72 (1971).

Fluorite mineralization is paragentically related to post-Cretaceous microsyenite dikes and Na syenites. High-temp. (260-275°) pneumatolytic-hydrothermal deposits show dark-violet disseminations of fluorite in quartz syenites and syenite-porphyries. The CO_2 inclusions in fluorite suggest a mineral-forming soln. pressure of 200-440 atm with a corresponding depth of formation of 800-1700 m. The K-Ar abs. ages of quartz-syenites and syenite porphyries (135-188 million yr) yield a Jurassic age. Vertical mineral zoning in the fluorite deposit is discussed in relation to the temp. gradient.

ARKHIPCHUK, R. Z. and ROSIKHINA, A. I., 1969, See Translations Section

ARNOLD, R. G. and RUTHERFORD, M. J., 1969, Data for brine and carbon dioxide filled liquid inclusions in quartz veins from the Coronation Mine: Symposium on the Geol. of Coronation Mine, Saskatchewan. Can. Geol. Surv. Paper #68-5, p. 213-228.

Liquid inclusions occur in quartz veins cutting the ore bodies in Coronation mine. Hand specimens collected from seven levels were examined and the contained liquid inclusions were found to be of three general types - brine-gas, brine-CO_2 fluid-gas and CO_2 fluid-gas. Interpretation of the observations permitted approximate estimates of the composition of the inclusion fluids and the conditions of trapping of the fluids, assuming the inclusions to be primary. Sphalerites and silicate gangue in the ore body were also examined for liquid inclusions, but without significant results. (Authors' abstract)

BABAEV, K.L., IBADULLAEV, S.I., POLYKOVSKII, V.S., and SMELJANETS, V.I., 1970, The application of mathematical analysis to the complex utilization of decrepitation and geochemical methods for exploration for hidden fluorite deposits (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 255.

Formation of the ore bodies was accompanied by formation halos which are discovered as a result of spectral analysis of the containing rocks, with statistical treatment. Halos of decrepitation activity, from hydrothermal impregnation, show asymmetric lognormal distribution. The distribution of F, Cu, Pb, Hg, Y, Sc, Ga and some others is close to hyperbolic. Statistical significance of various correlations of element distributions with decrepitation activity is given for several country rock types. Major element indicators in the halos of fluorite mineralization are Cu, Be, and Y, and minor indicators are Pb, F and Hg. (Authors' abstract, abridged by Ed.) (Editor's note: This abstract may contain typographical errors, as the original printing was partly illegible.)

BABKIN, P.V., SIDOROV, A.A., and GONCHAROV, V.I., 1970, The comparative analysis of physico-chemical conditions of minero-genesis on the mercuric and gold-silver deposits of the north-east of the USSR and in modern hydrothermal systems (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 248.

The results of explorations of gas - liquid inclusions in the minerals of mercuric and gold-silver deposits and the analysis of the available data on the modern hydrothermal systems allow us to compare some physical parameters of the mineroformational solutions of the areas of meso-cenozoic volcanism development and modern thermal regions of Kachatka, New Zealand and Southern California.

Zonation of the type argillization-adularization on the studied deposits and in the regions of the modern hydrothermal systems is characterized by the resemblance in composition of the primary/sodium-chloride/hydrotherms and also by the similar ways of their evolution and differentiation.

The ore-forming solutions of the gold-silver deposits are characterized by the complex hydrocarbonate-sulphate-chloride-sodium-calcium composition and the alkaline medium. In the supra-ore zone of argillization with the antimonial-mercuric mineralization the solutions had a sulphate composition proper with low values of pH. Mercuric and antimonial-mercuric proper deposits have been formed out of the solutions changing from alkaline to subacid.

Zones of argillization on the gold-silver and mercuric deposits are characterized by the greater depth of formation/usually, under the screen/, than it is in the areas of the development of the modern hydrotherms. The minerogenesis in these zones proceeds at the temperatures of 180-160°C.

The peculiarities of minerogenesis in the near-surface zone of the modern hydrothermal systems to a certain extent are similar to the conditions of mineralization in the supra-ore zone of gold-silver deposits. However, in the ore zone of the latter these analogies are far from evident. Temperature regime and the composition of solutions of the modern hydrothermal systems, sedimenting the cinnabar, are in resemblence with the corresponding parametres of the explored ore deposits of the North-East of the USSR, though the sedimentation of cinnabar in present conditions, usually, takes place at lower temperatures and pressure.

It is supposed that metasomatites of the contemporary hydrothermal systems to some extent are analogs to metasomatites of the pre-ore stage of the develpment of the zones of hydrothermally changed rocks of meso-cenozoic deposits. In the contemporary circumstances metasomatites zones can be referred to the category of uncompleted development, i.e. in them the essential concentrations of ore elements are absent. (Authors' abstract.)

BAKUMENKO, I.T., 1970, The study of crystallized and glassy inclusions in magmatic minerals, in Problems of Petrology and Genetic Mineralogy, Sobolev's Volume II: Moscow, "Nauka" Publishing House, p. 259-271 (in Russian).

Some peculiar features of crystallized and glassy inclusions in the effusive rocks as well as in the minerals of alkaline, acidic, neutral and basic rocks are reported. Temperatures of homogenization are given for the inclusions in the disseminated deposits of quartz, plagioclase, nepheline, olivine, pyroxene and leucite from the measurements made by the author and previous investigators. They are all above 1100°, indicating very small water contents in the vein rocks and its progressive accumulation in the process of magma crystallization. Nine analyses of the gas phase are given for some magmatic inclusions. Other than water, CO_2 and/or N_2 predominates in the gas phase. Small amounts of acid gases were found in two samples; no heavy hydrocarbons, O_2, CO, or H_2 was found. From the study of the above inclusions, the present author considers the possibility of differentiating silicate magma by means of liquid immiscibility as unlikely. (Author's abstract, extended by E.R.)

BALITSKII, V.S., 1970, Content and solubility of silica in natural thermal waters and gas-liquid inclusions in minerals: VNIISIMS, Geology and Experimental Studies, v. 12, "Nedra" Press, Moscow, p. 76-87 (in Russian).

An examination of the solubility of silica in a variety of experimental hydrothermal systems, and in four analyses of fluid inclusions (by Maslova). (E.R.)

BARKER, Colin, 1970, The gases in rocks and their contribution to the earth's atmosphere (abst.): Geol. Soc. Amer. Abstracts with Programs, v. 2, no. 7, p. 489 (Author at Department of Chemistry, University of Tulsa, Tulsa, Oklahoma 74104).

The analysis of volcanic emissions gives the current composition of volatiles reaching the earth's atmosphere but provides no information about the composition of past additions. Analysis of gases trapped by crystallizing magmas, i.e., the gases in rocks, provides information about the volatile components associated with magmas generated up to 3 b.y. ago. Few systematic studies have been made but the available data indicates a trend of increasing gas content with age for carbon gases, inert gases and nitrogen. This has important consequences for theories concerning the origin of the earth's atmosphere. If the entire mantle has been degassing and if crustal material has been derived ultimately from the mantle then the changes in the gas content of crustal rocks with time show that the amounts of nitrogen and carbon dioxide supplied to the earth's surface would be too large by a factor of 10^5. An alternative model, in which mantle material is added to the crust and then further degassed in subsequent remeltings, can be used to calculate the volume of rock which must be degassed to provide the volatiles now at the earth's surface. This model gives 2.6×10^{25} g*for carbon dioxide and 2.1×10^{25}g for nitrogen. These values are in good agreement with each other and with the volume of the crust which is 2.4×10^{25}g. However these are maximum amounts because of the effects of degassing which occurred before the formation of the oldest rocks analyzed. It is concluded that the volatiles now at the earth's surface could have been produced by outgassing a mass of rock equal to, or less than, the mass of the crust. (Author's abstract). (* of rock)

BARSUKOV, V. L., VOLOSOV, A. G., KOZERENKO, S. V., SUSHCHEVSKAYA, T. M., and BARANOVA, N. N., 1970, Scientific basis of geochemical methods of prospecting for deep ore deposits: in Scientific basis for geochemical methods of prospecting for deep ore deposits: Acad. Sci. USSR, Siberian Division, Institute of Geochemistry, Irkutsk, p. 79-98 (in Russian).

(Some decrepitation data on polymetallic deposits, and analyses of ions (Cl, HCO_3, F, S, Cu, Pb, Ag) in solution in inclusions in five samples of quartz from cassiterite deposits. Some of these same sample numbers are listed by Sushchevskaya, 1971, in a different format, with other ions analyzed as well. E.R.)

BARTHOLOMÉ, P., and PIRMOLIN, J., 1970, Fluid inclusions and stratiform mineralization at Kamoto, Western Katanga, Republic of the Congo (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 249.

At Kamoto, copper and cobalt are found as sulfides in two stratiform orebodies. The host rock is dolomite, chert or shale, and is conspicuously laminated. There is no metamorphism and no schistosity. It has been proven that mineralization was emplaced before tectonic deformation.

The two ore bodies are separated by a few meters of a barren dolomitic chert. The texture and structure of this rock will be described in detail, more particularly the chalcedony remnants, the large dolomite crystals which reach several centimeters in size, and the interstitial calcite. The dolomite is ordered.

Fluid inclusions have been found in the large dolomite crystals. Some of them contain a bubble and three daughter minerals; two of these have a cubic morphology and the third one is tabular. The behavior of these inclusions on heating is described. The bubble disappears at 140°C and the last crystal at 240°C. By leaching the crushed dolomite with double distilled water, a solution is obtained where Na:K is about 1.4 and (Na+K):Cl is about 0.4.

The meaning of these data is discussed with regard to the genesis of the ore, especially in the light of the close association between mineralization and sedimentary structures on one hand, of the evidence, presented earlier, for an economically important diagenesis on the other. (Authors' abstract.)

BARTOSHYNSKY, Z. V., GRYGORTCHUK, G. U., SOLOMIN, U. S., and SOLOMINA, T. A., 1970, Gold from the Aleksandrovsk deposit in East

Transbaikal: L'vov. Gos. Univ. Mineralog. Shornik, v. 24, no. 3, p. 322-325 (in Russian).

Most often gold forms irregular crystals, and well-formed crystals are rare. From homogenization of fluid inclusions, this gold-bearing mineral association was formed in the temperature interval of 410°C-260°C, first from gas and then hydrothermal solutions. (Authors' abstract).

BAZAROV, L. Sh., and MOTORINA, I.V., 1970, Study of mineral inclusions by freezing technique, in Problems of petrology and genetic mineralogy, V.S. Sobolev Memorial Volume II: Moscow, "Nauka" Publishing House, pp. 282-292 (in Russian)

Study of the phase transformations observed in the process of freezing of artificial and natural inclusions makes it possible to determine uniquely the solid phase composition in the multi-phase gas/liquid inclusions as well as that of predominant salts in two-phase inclusions and to evaluate concentrations of different unsaturated salts present in the inclusions. It also makes possible a rough estimate of the general salt concentration of solutions in the inclusions. As a diagnostic technique one used incongruent $KCl \cdot H_2O$ at - 6.6°C*, $NaCl \cdot 2H_2O$ at -0°C, $MgCl_2$ at -3.4°C etc. It was established that there are present no nonfreezing inclusions. Methods of suppressing resistance to freezing (metastability) were developed. Necessary and sufficient criteria for the rapid distinguishing between the ice phase (H_2O) and saline phase NaCl, KCl, $CaCl_2$, etc. are established. Four types of solutions are separated as a function of phase composition as well as methods of their investigation (Authors' abstract, modified by E.R.)   * Sic.

BAZAROVA, T.Yu. and KOSTYUK, V.P., 1970, A review of the results of the study of conditions of some alkaline rock formation in Siberian folded areas, in Problems of petrology and genetic mineralogy, Sobolev's Vol. II: Moscow, "Nauka" Publishing House, p. 235-245 (in Russian)

The geological state and composition of Paleozoic (seldom Mesozoic) alkaline rocks, widespread in the old folded belts of Siberia, are presented: Kuznetski Alatau and Minusinsky Basin as well as Tuva, Eastern Sajan, and Sub-Baikal regions.

The data concerning mass determinations of the homogenization temperature of included gases and fluids in the nepheline and other rock forming minerals (650-900°C and higher) are listed; accordingly the pressure, which is determined from the density and composition of solutions in the high-temperature inclusions in the nephelines of a number of alkaline massifs (1350-1470 atm), allow us to consider that these parameters reflect the crystallization conditions of minerals derived from magmatic melt. At the same time, homogenization temperatures for inclusions in nephelines of some alkaline massifs (Kuznetski Alatau) were 400-420°. Therefore, the above evidence suggests strong effect of processes of metasomatism on the formation of such rocks.

In the composition of inclusion cations, Na (8-13 wt. %) noticeably predominated over K, Ca, Si, Al, etc. Among the anions, Cl (3.40-6.40%) predominates over HCO_3, SO_4, and F.

In the gas phase of the primary inclusions CO_2 constitutes 75-97 volumetric %; the remainder is nitrogen and rare gases. (Authors' abstract, modified by ER).

BOCHKAREV, A.I., 1969, On the source of silica in the formation of cavties with crystals in carbonate rocks: Izv. Vyssh. Uchebn. Zav. Geologiya i Razvedka, 1969, no. 10, p. 56-59 (in Russian; translated in Internat. Geol. Review, v. 12, no. 9, p. 1018-1021, 1970).

Quartz crystal deposits are usually found in quartz bearing rocks. There crystal cavities are mainly late relative to quartz-veins, and the source of silica lies in the surrounding rocks (Karyakin 1955-1958).

But in quartz free rocks where is the source of silica? The answer was found in a quartz crystal deposit in dolomitic marble from South Ural.

Geometric relations of cavities to quartz veins show that cavities are late relative to veins. Decrepitometric study demonstrates clearly two generations of quartz: quartz veins giving one peak which begins at 350°C, and transparent crystals from cavities giving one peak which begins at 150/180°C; quartz layers with large grains at the boundary betweeen cavities and veins show both peaks. Chemical analyses were made at different distances from quartz veins and cavities. It appears that the SiO_2 content of the marble increases close to the quartz veins, from 0.6/1.0 to 35/54%, but decreases at the near contact of cavities (down to 13%). So the source of silica for the formation of quartz crystal cavities in carbonates lies in the zone of silification associated with early quartz veins (B. Poty).

BOGOLEPOV, V.G., NAIDENOV, B.M., and POLYVYANNYI, E. Ya., 1970, Isotopic composition of argon of gas-liquid inclusions in Akchatau quartz deposit: Akad. Nauk Kazakh. SSR, Vestnik, v. 26, no. 12, p. 58-60 (in Russian).

Widely different isotopic ratios were determined for argon from two groups of inclusions, one that decrepitated at 280-300°, and another at 400-440°C. (E.R.)

BUZINOVA, V.M., 1970, Relics of fluid channels in salt of the Gaurdak formation: Akad. Nauk SSSR Doklady v. 194, no. 1, p. 153-154; trans. in Doklady Acad. Sci. USSR, Earth Sci. Sect., v. 194, p. 25-27.

Several varieties of trains of gas or liquid plus gas inclusions in halite from Turmenia and Uzbekistan are described and attributed to "compression bands". Some traces of methane were found by gas chromatography. (E.R.)

CARSTENS, Harald, 1968, The lineage structure of quartz crystals: Contr. Mineral. and Petrol. v. 18, 295-304.

Etching and optical methods have been applied to study the lineage structure of quartz crystals from the Swiss Alps. It is shown that lineage boundaries form during growth in crystals of high dislocation density by a rearrangement of dislocations in low angle boundaries. The boundaries usually consist of parallel lines and are supposed to be nearly pure tilt boundaries. (Author's abstract)

CLOCCHIATTI, R., 1970, Study of glass inclusions and their alteration, a regional example from the Dolomites (Bolzano, Italy): Schweiz. Mineralog. Petrog. Mitt. v. 50, pt. 1, p. 159-166, (in French).

The glass inclusions in quartz phenocrysts from Permian porphyries and detrital volcanogenic quartz in Triassic carbonate rocks are of the following types:

1. Single phase glass inclusions. The glass has magmatic rock composition compatible with the total chemistry of the host rock. This has been established by microprobe studies.
2. Similar glass inclusions (also negative, high temperature quartz crystals) with a shrinkage void of 1/10 of the inclusion size.
3. Solid crystalline inclusions: rutile zircon, baddeleyite.
4. Glass alteration products.

The alteration of the included glass depends upon the following factors:

a. age of the inclusions;
b. size, both factors facilitate an auto-devitrification;
c. accessibility of solutions. Lavas with abundant secondary fluid inclusions show frequent devitrification of glass. Rocks more likely to fracture like igneous rocks provide access to altering solutions. More ductile material like the detrital quartz in carbonate rocks shows better preserved glass inclusions (P.J.M. Ypma).

CLOCCHIATTI, R., and TOURAY, J.-C., 1970, Remarques sur la note "Aluminum in quartz as a geothermometer" by W. H. Dennen, W. H. Blackburn, and A. Quesada: Contr. Mineral. and Petrol., v. 27, p. 332-342 (in French).

The proposed geothermometer is very difficult to use, particularly for magmatic quartz, because such quartz always contains aluminous glassy and and crystalline melt inclusions. (Authors' abstract).

COVENY, R.M. and KELLY, W.C., 1970, Quartz as a geologic barometer: Mich. Acad., v. 3, no. 3, p. 45-56.

A review of the possibilities of use of fluid inclusion data and other data to determine pressures of formation. (E.R.)

CZAMANSKE, G. K. and RYE, R. O., 1970, (Calibration of a sulfur isotope geothermometer): U.S. Geol. Survey Prof. Paper 700A, Geological Survey Research, p. A135-136.

A series of hydrothermal coprecipitation experiments were used to establish sulfur-isotope fractionation factors between sphalerite and galena as a function of temperature. As indicated by theoretical calculations and analyses of coexisting mineral pairs, sphalerite preferentially concentrates S^{34}. The applicability of the experimental curve to natural samples was tested on large crystals of sphalerite with included galena from several ore bodies. Filling temperatures of fluid inclusions in various generations of sphalerite range from 225° to 365°C. Maximum discrepancy between filling temperatures and temperatures indicated by δS^{34} values of apparently contemporaneous sphalerite and galena is about 40°C. Where sphalerite and galena precipitated at nearly the same temperature but clearly not contemporaneously, the isotope temperatures do not always agree well with the filling temperatures. (Authors' abstract, shortened)

DASHDAVAA, S., 1970a, Types of inclusions of mineralizing solutions in wolframite and origin of quartz-wolframite veins in the Ikh-Khairkhan deposit (Mongolia): L'vov. Gos. Univ., Mineral. Sbornik, v. 24, no. 2, p. 236-238 (in Russian).

Pseudosecondary inclusions (liquid-vapor) homogenize at 275-340°C and pressures of 600 to 25 atm. (E.R.)

DASHDAVAA, S., 1970b, On tourmaline from quartz pegmatites of Mongolia: L'vov. Gos. Univ. Mineralog. Sbornik, v. 24, no. 3, p. 355-357 (in Russian).

Tourmaline (schorl) crystals from quartz pegmatites of the Dzun-Bain massif contain primary inclusions with a temperature of homogenization of 186-245°C., in the liquid phase. The solutions are characterized by a high content of fluorine. Nine analyses for Na, K, Li, Ca, Mg, HCO_3, CO_3, Cl, F, SO_4 and $HSiO_3$ are presented. (Author's abstract, extended by ER).

DEICHA, G., 1970a, Present development in inclusion research and the problem of their future coordination: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 3-11 , (in French).

A review of inclusion studies indicates progress in the following fields:

1. Technical improvement of methodology and physical and chemical analysis of inclusion content.
2. Expansion into regional studies (with as an example the Alps) and application in igneous and metamorphic petrology.
3. Genesis of host minerals, and its application in geochemistry and geophysics.

Proposals are made to avoid duplication and increase the international cohesion of research by:

1. Establishing information centers on techniques, equipment, and nature of studies of the participating laboratories.
2. Regional inventory of location of inclusion material.

3. Distribution of bibliographic and photographic documentation material. (P.J.M. Ypma).

DEICHA, G., 1970b, The degree of freedom of geochemical solutions in mineralogy; relation between the genesis of mineral phases and fluid inclusions: Schweiz. Mineralog. Petrog. Mitt. v. 50, pt.1, p. 25-35, (in French).

A review article on the role fluid inclusions play in our understanding of the geochemistry of mineral forming solutions, and the physical chemistry of rock formation. Mere observation of inclusions furnishes data on composition, viscosity (Brownian movement), palaeolevels and convection in the inclusions by light-induced thermal gradients. The study of dynamic phase equilibria is facilitated by boiling effects of phases on homogenization, and flow due to concentration differences. The nature of the physical phase boundaries can also be directly observed in fluid inclusions. These data enable reconstruction of movement of fluids in the earth's crust by data on the fluid density and temperature gradients, concentration differences and diffusion rates, and fluid flow data because of inhomogeneity of the entrapped fluids (carrying lighter or heavier particles). (P.J.M. Ypma)

DEICHA, G., 1970c, Crystallogenetic disequilibrium and fluid inclusions, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 239.

The state of perfect equilibrium between free moving geochemical fluids and crystalline matter is an ideal, never fully reached within the Earth's Crust. The importance of a varying degree of supersaturation is particularly evident in the case of ascending hydrothermal or pneumatolytic solutions; fluctuations of undercooling are obvious in erupting magmas.

I. In the laboratory, equilibrium is also sometimes difficult to achieve, but disequilibrium during crystallogenesis is also not easy to bring under full control. A number of experimental data, on crystallization out of artificial melts, as well as out of liquids and gases of various compositions have shown that the gradients of undercooling, or of supersaturation, are the main factors of the diversification during nucleation and growth. The initial habit, as well as habit changes, of individual crystals and the inter- and overgrowth of crystals (such as meta and paragenetic twinning and epitaxy) are affected in the first line (Sixth Internat. Congress for Electron Microscopy, Kyoto, 1966, 481).

Although considered of lesser importance, minor irregularities in the growth topography, sometimes connected to dislocations, also lie under the direct influence of the same crystallogenetic factors. Such superficial departures from the geometric order are responsible for the formation, within the more or less disordered crystalline architecture, of cavities filled up with mother-solution or melt. The calibration, shape, abundance and distribution of such primary inclusions reflect the fluctuations of the physico-chemical disequilibrium during the whole genesis.

II. The results of "in vitro" experiments can be paralleled with "in crystallo" observations dealing with the dimensions, number, morphology and mutual relations of primary fluid and glass inclusions in minerals, gangue and rocks (Colloque des Inclusions, Schweizerische Mineralogische und Petrographische Mitteilungen, 1970, vol. 50). On the other hand, inclusions offer a wide range of possibilities to investigate the thermal behavior of natural magmatic melts, as well as that of hydrothermal and pneumatolytic solutions trapped within the host minerals. From the very start of heating and cooling observations on microscopic inclusions, it appeared that valuable information about the ability of geochemical fluids to remain undercooled, or supersaturated, could be obtained. A number of fluid inclusions specialists (Fluid inclusion Research — Proceedings of C.O.F.F.I., Washington, 1969) have already stressed the wide range of temperatures, or concentrations, attained by crystallogenetic disequilibrium in the "microcosm" of these small cavities.

The problem of the relations between the enclosed mother-liquid and the host-mineral is particularly interesting: combined dissolutions and redepositions of crystalline matter on the walls of the cavities, shape them to "negative crystals". Such recrystallizations affect as well intergranular inclusions (primary and secondary) as intergranular pores. The perfection of the crystallographic habit, toward which such cavities do trend (Fifth Internat. Congress for Electron Microscopy, Philadelphia, 1962, vol. 1, GG4), shows the ultimate possibilities of a near ideal equilibrium in the mineral realm of Nature, but on a reduced scale and involving sealed off geochemical fluids.

De ISEMME, A.H. and WENGER, A., 1970, Superdense water ice: Science, v. 167, p. 44-45.

Ice of density 2.32 ± 0.15 g/cm^2 was formed at very low pressures and temp. < 100K. It is probably amorphous. (ER).

DEMIN, Y., 1970, Structure of the aureoles of evaporation around the ore bodies of some polymetallic ore deposits of Rudni Altai (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 256.

In spite of the fact that the possibility of the utilization of the methods of study of the gaseous-liquid inclusions during the searching of hydrothermal ore deposits were shown by N.P. Ermakov already in 1954, the methods of study and characteristics of the structure of the aureoles of evaporation around ore bodies are insufficiently worked out to this day.

The aureoles of evaporation on three polymetallic ore deposits of the Rudni Altai (Tyshinski, Starkovski, and Strejhanksi) were studied. The traditional decrepitational investigations were followed by the study of homogenization of the inclusions and of the geochemical characteristics of area of the development of aureole of evaporation, which included the study of behaviour of the main rock-forming and ore-forming elements. The main results of the investigations carried out by us are as follows:

1) invisible aureoles of evaporation, exceeding 7-8 times the width of ore bodies, surround all the ore deposits;

2) aureoles of evaporation of simple morphology, developed around ore bodies, are almost symmetrical and are characterised by clear zonal structure, which is revealed by a gradual drop in decrepitational activity and a decrease of decrepitation and homogenization temperature gradients along the direction from the ore bodies to the aureoles. The structure of aureoles around the complex ore bodies are complicated, but the general behaviour of temperature gradient and decrepitational activity are preserved;

3) a close relation between the width of aureole and physical-mechanical properties of wall rocks, especially the effective porosity, is determined;

4) SiO_2, TiO_2, CaO, and Na_2O are taken out of the zone of the aureole of evaporation, whereas Al_2O_3, MgO, and K_2O are added. The iron oxides are removed on the edges of the aureoles, whereas they are collected on the central part;

5) the decrepitation intensity and decrepitation temperature are in positive correlation with the content of Cu, Pb, Zn, Ba and in negative correlation with Ni, Co, V, Ti, As. (Author's abstract.) (Editor's note: this abstract may contain typographical errors, as the original printing was partly illegible.)

DERJAGUIN, B.V., 1970, Superdense water: Sci. American, v.223, p. 52-71.

A popular account of experiments concerning preparation and properties of "anomalous water". (that may also occur in fluid inclusions) (ER). (See also "Deryagin")

DERYAGIN, B.V. and CHURAYEV, N.V., 1968, Do we know water?: Priroda (Nature), 1968, no. 4, p. 16-22 (in Russian); translated under title "Phenomenon of anomalous water described", by U.S. Joint Pubs. Research Service, Dept. of Commerce, JPRS 45,989, July 25, 1968, 14p.

An excellent summary of the Russian work on the preparation and properties of anomalous water, and the evidence for its occurrence, of possible pertinence to inclusion cryometry (ER).

DMITRIEV, S. D., 1970, Reliability of methods for studying mineralizing solutions and pneumatolytic mineralization; Izv. Vyssh. Ucheb. Zaved., Geol. Razved 1970, v. 13, no. 4, p. 81-86 (in Russian). CA 72(12)116(1970).

Two types of homogenization of aq. and gas inclusions in minerals exist, according to Ermakov (1966). The 1st, typical of essentially liq. inclusions, suggests (according to E.) a hydrothermal (aq) origin for the mineral. The 2nd, typical of gas-liq. inclusions, indicates formation of the mineral in a gaseous medium. This interpretation is based on the assumption of the homogeneity of the soln., during mineralization, with the soln. considered as a liq. in the 1st type and as supercrit. steam in the 2nd. The interpretation, however, contains 2 errors: (1) homogenous gas solns. in inclusions, homogenizing according to the 2nd type, are not supercrit. steam possessing crit. parameters ($t_c \geqslant 374.2°$ and $p_c \geq 218.2$ atm) because homogeneous gas soln. can exist at any temp. depending on the pressure and (2) gas-liq. inclusions of the 2nd type can form from heterogeneous solns. In addn. the pH of gas-liq. inclusions is usually detd. at room temp. without consideration for the fact that pH of soln. depends on the temp. and pressure.

DOLGOV, Yu. A., 1970a, Inclusions in the metamorphic rock minerals as indicated by conditions of metamorphism, in Problems of petrology and genetic mineralogy, V.S. Sobolev Memorial Volume II: Moscow, "Nauka" Publishing House, p. 272-281.(in Russian with English abstract)

Use of high resolution microscopy made it possible to find inclusions in minerals of metamorphic origin. Inclusions are high density liquids of aqueous salt brine solution or CO_2 (carbonic acid). Inclusions were also found consisting of two immiscible liquids (aqueous brine solutions - CO_2) as well as containing solid phase. The characteristic feature of such inclusions is the lack of gas bubbles. CO_2 densities of inclusions in kyanite were determined by the cryometric method. CO_2 density agrees with temperatures and pressures characteristic of almandine garnet from amphibole metamorphic facies. Beryl andalusite, sillimanite and quartz were studied in similar way. The new type of inclusions and the suggested methods of investigation may be used to evaluate conditions of the origin metamorphic and metamorphogenic deposits (Author's abstract).

DOLGOV, Yu. A., 1970b, Deep intrusions and ore veins connected with them (abst.), in Problems of hydrothermal ore deposition, Z. Pouba and M. Stemprok, eds.: Internat. Union of Geolog. Sciences, Series A, no. 2, p. 60-61 (in English).

Temperatures alone, as a result of the homogenization of the inclusions in minerals of ore veins, cannot serve as a basis for the extrapolation of the depth of formation (Dolgov, 1965).

A method of determining pressure (Bakumenko, Dolgov, and Bazarov) was used in studying inclusions of granites and pegmatites. Temperature, pressure and aggregate state of homogeneous solutions have been determined. For quartz from the block zone of pegmatite (body 1) the depth of formation with a lithostatic pressure of 1390 atm. is 6400 m. For the earliest cavity quartz the pressure is 640 atm. and depth is 6020 m. For pegmatite (body 2) from the same intrusion, the difference is greater. Other data for T and P are presented in a table (Bazarov, 1965). At a depth of about 6000 m, the aggregate state was gaseous but the density was very near to critical.

A second case refers to coarse-grained (pegmatoid) nepheline syenites. Using a high-temperature method of studying inclusions (Dolgov & Bazarov, 1965), a thermometric analysis of the inclusions in nepheline was made (Kerkis & Kostyuk, 1963). Results obtained were T = 840°, P = 1750 atm., depth = 7500 m. Temperature of formation is somewhat higher. Inversion of nepheline occurred at 850°. Temperature of inclusions is 840°. According to the paleogradient nepheline syenites had no pneumatolytic stage.

For hydrothermal ores the depth of formation can be extrapolated in terms of hydrostatic pressure. For granite pegmatites Bazarov determined temperatures of homogenization and pressures. For fluorite the range is 460°-220°C and 400 to 30 atm. Fluorite in hydrothermal conditions therefore was formed at 4000 m to 300m. (Author's abstract.)

DOLGOV, Yu.A., POGREBNYAK, Yu.F. and SHUGUROVA, N.A., 1969, Composition and pressure of gases in inclusions in tektites: Geokhimiya, 1969, no. 5, p. 603-609 (in Russian; translated in Geochem. Internat., v. 6, no. 3, p. 525-531, 1969).

The composition of gases in inclusions of various tektites: moldavites, indochinites, philippinites, and australites, has been analyzed and the presssures of the gases determined. It is shown that very low pressures in gaseous inclusions of tektites may be the result both of their formation at pressures below 1 atm and of a rapid cooling of the tektite material. A conclusion is made about the small changes of compositions and pressures of gases in inclusions of tektites since their formation (Authors; abstract).

DOLIDZE, I.D., 1970, Temperature conditions of formation of the Adzharian district copper-polymetallic deposits: Akad. Nauk Gruz. SSR Soobshch, v. 60, no. 2, p. 373-376 (in Russian).

Homogenization studies on a large number of inclusions (mainly in quartz and sphalerite) show a range of temperatures from 280 to 60°C. Each of three stages of mineralization start at a (decreasingly) high temperature, which drops with continued crystallization. (E.R.)

DOLIDZE, I.D., and GABICHVADZE, A.A., 1970, Chemical composition of the mineral forming solutions at the Adzharian district copper-polymetallic deposits: Akad. Nauk Gruz, SSR Soobshch., v. 60, no. 3, p. 621-624 (in Russian).

Aqueous extraction and analysis were made of inclusion fluids from crushed samples of various gangue minerals. (E.R.)

DOLOMANOVA, E.I., ELINSON, M.M., GASOIAN, M.S., and KOROLEV, N.V., 1970, New data on hydrothermal quartz in ore deposits of Transbaikal area (abst.), <u>in</u> Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 262.

A study of the physical properties of quartz and of the composition of gaseous-liquid inclusions in this mineral enabled us to establish the following regularities:

In the gas phase CO_2, H_2, N_2, and, on rare occasions, CH_4 and O_2 have been found. Gas saturation is greater in high-temperature quartz than in low-temperature varieties. It is higher in quartz that forms vein selvages and in quartz crystals from cavities than in other parts of the veins. The gas saturation of quartz changes along the strike and dip of the veins. It drops in intensely broken up quartz. The composition of gas and its saturation depend upon the composition and physical properties of the vein-enclosing rocks, upon the sequence of quartz crystallization, upon the temperature and pressure under which crystallization is taking place. Quartz of different deposits differs by the H_2/CO_2 ratio, which indicates different conditions of its formation.

In the liquid phase of gaseous-liquid inclusions the emmission microspectral analysis determined: Cl, B, S, CN, C, K, Na, Li, Si, Al, Ca, Mg, Ti, Fe, Cr, Ni, Zn, Sn, Pb, Ag. The amount of the liquid phase in quartz increases with a drop in the temperature of its formation.

The composition of gaseous-liquid inclusions changes substantially depending upon the rocks in which the vein formation is taking place and how intense the interactions between the hydrothermal solution and the enclosing rocks have been. The solutions enclosed in the vacuoles of quartz reflect the composition of hydrothermal solutions, from which metalliferous veins were formed and the local changes in the compositions of these solutions in an interaction with enclosing rocks.

For the first time by the use of infra-red spectroscopic methods ways have been worked out to determine quartz subjected to an inversion (β-modification) in hydrothermal granular vein aggregates of quartz. It has been established that at some deposits the hydrothermal process began at a temperature higher than the inversion temperature of quartz (> 573°C). (Authors' abstract.)

DOLOMANOVA, E.I., GASOYAN, M.S., RUDNITSKAYA, E.S. TYUTNEVA, G.K., and USPENSKAYA, A.B., 1970, Possibility of using the method of infra-red spectroscopy for the determination of temperatures of formation of massive vein quartz: Akad. Nauk SSSR Doklady, v. 192, no. 1, p. 155- 158 (in Russian); translated in Doklady Acad. Sci. USSR, Earth Sci. Sects., v. 192, p. 88-90, 1970 (published 1971).

Variations in the IR absorption spectra appear in the $3 \mu m$ region. Gas-liquid inclusions did not affect the absorption intensity but did modify it by spreading out the individual peaks. The spectra are recognizably different for different samples, and may be categorized into four different temperature-geologic occurrence groups (and hence might be used in connection with fluid inclusion studies, E.R.).

DOLOMANOVA, E.I., KOROLEV, N.V. and RYUKHIN, V.V., 1969, Microspectral determination of the composition of gas-liquid inclusions in quartz: Akad. Nauk SSSRm Izvestia, Seriya Geol., 1969, no. 87, p. 72-84 (in Russian).

Description of a qualitative to semiqualitative method, using emission spectrography for the analysis of leachates of fluid inclusions. Two small amounts of quartz are crushed and leached in 0.1 cm^3 double distilled water and, when dried, are transported to two copper electrodes. The spectrum is taken in the range 440 to 880 nm (visual grating spectroscopy).

29 samples of quartz were studied for 16 elements: Cl, F, B, S, Na, K, Ca, Mg, Al, Be, Fe, Cr, Mn, Ni, Ga, Sn. The samples came from:
pegmatites of the Adun-Tcholon deposit;
Sherlovaia Gora deposit (cassiterite, quartz, sulfides-type);
Zun-Undur deposit (wolframite, cassiterite, quartz-type); and
Ozernoe (Moscow region).

Results are tabulated in five categories as follows: abundant, present, small amount, traces, not detected. (the limit of the method is 10^{-9} gm). Cl is frequent; F is rare, found only in the early stages of mineralization; B and S are frequent in the late stages of mineralization; Na was usually detected except when CO_2 is abundant or inclusions are essentially gaseous; K is somewhat rarer, sometimes lacking in low temperature quartz veins; Ca and Mg are usual and abundant; Al is frequent, Be found only when Be minerals are present, Fe, Cr, Mn, are usual; and Sn was found only in the early stages of mineralization. (B. Poty).

DUNIN-BARKOVSKAYA, E.A., GOLOVANOV, I.M., and POLYKOVSKII, V.S., 1970, Temperature conditions of quartz vein formation with bismuth and copper mineralization in the Chatkal-Kurama Mountains: Uzb. Otd. Vses. Mineral. Obshchest. Zap., 1970, No. 23, p. 86-96 (in Russian). CA 75 (10) 105 (1971).

Cu and Bi-bearing quartz veins occur in the Chatkal-Kurama sulfide deposit, ranging from high-temp. Bi-contg. quartz-scheelite and quartz molybdenite veins to low-temp. quartz-Cu veins. Decrepitation data: chalcopyrite-bismuthinite (200-700°), quartz-fluorite-bismuthinite (200-500°), quartz-Au-tetradymite (200-500°), quartz-scheelite-bismuthinite (270-450°), quartz-carbonate-chalcopyrite (200-490°), and quartz-bismuthinite-chalcopyrite-hematite (250-380°). The total decrepitation activity in ore-bearing veins increases with depth. Exptl. data show that the compn. of the country rocks (granites, andesite, porphyries) does not affect the decrepitation pattern of quartz.

EL GHOZI, T., 1970, Simplified method for the preparation of material for rapid investigation of fluid inclusions: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 81-83 (in French).

The fact that many minerals produce smooth and flat cleavage or fracture fragments can be used to investigate for fluid inclusions without polishing or immersion media (P.J.M. Ypma)

ELINSON, M.M., 1970a, To the geochemistry of a gas phase, contained in inclusions of some minerals (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 264.

The choice of research methods on the gas phase of inclusions in minerals depends upon the nature of purpose, for which the study is made upon the needed detailization. When it is necessary to obtain a complete and detailed composition of gas components, including He and Ar determinations - a bulk analysis of a great number of incluions is used. In this case the samples should be correspondingly selected to establish an average gas composition from primary inclusions.

Research on the distribution of separate gases (CO_2, H_2S, O_2, H_2, CO and heavy hydrocarbons) within a mineral by relatively large inclusions (0.01 mm) is advisable by the method of studying individual inclusions.

In determining the direction of the process it is possible to use only the characteristic ratios of such gases as $\frac{H_2}{CO_2}$, $\frac{H_2}{He}$, $\frac{N_2}{Ar}$ and then no greater detailization of the analyses is needed, but it is necessary to obtain characteristic mean data on the composition of these gases, which can be done by 2-4 analyses of bulk samples of typical rocks or a study of 10-20 primary gaseous-liquid inclusions of a varying size for each typical sample.

The following components have been determined in the gas extracted from gaseous-liquid inclusions of different hydrothermal rocks by grinding samples with varying sizes of inclusions: H_2, CO_2, H_2, O_2, CO, CH_4, N_2, Ar, He, heavy hydrocarbons, sulfur-organic and fluoride-bearing compounds of boron and chlorine. Some gases (CO_2, H_2, N_2, Ar, He a. oth.) are, apparently, syngenetically associated with mineral-forming melts-solutions, while other gases are, possibly, of a secondary origin. In gases of individual inclusions exceeding 50 (µ?) acid gases, O_2, CO, heavy hydrocarbons, rarely hydrogen and an inert residue (N_2+Ar+He) have been found.

A low frequency of hydrogen occurrence in such investigations indicates, probably, its occurrence in inclusions lesser than 50 (µm?) big.

Preliminary data have been obtained on the effect on the composition of gas extracted from inclusions of various geological and geochemical factors, like texture of the mineral body, composition and permeability of enclosing rocks, etc. (Author's abstract.)

ELINSON, M.M., 1970b, The problem of zonation in the light of new data about the gaseous composition of solutions, taking part in formation of greisens and quartz-wolframite veins of West Tien Shan (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 258.

According to investigation of one of West Tien Shan's regions peculiarities of the local endogenic zoning of greisens and quartz wolframite veining, whose formation is connected with the concluding stage of forming Permotriassic igneous complex in Maidantal are characterized.

Nature of zonation of greisens and quartz wolframite veins is conditioned by pneumatolitic hydrothermal solutions, whose gaseous composition's study witness about the following:

The predominant components of gaseous phase of pneumatolitic hydrothermal solutions are hydrogen, nitrogen and carbonic-acid gas, hydrocarbonic gases, carbonic oxide, helium and argon are not discovered in gaseous phase of solutions.

Gaseous components of high-temperature pneumatolitic hydrothermal solutions of the early stage of greisenization took an active part in metasomatic alterations of enclosing granite.

Low-gaseous saturation of greisens can be caused by transition of some gases (hydrogen) from pneumatolitic hydrothermal solutions to mineral composition of greisen facies and by peculiar conditions of forming matters.

Pneumatolitic hydrothermal solutions of the young stage of forming greisens, which took part in formation of quartz-reefs with wolfram mineralization, had heightened gaseous saturation.

Nitrogen and hydrogen prevailed in composition of gaseous components, taking part in forming rocks of low horizons of quartz greisen bodies and hydrogen and carbonic-acid gas - in upper horizons.

Total gaseous saturation of rocks of lower wall of quartz greisen bodies is higher than gaseous saturation of hanging wall.

Peculiarities of local zonation exposed in process of study of physicogeochemical conditions of forming greisens and quartz wolfram veining have important significance for search of latent endogenic mineralization in West Tien Shan. (Author's abstract.)

ELINSON, M.M. POLYKOVSKIY, V.S. and SHUVALOV, V.B., 1969, Composition of the gas phase in solutions which formed maydantal greisen and quartz-tungsten veins: Geokhimiya, 1969, no. 5, p. 571-581 (in Russian; translated in Geochem. Internat., v. 6, no. 3, p. 493-503, 1969).

The composition of gases and its change during the formation of a quartz vein with wolframite mineralization under conditions of granite greisenization is considered. The main gas components, H_2, CO_2, and N_2, are connected with the mineral-forming solution and take part in the greisenization process. It has been established that earlier solutions contain ed more gas and that hydrogen penetrates into country rock to a greater extent than CO_2 and N_2. The data obtained widen our ideas about the geochemistry of the greisenization process. (Authors' abstract, edited E.R.).

ELLIS, A.J., 1970, Quantitative interpretation of chemical characteristics of hydrothermal systems: Geothermics (1970) - Special Issue 2, U.N. Symposium on the development and utilization of geothermal resources, Pisa 1970, v. 2, pt. 1, p. 516-528.

A review (44 references) of the surprisingly extensive quantitative data on natural and laboratory hydrothermal systems, the equilibria controlling the composition of the fluids, and the relationships to ore fluid (and fluid inclusion) composition. (E.R.)

EPPLER, W.F., 1970, The German journal "Goldschmiede Zeitung" publishes more or less regular short communications under the title "Das Edelsteinbild - eine Bildfolge interessanter Edelstein-Mikroaufnahmen", a suite of interesting gem microphotographs about solid and fluid inclusions, by W.F. Eppler. In 1969/70 the following titles appeared: Wachstunsröhren (growthtubes) in natural and synthetic aquamarines and emeralds, 3/69, p. 211; Flüsspat (pictures of fluid inclusions in fluorite), 4/69, p. 347; Sonderbare Einschlüsse (strange inclusions in gems produced by the immersion oils. Separate title) 9/70, p. 1043-44; Ein Heilungsriss im Alexandrit (a healing-fissure in alexandrite) 9/70, p. 1045 and 10/1211; Regen, Nägel, Eis und Schnee im Aquamarin (different forms of tube inclusions in aquamarines) 11/70, p. 1333; Amethyst und Rosa-Beryll mit "Tigerstreifung" (amethyst and pink beryl with "tiger stripes")

12/1471, p. 1471. (P.J.M. Ypma).

ERMAKOV, N.P., 1970a, Correlation of stages of veined oreformation and alterations of host rocks (as indicated by gas-liquid inclusions), (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 240. (Transliterated Yermakov in original)

For the complex polygenetic ore deposits and ore-fields on the ground of investigations of melt and solution inclusions in minerals and ores we have suggested (1950, 1957) the following division of hypoendogenetic ore process in time and space.

The period of perimagmatic activity characterizes all mineral associations found in the ore deposits as connected with the derivatives from an intrusion of definite age. An etap of ore-formation expresses itself within the period in the action of the solutions pertaining to the aggregate state; supercritical fluids correspond to the pneumatolytic etap and aqueous solutions to hydrothermal. The stage of mineralization only characterized within the etap certain differences in the physico - chemical parameters of the changing ore-forming medium as well as the discontinuity of the process, usually ascribed to intra ore adjustments. The level of mineralization, being a part of the stage is traced by relatively small pulsations and changes in P-T-C of chemistry.

The periods, etaps, stages and levels may be orebearing or barren of ore, but all of them are accompanied by characteriztic rock alterations, with took place under the action of melts and their different gaseous and liquid derivatives.

The levels of mineralization in ore bodies and wall rocks can be ascertained only with the help of elaborate mineralogical and microthermometrical investigations of gas - liquid inclusions of the solutions.

Under the guidance of the author complex deposits of different genetic types were studied. With the help of R.W. Kcholmsky (1965) and L. I. Koltun (1957) materials on some gold-bearing deposits: Kluchy in Zabajcalie, Beresowskoje and Kochcar in the Urals, were collected and studied. Similar to the polystaging process of endogenic formation of ore deposits for the wall rocks, we distinguish periods, etaps; stages and levels of pneumatolytic - hydrothermal transformation syngenetic with mineralization. They are ascertained with the help of careful geologic-mineralogic study and comparison of ore-paragenesis and altered rocks and parallel thermometric investigation of gas-liquid inclusions of oreformation and mineral forming solutions. It is necessary to differentiate and prove with the help of these methods the relation of discrete metasomatic alteration of rocks to the different etaps and stages of the mineralization process, since many of these changes have no direct connection with crystallization of ore veins. The most intensive and seemingly characteristic wallrock alterations are related to the preore stages of the process while their most widespread development is connected with the non-metalliferous pneumatolytic exhalation, steaming of rocks. The phenomenon of beresitization is a complex, mainly preore, process of regular changing of granitoid rocks in time; albitization, silification, tourmalinization, sericitization, and pyritization, of which the latter, together with late silification, and carbonization is synchronous with the formation of low temperature hydrothermal gold bearing veins in the Beresowskoje deposit and in a number of other deposits.

ERMAKOV, N.P., 1970b, The stages of ore formation, rock alteration, and beresitisation phenomenon, in Problems of petrology and genetic mineralogy, V.S. Sobolev Memorial Volume II: Moscow, "Nauka" Publishing House, p. 229-234 (in Russian with English abstract).

The periods, stages and steps of pneumatolitic hydrothermal transformations which are synchronous to mineralization are distinguised in the multi-stage process of endogenous ore deposits formation and in country rocks. They can only be recognized by careful geologic and mineralogical study as well as by parallel thermometric investigations of the gas-liquid inclusions of ore-forming and mineral-forming solutions. These methods are used to distinguish and to prove the connection between some metasomatic rock alterations and some definite stages of the mineralization process, because many of these processes have no direct connection with vein ore bodies' crystallization. Most intensive near-ore alterations often belong to pre-ore stage processes. Their wide regional distribution is not caused by ore-bearing pneumatolytic vapors in the rocks. The beresitization phenomenon is mainly a pre-ore process which took place at the same time as pyritization, late silification and carbonatization (Author's abstract, modified by ER).

ERMAKOV, N. P., BOGOYAVLENSKAYA, I. V., and MEL'NIKOV, F. P., 1970, History of the use of inclusions of mineral-forming media in the development of the theory of endogenous ore-formation (abst.): in History of concepts on mineral deposits, Int. Symp., Sum. Pap. p. 162-165, Int. Comm. Hist. Geol. Sci., Freiberg.

ERMAKOV, N.P. and DOLGOV, Yu.A., 1970, The future of applying mineralogical thermobarometry to the solution of petrological problems: Akad. Nauk SSSR Izvestia, 1970, no. 5, p. 48-57 (in Russian).

A review with two tables (31 references) of the published literature on the temperatures of homogenization of magmatic melt inclusions (range 600 to 1400°C) and of the composition of the gas in the bubbles in these inclusions (E.R.).

ERMAKOV, N. P., et al. (ed.), 1968a, Mineralogical Thermometry and Barometry, vol. 2, New methods and results of study of the parameters of ore formation: Moscow, Izd. Nauka, 310 pp. (in Russian).

The individual papers from this volume have been entered under the individual authors' names.

ERMAKOV, N. P., et al., 1968b, Second All-Union Conference on geothermometry-geobarometry and inclusions of ore-forming solutions in minerals; Summary and resolution of concluding session: Mineralogical Thermometry and Barometry, vol. 2, p. 296-307, Moscow, Izd. Nauka (in Russian)

FISCHER, J.F., 1970, Fluid inclusions, uralitization and grain size, Carbon River stock, Washington (abst.): Geol. Soc. Amer., Abstracts with Programs, v.2, no.2, p. 91-92.

The Carbon River stock is a small granodiorite body almost seven square miles in extent, located along the northwestern boundary of Mount Rainier National Park, Washington. Three petrographic features of this hypabyssal stock show a rough correlation. These are grain size of groundmass minerals, degree of uralitization of intratelluric augite and hypersthene crystals, and concentration of inclusions in quartz.

The grain size of the groundmass minerals does not bear a consistent relationship with the margins. Variations within single outcrops can be pronounced, suggesting that cooling rate may not have been a controlling factor. The uralite is of two forms. Augite produces colorless single crystal amphibole pseudomorphs which apparently replace the former pyroxene in a cell-by-cell process. Hypersthene alters to a colorless fibrous amphibole mass with slightly higher birefringence than the single crystals. The finest-grained rock studied has minimal formation of uralite. Coarser-grained rocks have higher degrees of uralitization. Concentrations of fluid and glassy inclusions in quartz grains follow the previous two trends. The finest-grained rock has 2×10^3 inclusions per cubic centimeter in quartz; the highest concentrations, 2×10^5 inclusions per cubic centimeter of quartz, occurs in the coarsest-grained rocks. The correlation of these factors suggests that 1) volatiles were not evenly distributed in the magma; 2) volatile content was the most important single factor in influencing magmatic crystallization; 3) uralitization was caused by the volatiles inherent in a given volume of rock, not volatiles which were "passing through". (Author's abstract).

FRIEDLAENDER, C.G.I., 1970a, Brownian movement in quartz, an attempt at quantitative evaluation; Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 13-20.

Evaluation of a movie film of the movement of a gas bubble in a liquid inclusion in quartz from Dunbrack Prospect, Musquodoboit River, Halifax County, Nova Scotia, resulted in the tentative determination of the viscosity of the liquid.(Author's abstract).

FRIEDLAENDER, C.G.I., 1970b, Brownian movement in liquid inclusions in quartz: some quantitative observations; Canadian Mineralogist, v. 10, pt. 2, p. 272-274.

The viscosity of the liquid in an inclusion in quartz from Dunbrack Prospect, Musquodoboit River, Halifax County, Nova Scotia, has been tentatively calculated based on the evaluation of a movie film of Brownian movement of a gas bubble. (Author's abstract).

GAVRILYUK, P.S., et.al., 1970, Temperature formation canditions of barite veins in the BashkisHlag deposit, Lesser Caucasus: Akad. Nauk Azerb. SSR, Izv., Ser. Nauk Zemle 1970, no. 5, p. 25-32 (in Russian). CA 75 (4) 137 (1971).

The Bashkishlag deposit is located in anticlinally folded volcanic-sedimentary rocks and intruded by subvolcanic intrusions and basic dikes. The barite-complex ore veins, 0.2-0.6 m thick,contain barite, quartz, calcite, pyrite, chalcopyrite, sphalerite, galena, bornite, and tetrahedrite. Decrepitometric and homogenization studies of gas-liq. inclusions in barite indicate that the veins were formed from hydrothermal solns. in a wide range of temp. (500-480° to 80°). The barite veins were aligned in a vertical temp. zoning caused by the decreasing temp. of solns. during their upward ascent. The vein deposit was formed under subsurface conditions.

GIGASHVILI, G. M., 1969, See Translations Section

GIGASHVILI, G. M., 1970, Thermodynamic conditions of metasomatic formation of siderite in Volhyn pegmatites: L'vov. Gos. Univ. Mineralog. Sbornik, v. 24, no. 3, p. 346-347 (in Russian).

Data on the temperature (280°-290°C), pressure (280 ± 20 atm) and phase state of solutions (boiling carbonic-water acid solutions) are given. These conditions lead to a metasomatic replacement of lithium-ferrogeneous biotite by hydromica and siderite. (Author's abstract)

GORNITZ, V. M., 1969, Mineralization, alteration and mechanism of emplacement, orphan ore deposit, Grand Canyon, Arizona (abst.): PhD dissertation, Columbia Univ., 196 pp.; Dissertation Abst. Intern., Sect B, Sci. and Eng., v. 30, no. 4, p. 1753B

The Orphan Mine uranium orebody occurs in a nearly circular, vertical pipe structure, about 350 feet in diameter, which penetrates Permian strata in the Grand Canyon, Arizona.

Uranium ore is concentrated along the pipe margins and also within the pipe. Primary metallic minerals include uraninite, chalcopyrite, bornite, chalcocite, tennantite, pyrite, and lesser amounts of sphalerite, galena, and rammelsbergite, in a zoned sequence.

Temperatures of formation determined by fluid inclusion thermometry of calcite range from 60 to 110°C. The estimated minimum temperature from burial of the sediments and the geothermal gradient is 58 ± 5°C.

U/Pb ages show that the uranium is much younger than the enclosing rocks. Sulfur isotope ratios are enriched in S^{32} over S^{34}. Although the pipe structure, ore distribution and mineralogy suggest an origin from ascending hydrothermal solutions, the lack of a nearby igneous source of appropriate age, apparent low temperature conditions and sulfur isotopes enriched in S^{32}, which imply bacterial reduction of sulfate, would make a direct magmatic hydrothermal origin unlikely. The ore solutions may have been derived from a distant hydrothermal source, and then have mingled with ground water. (Author's abstract, shortened).

GOVOROV, I.N., 1970, Thermodynamics of aluminosilicate rock greisenization, in Ocherki Fiz.-Khim. Petrologii, v. 1970, no. 2, ed. by V.A. Zharikov: Moscow, "Nauka" Press, pp. 15-27 (in Russian).

Geothermometric and thermobarometric studies of the greisenization of aluminosilicate rocks in pneumatolytic deposits are made. Gas-liquid inclusions in the greisen and quartz-vein minerals are composed of Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, and F^- ions. The greisen minerals include topaz, tourmaline, fluorite, andalusite, pyrophyllite, and cassiterite. Greisenization is accompanied by the addn. and removal of certain elements. Stability fields of topaz, muscovite, biotite, and tourmaline are calcd., under different pressure-temp. conditions (Chem. Abstracts).

GOVOROV, I. N., FLIPPOVA, T. G., EFIMOVA, M. I., et al, (3), 1970, Geochemical types and depth parameters of Far East ore-bearing hydrotherms (from data on gas-liquid inclusions in minerals): Vop. Geol., Geokhim, Metallogen. Sev.-Zapad. Sekt. Tikhookean. Poyasa, Mater. Nauch. Sess. 1969 (Pub. 1970) p218-224 (in Russian). Edited by Govorov. I. N., Dal'nevost. Geol. Inst.: Vladivostok, USSR. CA 75 (7) 80 (1971).

Two geochem. series of ore-bearing hydrothermal solns. were sepd., from data on gas-liq. inclusions in minerals: (1) alkali-halogen granitogenic and (2) alk. earth-S related to granites of elevated basicity, intermediate magma, and solns. of deep-seated and vadose origin. The 1st series contain 3 geochem. types of hydrothermal solns: alkali-halogen-bicarbonate (albitite-greisen formation), Na chloride (quartz vein-greisen and cassiterite-silicate formations), and alk.-F (apogranite fluoride greisens). The 2nd series contains 4 types: (1) Ca-Na-S-bicarbonate (cassiterite quartz veins of sulfide formation, skarn-sulfide-scheelite, quartz-scheelite, and Au-quartz-formations), (2) Ca-Mg-bicarbonate-S (Sn-sulfide ores), (3) Ca-S-bicarbonate (skarn-galena-sphalerite formation), and (4) alk.-Mg-Ca-S-halogen (skarn-greisen-sulfide formation). Contrary to greisen and cassiterite-silicate formations, related to the 1st series of the hydrothermal solns., the cassiterite-sulfide deposits are related genetically to more deep-seated intrusions of granodiorite-tonalite or diorite-monzonite compns. providing the residual hydrothermal solns. of cassiterite-quartz stage with an elevated concn. of S compds. and lower content of halogens.

GROVES, D.I., SOLOMON, M., and RAFTER, T.A., 1970, Sulfur isotope fractionation and fluid inclusion studies at the Rex Hill Mine, Tasmania: Econ. Geol., v. 65, p. 459-469.

Fluid inclusion studies on quartz and fluorite from the Rex Hill orebody indicate that they were deposited from aqueous solutions of variable salinity and relatively high K/Na and Li/Na ratios. Corrected filling temperatures of the inclusions (assuming a pressure of 300 atmospheres) indicate that the formation of quartz and fluorite varied from about 260° to 410°C with most deposition occurring between 330° and 350°C.

Fractionation of S^{32} and S^{34} between coexisting sphalerite and galena, which are intimately intergrown with the quartz and fluorite, is relatively uniform. This confirms that there was no marked departure from equilibrium during their deposition, thus supporting independent evidence of textural equilibrium. Fractionation factors from coexisting galena-sphalerite pairs indicate a general range of temperature of deposition from 335° to 460°C with a mean of 392°C. This temperature is at least 50° higher than that expected from the fluid inclusion studies although the temperature ranges do overlap.

The FeS contents of sphalerites show no correlation with their formation temperatures indicated by isotope fractionation, and their erratic compositions are consistent with the textural disequilibrium they display with respect to pyrite. The compositions of arsenopyrites are broadly compatible with the temperature ranges indicated by fluid inclusion data and isotope fractionation. Authors' abstract.

GUBELIN, E., 1969, On the nature of mineral inclusions in gemstones (Pt. 1): Gems and Gemology, v. 13, no. 2, p. 42-56;(Pt. 2) ibid, no. 3, p. 74-88.

A fairly extensive review (49 references) of the various types of solid inclusions in gemstones and their identification, with 80 excellent color photographs.(E.R.).

GUNTHER, R. T., 1939, Dr. William Thompsen, F.R.S., a forgotten English mineralogist, 1761-c 1806: Nature, v. 143, p. 667-668.

Of historical interest, in that Gunther found that Thompson proved the presence of "naphtha" droplets in quartz crystals from Tuscan and other localities, by grinding the inclusions open with an emery wheel. (E.R.)

GUROVA, E. P. and VAL'TER, A. A., 1968, On formation temperatures of fluorite from Lower Cambrian sandstones of Podolia: Geologiya Rudnykh Mestorozhdenii, v. 10, no. 2, p. 84-86 (in Russian). Homogenization temperatues were measured; most were <200°C. (E.R.)

HAAS, J. L., Jr., 1970a, The effect of salinity on the maximum thermal gradient of a hydrothermal system at hydrostatic pressure and near boiling (abst.): Amer. Geophy. Union Trans. (EOS), v. 51, no. 4, p. 453.

The effect was determined to 325°C and 28.4 wt. % salts by approximating the natural brines with data for density and vapor pressure of NaCl solutions. In a truly open hydrothermal vein system having fluid at constant salinity, the nearest approach of the 200°, 250°, and 300° isotherms to the ground water table (p=1 atm) is given below. If salinity varies, the nearest approach is fixed by the thickness of each nearly isochemical layer and the interface temperature.

Wt. per cent Salts (as NaCl)	0.0	5.0	10.0	15.0	20.0	25.0
Depth, 200° isotherm (ft)	530	492	455	419	381	342
Depth, 250°isotherm (ft)	1505	1390	1280	1175	1070	965
Depth, 300°isotherm (ft)	3550	3245	2970	2705	2455	2205

Convection in an isochemical system leads to geysers. Dissolved volatiles more strongly affect pressure than density, lowering the above gradients (Author's abstract).

HAAS, J.L., Jr., 1970b, An equation for the density of vapor-saturated NaCl-H_2O solutions from 75° to 325°C: Amer. Jour. Sci., v. 269, p. 489-493.

Literature values of the density of vapor-saturated NaCl-H_2O solutions between 75° and 325°C and up to saturation or 7.3 molal, whichever is lower, were correlated by the use of the empirical Masson's Rule: $\phi=\phi_* + s\, m^{1/2}$, where ϕ is the apparent molal volume of NaCl, m is the concentration, $\phi_* = -167.219 + 448.55\, V_o - 261.07\, V_o^2$, $s= (-13.644 + 13.97\, V_o) \cdot (V_c/(V_c-V_o))^2$, and V_o and V_c are the specific volume and the critical volume of H_2O, respectively. The standard deviation between the calculated densities and the source data is 0.002 g/cm^3. (Author's abstract).

HAAS, J.L., Jr., 1970c, Fugacity of H_2O from 0° to 350°C at the liquid-vapor equilibrium and at 1 atmosphere: Geochim. Cosmo. Acta, v. 34, p. 929-932. (Author's name incorrectly spelled "Hass" in original).

The fugacity and fugacity coefficient of H_2O at the liquid-vapor equilibrium, the fugacity, and the Gibbs free energy of formation of H_2O at 1 atm (1·01325 bars) total pressure have been calculated from published data on the physical and thermodynamic properties of H_2O and are presented at ten-degree intervals from 0° to 350°C (Author's abstract).

HAYWARD, A.T.J., 1970, Negative pressure - Suction pump with 17 metre lift: Nature, v. 225, no. 5230, January 24, p. 376.

Contains a discussion of negative pressure in general, hence pertinent to fluid inclusion metastability. (ER).

HELZ, G.R. and BARNES, H.L., 1970, Hydrothermal solubility of magnetite, (abst.): Amer. Geophy. Union, Trans. (EOS), v. 51, no. 4, p. 436.

Magnetite solubility has been measured from 25° to 500°C in aqueous solutions with a vapor phase present; acidity, oxygen fugacity and NaCl concentration were varied. Under these conditions, magnetite solubility increases rapidly with acidity and with temperature above 300°; below 300°, variation of solubility with temperature is small. Solubility is independent of chlorinity and oxygen fugacity. These results indicate that magnetite solubility is controlled by hydroxyl complexes containing Fe^{2+} in the ratio 1:2. Dissolving of magnetite involves neither oxidation-reduction reactions nor the formation of chloride complexes. Of the variables temperature, acidity, chlorinity, and oxygen fugacity, only the first two can be principal controls of magnetite solubility in natural hydrothermal solutions. At 500°, solubilities in excess of 1000 ppm were observed in mildly acidic solutions. Cooling such solutions to 300° or below causes precipitation of roughly half the iron, whereas neutralization causes virtually quantitative precipitation. In the neutral to alkaline region, solubility is less than 1 ppm. (Authors' abstract). (Particularly pertinent to the occurrence of magnetite as a daughter crystal; Ed.).

HEMMINGSEN, E.A., 1970, Supersaturation of gases in water: absence of cavitation on decompression from high pressures: Science, v. 167, p. 1493-1494.

H. achieved 140 atm. for O_2 and 270 atm. for He in water. Of pertinence to inclusion metastability. (ER).

HEYL, A.V., 1970, Some aspects of genesis of stratiform zinc-lead-barite-fluorite deposits in the Mississippi Valley, United States, p. 95-99, <u>in</u> Problems of hydrothermal ore deposition, ed. by Z. Pouba and M. Stemprok, Int. Union of Geol. Sciences Series A, no. 2, 1970.

A review (33 refs.) of a large number of occurrences of Mississippi Valley type ore deposits throughout central and eastern U.S., including data on fluid inclusions (E.R.).

HILL, R.E.T., and BOETTCHER, A.L., 1970, Water in the earth's mantle: Melting curves of basalt-water and basalt-water-carbon dioxide: Science, v. 167, p. 980-982.

At depths below about 45 kilometers in the earth, the presence of high proportions of carbon dioxide does not significantly affect the temperature of the beginning of melting of basalt-water compositions. Water must be present only in trace amounts in the solid part of the silicate mantle if it contains appreciable proportions of basaltic composition, (Authors' abstract). (Pertinent to the study of CO_2 inclusions in olivine nodules; Ed.).

HOLLOWAY, J.R., 1970, Fluid compositions in a basalt-H_2O-CO_2 system (abst.): Geol. Soc. Amer. Programs with Abstracts, v.2, no. 7, p. 579-580.

Three gms 1921 Kilauea basalt were equilibrated with 1 gm H_2O and

2 gms CO_2 (60 mole % H_2O, 40 mole % CO_2) at 800°, 900°, 1000° and 1100°C and 2, 5 and 8 kb. Oxygen fugacity was buffered by Ni/NiO. The resulting fluid was separated and analyzed for Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, Ba, and Sr.

Total solute content tends to decrease with T and increase with P; it ranges from 0.5 to 2 wt% of the fluid. SiO_2 (27-67), Al_2O_3 (6-34) and MgO (9.5-18 wt%) constitute more than 75 wt% of all solutes. Large variations in fluid composition occur with changes in P and T, but no obvious correlations exist between fluid compositions and condensed phase assemblage. The following ranges in oxide ratios (wt% in solute/wt% in basalt) were observed: Fe_2O_3=0.07-0.5; SrO=2-3; Na_2O=1.2-4.0; K_2O=5 at 800°C, 2-3 at higher T; SiO_2=0.5-0.9 and Al_2O_3=2-3 at 2 kb; SiO_2=1.0-1.4 and Al_2O_3=0.5-1.5 at 5kb. Correlations in the fluid are positive between the following: (Ti, Al), (Mn, total Fe), (Mn, Sr, Al); and negative between (Si, Al), (Si, Mg), (Si, Mn), (Si, Sr).

Gas transfer appears to be ruled out as a mechanism for differentiation at least under conditions similar to those of this study. This is due to the very high Mg/Ca and Mg/Fe ratios in the fluid phase solutes and the low total solubility. Iron deposits, such as Cornwall, Pa., may form when aqueous solutions from a mafic magma contact carbonate wall rocks; the increase in CO_2 in the fluid would greatly decrease Fe solubility. (Author's abstract).

HOLSER, W.T. and ANDERSON, R.Y., 1970, Bromide distribution in Castile halites, Delaware basin, Texas (abst.): Geol. Soc. Amer., Abstracts with Programs, v.2, no. 7, p. 580.

A nearly complete core of the Castile evaporite has for the first time allowed detailed study of bromide distribution in the halite. The general bromide concentration in all three halite units on a sampling scale of 30 cm is very smooth, with trends in the range 25 to 45 ppm over 30 m or more. It remians at this low level through the Castile halites and the first few hundred feet of the overlying Salado Formation. The trends in Castile bromide profiles are related to variations in halite varve thickness, which continue oscillations of varve thickness in the contiguous anhydrite units, and have a period of about 1000-3000 years. Oscillations with this period culminated in the major halite units of the Castile, but the general bromide level in successive halite units does not show the progression expected if brines were accumulating in the basin.

Shorter oscillations, with a period of about 200 years, observed in thicknesses of both anhydrite and halite units, are not evident in bromide profiles.

Halite varves 2 to 6 cm thick were sampled on a millimeter scale. In the uppermost halite unit, bromide microprofiles show a decrease in bromide immediately adjacent to anhydrite lamellae; in deeper halite units no variation can be detected. (Authors' abstract). (Of pertinence to the Cl/Br ratios in inclusions in NaCl and elsewhere; Ed.)

IKORSKII, S.V., 1970, The inclusions of hydrocarbon gases and bitumens in the minerals of some igneous rocks (after an example of the Khibini alkali massif) (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 265.

The Khibini alkali massif (the Kola Peninsula) is an example of the thorough study of hydrocarbon gases and bitumens in the igneous rocks. This report summarises the results of examinations the gas and bitumen inclusions in the rockforming minerals of the Khibini massif such as nepheline, kali-soda fedlspar, eudialyte, enigmatite, arfvedsonite, aegirine, sphene, albite, hackmanite and natrolite. The microexaminations of minerals (nepheline and eudialyte) were carried both in the common and ultra-violet light by ordinary temperature and by heating to 600°C. The recovery of gases from minerals was accomplished by grinding of samples in the hermetically sealed mill, the isolation of bitumens--by extraction with chloroform. The composition of the bitumen "A" chloroform extract was studied by means of chemical and spectral analyses.

Fig. 1. Faceted gas inclusions in nepheline, x 1000.

Fig. 2. The gas inclusion in eudialyte with drops of bitumen on the walls of a cavity. Photographed in ultra-violet light, bitumen in luminous, x 220.

Nepheline contains gas and gas-liquid inclusions (fig. 1); in eudialyte there are apart from them vacuoles containing a bituminous substance luminous in ultra-violet light (fig. 2) and remaining preserved within the temperature range to 580°C. Gas and bitumen inclusions in minerals spatially are closely connected with aegirine, feldspar and villiaumite inclusions. All of them are disposed along cleavage or along the differently oriented zones. High contents of hydrocarbon gases (methane and homologues--ethane, propane, buthane) are characteristic only of several minerals (nepheline, eudialyte, enigmatite) having been crystallized on the early stages of the massif formation, and practically are absent in those formed due to the postmagmatic processes. The hydrocarbons represented by high-molecular paraffines and sometimes by aromatic compounds were also recognized present in the bitumen extracted from nepheline, kali-soda feldspar, eudialyte, and aegirine.

The close paragenesis of hydrocarbon gas and bitumen inclusions in primary minerals (nepheline, eudialyte) with aegirine and villiaumite inclusions suggest that the formation of inclusions in crystals occurred at the stage of the magmatic minerogenesis transient to hydrothermal one. The data obtained assume that the accumulation of bitumens and hydrocarbon gases inside the inclusions cavities might have happened at the expense of carbonaceous substance (probably seized in the form of dispersed particles by minerals in time of their crystallisation) during autometamorphous alterations of alkali rock. At the same time hydrocarbon gases and bitumens are supposed to have been originated as a consequence of interaction between the volatile components of the alkaline melt-solution and minerals at the final stage of magmatic minerogenesis. (Author's abstract.)

IMAI, Hideki, KATAYAMA, Nobuo and FUKUOKA, Isao, 1970, Geology and mineral deposits of the Akenobe mine and the Ningyo-Toge uranium deposits: Guidebook 8, Excursion B 4, IMA-IAGOD Meeting Tokyo-Kyoto, 23 pp.

Imai presents otherwise unpublished S isotope data of Sakai and Yamamoto, and decrepitation data (66 samples) from an earlier paper by Takahashi et al (1955, in Japanese), on the Akenoke mine. Temperatures range from 150-350°C. (E. R.)

IMAI, H. and TAKENOUCHI, S., 1970, Fluid inclusion study at the Taishu mine, Japan, as related to geologic structure, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 237.

The Taishu mine is a zinc and lead deposit, belonging to mesothermal vein type. Veins occur in the Paleogene sediments around the granitic mass. The vein fissures are classified into two types, (A) gently dipping reversed bedding fault, (B) strike-slip fault.

The ore-forming fluid would flow upward and outward from the granite magma along the fissures of type (A), and pour into the fissures of type (B). The deposit reveals the zonal distribution of minerals. The distribution of minerals is, from lower to upper part, barren quartz, pyrrhotite, sphalerite, galena and barren calcite zone.

Fluid inclusions in quartz crystals from some parts of the veins and of the granite mass in the mining area are studied by volumetric measurement under the microscope and be means of heating stage- and freezing stage-microscope. Some of the results are shown in the following table. No. 1 is the quartz in the granite in the mining area. No. 2 is the vein quartz near the granite mass. No. 3 is the vein quartz farther away from the granite mass than No. 2 vein quartz.

From these data, it is recognized that the temperature of the ore-forming fluid drops and the salinity of the fluid diminishes upward and outward from the granite mass. (Authors' abstract)

Kind ofquartz.	Homogenization temperature(°C).	Phases in inclusion	Freezing point (°C)	NaCl salinity (%)
No.1 quartz in the granite in the mining area.	350°-500°C	Liquid, vapor, halite, calcite(?), undetermined opaque mineral		31-56% (calculated by volumetry)
No.2 vein quartz from the Shintomi vein,-70mL	350°-370°C	same as above		30-33% (calculated by volumetry)
	250°-310°C	liquid, vapor, (calcite(?))	-3°--13.6°C	5-20%
No.3 vein quartz from the Shirodake vein, OmL	235°-250°C	liquid, vapor	-4.5°C	7.2%

KAMB, B., 1970, Superheated ice: Science, v. 169, p. 1343-1344.

A discussion of the interpretation of some experiments by Schubert and Lingenfelter (Science, v. 168, p. 469, 1970) on the superheating of water and ice during pressure drop. Similar phenomena, under even more striking conditons, have been observed in fluid inclusions in minerals by Roedder (Science, v. 155, p. 1413-1417, 1967). (ER).

KARPOV, G.A., 1970, Recent fluorite in core sample from Bolshe-Bannoe deposit of hydrothermal waters, Kamchatka, in Mineral. Gidroterm. Sist. Kamchatki Kuril'skikh Ostrovov, ed. S.I. Naboko: Moscow, "Nauka" Press, p. 110-116 (in Russian) (C.A. v.74, no. 18, 1971).

Fluorite is described from hydrothermally metamorphosed andesites, dacites, and tuffs in the deposits of hydrothermal waters (hydrocarbonate-sulfate) with mineralization of 1.4 g/l, 165°C, and pH 7.5-8. Fine grained octahedral crystal-aggregates are isotopic with n=1.435. Fluorite is assocd. with quartz, stilbite, anhydrite, chlorite, and analcime. The chem. compn. of the thermal water shows NH_4^+ 17.2, Na^+ 198.4, K^+ 11.51, Ca^{2+} 64.13, Fe^{3+} 3.9, Cl^- 106.4, F^- 2.0, HCO_3^- 197.0, SO_4^{2-} 344.9, and S^{2-} 5.0 mg/l. The temp. of homogenization of the gas-liquid inclusions in fluorite is detd. to be 160°. The cubic crystals of fluorite form at a lower temp. than octahedral crystals.

KARTSEV, A.A., ABRAMOVA, O.I. and DUDOVA, M.Ya., 1969, Organic substance(s) in mineralized waters: Akad. Nauk SSSR Izvestia, Ser. Geol., 1969, no. 7, p. 137-138 (in Russian); translated in Internat. Geol.

Review, v. 12, no. 3, p. 270-271 (1970).

Analyses are presented for organic carbon in mineralized waters squeezed from a series of rocks (36-118 mg/liter). (Of pertinence to analyses of organic materials in fluid inclusions from many samples; Ed) (E.R.)

KARZHAVIN, V.K. and VENDILLO, V.P., Thermodynamic equilibrium and conditions for existence of hydrocarbon gases in a magmatic process: Geokhimiya, 1970, no. 10, p. 1165-1173, (in Russian; translated in Geochem. Internat., v. 7, no. 5, p. 797-803, 1970).

Results are given from mathematical processing of two systems representing a mixture of gases under conditions of thermodynamic equilibrium over a wide range of temperatures and pressures. The first system reflects the thermodynamic scope for formation of methane in the crust from a gas containing CO and H_2 at high P and T. The second system concerns the possible formation of hydrocarbons with many carbon atoms from methane in response to P and T. The application of the results to natural conditions is considered. The computer calculations were performed by Newton's method for P from 1 to 5000 atm and T from 500 to 1500°K. (Authors' abstract) (Ed.note: Of pertinence to the origin of the organic gases in inclusions in alkalic rocks).

KASTNER, Miriam, 1970, An inclusion hourglass pattern in synthetic gypsum: Amer. Min., v. 55, p. 2128-2130.

Gypsum crystals grown in a fine-grained calcite mud trapped solid inclusions of calcite as an hourglass in the portion formed by the fastest-growing face when growth was fast; slower growth yielded clear gypsum crystals. (Similar phenomena are noted for liquid inclusions in hourglass patterns in some synthetic crystals. Ed.)

KELLY, W. C. and GODDARD, E. N., 1969, Telluride ores of Boulder County, Colorado: Geol. Soc. Amer. Memoir 109, 237 pp.

Pages 173-177 (and plate 12) deal with fluid inclusion thermometry on these deposits, and include description of the heating stage and calibration methods used. Some rough determinations of salinity (low) by freezing were made. Homogenization temperatures of 237-315° are recorded and compared with a wide variety of other geothermometers. (E.R.)

KELLY, W.C. and TURNEAURE, F.S., 1970, Mineralogy, paragenesis and geothermometry of the tin and tungsten deposits of the Eastern Andes, Bolivia; Econ. Geol., v. 65, p. 609-680.

Numerous geothermometers were applied to ores of the Eastern Andes of Bolivia in order to evaluate temperature as one factor in zoning and paragenesis of the deposits, and also to test the thermometers themselves where results could be checked against available field evidence. Some 225 specimens were analyzed representing 53 deposits and several ore types, chiefly the tin and tungsten ores.

The stratigraphic record suggests that ores of the subvolcanic setting of central and southern Bolivia formed at depths on the order of 350 to 2,000 m and at total pressures of approximately 30 to 500 bars. Comparable estimates for the somewhat deeper deposits of plutonic association in the Cordillera Real are depths of 2,000 to 4,000 m and pressures of about 190 to 1,000 bars.

A similar paragenesis is indicated for the tin and tungsten deposits and consists of (1) an early vein stage in which most tin and tungsten was deposited, (2) a base-metal sulfide stage, (3) hypogene alteration of pyrrhotite to pyrite, marcasite, and siderite and (4) late crusts and veinlets of siderite, fluorite, and a variety of hydrous phosphate minerals some of which are supergene.

The Bolivian ores contain most of the sulfide minerals proposed, at one time or another, as geothermometers, but present attempts to use them have been largely unsuccessful. Pyrrhotite compositions were modified during replacement by pyrite, marcasite, and siderite and most do not reflect intitial depositional temperatures. Arsenopyrite gave only rough indications of temperature and was essentially useless as a geobarometer. Sphalerite displays complex polytypism in the Bolivian ores, but this could not be correlated with variables of geologic interest. The present iron content of sphalerite reflects initial equilibrium with pyrrhotite, but its significance in terms of temperature is debatable. Miscellaneous thermometers such as sulfide invariant points, the high-low quartz inversion, melting of native bismuth and sulfide exsolution temperatures are considered and some yield useful temperature limits.

Fluid inclusion studies reveal highly systematic trends of salinity and depositional temperature during formation of the tin and tungsten ores. Tin-bearing fluid of the early vein stage were complex, NaCl-rich brines of low CO_2 content. During precipitation of cassiterite and early quartz, salinities reached values as high as 46 weight percent, but the later ore fluids were more dilute and gradually approached fresh water in closing stages of mineralization. Depositional temperatures first increased from about 300° to 530°C during the early vein stage and then declined steadily to less than 70°C in the later stages. Minerals of the main sulfide stage formed as temperatures declined from about 400°C to 260°C. Fluid inclusions in siderite indicate temperatures of 260°C to 200°C for the hydrothermal alteration of pyrrhotite. Late fluorite of the Colquiri lode was precipitated at temperatures between 200°C and 133°C. The late hydrous phosphate minerals formed below 70°C. Many events of the hypogene sequence could be attributed chiefly to cooling of the vein fluids and are so interpreted, but little is known of the wall rock alteration and its influence on paragenesis.

Active boiling of the early vein fluids is indicated by the fluid inclusions in quartz and cassiterite. This boiling upgraded salt contents of the early vein fluids while driving CO_2 into the associated vapor phase. This vapor transported some mineral matter, as evidenced by daughter minerals in gas-rich inclusions, but the identity and quantitative significance of this material are unknown. The early boiling favored precipitation of quartz and cassiterite and may explain the restricted vertical distribution of very high-grade tin ore in several deposits of shallow origin in central and southern Bolivia. Evidence of boiling in several major deposits of the Cordillera Real suggests that these ores, though formed in the plutonic setting, were still deposited at depths of less than 3,000 m. This limit is compatible with that based on stratigraphic reconstructions of rock cover at the time of mineralization.

All data gathered in this study are consistent with a single, prolonged "event" of mineralization for the individual tin and tungsten deposits throughout Bolivia. The deposits could differ in age, but there is no convincing evidence that they are hybrid products of hydrothermal regenerative processes. A magmatic source is preferred for the mineralizing NaCl brines and their contained metals, but the progressive cooling and dilution of these brines may reflect gradual influx of meteoritic water to the magmatic hydrothermal system. (Authors' abstract).

KHETCHIKOV, L.N., DOROGOVIN, B.A., KOKAREV, G.N. and MALYSHEV, A.G., 1970, Relations between temperature of homogenization and decrepitation of gas-liquid inclusions in quartz of crystal-bearing deposits: VNIISIMS, (Vses. Nauch.-Issled. Inst. Sin. Miner. Syr'ya) Trudy, Geol. and Experimental Studies, v. 12, p. 88-92, (in Russian).

A comparison of decrepitation and homogenization temperatures for inclusions in quartz from Kazakhstan reveals several errors. A possible way of avoiding such errors is discussed. (ER).

KHETCHIKOV, L.N., DOROGOVIN, B.A. and SAMOILOVICH, L.A., 1968, Dependence of corrections for homogenization and decrepitation temperatures of gaseous-liquid inclusions in quartz on pressure, density, and composition of solutions: Geol. Rudnykh Mestorozh.,1968, no. 3, p. 87-97 (in Russian); translated in Int. Geol. Review, v. 12, no. 4, p. 412-420.

The temperature (T) corrections for pressure (P) determined from study of the thermodynamic properties of mineral-forming solutions and homogenization of gaseous-liquid inclusions in quartz, are similar to each other.

The homogenization temperature (T_H) of solution in inclusions is always lower than the formation temperature (T_F) of quartz and the value of the temperature correction (T_C) increases with the P.

T_C for P also depends on the solution density and composition, but the effects of these factors are considerable only at high P. In determinations of the true T_F of minerals of hydrothermal deposits from the gaseous-liquid inclusions, it is therefore sometimes sufficient to make corrections for T_H which depend only on P, disregarding the effect of the solution density and composition.

The temperature of decrepitation (T_D) of gaseous-liquid inclusions in synthetic quartz differs from T_F of the minerals and depends on the conditions of growth.

At $P < 700$ atm during synthesis of quartz T_D of the start of decrepitation is higher than T_F. At $P > 900$-1000 atm it is below this value.

The correction for T_D decreases with increasing P in the first case, but increases with P in the second.

T_D depends on the solution density: the difference between T_D of the inclusions and the synthesis T decreases with increasing solution density (at a constant P during mineral formation).

T_D of inclusions depends on their size and the position in the grain. The extent by which T_D exceeds T_H is determined by the ratio of R, the distance from the inclusion to the nearest grain edge, to r, the radius of the inclusion. With r=const., an increase in R leads to an increase in T_D; with R=const., an increase in r reduces T_D.

Thus, T_H and T_D of gaseous-liquid inclusions in minerals are affected by many factors, which, if disregarded, may lead to considerable errors in determinations of T_F by the homogenization and decrepitation methods. (Authors' conclusions).

KHETCHIKOV, L. N., DOROGOVIN, B. A., and SAMOILOVICH, L. A., 1968, Dependence of correction for homogenization and explosion temperatures of gas-liquid inclusions in minerals on pressure, density, and composition of solutions: Geologiya Rudniykh Mestorozhdenii, v. 10, no. 3, p. 87-97 (in Russian).

KHETCHIKOV, L.N., DOROGOVIN, B.A. and SHATAGIN, N.N., 1970, Multiple regression analysis for determining mineralization pressure: Geol. Rudnykh Mestorozh., 1970, no. 6, p. 112-114 (in Russian).

Data from decrepitation and homogenization temperatures, and other factors such as inclusion size are used to calculate pressure in inclusions of several classes in terms of volume precent vapor phase. (ER)

KHETCHIKOV, L.N., ONTOYEV, D.O. and DOROGOVIN, B.A., 1970, Genetic features of rare metal deposits of the Transbaikal from study of gas-liquid inclusions in quartz: Geol. Rudnykh Mestorozh., v. 12, no. 4, p. 71-83 (in Russian).

A detailed study of a series of deposits by homogenization (470-190°C), type of homogenization, and the analysis of the gases in the inclusions (for acid gases, CO_2, CO, and N_2) (E.R.).

KHETCHIKOV, L.N. and SAMOILOVICH, L.A., 1970a, Thermodynamic parameters of solutions having the composition of gas-liquid inclusions in quartz: Vopr. Geol., Geokhimii Metallogenii Sev.-Zap. Sektora Tikhookean. Poyasa 1970, p. 246-248, (in Russian). From Ref. Zh., Geol., V.1971, Abstr. No. 2V177.

Apparently very similar to the material given by the same authors below in the following item (Khetchikov and Samoilovich, 1970b).

KHETCHIKOV, L.N. and SAMOILOVICH, L.A., 1970b, The possibilities of the decrepitation method in mineral thermometry: Akad. Nauk S.S.S.R., Izvest., Ser. Geol., 1970, no. 7, p. 92-98. (See Translations Section).

KHETCHIKOV, L.N., and SAMOILOVICH, L.A., 1970c Experimental data for the solution density, concentration and composition effects on the homogenization temperature (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 267.

The general effect of density, concentration and composition of the solution on the homogenization temepratures is well known, but the data on this dependence is still insufficient. We have no experimental proof on the P-F-T-X dependence for the multi-component systems, that are in close compositional relationship with the natural mineral-forming solutions.

Some previously elaborated methods become of use in the thermodynamic parameter determination (P-F-T-X) for the water solutions of the sodium, potassium, lithium and calcium chlorides as the most frequent components in the mineral forming hydrothermal solutions. Studies have been successfully performed over chloride-carbonate-sodium multi-component systems, having the rate of mineralization of 50 and 150 gr/l. These systems are compositionally identical to the quartz crystal fluid inclusions content. Other studies were pertaining to the mineralized waters of the presently functioning Eastern Siberia sources. The experimental temperatures ranged of 160 to 550°C under the pressures up to 1500 atm.

It is established that the homogenization temperature changes with the solution density variations, the latter being conditioned by the system filling factor. Thus, the homogenization temperature for an 8% potassium chloride solution was found 348°C, the filling fator F being 0.70; and 193°C with F=0.90. The same temperatures for the multi-component chloride-carbonate-sodium solutions, mineralized in the rate of 50 gr/l, was found to vary from 353°C (F=0.65) to 170°C(F=0.90). In determining the mineral forming temperatures on the homogenization temperature basis one must make account of the fact that the correction imposed by the density variations depends on the pressure developed. The pressure being close to that of the homogenization, the value of the correction grows with the increase of the solution density. Under more severe pressure conditions this dependence is inverse.

An increase in the salt concentration always implies an increase in the homogenization temperature, the importance of this dependence being also in the inverse relation with the solution density. Thus the extention of the concentration from 0 (pure water) to 15%, with F=0.65 increases the homogenization temperature by 100°C, the same experiment with F=0.9 resutls in 20°C increase only.

The composition of the solution produces another effect on the homogenization temperature. For monomolar solutions of the univalent metal chlorides in particular, the highest homogenization temperature is that of potassium chloride, the sodium chloride revealing the lowest (F-equal). A change in the anion composition alters the homogenization temperature too.

The weakly mineralized solutions of the natural Eastern Siberia sources differ just slightly from the pure water, as regards their thermodynamic parameters. The rate of mineralization increased, the difference becomes more important. (Authors' abstract.)

KHETCHIKOV, L.N. and TASHKER, E.M., 1970, Mechanism of (study of) gas-liquid inclusions in quartz from crystal-bearing veins: VNIISIMS, (Vses. Nauch.-Issled. Inst. Sin. Miner. Syr'ya), Trudy, v. 13, p. 68-74 (in Russian). CA 75 (11) 106 (1971).

The method of investigation of gas-liq. inclusions in SiO_2 crystals in veins is given. Chem. anals. of these inclusions are presented.

KHITAROV, N.I., KHUNDADZE, A.G., SENDEROV, E.E. and SHIBAYEVA, N.P., 1970, The effects of volcanic rocks on the compositions of hydrothermal solutions: Geokhimiya, 1970, no. 6, p. 678-692, (in Russian); translated in Geochem. Internat., v. 7, no.3, p. 469-482.

A systematic study of the effects of water and solutions of NaCl, KCl, $CaCl_2$, NaOH, KOH, Na_2CO_3, and $NaHCO_3$ on volcanic rocks and glasses made from them was completed under dynamic conditions at 200° and 300°C, at 300 atm. The relative decomposition rate of acidic (essentially vitreous) to basic (essentially crystalline) rocks by alkali solutions decreased in that sequence, while attack by water and chloride solutions was nearly constant. The initial glass content controlled the overall solute content and produces supersaturation in silica, while rock type and nature of initial solution controlled chemical composition of the final solute.

Silica and alkali entered neutral and acidic solutes while Al, Fe and Mg accumulated in the residue. Calcium entered the solute in appreciable amounts in the presence of chloride. - J.L. Haas.

KINES, Tuncay, 1969, Geothermometry of the Keban Mine area, Eastern Turkey: Bull. Miner. Res. Explor. Inst. Turk. 1969, No. 73, p. 28-33 (in English). CA 75 (3) 164 (1971).

The Keban Mine is 1 of the most important Pb and Zn producers in Turkey. The Keban metamorphic massif consists of calcschist, dolomite marble, phyllite, and marble. Skarn zones have developed in assocn. with the intrusion of quartz-syenite porphyry. The magnetite deposit of Zerevandere, the scheelite deposit of Kebandere, and the main sulfide deposit were formed as part of the process of skarn formation. Minor amts. of some Mn minerals, and the minerals vanadinite and descloizite derived from the main sulfide deposit, are also found in the district. A temp. range of formation of 78-620° is estd. for the ore minerals of the main sulfide deposit. For the ore minerals of the scheelite and magnetite deposits the temp. range is 225-743°.

KISSLING, AL., and POMÎRLEANU, V., 1970, On the formation temperature of minerals from the Ocna de Fier - Dognecea Skarn, Romania (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 275.

Ocna-de-Fier and Dognecea (Moravitza, Vasko, Dognacska in old literature, respectively) are situated in the south-west of Romania. The mineral sequence corresponds to a zonality dependent upon volumetric lattice energy and upon formation temperature.

The formation temperatures of minerals were determined by the homogenization and decrepitation method, pressure corrections omitted.

The temperature ranges determined were: Calcite (2131): 232°-278°, blue 236°-285°, white 50-70 cm crystals 266°-308°; Dolomite: 212°-308°; Quartz: Japanese twin 280°-290°; covered with palygorskite 310°-335°, biterminal 285°-290°; in paragenesis with hematite 300°-310°; Hedenbergite; 285°-320°; Diopside: 384°-450°; Andradite (110): 379°-406°, (211) in paragenesis with hematite 402°-515°, (211) in paragenesis with magnetite 483°-504°; Hematite: 355°-416° in paragenesis with andradite/magnetite (110) in limestone 332°-402°, in paragenesis with andradite 493°-517°. Ludwigite: finely needle-shaped 490°-520°, fibrons crystals 403°-422°; Wolframite 380°-470°. Epidote from endoskarn 358°-402°.

The temperatures determined are in agreement with those established for other similar deposits; for Kuga, Yamaguchi hedenbergite (Imai and Ito, Mining Geology Japan. Journal, 9, 27-32, 1959) and for mineralization at Conception del Oro (Buseck, Econ. Geology, 61, 97-136, 1966), as well as with those established by other authors. (Authors' abstract.) (Editor's note: this abstract may contain typographical errors, as the original printing was partly illegible.)

KLUEH, R.L., 1969, Bubbles in solids: Science and Technology, no. 93, October 1969, p. 5-13.

A review of the many poorly understood phenomena involving nucleation and growth of gas inclusions in solids. Although it deals mainly with hydrogen in metals, it is pertinent to some natural fluid inclusions (E.R.).

KLYAKHIN, V.A. and LEVITSKIY, N.F., 1968, Possible role of NH_4^+ in the hydrothermal process: Akad. Nauk SSSR, Sibir. Otdel., Geolog. i Geofiz., 1968, no. 9, p. 10-15 (in Russian; translated in Geochem. Internat., v.6, no. 1, p. 193-198, 1969).

Analyses (17) of aqueous extracts from fluorite and other minerals from S. Gissar and other localities show NH_4^+ to constitute from 1.2 to 20.4 percent of total cation equivalents. From this a review of experimental work showing large increase in the hydrothermal solubility of various heavy metals in the presence of NH_4, Cl, the authors conclude that NH_4^+ has been important in ore transport and should be looked for regularly in fluid inclusion analyses. (E.R.).

KOGARKO, L.N. and KRIGMAN, L.D., 1970, Phase equilibria in the system nepheline-NaF: Geokhimiya, 1970, no.2, p. 162-168, 1970, (in Russian); translated in Geochem. Internat., v. 7, no. 1, p. 103-107.

This system has a wide region of coexistence of two immiscible liquids. The system is not binary, and there is a comparatively small region where nepheline is in equilibrium with two liquids. This region and the liquation region together indicate that immiscibility effects should occur in the formation of fluorine-rich agpaitic alkali rocks. (Authors' abstract). (Ed. note: Such immiscibility should be found in heating experiments on melt inclusions in these rocks.).

KOGARKO, L.N., and ROMANCHEV, B. P., 1970, The investigations of microinclusions in minerals bearing on the genesis of Khibina apatite deposits (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 253.

Apatite deposits in Chibina alkaline massif represent the stratified ore body, placed in hanging part of apatite-nepheline intrusion. The main rock-forming minerals of these deposits are nepheline and apatite. The primary inclusions in the nepheline and the apatite are multiphase and usually homogenized into melts at the temperatures 750-930°C. One can observe the regular decrease in the temperatures of the microinclusion homogenization in minerals from the contact rocks of the apatite deposits to the center of apatite-nepheline intrusion. The investigation of the mineralogical composition of the microinclusions in apatites showed the presence in them, such minerals as sodalite, potassium feldspar and villiaumite.

The investigation of the microinclusions and having the experimental data by melting diagram containing apatite confirms the origin of the apatite deposits by a crystallization differentiation. The crystallization of the apatite-nepheline intrusion took place in the direction from the lower and upper contacts to the central part. This is confirmed by the distribution of rare earths in the apatite rocks and deposits of apatite-nepheline intrusion. (Authors' abstract)

KOGARKO, L.N. and RYABCHIKOV, I.D., Differentiation of alkali magmas rich in volatiles: Geokhimiya, 1969, no. 12, p. 1439-1450, (in Russian; translated in Geochem. Internat., v. 6, no. 6, p. 1113-1123, 1969).

Accumulation of volatiles (Cl, F, P_2O_5, CO_2) gives rise to immiscibility during the crystallization of alkali rocks. Results are given on immiscibility in the systems Na, Al, Si 0, F and Na, Al, Si O, Cl, which explain the origin of some fluorine-bearing rocks and sodalite syenites in massifs or agpaitic alkalic rocks. (Authors' abstract) (Ed. note - such immiscibility should be found in heating experiments on inclusions in such rocks).

KOKORIN, A. M. and KOKORINA, D. K., 1970, Temperature formation characteristics of the Khrustal'noe tin deposit: Vop. Geol., Geokhim. Metallogen. Sev.-Zapad. Sekt. Tikhookean. Poyasa, Mater. Nauch. Sess. 1969 (Pub. 1970), p.284-6 (in Russian). Edited by Govorov, I. N., Dal'nevost. Geol. Inst.: Vladivostok, USSR, CA 75 (7) 80 (1971).

The temp. formation characteristics of the deposit were studied by decrepitation and homogenization of inclusions in minerals of the Volkovsk and No. 17 ore veins. The quartz of the Volkovsk vein is heterogenous according to the formation temp. with a predominance of early pre-sulfide quartz which formed at 300-400°. A high-temp. quartz (370-410°) is present in vein parts rich in cassiterite. The quartz thermometer suggests that temps. >360° were the most favorable for deposition of cassiterite. Vein No. 17 was formed at 80-360°. The vein has horizontal temp. zoning coinciding with the distribution of ore mineralizations.

KOLTUN, L. I., PIZNYUR, A. V., 1970, The results of inclusion study of mineral associations from the Buhdaja molybdenum polymetallic occurrence: L'vov Gos. Univ. Mineralog. Shornik, v. 24, no. 3, p. 274-284 (in Russian).

The Buhadaja molybdenum polymetallic occurrence is connected with the crater of a volcano. It was formed with the help of pneumatolitic and mainly hydrothermal solutions the temperature of which dropped from 450° to 46°C. The pressure during the formation period changed from 850 to 200 atm and only at the moment of the explosion it reached 2500-2600 atm. (Authors' abstract corrected).

KOMATSU, Masayuki and YAJIMA, Junkichi, 1970, Chemical composition of glass inclusions in the phenocrysts of some volcanic rocks: Proc. Japan Acad., v. 46, no. 7, p. 672-677 (in English).

Eight electron microprobe analyses are given of glass inclusions in phenocrysts of olivine, hypersthene, and quartz from a series of basalts, and are related to the host rock (ER).

KORMUSHIN, V.A., 1970, Geochemical characteristics of the high temperature quartz-forming solutions of the chamber-pegmatites on the data of the study of gas-liquid inclusions (abst.), <u>in</u> Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 266.

In the chamber-pegmatites we often find quartz crystals with the characteristic combing structure. The forming of the combing structure appeared as a result of the crack curing in quartz origined by the α-β transformation (Dolgov, Mineralogical Collection of the L'vov's Geological Society, <u>9</u>, 1957).

It is possible to observe numerous gas-liquid inclusions on the cured cracks the composition of the inclusions reflects the quartz crystallization conditions at the temperature nearly 573°C. If to take into consideration that the quartz of the combing structure is situated in the quartz crystals foundation then the quartz-forming solutions of inclusions characterize the most high temperature solutions of the pegmatitous process.

As the object for studying there was taken the combing quartz of the pegmatites of the Central Kazakhstan and the Ukraine granite massives.

On the data of the results of the water extract chemical analysis and of the micro gas analysis in accordance with the author's method the determination of the weight qualities of the components in the quartz-forming solution was made.

On these data it was determined that the crystallization of quartz originated from the high-dense gas solutions in the environment of sulphurhydrogen and carbon dioxide in the presence of the sum of ions Na^+, K^+, Ca^{++}, Cl^-, HCO_3^-, SO_4^{--} about 15-20 gr. per litre. The relation of K/Na in the solution was less than 1.0. The absence of F is characteristic of the solutions.

The high containing of sulphur-hydrogen and the presence of the small quantity of SO_4^{--} ions lowers the containing of the S^{--} ions in the quartz-forming solution in a considerable degree and this increases the containing of the HS^- ion (Betechtin, 1953).

The gas-saturity of the solution ("the degree of fluidity") was being evaluated as the relation of the gas weight in the solution to that of the water. For the studied solutions the degree of the gas-saturity was being changed from 3.64 to 2.33. (Author's abstract; sic.)

KORYTOV, F. Ya., 1970, Types of vertical temperature zoning in fluorite deposits (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 257.

The study of fluorite deposits of some provinces (Transbaikalia, etc.) shows that alongside with lateral temperature zoning (stage-by-stage and facies) there is vertical zoning in them. There are the several types of such zoning (direct, reverse, concentric, compound, etc.). Reverse temperature zoning is the most widespread. It is zoning where the upper level of deposits (and of individual ore bodies) is mainly high-temperature minerals of the early stages of mineralization. Toward lower levels of the deposits these early minerals (quartz, octahedral fluorite with rich colour, etc.) were gradually or sharply changed by late and more complex associations of low-temperature minerals (cubic fluorite with light colour, quartz, barite, calcite, sulphides, sometimes gearksutite etc.). In these cases the average temperature of ore formation as well as temperature of crystallization of the minerals belonging to separate stages fall downwards (in ore bodies) with temperature gradient 5-60°C and more per 100m. This zoning is often underlined by conforming changes of types of hydrothermal alteration of the wall rocks and change of structures of ore.

Reverse temperature zoning is the most widespread in the fluorite deposits in Transbaikalia (Kalangui, Ibagaitui, Usugly, Garsonui etc.), Middle Asia (Takob, Bigar etc.), Mountain Altai (Kayancha etc.). It is apparent from analysis of available materials that such zoning exists in some foreign fluorite deposits (USA, Mexico, Germany, England, France, Czechoslovakia, etc.). The distinctive vertical temperature zoning in which the most upper and lower parts of deposits represent chiefly minerals of late low-temperature stages is more rare. The mid levels of these deposits have mainly minerals of early high-temperature stages of mineralization (Brikachanskoe in Transbaikalia). There are also rare fluorite deposits with direct vertical temperature zoning where downwards in ore bodies the role of minerals of early stages of mineralization rises with corresponding increase of temperature of ore emplacement (Mogov in Middle Asia). Some fluorite deposits (Agata-Chibargata in Middle Asia) have compound vertical temperature zoning representing various combinations of some preceding types of zoning.

Types and distinctness of vertical temperature zoning are sometimes various in different parts of fluorite deposits or ore bodies. For instance there are ore bodies where reverse zoning is on one flank but direct or compound zoning exists on another flank.

The principal cause of the origin of temperature zonine in fluorite deposits is successive laying and opening of ore-containing fissures parallel of the evolution of ore-bearing solutions (stages of mineralization). (Author's abstract.)

KOSTYUK, V.P. and PANINA, L.I., 1970, Crystallization temperatures of alkalic rocks of the Gulinskaya intrusion: Akad. Nauk SSSR, Doklady, v. 194, p. 919-921 (in Russian); translated in Doklady Acad. Sci. U.S.S.R., Earth Sci. sects., v. 194, p. 164-165 (1971).

The homogenization method was applied to melt inclusions (both glassy and with daughter crystals) in nepheline, olivine, and pyroxene from the alkalic rocks. Homogenization temperatures of 950--1230°C are reported. Secondary inclusions of saline fluids in late potassium feldspar homogenized at lower temperatures. (ER).

KOTOV, E.I., et. al., 1970, Formation temperatures of some hydrothermal uranium deposits: Ocherki Geol. Geokhim. Rudnykh Mestorozhd., 1970, F.I. Vol'fson, Ed., "Nauka" Press, Moscow, p. 146-154 (in Russian). CA 75 (4) 135 (1971).

Decrepitation and homogenization data of ankerite, fluorite, calcite, sphalerite, galena, pyrite, and quartz indicate 3 groups of hydrothermal U deposits and fluorite deposits. The U deposits of U-Mo formations are formed in the range 330-100° corresponding to the beresitization temp. The decrepitation temps. of uraninite from quartz porphyries (210), intrusive rocks (205), metamorphic rocks (200), granodiorites (185), mudstones (200), and sandstones (195°) are calcd (?). Paragenetic mineral assemblages in different stages are described. Hydrothermal deposits of geoanticlinal blocks occur in Middle-Upper Paleozoic sedimentary and effusive rocks.

KOZLOV, Ye.K., BELYAYEV, K.D., SHOLOKHNEV, V.V., and DOKUCHAYEVA, V.S., 1970, Nitrogen and hydrocarbon gases in ultramafic rocks of the Sopcha stock of the Monchegorsk pluton, Kola peninsula: Akad. Nauk SSSR Doklady, v. 194, no. 5, p. 1190-1193 (in Russian); translated in Doklady Acad. Sci. USSR, Earth Sci. Sects., v. 194, p. 200-203 (1971).

Organic gases, consisting of approximately two-thirds CH_4 and one-third N_2; with $\leq 4\%$ each of He and C_2H_6; $\leq 1\%$ H_2; $\leq 0.1\%$ C_3H_8; and $\leq 0.01\%$ of the other constituents (10 analyses), flow from bore holes and mine workings in these ultramafic Proterozoic intrusives. Mineralized waters (two analyses) also flow from these rocks. The gases, which resemble those from some gas-oil fields, are believed to have migrated into the stock along faults considerably after its consolidation(ER)

KRANZ, R. L., 1968, Participation of organic compounds in the transport of ore metals in hydrothermal solution: Inst. Mining Metallurgy Trans., sec. B, v. 77, p. B26-B36.

The remnants of a former crystallization event have remained trapped in the gas and liquid inclusions of minerals. It is therefore understandable that these inclusions have aroused increasing interest. It is hoped, from the analysis of these inclusions, to gain new insight into the chemistry of the gases and solutions present during mineral formation. The gases present as inclusions in the crystal lattice of fluorite and feldspar samples were extracted, by grinding under a vacuum, and finally subjected to mass-spectrometric analysis. Primarily inorganic gases and traces of low molecular weight hydrocarbons were obtained from the light-coloured fluorite samples and measurable quantities of fluorinated hydrocarbons, in addition to sulphuryl fluoride and thionyl fluoride, were found in the deep violet coloured varieties. Furthermore, in the uraniferous fluorites some amino acids and in the feldspar samples many organic amino compounds as amines and nitriles of low molecular weight could be detected. A direct relationship between organic matter, especially of amino groups, and the uranium and thorium content could be observed. These results make very plausible the hypothesis that the substances found are due to radiation-chemical products formed from high volatile hydrocarbons, ammonia and water inside the mineral inclusions, and that even amino acids could be formed in this way during geological time. That the occurrence of amino acids in rock-forming minerals offers a proof of a former life must be viewed with caution since an abiogenic, radiation-chemical origin of these compounds is possible. The influence of these compounds on the solubility and recrystallization of mineral material is discussed. Some model-experiments prove the high solubility of mineral matter in very dilute solutions of amines, amino acids and nucleic acids. The influence of such transport reactions on the distribution of the radioactive nuclides of the uranium and thorium series and the age determination by lead-lead and uranium-lead methods should be borne in mind. (Author's abstract)

KRANZ, Reimar, 1969, Chapter 21, Organic compounds in the gas-inclusions of fluorspars and feldspars, p. 521-533 in Organic Geochemistry, G. Eglinton and M.T.J. Murphy, eds.; New York, Springer-Verlag, 828 pp.

A review of the experimental procedures and analytical results obtained in a study of several samples of fluorspar from Wölsendörf (Kranz, 1965, 1966, 1967) and ceramic feldspar from the Oberpflaz district that evolved enough gas during melting to cause manufacturing problems. A variety of hydrocarbons and fluorinated hydrocarbons were found in the fluorite, possibly formed by natural irradiation. The feldspar evolved hydrocarbons, low molecular weight amines and ammonia (in addition to CO, CO_2, H_2N_2, He and Ar). (E.R.)

KRANZ, R.L., 1970a,Organic geochemistry and radioactive disequilibrium in the Ag-Co-U-ore-veins of Wittichen, Black Forest, Germany (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 261.

Organic compounds are present in minerals. Our investigations concerning organic compounds were conducted on gaseous and liquid inclusions present in mineral fractions containing radioactive metals. The inclusions here investigated are separate phases within the solid mineral material. The gases and liquids present were extracted by a vacuum grinding technique and analysed by gas-chromatographic and mass-spectrometric means. In contrast to the organic species present in all rock samples like volatile hydrocarbons, the investigation performed revealed measurable quantities of organic amino compounds as amines and nitriles of low molecular weight in uranium, thorium, and radium containing minerals. It was found, that the content of organic matter especially of amino-groups depends on the radioactive metal content of the mineral. It is suggested that this kind of organic substances associated with radioactive nuclides is formed by irradiation of highly volatile hydrocarbons, ammonia, and water within the mineral inclusions (Kranz, Naturwissenschaften, 53, 593, 1966; 54, 469, 1967; Ber. Dtsch. Keram. Ges., 44, 430, 1967; Applied Earth Sci., 77B, 26, 1968). In some highly radioactive feldspar samples taken from the wall-rock of the ore-veins of Wittichen amino acids like glycine, alanine and amino-butyric acid were isolated; the analysis indicates the presence of a sulfur containing amino acid (methionine). Furthermore nitrogen containing heterocyclic compounds as pyrrole, pyrrolidine and β-picoline, and its fluorinated derivatives were found.

It was shown by Neuberg, Mandl and Grauer (Biochim. Biophys. Acta, 8, 654, 1952; 10, 540, 1953) as well as by Evans (Bull. Inst. Mining Met., 65, 13, 1955), that the organic compounds change the solubility and recrystallization characteristics of mineral material. They found a considerable increase in the solubility of various rock-forming minerals and ores in very dilute aqueous solutions of amino acids, nucleic acids, and the so-called "humic-acids". These results were confirmed by investigations on feldspars by Kranz (Schweiz. Mineral. Petrogr. Mitt., in press). In the investigations conducted on the Ag-Co-U-ore-veins of Wittichen it was observed, that the organic fraction present effects the migration of the radioactive nuclides of the uranium series. In this way uranium, radium, and radio-lead are transported separately into different minerals of the wall-rock, while other nuclides remain in the original ore-vein. Such transport reactions do change the state of radioactive equilibrium of the uranium ore and the age determinations by lead-lead and uranium-lead methods are affected, as shown in the case of torbernite. (Author's abstract).

KRANZ, R., 1970, First results of an organic-geochemical investigation of the pegmatite of Hagendorf-South: Schweiz. Mineralog. Petrog. Mitt. v. 50, pt. 1, p. 173-182, (in German).

The Hagendorf pegmatite body has been investigated for the volatile content of the fluid inclusions in feldspar, quartz and triphylite. The extraction procedures involve high vacuum ball-milling (1×10^{-6} Torr) and gaschromatographic and mass spectrometric analysis of the contents. Fluid inclusions were not actually observed in the feldspars. Gas release is in the order of 500-2500 mm^3/g material (at normal P and T). The main constituent is water, followed by 15-30mm^3 H_2, N_2 and CO_2 and 100-500 ppm (volume fraction) of organic compounds. The feldspar organic extract shows variations with depth.

Organic content is highest in the eutectic zone (in triphylite), in feldspar in the phosphate zone, and near the quartz core. The presence of low molecular hydrocarbons C_1-C_4, ethylene, ethyl- and ethylamines, NH_3 and CH_3F has been demonstrated, but also indications for heterocyclic nitrogen compounds like pyrrol, pyrrolidine and pyridine-derivates have been obtained. There exists a positive correlation between radioactive elements and organic compounds. (M.A.Stalder)

KRENDELEV, F. P., ZOZULENKO, and ORLOVA, See Translations Section

KULIK, N.A., 1970, Simultaneous growth of uraninite and brannerite and formation conditions of uranium minerals, in Geokhim. Mineral. Radioktiv. Elem. Sib., A.S. Mitropol'skii, ed.: "Nauka", Sib. Otd.: Novosibirsk, p. 17-53 (in Russian). Chem. Abs, 74, no. 10 (1971).

Brannerite is formed when titania reacts with UO_2 under hydrothermal conditions - $2TiO_2 + UO_2 \rightarrow UTi_2O_6$. U mineralization is described in the quartz-carbonate veins assocd. with quartz-chlorite-sericite schists and dikes of quartz-diorite-porphyry. Uraninite and brannerite are accompanied by pyrite, chalcopyrite, native Au, and tellurides of Ni and Au. The nature of the common grain boundary suggests that uraninite and brannerite developed simultaneously. Petrographic and optical data of the ore zone are given. The min and max temps. of U minerals formation are detd. by the mineral assemblages. Homogenization temps. of gas-liq. inclusions fall in 2 intervals, 210-250° and 300-310°, depending upon the gas/liq ratio. The pressure, pH, and Eh (redox) conditions of deposition are discussed.

KUZNETSOV, V.A., VASIL'EV, V.I. and OBOLENSKII, A.A., 1970, The sources and conditions of deposition of ore matter in mercury deposits, p. 137-140 in Problems of hydrothermal ore deposition, Internat. Union Geol. Sci., Series A, No. 2, ed. by Z. Pouba and M. Stemprok, 1970.

Studies of inclusions in quartz, calcite, and cinnabar, by both homogenization and decrepitation methods, show that the probable temperature of formation of the deposits ranged from 210 to 70°C, with the bulk of the cinnabar at 120-70°C (E.R.).

KVENVOLDEN, K.A., and ROEDDER, Edwin, 1970a, Hydrocarbons in fluid inclusions of quartz crystals from South West Africa (abst.): Geol. Soc. America Abstracts with Programs, v. 2, no. 7, p. 599-600.

Preliminary abstract of material given in more detail in article of somewhat different title in Geochim. Cosmochim. Acta, v. 35, p.1209-1229, 1971.

LEACH, D.L., NELSON, R.C., WILLIAMS, D.L., and McCLURE, J.W., Fluid inclusion study of the northern Arkansas zinc district (abst.): Paper presented at Third International COFFI Symposium on Fluid Inclusions, Montreal, Aug. 22-23, 1972. (This abstract received too late for inclusion in full program presented in previous issue of COFFI).

The ore deposits of northern Arkansas, located on the southern flank of the Ozark Uplift, are stratiform in nature, and are believed to be part of the general Mississippi Valley type mineralization.

Sphalerite mineralization was by hot, strongly saline brines as shown by homogenization and freezing point depression determinations made on many primary and pseudosecondary fluid inclusions from 21 mines within the district. Primary and pseudosecondary inclusions in sphalerite homogenized in the range 84° to 132°C. Pressure corrections probably do not exceed +10°C.

With few exceptions, the freezing data show that the salinity of the inclusion fluids is greater than 22 weight per cent salts, having freezing points in the range -19.5° to -23°C. The exceptions include some sets of primary and pseudosecondary inclusions with freezing points of -11.5° to -12.4°C (15 - 16% NaCl equivalent weight per cent).

Homogenization temperatures of 85° to 133°C and freezing points of -18.5° to -21.0°C from primary inclusions in quartz from the Monte Cristo mine are essentially identical to the data obtained for sphalerite.

The mineralization in the northern Arkansas zinc district is probably genetically related to the mineralization in the Tri-State district to the northwest as suggested by the close similarity of fluid inclusion data, mineralogy, and general habitat of the ores.

LEBEDEV, L.M., 1970, Metalliferous thermal brines of the Cheleken peninsula and modern ore deposition (abst.): Internat. Symp. on Hydrogeochemistry and Biogeochemistry, Tokyo, 1970, Abstracts, p. 24. (Author at Institute of Ore Deposits Geology, Petrography, Mineralogy and Geochemistry, USSR Academy of Sciences, Moscow, USSR).

Highly-mineralized thermal waters found in the Cheleken are confined to a large brachyanticlinal fold, situated in the western part of the Cis-Balkhan depression. They are contained in the sandy-argillaceous red-coloured Neogene strata. The brines are of intrinsic chloride calcium-sodium composition with a bulk mineralization of 150-290 g/l. Hydrocarbons,+less often hydrogen and hydrogen sulphide are major constituents of the dissolved gases. The pH varies from 5.5 to 7 in different aquifers. The Eh value changes from +100 up to +185, decreasing in the sulphuretted waters down to -95. The temperature does not exceed 100°C. A characteristic feature of brines is their high metal-bearing capacity. Besides the major components they contain (in mg/l) Pb - from 0.5 to 200; Cu - from 0.05 to 15; Zn - from 0.1 to 8; Cd - from 0.01 to 8.5; As - up to 1.0. Rather elevated amounts of Mo, W, and Sn are present as well. These metals occur in the brines as negatively charged chloride complexes. In the course of discharging, those brines, which are integral part of the Cheleken geothermal system, are carrying away substantial amounts of metals, ranging as follows (in tons per year): Pb - 300-350; Zn - 50; Cu - 35; Cd - 20 and As - 8. In a great quantity of wells native lead is deposited at an exceedingly high rate, reaching occasionally 1.5 and up to 2.5 tons per year. When mixed with the sulphides of hydrogen, these metal carrying brines do favor the sulphide-zinc ores deposition. (sic). (Author's abstract).

LIDSTRÖM, Lars, 1968, Surface and bond-forming properties of quartz and silicate minerals and their application in mineral processing techniques: Acta Polytechnica Scandinavica, Chemistry including Metallurgy Series No. 75, Stockholm, 149 pp. (in English)

In the grinding of quartz and silicates, surface layers with a disrupted lattice or of a gel-like nature up to 0.15 µm thick, depending on the method of grinding, are formed on the particles. These surface layers have been studied by various microscopic methods and their thickness has been determined by X-ray diffraction and DTA as a function of the method of grinding. A strikingly large proportion of the grinding energy input can be stored in the disrupted-lattice layer produced by rapid dry grinding. The liberation of this energy at elevated temperature has been studied by DTA. When stored in water, the disrupted-lattice quartz releases the stored grinding energy within 24 hours, reverting to crystalline form.

The binding of water to quartz has been studied by NMR, and the results show that the disrupted-lattice quartz, when wetted, surrounds itself with a zone of interface-stabilised water up to 2 μm thick, while gel-like and amorphous surfaces collect much thinner water envelopes. The thickness of the water layer can in this case be said to reflect the reactivity of the particles in a water phase.

The reaction mechanisms involved in flotation with amine collectors have been established by potentiometric titration performed direct on the mineral and by flotation experiments, and it has been found that these reactions obey chemical laws. At pH levels below 9 it is primarily aminium ions that react with the silicate ions of the mineral, while at higher pH the reaction is between free amine and any silica present on the particle surfaces. The higher the SiO_2 content of the mineral, the better it floats.

The electrokinetic potential of dry- and wet-ground quartz at various pH levels has been measured by electrophoresis and the thickness of the rigid water layer that accompanies the particles has been calculated.

Experiments performed have shown that the reactivity of freshly ground quartz and silicate minerals can also be utilised to absorb large quantities of metallic ions from metal-ion-rich water, e.g. mine water, or to remove mercury from polluted waters.

The disrupted-lattice quartz, which is reactive and forms strong water bonds, is found to cause silicosis much more rapidly than normal quartz of similar particle size. In the manufacture of autoclaved lime-quartz products, too, the disrupted-lattice quartz is found to give a higher compressive strength than normal quartz, thereby permitting shorter hardening times. (Author's abstract, included here because of its pertinence to a variety of inclusion extraction problems (Ed.)).

LE MAHIEU, G. C., (compiler), 1970, Tin mineralization of the world arranged geographically, an annotated bibliography derived from Chemical Abstracts and Mineralogical Abstracts, 3 vols, (approx. 500 p): The Hague, Netherlands, The Billiton Maatschappij N.V.

Those studies of tin ores including work on fluid inclusions in which the inclusion data are mentioned in the published abstract will all be found here, but mainly scattered. (E.R.).

LERAY, J.L., 1970, Some physical-chemical processes involved in the generation of vacancies during crystal growth: Schweiz. Mineral. Petrog. Mitt., v. 50, pt.1, p. 21-24.

Review of some physical and chemical processes contributing to formation of vacancies during crystal-growth as observed on dihydrated copper chloride: diffusion of solute and impurities; absorption of additives in the course of regular growth; oriented dendritic growth in heterogeneous solutions; spherolithic growth. (Author;s abstract; the term "vacancies" refers here to inclusions. Ed.)

LEZIER, J.C. and YAJIMA, J., 1970,Thermometric studies of two fluorite veins from the Achemèche massif (central Morocco): Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 85-90, (in French).

Two types of primary fluid inclusions were encountered in the Djebel Bergamon and Djebel Kifane near El Hamman in the massif of Schemèche: one undersaturated with NaCl and another saturated at homogenization temperatures. Some seemingly two-phase inclusions appeared to be supersaturated at room temperature after thermal (cooling) shock treatment. The difference in temperatures between disappearance of the solid phase (Ts) and disappearance of the vapor phase (Tb) allows for pressure estimation. Temperatures of formation are between 105° and 140°C. Salinities are up to 30% equiv. NaCl. The Tb-Ts difference (30°C) points to undersaturation in the higher T reaches and saturation near 100°. (P.J.M. Ypma).

LITVINOV, V.L., LYAKHOV, Yu.V. and Popivnyak, I.V., 1970, Paleotemperature zoning in the Kariisk gold deposit (eastern Transbaikalia): Geolog. Rudnykh Mestorozh., 1970, no. 5, p. 96-101 (in Russian).

Homogenization temperatures of 500 to 370°C were determined and pressures of $\gg$760 to 300 atm. were calculated (E.R.).

LOFOLI, P., 1970, Internal characteristic of detrital minerals as exemplified by the deposits of the Congo Basin: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 37-40, (in French).

The presence and size of fluid inclusions might be used as a transport parameter for detrital quartz grains. Mechanical abrasion seems to favor parts rich in fluid inclusions. Depositional sequences from early fluid inclusion-rich quartz to a later barren one have been noticed in the Congo Basin. (P.J.M. Ypma).

LOVE, J.D. and GOOD, J.M., 1970, Hydrocarbons in thermal areas, northwestern Wyoming: U.S. Geol. Survey Prof. Paper 644-B, p. 1-23.

Five natural occurrences of hydrocarbons are reported, associated with sulfur, in active thermal areas. Four are underlain by young volcanic rocks. The origin of the hydrocarbons is presumably by distillation from underlying sediments. (E.R.).

LYASHKEVICH, Z. M., and KOVALEVICH, V. M., 1970, On genesis of nepheline in rocks of the Oktjabr'sky massif: L'vov. Gos. Univ. Mineralog. Sbornik, v. 24, no. 3, p. 342-345 (in Russian).

Nepheline from foyaite of the Octjabrsky massif is described in the paper. Solid (aegirine, [illegible] and cancrinite), gas-liquid, and liquid-gas inclusions occur in the nepheline. The gas-liquid inclusions homogenize at a temperature of 120°-450°C and correspond to the stage of albitization, which is widely manifested in the massif. Analyses of water leachates of inclusions from nepheline and albite are given for Na, K, Li, Ca, Mg, Mn, Fe, Al, Cl, SO_4, HCO_3, CO_3, BO_3, F, SiF_6, and pH. The liquid-gas inclusions homogenize at 650°-770°C, obviously corresponding to nepheline crystallization. The crystal-chemical formula of nepheline is $Na_{0.74}K_{0.18}Al_{0.95}Si_{1.05}O_4$. Crystal-chemical and thermometric data prove nepheline to be of primary, magmatic origin. (Authors' abstract, extended by E.R.).

MACHAIRAS, G., 1970, The association of fluid inclusions and gold particles in auriferous quartz: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 167-171, (in French).

A direct correlation between gold content: 30-40 g Au/ton and CO_2-bearing inclusions has been established for S. American, French and Canadian quartz veins. This quartz contains 0.26-0.31 mg CO_2/g of quartz. The latter has been determined colorimetrically after crushing and release of CO_2 from the host mineral within the test tube. (P.J.M.Ypma).

MALININ, S.D. and KHITAROV, W.I., 1969, Reduction of sulfate sulfur by hydrogen under hydrothermal conditions: Geokhimiya, 1969, no. 11, p. 1312-1318 (in Russian; translated in Geochem. Internat., v. 6, no. 6, p. 1022-1027).

Of pertinence to all analyses of inclusions for both sulfate and hydrogen. (ER).

MALYSHEV, A.G., 1970, The possibility of the (study) of crystal bearing pegmatites and quartz veins by chemical analyses of aqueous extracts from quartz: VNIISIMS, Geology and Experimental Studies, v. 12, p. 14-21 ("Nedra" Press, Moscow; in Russian). (See Translations Section).

MANUCHARYANTS, B.O., NAUMOV, V.B. and KHODAKOVSKIY, I.L., 1970, Physico-chemical conditions of formation of hydrothermal deposits of antimony and mercury: Geokhimiya, 1970, no. 11, p. 1291-1301 (in Russian); translated in Geochem. Internat., 1970, p. 911-923.

Investigation of gas-liquid inclusions in minerals of hydrothermal antimony-mercury deposits shows that the temperature of formation of stibnite and cinnabar did not exceed 250°C (in most cases, the minerals crystallized at temperatures between 75 and 200°C) and the pressure of solutions ranged from a few tens to 1500 atmospheres. Determination of carbon dioxide content in the inclusions and thermodynamic analysis of mineral equilibria indicate that mercury and antimony sulfides crystallize mainly from acid solutions (Authors' abstract).

MEĹNIKOV, F.P., 1970a, Freezing investigations of mineral-forming solutions in inclusions (with a film), (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 242.

(In the) cryometric method, without opencasting, investigating solution inclusions in minerals and rocks under negative temperatures making use of specially constructed devices, when previously cooled gaseous and liquid solutions locked in inclusions are being cooled and heated, there occur different physico-chemical phenomena making it possible to obtain important data about concentration, density and chemical composition of these solutions.

Under cooling, the solutions having considerable concentration without attaining supersaturation, there is observed a subsequent evolution of crystallohydrates of different salts, the consequent cooling resulting in the formation of cryohydrates. When the temperature rises different compounds being formed in the process of cooling begin to melt or dissolve by stages, the fact testifying the multicomponentcy of the given solution.

No crystallohydrates are formed in inclusions when cooling weakly concentrated solutions. At a definite temperature point the crystallohydrate solutions get quickly and entirely frozen. When performing experiments the change in cooling and heating regime would give approximate data of the water and salt amounts within inclusions.

While cooling essentially-gaseous inclusions some gases, locked in inclusions, liquify. Cooling such inclusions without carrying out any special chemical determinations, it is possible to reveal the presence and approximate amount of carbonic acid and sulphuretted hydrogen within gases locked in inclusions.

The solution cryohydrate points in inclusions obtained from the crystal growth zones of different minerals makes it possible to appreciate the approximate concentration of mineralogenetic solutions in the process of mineral crystallization.

MEĹNIKOV, F. P., 1970b. The dynamics of physico-chemical processes in mineral-forming solution inclusions under temperature changes (with a film) (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 259.

The interpretation of the results of various investigations of inclusions depends upon the understanding of their character and of the mechanism of their formation. When investigating inclusions by different methods, it is possible to obtain data on temperature and pressure during the process of endogenic mineral formation, concentration, pH, and chemical composition of mineral-forming solutions.

Inclusions, as closed natural physico-chemical systems, make it possible to obtain not only their statistical characteristics of filling but their thermodynamical parameters as well, to observe also the different physico-chemical processes within them which take place under changing temperatures, and to clearly show the dynamics of these processes.

We present a diagram of the changes of the aggregate state of mineral-forming environment in inclusions, within a great range of positive and negative temperatures.

The diverse character of the aggregate state changes, under different temperatures in inclusions both containing and not containing a gaseous carbonic acid under room temperatures, has already been elucidated.

The film presents different types of crystallization and recrystallization of 'mineral-prisoners' in inclusion solutions under negative temperatures, which depend upon the concentration and chemical composition of these solutions.

It has been shown that while cooling inclusions under lower than average temperature, to the freezing point a change takes place (increase and decrease) of solution densities in inclusions. Sometimes, before freezing, the solution becomes even viscous.

While heating inclusions under higher than room temperature, one can observe an intensive movement of liquids within them, this results in a circular rotation of microminerals in inclusions.

The changes in the inclusion heating and cooling rate control the crystallization and dissolution of solid phases, induce their spontaneous crystallization, and the formation of two-phase inclusions of the matrix solution within the 'micromineral-prisoners' themselves.

While heating inclusions of different gas-liquid CO_2 ratios under room temperature one can observe both the processes of homogenizing and gaseous or liquid carbonic acid, as well as a microsystem behaviour under critical state.

As the film shows, the elucidation of the processes taking place in inclusion microsystems under temperature changes, promotes the building of a model of endogenic mineral and ore forming processes in macrosystems. (Author's abstract.)

MILLER, S.L. and SMYTHE, W.D., 1970, Carbon dioxide clathrate in the Martian ice cap: Science, v. 170, p. 531-533.

Data are given on the dissociation pressure for CO_2 hydrate (given here as $CO_2 \cdot 6H_2O$), that may be useful to inclusion cryometry. (ER).

MIYAZAWA, T., 1970, Lowest limit and depth of formation of hydrothermal veins, p. 204-208 in Problems of Hydrothermal Ore Deposition, ed. by A. Pouba and M. Stemprok, Internat. Union of Geol. Sci., Ser. A, no.2 (1970).

A short review of extensive work in which homogenization temperatures of inclusions in quartz (and also barite, fluorite, calcite, rhodochrosite, and sphalerite), from a series of Japanese ore deposits, were used to plot isotherms on vein maps, and hence to determine thermal gradients. These gradients vary from mine to mine but are generally in the range of 3-5°C per 10m, up to 7°/10m. These temperatures are also used to estimate the depth of formation and the lower limit of mineralization. (ER).

MIYAZAWA, Toshiya, HASHIMOTO, Mitsuo and HARADA, Kazuo, 1970, Crystalline schists of the Nagatoro area, and geology and ore deposits of the Chichibu mine: Internat. Min. Assoc. - Internat. Assoc. Genesis Ore Deposits 7th Gen. Meeting, Japan, Guidebook 5, Excursion A8, 49pp (in English).

Quotes decrepitation data (from Takahashi, et.al., 1955) and homogenization data (from Miyazawa and Park, 1970). (Both of these references were in Japanese). (ER).

MIYAZAWA, T., TOKUNAGA, M., OKAMURA, S. and ENJOJI, M., 1970, Formation temperatures of veins in Japan, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 241.

Numerous veins of various kinds are known in Japan. Among them, veins of copper, lead-zinc, gold-silver, manganese (rhodochrosite) and tin-tungsten are important economically. For the past ten years we have been studying the temperature of formation of these veins, using the heating microscope stage. More than thirty veins have been studied and many data on their formation temperature have been accumulated. Minerals used for the temperature measurement were quartz, barite, fluorite, calcite, rhodochrosite and sphalerite.

According to the data, the formation temperatures of copper, lead-zinc, gold-silver, manganese and tin-tungsten veins of subvolcanic type range from 320° to 170°C, 240° to 180°C, 230° to 180°C, 180° to 120°C, and 155° to 80°C respectively, and those of lead-zinc veins of plutonic type from about 390° to 250°C. Formation temperatures of fluorite veins range from 160° to 50°C. Judging from the modes of occurrence of the veins, etc., these values may be considered reasonable as to their formation temperatures.

Moreover, on the basis of the isothermal curves drawn from the temperature data of the veins, we will discuss the direction of flow of the ore solution. (Authors' abstract)

MOMICCHIOLI, F., DEVOTO, O., GRANDI, G., and COCCO, G., 1970, Thermodynamic Properties of Concentrated Solutions of Strong Electrolytes I. Activity Coefficients of Water From Freezing-Point Depressions for Alkali Chlorides: Berichte der Bunsen-Gesellschaft für Physikalische Chemie, v. 74, no. 1, p. 59-66 (in English).

A systematic study of thermodynamic properties of concentrated solutions of strong electrolytes is undertaken. Accurate freezing-point depressions for all the alkali chlorides up to very high concentrations (>3m) are measured and the corresponding rational activity coefficients of the water determined. "Best" values are recalculated for the parameters of the Debye-Huckel theory (short-range interactions being accounted for according to the "effective dielectric constant" model and the effects of "higher terms" being included). Curve-fitting procedures are carried out for various concentration intervals so as to test the theory with increasing concentration. The ion size parameter a is found to be almost independent of the concentration interval for all of the salts considered, but for lithium chloride. Standard deviations change from ± 1.10^{-3}°C to ± 1.10^{-2}°C in passing from the smallest to the largest concentration interval, whereas they are nearly the same for all of the alkali chlorides at any one concentration interval. Authors' abstract.

MONTORIOL-POUS, Joaquín, 1970, Nota sobre la decrepitometría de la celestina (Note on the decrepitation of celestite): Acta Geol. Hispan., v. 5, no. 3, p. 70-71 (in Spanish).

Four morphologically different types of celestite from Barcelona yielded too high temperatures, but the 4 decrepigrams were characteristic of the four types. (ER).

MORGENSHTEIN, L.E., 1970, New empirical formulas and curves for calculating the probable homogenization temperatures of gas-liquid inclusions in quartz and calcite (southern Fergana, Abshir-Austan ore field): Uzb. Geol. Zh. 1970, v. 14, no. 3, p. 39-45 (in Russian). CA 73 (9) 131 (1970). (Author at Inst. Geol. Geofiz. im Abdullaeva, Tashkent, USSR).

A logarithmic treatment of the homogenization temp. (t) and the vol. of the gas phase (g) in a gas-liq. inclusion is presented. The t in primary minerals is calcd. based on an empirical formula: $\log t = \alpha \log g + \log k$. The value of t increases with the g content (%). The t in quartz and calcite is increased with a decrease in the Hg component (s.c). Curves are presented for interpreting the physiochem. conditions of ore genesis.

MOSKALYUK, A. A., 1970, Study of mineral-forming solutions by the method of aqueous extraction (with examples from pegmatites and crystal-bearing quartz veins): Autoreferat (author's abstract) of a dissertation for degree of Candidate Geol.-Min. Sci., under A. I. Zakharchenko: Leningrad, 1970, VSEGEI, 26 pp (in Russian).

An extensive study, particularly of water leaches of quartz. Includes 55 analyses, for Li, K, Na, Mg, Ca, Ba, Sr, Cl, F, SO_4, HCO_3, SiO_2, and pH (although not all on every sample). (E.R.)

MUELLER, George, 1969, Hydrothermally differentiated carbonaceous complexes from the Illinois-Kentucky fluorspar district (abst.): Geol. Soc. Amer. Abstracts with Programs for 1969, Part 7, p. 154-155.

The inclusions of organics within the gangues of the orefield differ from all the hitherto described sediments in being differentiated into two principal phases which, under the microscope, reveal sharp boundaries against each other. The inclusions are filled with a mainly paraffinic, vaselinous oily phase, and they are lined with microspheres and rounded microparticles of a solid organic phase, into which the aromatic and the polar molecules are concentrated. In the fluorite crystals, both the elaborate distribution patterns of four-fold symmetry, and the habits of the individual organic microparticles are governed by the crystallographical orientations of the host. The latter phenomenon of crystallographical ordering of microparticles is absent in the quartz and the calcite crystals of the orefield. The theoretical implications of the above outlined phenomena are discussed. The separation of a mainly paraffinic oil through the effects of hydrothermal agencies may be of significance in relation to the genesis of some petroleums. The concentration of the bulk of the polar molecules, including amino acids into a distinct phase and the crystallographical ordering of this phase may prove to be stages of chemical evolution. (Author's abstract).

NABOKO, S.I., 1968, Chemistry of natural mineral-forming solutions: Geolog. i geofiz., 1968, no. 3, p. 3-13 (in Russian); translated in Internat. Geol. Rev., v. 12, no. 1, p. 26-33 (1970).

The author reports considerable data on the chemistry of modern hydrothermal systems and relates it to the mineralogy of the host rocks and their alteration products. (ER).

NADEAU, J. E., 1968, Temperatures of fluorite mineralization by fluid inclusion thermometry, Sweetwater barite district, East Tennessee (abst.): Geol. Soc. Amer. Spec. Paper 115, p. 490.

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 specimens 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) (Ed.'s note: The higher temperatures here were found to be in error - see Econ. Geology, v. 68, p. 113, 1973.)

NAIBORODIN, V. I., and GONCHAROV, V. I., 1970, Temperature conditions of the Agatovsk gold-silver deposit formation, Northeastern USSR: Geol. Rudnykh Mestorozhd., v. 12 no. 6, p. 46-51, (in Russian).

Homogenization of fluid inclusions in various minerals from epithermal Au-Ag mineralization of volcanic affiliation. (E.R.)

NASH, J. T., 1970, (Fluid inclusions in some Nevada ore deposits): U.S. Geol. Survey Prof. Paper 700A, Geological Survey Research, p. A2.

Gold-quartz-adularia veins occur in phyllitic rocks of the Raspberry Formation (Triassic) near a Tertiary granodiorite intrusive in the Tenmile district near Winnemucca, Humboldt County, Nev. Fluid-inclusion studies show that the mineralizing fluids were of very low density, near 0.65 g/cm^3, the lowest observed to date for this type of deposit. Homogenization temperatures for the gold stage of mineralization range from 270°C to 330°C for eight deposits; a pressure correction of about 15°C should be added to obtain crystallization temperatures. Depression of freezing-point determinations range from -0.2°C to -4.4°C, equivalent to 0.4 to 7.3 wt percent NaCl. Most values for the gold stage are in the range 0.9 to 2.1 wt percent NaCl.

In the Copper Canyon district, Lander County, Nev., fluid-inclusion studies revealed a district fluid zonation. A dense brine occurs in inclusions in the contact zone near the intrusive, and a low density, moderately saline fluid in those peripheral to the contact. Economic copper values are restricted to the brine environment, whereas precious metal, lead, and zinc values are related to the less saline fluids. In this district, thermal zonation is not as conspicuous as fluid-density zonation. (Author's abstract)

NAUMOV, V.B., 1969, Thermometric investigation of quenched magma inclusions in the quartz phenocrysts of rhyolites: Geokhimiya, 1969, no. 4, p. 494-498 (in Russian; translated in Geochem. Internat., v. 6, no. 2, p. 379-383, 1969).

Homogenization temperature of gas + glass inclusions in quartz phenocrysts have been determined. The glass inclusions begin to melt at 680-700°C; homogenization temperatures range from 1030 to 1320°C, but most occur in the 1200=1320°C range. (L.P. Greenland).

NAUMOV, V.B. and MALININ, S.D., 1968, A new method for determining pressure by means of gas-liquid inclusions: Geokhimiya, 1968, no. 4, p. 432-441, (in Russian, translated in Geochem. Internat., v. 5, no. 2, p. 382-391, 1968).

The method makes use of inclusions containing liquid CO_2, liquid water, and vapor. It is based on a straight-line extrapolation, on a P-T plot, from the point representing partial homogenization (liquid and gaseous CO_2), through the temperature of decrepitation (assumed to be always at 850 atmospheres for quartz), on to the temperature, and hence pressure, at homogenization. The errors are stated to be less than 10 percent. (E.R.)

OHMOTO, Hiroshi, 1969, The Bluebell mine, British Columbia, Canada. (Parts I and II) (abst.): PhD dissertation, Princeton Univ. 206 pp. Dissert. Abst. Internat. Sect. B, Sci. and Eng., v. 30, no. 3, p. 1204B.

Part I: Mineralogy, paragenesis, fluid
inclusions, and the isotopes of lead,
carbon, oxygen, and hydrogen.

Pyrrhotite, sphalerite, and galena are the major sulfide minerals, and knebelite, calcite, and quartz the major gangue minerals in the massive lead-zinc ore bodies of the Bluebell mine, British Columbia, which have replaced metamorphosed limestone of Cambrian age.

Detailed paragenesis study and filling temperature measurements of fluid inclusions in ore and gangue minerals indicate that the massive replacement ores were deposited at temperatures between ca. 500°C and ca. 430°C, and that the later minerals in vugs were deposited at temperatures between ca. 430°C and 320°C.

Freezing temperature measurements on inclusion fluids showed that the salinity of the hydrothermal fluids changed from ca. 10 wt.% to ca. 3 wt.% NaCl equivalent during a decrease of the fluid temperatures from ca. 450°C to ca. 320°C.

The fugacity of sulfur in the ore fluids, indicated by the iron content of sphalerite and the temperature data, was shown to have been within 1.5 orders of magnitude of the pyrrhotite-pyrite boundary during the entire period of ore deposition.

The isotopic composition of lead in the ore galena and the "lamprophyre" dikes, which are closely related in time and space, indicates that the ore leads are not genetically related to the "lamprophyre" dikes. The large variation in lead isotope ratios of the galena suggests that the lead was not derived from a homogeneous source.

δO^{18} measurements on quartz and calcite samples, and the filling temperature data for these samples showed that the δO^{18} values of the hydrothermal solutions changed gradually from ca. +5 o/oo (SMOW) at ca. 450°C to ca. -13 o/oo at ca. 320°C during the earlier stages of quartz, carbonate, and sulfide precipitations in vugs. During the same period the carbon isotopic composition of the carbonates was nearly constant at δO^{13} values of -7 ± 2 o/oo (PDB); and δ D values of fluid inclusions in calcite and quartz are in the range -147 o/oo to -157 o/oo (SMOW).

During the last stage of quartz, calcite, and pyrite deposition between ca. 360°C and 320°C, the δO^{18} value of the solutions returned to ca. +6 o/oo. During this stage the $\delta\ C^{13}$ value of the calcite was quite variable, but tended to become more positive, reaching values as large as +4 o/oo.

There is a strong resemblance between the salinity - δ D -δO^{18} relationships during the later stages hydrothermal solutions in the Bluebell mine and those of Salton Sea brines (Craig, 1966) and other normal chloride or near-neutral hot springs described by Craig (1963).

These results suggest that the hydrothermal solutions responsible for at least the later stages of mineralization in the Bluebell mine were largely meteoric in origin. The observed variations in δO^{18} and δO^{13} values of the solutions are interpreted as the result of different degrees of isotopic equilibration of meteoric waters with a variety of country rocks over a considerable range of temperatures.

Part II: Chemistry of the hydrothermal fluids
(Gases and salts in fluid inclusions).

Gases and salts in inclusion fluids from the hydrothermal mineras (knebelite, galena, sphalerite, pyrrhotite, arsenopyrite, quartz, and calcite) of the Bluebell mine were analyzed by mass-spectrometer and atomic absorption techniques.

H_2O comprises over 93 mole percent of the total gases from the fluid inclusions, CO_2, H_2, and CH_4 are the other principal gases. CO, C_2H_6, other hydrocarbons, and N_2 were also observed. The mole ratio of m_{CO_2}/m_{H_2O} is between 0.5×10^{-2} and 4×10^{-2} for all samples except one knebelite sample which gave a value of ca. 10^{-4}. m_{H_2}/m_{H_2O} and m_{CH_4}/m_{H_2O} values ranged from 3×10^{-4} to 2×10^{-2} and from 7×10^{-5} to 10^{-2} respectively for all samples. No H_2S was detected in the fluid inclusions implying that m_{H_2S}/m_{H_2O} values are below 10^{-5}.

The calculations for gas equilibria for the principal components indicate that the observed gas compositions are nonequilibrium assemblages at temperatures below the homogenization temperatures of inclusion fluids. At temperatures ca. 50°C above the homogenization temperatures most of the observed gas proportions can be interpreted as being in equilibrium.

The calculated fugacity of oxygen in the hydrothermal fluids is between 10^{-29} and 10^{-25} atm. at ca. 450°C, and ca. 10^{-35} atm. at ca. 300°C.

Concentrations and concentration ratios of Na, K, Ca, Mg, Fe, Zn, and Cl in the fluids showed wide variation. The total salt concentration, and the K/Na and Ca/Na atomic ratios appear to have decreased with time during the hydrothermal mineralization, from above 10 wt. percent to ca. 1 wt. percent, from above 0.6 to ca. 0.03, and from above 4.0 to ca. 0.02, respectively.

Comparison of the gas compositions and the salt chemistry of the inclusion fluids suggests that during the sulfide deposition and the early stage quartz-calcite deposition in vugs the hydrothermal fluids were distinctly different in chemistry from the fluids of the later quartz-calcite deposition. The later fluids are most likely to be meteoric water. The fluids responsible for the sulfide deposition could be magmatic, connate, or meteoric water which had a history entirely different from the later fluids. (Author's abstract)

OHMOTO, Hiroshi, 1970a, Fluid inclusions and isotope study of the lead-zinc deposits at the Bluebell mine, British Columbia, Canada (abst.): Internat. Symp. on Hydrogeochemistry and Biogeochemistry, Tokyo, 1970, Abstracts, p. 23.

Mainly covers material given in Ohmoto and Rye, 1970.

OHMOTO, Hiroshi, 1970b, Influence of pH and f_{O_2} of hydrothermal fluids on the isotopic composition of sulfur species (abst.): Geol. Soc. Amer., Programs with Abstracts, v. 2, no. 7, p. 640.

Available thermochemical data and isotopic fractionation factors permit quantitative evaluation of the effect of the chemistry of hydrothermal fluids on isotopic composition of sulfur bearing minerals.

When isotopic and chemical equilibria are attained among sulfur species in solutions (H_2S, HS^-, $S^=$, $SO_4^=$, KSO_4^-, and $NaSO_4^-$) and between these species and precipitating mineral phases, δS^{34} values of minerals are controlled mainly by: 1) isotopic composition of total sulfur in the fluids ($\delta S^{34}_{\Sigma S}$), 2) temperature, 3) fugacity of oxygen, and 4) pH. The ionic strength and the salt composition (e.g., K/Na ratio) can effect the δS^{34} values slightly. The δS^{34} values of minerals, however, are not directly dependent on the fugacity of sulfur nor on the total sulfur content of the fluids.

At 250°C in geologically important pH-f_{O_2} regions, the δS^{34} value of pyrite precipitating from a solution in which the mean value of δS^{34} is zero can vary from +5 to -26 °/oo: an increase in f_{O_2} of one log unit or of pH by one unit can decrease the δS^{34}_{py} value by as much as 20 permil. Sulfides of $\delta S^{34}=0$ °/oo need not have precipitated from solutions in which $\delta S^{34}_{\Sigma S} = 0$ °/oo. This conclusion casts rather serious doubts on many genetic interpretations currently placed on the isotopic composition of sulfur in sulfide minerals. (Author's abstract).

OHMOTO, Hiroshi, 1970b, Fluid inclusions and isotope study of the lead-zinc deposits at the Bluebell Mine, British Columbia, Canada, (Abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 132.

At the Bluebell mine, pyrrhotite, sphalerite, and galena occur as the major sulfide minerals, and knebelite, quartz, and calcite as the major gangue minerals in the Tertiary lead-zinc ore bodies, which replaced Cambrian limestone beds.

A detailed study of the paragenesis, and filling-temperature measurements of fluid inclusions in ore and gangue minerals have indicated that the massive ores were deposited at temperatures higher than 450°C, and that the later minerals in vugs, which make up about 10 percent of the hydrothermal minerals, were deposited at temperatures between 450°C and 320°C. Pressure on the hydrothermal fluids was estimated to be in the range 300 to 800 atms.

Freezing temperature measurements, and the analyses of gas and salt composition of inclusion fluids by mass-spectroscopy and atomic absorption spectroscopy have shown the gradual change of the chemical composition of the hydrothermal fluids with time and with temperature.

Stage	T(°C)	Salinity (=K+Na+Ca+Cl) (wt.%)	K/Na (atomic)	Ca/Na (atomic)	Zn (ppm)	CO_2 (moles/kg H_2O)	H_2 (moles/kg H_2O)	CH_4 (moles/kg H_2O)	H_2S (moles/kg H_2O)
Early	500-450	15-10	.6	4.0	<2200	1.3	1.0	.20	<.001
Last	350-320	3-1	.03	.20	100-20	1.3	.05	.014	<.001

The gases did not re-equilibrate to room temperature during cooling and define a range of oxygen fugacity of the hydrothermal fluids in equilibrium with the mineral phases of the ore bodies.

The δD values of water from fluid inclusions of different generations are constant in the range -155±5 o/oo (SMOW). Oxygen isotope measurements of quartz and carbonate samples indicated that the δO^{18} values of the hydrothermal fluids changed gradually from + 6 o/oo (SMOW) at 450°C to -13 o/oo at 320°C. The δ S34 values of the hydrothermal fluids idicated by the sulfur isotopic composition of sphalerite, galena, pyrrhotite, and pyrite also changed gradually from +12 o/oo at the early stage to +5 o/oo at the last stage of ore deposition. The lead isotopes of galena belong to B-type anomalous lead.

All these data suggest a meteoric origin for the water, and a sedimentary origin for the dissolved gases and salts in the hydrothermal fluids from which the Bluebell lead-zinc ores were deposited.

OHMOTO, Hiroshi, BORCSIK, Maria, and HOLLAND, H. D., 1969, Chemistry and origin of hydrothermal fluids at the Bluebell mine, British Columbia (abst.): Geol. Soc. Amer. Absts. with Programs 1969, pt. 7, p. 165.

The composition of inclusion fluids in minerals of the Bluebell mine has been determined by mass spectroscopy and atomic absorption spectrometry:

	Component	Early Stage Fluids	Late Stage Fluids
CO_2	(moles/kg H_2O)	1.3 ± 0.5	1.3 ± 0.5
H_2	(moles/kg H_2O)	1.1 ± 0.2	0.03 ± 0.02
CH_4	(moles/kg H_2O)	0.5 ± 0.3	0.004 ± 0.001
H_2S	(moles/kg H_2O)	<0.001	<0.001
Total	salts (wt. %)	>10	2 ± 1
K/Na	(atomic)	0.7 ± 0.2	0.03 ± 0.01
Ca/Na	(atomic)	>4	0.15 ± 0.05
Zn	(ppm)	<2000	<300

The gases did not reequilibrate to room temperature during cooling, and define a range of oxygen fugacity in equilibrium with the mineral phases of the ore bodies at temperatures between 350 and 500°C.

The chemistry of fluids and the isotopic composition of hydrogen, carbon, oxygen, sulfur, and lead suggest a meteoric origin for the water and non-juvenile origin for the dissolved gases and salts in the fluids from which the Bluebell lead-zinc ores were deposited. (Authors' abstract).

OHMOTO, Hiroshi, KAJIWARA, Yoshimichi and DATE, Jiro, 1970, The Kuroko ores in Japan: Product of sea water? (abst.): Econ. Geol., v. 65, p. 738-739.

The mode of occurrence and textures of stratabound copper-lead-zinc deposits in the northern parts of Japan, the Kuroko, suggest that the ore deposition was associated with submarine volcanic activity during Middle Miocene time, and that the ores were formed on the sea floor and/or in unconsolidated sediments.

δS^{34} values of pyrite (36 samples from 7 mines) show a gradual decrease towards top of the sequence: +8.2 to +6.5 in disseminated ores and veins in the footwall rhyolite; +7.1 to +4.6 in stratiform pyrite ores and yellow ores; +7.0 to +3.0 in black ores; -5.0 to -6.0% in hematite-rich layers. The changes in δS^{34} values of other sulfide minerals (45 samples) parallel the δS^{34} values of pyrite with Δ_1 values, $\Delta_1 = \delta S_{py}^{34} - \delta S_1^{34}$ of 1.3 ± 0.4 for sphalerite, 1.4 ± 0.2 for chalcopyrite and 3.9 ± 0.2^{o}/oo for galena. The temperatures of deposition indicated by the δS^{34} values of coexisting sulfides are between 200 and 300°C compared to a temperature range, 100 to 265°C, indicated by the fluid inclusion filling temperatures of quartz, barite, and sphalerite.

δO^{18} values of fluid inclusions from 4 samples of pyrite from the yellow ores are between -1.6 and -0.1^{o}/oo (SMOW). The δS^{34} values of sulfides, and the mineralogy and chemistry of the ores can be best explained if the sulfur in solutions was around +20^{o}/oo (i.e., the value of present-day sea water)and if the minerals precipitated at around 250°C in chemical and isotopic equilibria with solutions of sea water composition. (Authors' abstract).

OHMOTO, Hiroshi, and RYE, R. O., 1969, The ores of the Bluebell mine British Columbia - a product of meteoric water? (abs.): Geol. Soc. America Spec. Paper 121, p. 222-223.

Pyrrhotite, sphalerite, and galena are the major sulfide minerals, and knebelite, quartz, and calcite are the major gangue minerals in the massive lead-zinc ore bodies of the Bluebell mine, British Columbia, which have replaced metamorphosed limestones of Cambrian age.

The ∂D(SMOW) values of five samples of water from primary fluid inclusions in calcite and quartz fell in the range -152 ± 5‰. δO^{18} measurements on 54 samples of quartz and calcite, and filling temperature measurements for the same samples showed that the δO^{18}(SMOW) values of the hydrothermal solutions changed gradually from + 5‰ at ca. 430°C to -13‰ at ca. 300°C during the earlier stages of quartz, calcite, and sulfide precipitation in vugs. The decrease in temperature and δO^{18} value were accompanied by a decrease in the salinity of the fluids from ca. 10 wt percent to ca. 2 wt percent equivalent NaCl. During the same period the isotopic composition of carbon was nearly constant at -8‰ (PDB) in calcite and near -6‰ (PDB) in the solutions.

During the later stages of quartz and calcite deposition between 350°C and 300°C, the δO^{18} value of the solutions returned to ca. +5‰. During this stage the δC^{13} value of the calcite was quite variable, but tended to become increasingly more positive, and reached values as large as +4‰.

These results suggest that the hydrothermal solutions responsible for the stages of mineralization studied by us were largely meteoric in origin and that the observed variations in δO^{18} and δC^{13} are the result of different degrees of isotopic equilibration of meteoric waters with a variety of country rocks. (Authors' abstract).

OHMOTO, Hiroshi and RYE, R.O., 1970, The Bluebell mine, British Columbia. I. Mineralogy, paragenesis, fluid inclusions, and the isotopes of hydrogen, oxygen, and carbon: Econ. Geol., v. 65, p. 417-437.

At the Bluebell mine, pyrrhotite, sphalerite, and galena occur as the major sulfide minerals, and knebelite, quartz, and calcite as the major gangue minerals in the Tertiary lead-zinc replacement ore bodies.

A detailed study of the paragenesis, and filling temperature measurements of fluid inclusions in ore and gangue minerals have indicated that the massive ores were deposited at temperatures higher than 450°C, and that the later minerals in vugs which make up approximately the final 10 percent of the hydrothermal minerals, were deposited at temperatures between 450°C and 320°C. P_{H_2O} in the hydrothermal fluids was estimated to be in the range 300 to 800 atms, and the depth of the ore deposition approximately 6 km.

Freezing-temperature measurements on inclusion fluids have shown that the salinity of the hydrothermal fluids changed gradually from about 10 wt percent to about 3 wt percent equivalent NaCl during a decrease of the fluid temperatures from 450°C to 320°C.

Analyses of oxygen isotopic composition of quartz and carbonate samples, and the temperature data for these samples indicate that the δO^{18} values of the hydrothermal fluids changed gradually from +5°/oo to -13°/oo (SMOW) accompanied by the decrease of the fluid temperatures from 450°C to 360°C during the earlier stages of quartz-carbonate-sulfide precipitation in vugs. During the same stages the isotopic composition of hydrogen in the fluids was nearly constant at a δD value of -152±5°/oo (SMOW). The isotopic composition of carbon in the fluids was also uniform at a δC^{13} value of 5.5±°/oo (PDB).

During the last stage of mineralization at temperatures between 360°C and 320°C, the oxygen and carbon isotopic composition of the fluids both became more positive, reaching δO^{18} and δC^{13} values as large as +6°/oo.

There is a great similarity between the temperature-salinity-δO^{18}-δD relationships in the hydrothermal solutions at the Bluebell mine and those of the Salton Sea brines described by Craig (1966). This similarity suggests that the hydrothermal solutions responsible for at least the later stages of mineralization in the Bluebell mine were largely meteoric in origin. The observed variations in δO^{18}, temperature, and salinity values of the solutions can be interpreted as resulting from initial uniform meteoric water that obtained a variety of temperature, salinity, and δO^{18} values due to differing degrees of equilibrium with a variety of rocks. The data can also be interpreted as the result of mixing of two meteoric waters, one hot and well equilibrated with country rocks, the other cooler and less well equilibrated.

The δC^{13} values of the earlier fluids reflect carbon from a juvenile source, carbon from graphite, and/or carbon from a limestone source that re-equilibrated with graphite in the country rocks. (Authors' abstract). (Note-the design of the heating stage is also given. ED.).

OHRING, Milton and TAI, King Lien, 1969, Gas-Filled Bubbles in Ionic Solids: J. Amer. Ceramic Soc., v. 52 no. 10, p. 559-562.

A device to selectively introduce gases into a melt of KCl from which single crystals or oriented bicrystals are being pulled is described. The insoluble gases (e.g. Ar, Cl_2, N_2, and CO_2) were incorporated into the growing crystals in the form of bulk and grain boundary bubbles having a decided crystallographic appearance. The as-grown bubbles of Ar and Cl_2, were extended along the growth axis, whereas those of N_2 and CO_2 were compressed in this direction. The bubble shapes are expected to depend on surface energy considerations and on the way in which the gas interacts with the solid; the bubble geometries were qualitatively consistent with available data on the theoretical adsorption behavior of these gases on (100) crystal faces of KCl. On annealing under load, the bubbles became highly faceted. Only the very stable (100) plane developed; this indicates the extreme anisotropy of the surface energy even at temperatures approaching the melting point. The failure of bubbles to evolve completely into cubes is probably due to the difficulty of establishing growth habits normal to the (100) plane. (Authors' abstract)

PAWLOWSKA, Jadwiga, 1969, Significance and methods of geothermometry and geobarometry in a study of endogenetic deposits: Przegl. Geol., v. 17, no. 11, p. 552-555 (in Polish). A review (E.R.).

PERING, Katherine, and PONNAMPERUMA, Cyril, 1969, Alicyclic hydrocarbons in the immediate geologic environment of a bitumen deposit in north Derbyshire, England (abst.): Geol. Soc. Amer. Abstracts with Programs for 1969, Part 7, p. 172.

Within the lead-zinc ore field of North Derbyshire, England, are deposits of several morphologically distinct solid and liquid bitumens. Earlier work in this laboratory showed that the bitumens in the largest of these deposits, near Castleton, exhibit two different types of hydrocarbon distribution patterns, one of which is a very complex mixture of isomers which does not resemble those from typical sediments. Possible explanations for these differences are being investigated to obtain a clearer understanding of the means by which compounds of biogenic significance can be altered in geologic environments. The stratigraphic placement of the bitumen is in the ore-bearing horizon of the lower Carboniferous limestones near their contact with the overlying shales. This placement, and the presence of free crystals of fluorite, calcite, galena and marcasite in the bitumen deposit suggest two possible explanations for the hydrocarbon differences: selective alteration by hydrothermal fluids, or fluid transport of organic matter into the deposit from two or more points of origin. Analyses show that one type of alkane distribution pattern is almost identical to those isolated from the overlying shales. However, analysis of limestone, fluorite, clay and crude oil samples reveals no distribution similar to the more complex type of alkane mixture also found in the deposit. (Authors' abstract).

PERNA, Guiliano, 1970, Fluid inclusions in crystals: Atti Accad. Roveretana Agiati 1968 (Pub. 1970), V. 8, p. 11-21 (in Italian). A review with 13 references (ER)

PETERSIL'E. I.A. and SÖRENSEN, H., 1970, Hydrocarbon gases and bituminous substances in rocks from the Ilímaussaq alkaline intrusion, South Greenland: Lithos, v. 3, p. 59-76.

Samples of poikilitic sodalite syenite (naujaite),sodalite foyaite and augite syenite from the Ilímaussaq alkaline intrusion in South Greenland contain hydrocarbons in vacuoles in the minerals and in intergranular micro-pores. Samples of lujavrite and gabbro have very low gas contents. Methane is the predominant hydrocarbon; the contents of CO_2 and CO are insignificant. The carbon of the hydrocarbon gases of naujaite is enriched in C^{13}. The rocks contain disseminated bituminous substances composed mainly of oil, alcohol-bensol resins and asphaltenes. The hydrocarbon gases and the bituminous substances are thought to be of inorganic origin. The methods of examination are described. (Authors' abstract).

PHILPOTTS, J.A., SCHNETZLER, C.C. and PHILPOTTS, A.R., 1970, Monteregian mixed rocks: some trace element data (abst.): Geol. Soc. Amer., Abstracts With Programs, v. 2, no. 7, p. 652-653.

These and other studies support the hypothesis that silicate liquid immiscibility is involved in the origin of these rocks. Evidence should be looked for in melt inclusions. (E.R.).

PINCKNEY, D.M. and HAFFTY, Joseph, 1970, Content of zinc and copper in some fluid inclusions from the Cave-in-Rock District, Southern Illinois:

Econ. Geol., v. 65, p. 451-458.

Zinc, copper and chlorine analyses have been made of fluids included in crystals of fluorite, quartz, and barite. The objectives of the study were to determine the amount of zinc and copper in the fluid inclusions, and to see if the amounts of these metals changed with time of deposition and location.

The crystals are from hydrothermal deposits characterized by fluorite, sphalerite, galena, and minor chalcopyrite. The inclusion water was recovered by crushing the crystals in a vacuum line, and the salts were recovered by leaching the crushed sample with water. The leach solutions were analyzed by atomic absorption spectroscopy.

The ranges of concentration in the inclusions are: zinc, 10 to 1,040 ppm (parts per million); copper, undetectable to 350 ppm; and chlorine, 2,500 to 152,00 ppm.

Variations in the base metal and chlorine content were found relative to periods of deposition of sphalerite. In one ore body the amount of base metals and chlorine was greater in the interior than at the edges of the body.

A good correlation exists between zinc and chlorine for the sulfide-ore solutions as samples with high zinc concentrations also have correspondingly high chlorine concentrations. (Authors' abstract).

PIRMOLIN, J., 1970, Inclusions fluides dans la dolomite du gisement stratiform de Kamoto (Katanga Occidental). Annales Soc. Géol. Belgique, v.93, pt. II, p. 397-406 (in French).

In the dolostones and shales of the "Mines Serie" at Kamoto, two strata-bound orebodies are found. Between them, there is a thick bed of unmineralized cherty dolostone, with locally large dolomite crystals. In these crystals, fluid inclusions have been observed which contain a bubble and three daughter crystals. The three daughter crystals dissolve at about 55°C, 120°C, and 200°C. (Author's abstract, modified).

PIZNYUR, A. V., 1970, Thermodynamic conditions of formation of mineral associations of the molybdenum polymetallic occurrence Shahtama (Eastern Transbaikal): L'vov. Gos. Univ. Mineralog. Shornik, v. 24, no. 2, p. 207-213 (in Russian).

The deposit is related to eruptive breccia and was formed during five stages. Before the time of the explosion the pressure reached 2300-2550 atm. The temperature of the mineral formation of pneumatolytic and sodium-rich hydrothermal solutions varied from 400° to 45°C. (Author's abstract).

PIZNYUR, A. V., and SOLOMIN, Yu. S., 1969, Mineralogy and genesis of molybdenum deposits: L'vov Gos. Univ., Mineral. Sbornik, v. 22, no. 4, p. 378-385 (in Russian).

Mainly a study of fluid inclusions in quartz from the five stages of mineralization in the Davenda deposit in the Eastern Transbaikal. Homogenization temperatures ranged from 435° to 80°C, and the inclusion fluid density ranged from low (hence "pneumatolytic") to high ("hydrothermal"). (ER)

POKROVSKIY, P. V., and PURTOV, V. K., See Translations Section

POMÎRLEANU, V. and MÎNZĂRARU-JUDE, L., 1970, Sur les inclusions fluides présentes dans les cristaux d'apatite de quelques pegmatites de Roumanie (Fluid inclsuions in apatite crystals from Roumanian pegmatites): Acta Geol. Acad. Sci. Hungaricae, v. 14, p. 63-70 (in French).

Two-phase (water plus vapor), and three-phase (liquid CO_2 + liquid water + vapor) inclusions from apatite are illustrated and homogenization data reported. The CO_2 phases homogenize at 23-29.5°C and complete homogenization occurs at 322-390°C (ER).

POMÎRLEANU, V. and MOVILEANU, A., 1970, Geothermometry of some pegmatites in Romania, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70:

Tokyo, Science Council of Japan, p. 135(The identical abstract appears on p.254 also)

With a view to determine the formation temperature of some granitic pegmatites of the Carpathian Arc of Romania, the fluid inclusions occurring in quartz, apatite, tourmaline, spodumene, beryl and muscovite were studied. The fluid inclusions are considered as "actual samples of the ore-forming fluids" of the media from which minerals have crystallized (Roedder, Genetic Problems Ores, XVI, 218, 1960; Yermakov, Research Ore-Forming Solutions IX, 5-7, 1966). According to the types and features of fluid inclusions, most minerals (quartz, apatite, tourmaline, spodumene and beryl) formed from aqueous solutions CO_2-saturated and from salt-saturated solutions (quartz, beryl, muscovite).

The mineral formation temperatures determined by the fluid inclusion homogenization and decrepitation method (pressure correction excepted) ranged between 530° and 300°C. Minerals depositing during the pegmatitic process took place within this temperature interval. Lower temperatures (300°C to 100°C) obtained by studying secondary fluid inclusions are characteristic for the action of the hydrothermal replacement process which led to forming of some neoformation minerals on account of the preexistent minerals.

The temperature of muscovite formation was determined by studying fluid inclusions and also by applying the paragonite-muscovite system diagram. Pegmatite muscovite occurring in Sadul valley formed between 360°C and 425°C, while muscovite from paragneisses and micaschists (rocks supposed to enclose the paragonite-muscovite assemblage) in pegmatitic bodies proximity, formed between 570°C and 600°C.

POMÎRLEANU, Vasile and MURARIU, Titus, 1970, Summary of studies of tourmaline from pegmatites in Romania: Ber. deutsch. Ges. geol. Wiss., B, Miner. Lagerstättenf., v. 15, no. 2, p. 175-186 (in German).

Primary inclusions of several shapes with combinations of various amounts of CO_2 and water solutions, are reported. Some develop a vapor bubble only on cooling to below 18°C. Decrepigrams show maxima at 275-375°C. (E.R.).

POTY, Bernard, 1968, La croissance du quartz lamellaire sur l'exemple des cristaux de la Gardette (Isere, France)(The growth of lamellar quartz as examplified by La Gardette quartz crystals, Isere, France), in Papers and Proceedings of the 5th Meeting of Internat. Min. Assoc., Cambridge, 1966: London, The Mineralogical Society London, p. 54-62.

Quartz crystals from La Gardette (Dauphine, France), have a lamellar structure and were formed in a medium the characterisitics of which varied suddenly a number of times. This produced a zoned structure through irregular adsorption of impurities. Chemical analyses of layers, in the positive rhombohedron sector, show that the rate of growth is the parameter which controls the impurity content (Al, Li) of the crystal. A layer grows between two movements of the fault in which the vein lies. At the beginning quartz traps some 400 ppm of Al, but at the end we find only half of this amount. Hemihedral faces, s and x, appear only when the rate of growth is low, and tend to disappear as soon as it increases. Indeed it is observed that they appear and disappear many times during the growth of one crystal. (Author's abstract). (Ed!s note: this is a short version of the material presented in much greater detail (162 pp) by Poty, 1969- see Fluid Inclusion Research - Proceedings of COFFI, 1969, p. 62).

POTY, B. and STALDER, H.A., 1970, Cryometric determinations of salt- and gas-contents of fluid inclusions in quartz crystals from mineral fissures of the Swiss Alps. Preliminary Note: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 141-154 (in German).

Freezing stage data on quartz inclusions from the Swiss Alps fall in two categories: formation of gas hydrates and freezing point depression of the brine because of salts (NaCl). The CO_2-hydrates from the Penninikum and Gotthard Massif melt between +7.2° and +11.4°C. The CH_4-hydrates from the Helvetikum melt between +16° and +18°C. An unknown hydrate (possible from a high pressure hydrocarbon compound) melts between +2° and +6°C. Salts occur in varying concentrations, but no saturated solutions were found. Some frozen inclusions melt below -21.1°C (the eutectic of NaCl and H_2O) indicating other saline constituents than NaCl. The freezing stage data can be correlated with the following geologic setting:

1. High salt contents occur near evaporite deposits (7-13% NaCl).
2. In the presence of CO_2, the salt content in the same group of materials is lower (12% versus 9% NaCl; Aar Massif).
3. Increase of metamorphic grade: zeolite facies minerals contain 2% NaCl, green schist - stilpnomelane facies 6-9% NaCl.
4. Influence of the country rock: granites have inclusions with 6-10% NaCl, amphibolites 2-6% NaCl.

The retrograde vein minerals in Tessin reflect greenschist rather than sillimanite facies and have accordingly lower salt content: 3-6% NaCl. (Authors' abstract, modified by P.J.M. Ypma).

POWERS, H.E.C., 1970, Sucrose crystals: inclusions and structure: Sugar Technol. Reviews, v. 1, p. 85-190 (dated 1969/1970).

A very extensive review (108 references and 97 photomicrographs) into the growth of crystals of sucrose and the nature and origin of various solid, liquid, and gaseous inclusions in sugar. Of pertinence to many studies of fluid inclusions in minerals, particularly in the problems of the mechanism of trapping of inclusions. (ER).

PRASOLOV, E.M. and TOLSTIKHIN, I.N., 1969, Isotopic composition of helium and argon in the fluid inclusions in rischorrite: Geokhimiya, 1969, no. 2, p. 231-234, (in Russian; translated in Geochem. Internat., v. 6, no. 1, p. 163-166, 1969).

Mass spectrometric analysis of fluid inclusions in rischorrite gives a He^3/He^4 ratio of 85 x 10^{-8} and an Ar^{40}/Ar^{36} ratio of 2380. The Ar^{36} content was 0.5 x 10^{-8} cm^3/gm and was apparently initially present in the inclusions and not a result of air contamination. The source of this included Ar^{36} is not yet known with certainty. (F.J. Pearson, Jr.)

PRASOLOV, E. M., and TOLSTIKHIN, I. N., 1970, Isotopic composition of helium and argon from microinclusions in quartz: Akad. Nauk SSSR Doklady, v. 191, no. 3, p. 653-655 (in Russian).

A review of the literature plus two new analyses of quartz from the Aldan. (E.R.)

PULOU, R., deCROISANT, J. and GRITTI, C., 1970, Apparatus for the registration of decrepitation and its application towards the determination of deposition temperatures of minerals: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 59-66, (in French).

An instrument is described that registers decrepitation sounds as a function of temperature. The temperature range is 20-450°C. Sample size is 2-3 grams. Different grain sizes are used: between 1.2 and 0.2 mm. Barite and fluorite give clearly reproducible results: peaks at 200 and 290°C for barite and a broad peak near 300°C for fluorite (P.J.M. Ypma).

PURTOV, V.K., 1970, Mode of origin of quartz crystals at one south Ural deposit: Akad. Nauk SSSR, Doklady, v. 194, no. 6, p.1415-1417 (in Russian); translated in Doklady Acad. Sci. USSR, Earth Sci. Sects., v. 194, 1970, p. 204-206 (issued 1971).

Two types of CO_2-bearing fluid inclusions are found, homogenizing in the liquid and in the gas phase. Both types show similar temperatures of homogenization (CO_2 phases at 27-31°C and complete homogenization at 300-315°C), but the variations are systematic through the crystals, indicating systematic changes in T and particularly in P (ER).

RABIDEAU, S.W. and FLORIN, A.E., 1970, Anomalous water: characterization by physical methods: Science, v. 169, 48-52.

(Editor's note - this is only one of many papers published in this general period discussing the evidence for or against "anomalous water" (see Deryagin, 1970).) This one suggests it is a sodium borate solution. (ER).

RADKEVICH, E.A., GOLOVKOV, G.S., KOKORIN, A.M., KOKORINA, D.K., KOROSTELEV, P.G. and STEPANOVA, M.V., 1970, Vertical scope of mineralization and distribution of trace elements in minerals of deposits of different depth formation (stanniferous zones, Komsomolsk District) (abst.), in Problems of hydrothermal ore deposition, Z. Pouba and M. Stemprok, eds.: Internat. Union of Geolog. Sciences, Series A, no. 2, p. 217-218 (in English).

In the Komsomolsk district stanniferous quartz-tourmaline zones of Upper Cretaceous age intersect Upper Cretaceous effusive sheets about 1 kilometer thick; mineralization is developed over a vertical interval of about 1200 meters.

Type A deposits (Tab. 1) occur in Jurassic sediments and were emplaced at a depth of about 1 kilometer. Type B deposits, also in Jurassic sediments, were emplaced at shallower depths, probably within a few hundred meters of the surface. Temperature of deposition is remarkably similar in both types of deposits indicating easy movement of the ore forming fluid along vertical fractures. Commencing at about 360°C in the tin-tourmaline phase, temperatures declined to 285°C in the sulphide phase as measured by fluid inclusions. Type B deposits are notably enriched in the trace elements niobium and tungsten. (Authors' abstract)

Table 1. The temperature of homogenization of gas-liquid inclusions in quartz and content of trace elements in cassiterite of deposits of various depth of formation.

Stages / horizons	temperature of homogenization °C			trace elements content in cassiterite; numerator-average content in wt %; denom. - no. of samples		
	Quartz-cassiterite		quartz-sulphide			
	I	II	III	Nb_2O_5	WO_3	In
	type B deposit					
1	363-301	–	286-238	$\frac{0.028}{6}$	$\frac{0.314}{6}$	$\frac{0.005}{6}$
2	294-285	–	261-230	$\frac{0.021}{4}$	$\frac{0.228}{4}$	$\frac{0.006}{4}$
3	359-290	–	268-221	$\frac{0.016}{3}$	$\frac{0.285}{3}$	$\frac{0.004}{3}$
4	–	–	–	$\frac{0.019}{3}$	$\frac{0.147}{3}$	$\frac{0.003}{3}$
	type A deposit					
1	338	350-361	291	$\frac{0.007}{4}$	$\frac{0.090}{4}$	$\frac{0.003}{4}$

2	340	367-371	285	$\frac{0.009}{2}$	$\frac{0.040}{2}$	$\frac{0.003}{2}$
3	346	380-384	279	$\frac{0.011}{5}$	$\frac{0.112}{4}$	$\frac{0.004}{4}$
4	-	-	-	$\frac{0.015}{5}$	$\frac{0.132}{3}$	$\frac{0.005}{3}$
5	344	-	281	-	-	-

RASUMNY, Janine, 1970, Methode de reconnaissance du milieu de genese initial des quartz authigenes: Bull. Mensuel. Soc. Linn. de Lyon, V. 39, no. 1, p. 45-48.

A short review (12 references) of the use of the crushing stage (E. R.)

RAZIN, L.V., 1968, Problem of the origin of platinum metallization of forsterite dunites: Geolog. Rudnykh Mestorozh., 1968, no. 6, p. 10-25 (in Russian); translated in Internat. Geol. Review, v. 13, no. 5, p.776-788 (1971).

Refers to studies of the homogenization of inclusions in dunite forsterites at >700-800°C by Lesnyak, 1962 (Significance of inclusions of solutions and melts in minerals as one of the basic factors in the classification of hypogene deposits: L'vov Gos. Univ. Mineral. Sbornik, no. 16) (E.R.)

ROBINSON, B.W. , FRITZ, Peter, KROUSE, H.R. and MORTON, R.D., 1970, Stable isotopes of the Echo Bay deposit, N.W.T., Canada (abst.): Geol. Soc. Amer., Abstracts with Programs, v. 2, no. 7, p. 665.

The Echo Bay vein-type uranium deposit (U-Pb age of 1450 m.y.) occurs within an area of Proterozoic sediments, volcanics and intrusives. The sequence of deposition, from early to late, is: pitchblende, Co-Ni arsenides, dolomite, sulfides with dolomite and calcite, and native silver with minor quartz.

S isotope measurements on co-existing sphalerite and galena (2 pairs) for early and intermediate sulfide stage give temperatures of 200°C and 180°C respectively. Primary fluid inclusions in intermediate sulfide stage dolomite (21 measurements) and late quartz (10 measurements) represent a saturated brine and give homogenization temperatures of 165±10°C.

fS_2 and fO_2 as indicated by the Fe content of sphalerites and by the mineral parageneses decreased during the sulfide and silver deposition from log-13 to -17 and log-39 to -44 respectively. δS^{34} values of the sulfides changed from $-3^{o}/oo$ in the early stage to $+27^{o}/oo$ in the late stage (35 samples). This change can be explained by the decreases in fO_2 values of a solution which initially contained sulfur of $+27^{o}/oo$ and moved from a SO_4^{--} species enriched state to a HS^- enriched state. The sulfur is probably of non-juvenile origin.

δO^{18} values of the dolomites are $+22^{o}/oo$ (SNOW) for 2 samples of pre-sulfide stage and $+14-2^{o}/oo$ for 7 samples of intermediate sulfide stage. δC^{13} values are uniform at -3-1° (PDB) for all 9 samples. The change in δO^{18} values possibly represents a lower temperature for the pre-sulfide stage. Calcites are isotopically lighter than corresponding dolomites, possibly due to recrystallization by ground water. (Authors' abstract).

ROEDDER, Edwin, 1969, Varvelike banding of possible annual origin in celestite crystals from Clay Center, Ohio, and in other minerals: The Amer. Mineral., v. 54, p. 796-810.

Some celestite shows a rhythmic, paired banding that may be of annual origin, visible with well-collimated transmitted light as straight, parallel, alternately darker and lighter bands, mainly parallel {210}.

Although the thickness of the individual bands and of band pairs varies widely within a given crystal, these thicknesses are very uniform for sequences of hundreds of pairs. Individual pairs range from 3-70 μm total width, and may be traced laterally without thickness change for 0.5 cm; some continue over former crystal terminations. They are visible owing to minute differences in index of refraction (proven with Nomarski interference contrast illumination) arising from variable substitution of barium for strontium (proven by electron microprobe). Somewhat similar banding is found in agate and "colloform" sphalerite from other localities.

Of eight mechanisms proposed, only one, annual seasonal variation, seems appropriate for these samples. It is hence concluded that the warm brine from which the celestite grew was diluted with surface water that varied in composition or amount over a yearly cycle, causing the compositional banding. If the band pairs are truly annual, i.e., if they are "varves", they yield valuable rate data on diagenetic processes and the hydrologic regimen , and should be searched for in other samples. (Author's abstract). (Note: A very similar abstract was published as part of the IMA meeting scheduled for the 1968 IGC in Prague, but never held. The planes of secondary fluid inclusions in this material have coalesced into perfectly regular "beads", one for each pair of bands crossed, and hence makes the presence of the banding much more visible. E.R.).

ROEDDER, Edwin, 1970a, Metastability in fluid inclusions, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70; Tokyo, Science Council of Japan, p. 238.

Fluid inclusions in minerals are exceedingly small chemical systems, very effectively isolated from their surroundings. As a result, they frequently exhibit metastable equilibria, generally from lack of nucleation of those stable phases that should form after some change in conditions. Metastability may persist over extensive ranges of temperature and pressure, and for geologic time. Metastability in natural fluid inclusions, as found, provides several types of otherwise unobtainable data (such as on cooling rates), and metastability induced by laboratory conditions can also provide useful information. Both varieties of metastability, however, can and frequently do cause erroneous conclusions when they are not recognized.

The most common and potentially useful types of metastability are from failure to nucleate:

1) a vapor bubble or daughter crystals on cooling, (both in melt and aqueous inclusions);

2) ice or other crystal phases on cooling aqueous inclusions below room temperature; and

3) a vapor bubble on heating frozen aqueous inclusions.

Other, laboratory-induced nonequilibrium conditions, particularly from sluggish mixing in frozen aqueous inclusions that became stratified during melting, or sluggish solution of daughter minerals at high temperatures, can cause experimental difficulties but have no known compensating usefulness.

As long as an assemblage remains static, there is no valid criterion for determining if it is stable or metastable. If, however, there are differences in behavior of otherwise similar inclusions, or a given inclusion behaves differently in sequential but apparently duplicate experiments, metastability may be involved. Any sudden or irreversible phase change other than from leakage in an inclusion under constant temperature conditions signifies that the former assemblage was metastable.

ROEDDER, Edwin, 1970b, Natural and laboratory crystallization of lunar glasses from Apollo 11, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 7.

Many different types of glass are found in the lunar samples, formed by a variety of processes. As a result of the very wide range in composition of these galsses, rates of nucleation and growth of crystals in them vary over many orders of magnitude. In addition, individual fragments or rocks have been exposed to a wide range of thermal histories, yielding a spectrum of degrees of devitrification and crystallization textures.

Individual samples of lunar glasses were subjected to various thermal treatments, in vacuum, for periods of a few seconds to days. Interpretation of the resultant data is fraught with considerable difficulty, but a few limits can be placed on both the maximum and the minimum cooling rates. Phenocrysts of olivine in some of the crystalline rocks must have cooled relatively slowly to somewhat below 1100°, and then relatively rapidly. On the other extreme, some of the high-index glass particles in the lunar soil must have cooled at least hundreds of degrees per second. A few of the glass spheres have crystallized to form structures resembling meteoritic chondrules. This may only signify, however, that some aspects of the cooling history of the two types of materials were similar. (author's abstract).

ROEDDER, Edwin, 1970c, Application of an improved crushing microscope stage to studies of the gases in fluid inclusions: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 41-58.

Ever since Deicha (1950) described the use of his crushing stage to detect the presence of gases under pressure in fluid inclusions, this technique (crushing a sample in oil between glass plates) has been applied in a variety of inclusion studies. Several new versions of Deicha's stage have been constructed; they are inexpensive, easy to use, and adaptable to a variety of situations. The devices consist, in essence, of a pair of metal plates, joined by a horizontal hinge pin at one end and a vertical screw at the other. The lower plate is heavy, to provide stability without clamping when placed on the stage of the microscope. The glass plates with sample are placed between the metal plates, and centered on a vertical viewing hole. Crushing force is applied by the screw. Automatic aligning and correction from simple rotary to partially translational movement of the glass plates is achieved by mounting the support for the lower plate on a round, segmented horizontal pivot pin, whose axis is parallel with the hinge axis. The axis of the pivot pin is interrupted where it crosses the optical axis. Ordinary glass microscope slides are used for most operations, so that loss from scratching or breaking will be of no concern.

The crushing technique permits the recognition of the presence of as little as 10^{-14} grams of noncondensable gases (less than a billion molecules). In this low range its use has placed some exceedingly low limits on the maximum rate of leakage of certain fluid inclusions, based on the complete absence of noncondensable gases. Its use has also placed extremely low limits on the maximum rate of diffusion of air through obsidian glass, both anhydrous and hydrated, at surface temperatures.

When the embedding oil is replaced with appropriate solvents or nonsolvents for specific expected gases (methane, CO_2, etc.), the technique permits some qualitative "analysis" of the gases evolved, and even the recognition of some mixtures of several gases. Its greatest usefulness lies in providing estimates of gas pressure at room temperature (permitting better extrapolations to that at the time of trapping), and in the ease with which useful data may be obtained on the many samples that are too small for quantitative analysis by more elegant methods such as mass spectrometry. (Author's abstract).

ROEDDER, Edwin, 1970d, 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 Vol. II, p. 247-258 (in Russian with English abstract).

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 result of trapping at depth, of three discrete, immiscible, individually 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).

Ed's. note: This title and abstract are given here as originally submitted for publication. The English title and abstract in the published version (p. 258) were erroneous.

ROEDDER, Edwin and WEIBLEN, P.W., 1970a, Silicate liquid immiscibility in lunar magmas, evidenced by melt inclusions in lunar rocks: Science, v. 167, p. 641-644.

This is in effect a long abstract of material given in more detail in the following citation, 1970b.

ROEDDER, Edwin and WEIBLEN, P.W., 1970b, Lunar petrology of silicate melt inclusions, Apollo 11 rocks: Geochim. Acta, Suppl. 1, Proc. Apollo 11 Lunar Sci. Conf., v. 1, p. 801-837.

Silicate melt inclusions, now consisting of glass ± daughter minerals, in 92 sections from 26 rocks and 76 sections of soil fragments provide the following data on lunar petrology:

Abundant evidence exists of late-stage, silicate liquid immiscibility in all sections examined from 15 crystalline rocks, in the fragments of crystalline rocks from the lunar soil, and in most breccias. The glasses resulting from the quenching of these liquids are found to differ widely in index of refraction and color but vary little from the following normalized averages of 39 microprobe analyses (high- and low-silica glasses, respectively): SiO_2 76·2, 46·4; Al_2O_3 11·6, 3·1; FeO 2·6, 32·3; MgO 0·3, 2·2; CaO 1·8, 11·3; Na_2O 0·4, 0·1; K_2O 6·6, 0·3; TiO_2 0·5, 4·3. Compositionally, these are essentially potassic granite and pyroxenite. The high-silica glass constitutes only about 1 per cent of the rock, as inclusions and as vug lining. The immiscibility, which has been verified with quenching runs on synthetic melts held in pure iron containers in vacuum in the range of 1045-1135°C, may be important in the distribution of lunar highlands and tektites.

Sequential heating experiments (in vacuum) to determine the crystallization or melting of daughter minerals in multiphase inclusions in early olivine phenocrysts from rock 10020 yield the following approximate temperatures for the magma: ilmenite liquids - 1210°C; joined by pyroxene - 1130°C; joined by plagioclase - 1105°C; solidus - < 1065°C. These data refer to olivine-saturated liquids, as the runs were made in olivine "containers". Inclusions with similar daughter minerals occur in olivine phenocrysts from several other lunar rocks.

Heating experiments show that there are small amounts of volatile constituents in these inclusions. Also, a few gas-filled inclusions were found.

Devitrification of the glasses, and the formation of inclusion daughter minerals, both before sample collection and in the laboratory, place some limits on both the maximum and minimum cooling rates. (Authors' abstract).

ROEDDER, Edwin and WEIBLEN, P.W., 1970c, Silicate immiscibility in lunar rocks: Geotimes, v. 15, no. 3, p. 10-13.

A short, popularized account of material in previous item.

ROEDDER, Edwin and WEIBLEN. P.W., 1970d, Silicate melt inclusions in Apollo-12 rocks similar to those in Apollo-11 rocks and in some terrestrial basalts (abst.): Amer. Geophys. Union Trans. (EOS), v. 51, p.583.

Preliminary abstract of material given in more detail in article of somewhat different title in Lunar Sci. Conf. 2d, 1971, Proc., v. 1, Geochim. Cosmoch. Acta Supp. 2, Cambridge, Mass., MIT Press, p. 507-528.

ROEDDER, Edwin and WEIBLEN, P.W., 1970e, Lunar petrology of silicate melt inclusions, Apollo 11 and 12, and terrestrial equivalents (abst.): Geol. Soc. America Abstracts with Programs, v.2, no. 7, p. 666.

Invited paper at symposium - essentially same material as in item 1970d. Similar abstract printed by NASA in their 1971 Lunar Science Conference, Abstracts of Papers.

ROSE, A.W., 1970, Zonal relations of wallrock alteration and sulfide distribution at porphyry copper deposits: Econ. Geol., v. 65, p. 920-936.

Most of the porphyry copper deposits are characterized by a similar pattern of lateral zoning involving sulfides and silicate alteration assemblages. A central zone of biotite-orthoclase alteration is surrounded by a partial to complete halo of quartz-sericite alteration. Propylitic alteration commonly forms a further halo if rocks of appropriate composition are present. The hypogene sulfides also are zoned, from a central zone with a low pyrite/chalcopyrite ratio and generally low total sulfides, through a zone of moderate sulfides with dominant chalcopyrite, then to a halo of high pyrite/chalcopyrite and high total sulfides which grades outward to lower total sulfides. The highest copper content normally occurs within the biotite-orthoclase zone or at its outer borders with quartz-sericite alteration. The silicate and sulfide zoning is generally centered on a granitic porphyry stock.

Lead and sulfur isotope data, as well as the zoning, suggest that the ore fluid traveled outward from the porphyry, starting at high temperatures and relatively high K/H ratios in the orthoclase field, thereby forming the biotite-orthoclase alteration. In order to form the strong sericite alteration, cooling of the fluid is concluded to be the most probable means of changing mineral equilibria. A model calculation, for a large porphyry copper ore body, of heat losses to wall rock during outward flow of the solution shows that this mechanism cannot be the major means of cooling. The calculation also demonstrates that mineral deposition from solutions as dilute as 1-100 ppm base metals encounters grave difficulties in cooling from temperatures of 500°C or above, because of the huge volumes of solution involved to form a porphyry copper orebody, and the resulting huge amount of heat that must be dissipated. Copper concentration in the ore fluid on the order of 1,000 ppm or higher are therefore suggested. Cooling by expansion or by mixing with cool ground water seems an attractive means of bringing the high temperature ore fluid into the muscovite stability field. These processes are probably also instrumental in causing metal sulfide precipitation. (Author's abstract).

RUCHKIN, G. V., and NIKOLAYCHUK, G.V., 1968, Zoning of sulfide deposits in the ore-bearing district of Blyava (southern Urals): Geology of Ore Deposits, v. 10, no. 6, p. 49-60 (in Russian; English abstract in Econ. Geology, v. 65, p. 229, 1970).

A series of deposits were examined by various procedures, including decrepitation analysis (260-380°C). (E.R.)

RYABCHIKOV, I.D., 1970, Zinc concentrations of chloride solutions in equilibrium with granitoid minerals at high temperatures and pressures: Akad. Nauk SSSR Doklady, v. 194, no. 6, p. 1418-1420 (in Russian); translated in Doklady Acad. Sci. USSR, Earth Sci. Sects., v. 194, 1970, p. 207-209 (issued 1971).

R shows that concentrated chloride solutions should be capable of extracting significant amounts of Zn from rocks, and hence can be regarded as potential ore fluids. (ER).

RYE, R.O. and CZAMANSKE, G.K., 1970, Experimental determination of sphalerite-galena sulfur isotope fractionation and applications in geothermometry (abst.): Internat. Symp. on hydrogeochemistry and biogeochemistry, Tokyo, 1970, Abstract of Papers, p. 130.

Sulfur isotope fractionations between sphalerite and galena in the temperature range 600 to 225°C have been determined by a series of coprecipitation experiments. The experimental technique involved simultaneous solution, transport and coprecipitation of galena and sphalerite in 10 cm platinum tubes charged with 6N NH_4Cl . Experiments were run under temperature gradients of about 5°C over the length of the tubes. The fractionations are considered to be equilibrium factors because they were approached from opposite sides of the equilibrium distribution. The experimental fractionations are represented by the equation $1000 \ln \alpha_{sl-gn} = 0.691\ (10^6\ T^{-2})$.

The applicability of the experimental curve to natural samples was tested on large crystals of sphalerite with intergrown galena from several ore deposits. By sampling from polished plates of zoned crystals it was possible to obtain nearly contemporaneous sphalerite and galena. Temperatures of deposition were determined from filling temperature measurements of fluid inclusions in sphalerite. Filling temperatures of fluid inclusions in the various samples range from 365 to 200°C. Maximum discrepancy between filling temperatures and temperatures indicated by $\delta^{34}S$ values of apparently contemporaneous sphalerite and galena is about 40°C. Where sphalerite and galena precipitated at nearly the same temperature but clearly not contemporaneously the isotope temperatures do not always agree well with the filling temperatures (Authors' abstract).

RYE, R. O. and SAWKINS, F. J., 1970, (Nature of ore fluids at Calsapalca Ag-Pb-Zn-Cu mine, central Peru): U.S. Geological Survey Prof. Paper 700A, Geological Survey Research, p. A136.

Studies of primary fluid inclusions indicate that the temperature of the hydrothermal fluids dropped from 370° to 260°C and that the salinity of the fluids varied erratically from 4 to 40 equivalent weight percent NaCl. δO^{18} values of quartz and early calcite indicate that the δO^{18} of the hydrothermal fluids was nearly constant (7.5 ± 0.5 per mil relative to SMOW) and that the hydrothermal fluids were derived from a high-temperature silicate source. δO^{18} values of the late calcite, however, indicate that late hydrothermal fluids were distinctly different from the early fluids. The δC^{13} values of calcite indicate a deep-seated source for the early hydrothermal carbon but a limestone source for the later hydrothermal carbon. The narrow range of δS^{34} values for the sulfides indicate a deep-seated source for the hydrothermal sulfur. The δD values of inclusion fluids indicate that the ore was deposited from deep-seated waters distinctly different from the surface waters that deposited the late-stage gangue minerals. (Authors' abstract)

SABOURAUD-ROSSET, C. and TOURAY, J.C., 1970, The conditions of growth of quartz in evaporite sedimentary environment according to fluid inclusion studies (with examples from Vanoise and Corbières, France): Schweiz.

Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 91-97 (in French).

Fluid inclusions in quartz from gypsum, dolomite or halite beds, indicate NaCl saturated brines. Homogenization reveals significant differences between disappearance of the vapor phase: Tb (between 100° and 150°C) and the disappearance of the solid phase: Ts (between 150° and 350°C). which indicates saturation with NaCl at entrapment and a pressure of more than 1 Kb. Hematite is a common daughter mineral. The Corbières quartz has lower temperatures (Ts): around 200°C, and contains anhydrite crystals in the fluid inclusions. The quartz occurs in Triassic evaporites and is supposed to have formed epigenetically from brines resulting from dissolution of halite beds. (P.J.M. Ypma).

SAMOILOVICH, L.A., 1970, The relationship of the thermodynamic parameters P-F-T for aqueous solutions of Na_2CO_3 at high temperatures and pressures: VNIISIMS, Geology and Experimental Studies, v. 12, p. 93-100 (in Russian).

Experimental data on the systems Na_2CO_3-H_2O and Na_2CO_3-NaOH-H_2O at pressures up to 182 Kg/cm^3 and temperatures up to 361°. (ER)

SAMOILOVICH, L.A. and GORDIENKO, L.A. 1970, Some methods of study of optical inhomogeneities in crystalline quartz: VNIISIMS, Geology and Experimental Studies, v. 12, p. 116-120 (in Russian).

Of pertinence to recognition of growth zones, etc. (ER).

SATO, Takeo, 1970, Physicochemical environments of "Kuroko" mineralization at Uchinotai deposit of Kosaka mine, Akita prefecture, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 143.

Uchinotai deposit of Kosaka mine is a typical example of "Kuroko" deposit, which is a stratabound lead-zinc-copper mineralization related to the Miocene submarine volcanism.

The ore bodies can be classified by the following characteristics: (1) the uppermost bedded ore which is a complex mixture of galena, sphalerite and barite with considerable amounts of pyrite and chalcopyrite (Kuroko or black ore), (2) bedded, rather monotonous ore of pyrite and chalcopyrite underlying the Kuroko (Oko or yellow ore), (3) the lowest impregnated and network ore of pyrite and chalcopyrite which is characterized by strong silicification and which grades downward into barren rock (Keiko or siliceous ore) and (4) massive gypsum ore separated from the above sulfide ores by clay zone. The boundaries of the former three varieties are rather sharp. Textural and structural features of Kuroko and a part of Oko suggest their sedimentary origin.

On the basis of detailed mineralogical investigations of the coexisting minerals in the ores together with the aid of fluid inclusion studies, the depositional conditions of the ores are inferred as follows:

	T, °C	pH	$-\log f_{O_2}$(atm)	$-\log f_{S_2}$(atm)
Kuroko (upper) (galena-sphalerite-barite)	100-150	5-6	~58(at 100°C)	~18(at 100°C)
Kuroko (lower) (sphalerite-pyrite-chalcopyrite-barite)	150-200	4-5.5	~52(at 150°C)	~17(at 150°C)
Oko (pyrite-chalcopyrite)	~200	4-5.5	~44(at 200°C)	~14(at 200°C)
Keiko (pyrite-chalcopyrite-quartz)	200-300	4-5.5	~36(at 250°C)	~11(at 250°C)

It is concluded that the ore-forming solution is sulfur-poor ($\Sigma S=10^{-3}-10^{-5}$ m at 250°C) and that barite in the Kuroko (in strict sense) has been precipitated not in equilibrium with sulfide minerals. Observed mineral zoning is most reasonably explained in terms of temperature decrease of the ore-forming solution containing the metals as chloride complexes.

SAWKINS, F.J. and RYE, R.O., 1970a, The Casapalca silver-lead-zinc-copper deposit, Peru: An ore deposit formed by hydrothermal solutions of deep-seated origin? (abst.): Econ. Geol., v. 65, p. 740. (Also printed in Geol. Soc. America, Abstracts with Programs, v. 2, no. 7, p, 674-675. 1970).

The extensive Casapalca vein system occurs in Tertiary red beds and volcanics. The deposits contain primarily pyrite, sphalerite, galena, and tetrahedrite, accompanied by quartz and minor calcite gangue; vugs are common in many parts of the vein system.

Studies of fluid inclusions in quartz, sphalerite, and calcite crystals indicate that ore deposition took place over the temperature range 370 to 280°C, by hydrothermal solutions whose salinity varied erratically from 4 to 40 equivalent weight percent NaCl. The distribution of vapor phase inclusions in main-stage minerals indicates sporadic "boiling" of the hydrothermal fluids. The temperature data suggest a progressive drop in temperature with time, but preclude the existence of sharp temperature gradients within the vein system during mineralization.

Stable isotope measurements on vein minerals indicate a deep-seated source for sulfur (δS^{34} values of sphalerite range from -0.4 to +1.2‰) and for hydrothermal carbon in earliest calcite (δC^{13} values range from -9.9 to -7.2‰ (PDB)), and a very uniform high temperature silicate source for the hydrothermal solutions (δO^{18} values of hydrothermal solutions based on fluid inclusion data range from +7 to +8‰ SMOW).

δD values from inclusions in sphalerite range from -51 to -65‰, distinctly different from the -118 and -144‰ average values obtained respectively from present-day local meteoric waters and from inclusions in post-sulfide calcites. The stable isotope data imply a deep-seated origin for the main-stage inclusion fluids, and indicate that mixing with meteoric waters was restricted to the final stages of hydrothermal activity (Authors' abstract).

SAWKINS, Frederick J. and RYE, Robert O., 1970b, Fluid inclusion and stable isotope studies of the Casapalca silver-lead-zinc-copper deposit, Central Andes, Peru, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 133.

The extensive Casapalca vein system occurs in Tertiary redbeds and volcanics and has produced about 10 million tons of ore. The deposits contain primarily pyrite, sphalerite, galena and tetrahedrite, accompanied by quartz and minor calcite gangue; vugs are common in many parts of the vein system. Quartz was precipitated throughout the period of sulfide deposition, but calcite deposition was restricted to the late and final stages of hydrothermal activity.

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SELLA, C. and DEICHA, G., 1970, Electron microscopy of a calcite sample from Vaduz (Liechtenstein): Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 155-158 (in French).

Electron microscopical observation (10,000x) of a replica of a calcite fragment shows intra- and inter-granular cavities and effects of secondary solution corrosion. (P.J.M. Ypma).

SENDEROV, E.E. and KHITAROV, N.I., 1970, Zeolites, their synthesis and conditions of formation in nature: Moscow, "Nauka" Publishing House 283 pp. (in Russian).

Includes a section (pp. 177-188) on "Parameters of physico-chemical conditions for zeolitization by geological investigation of recent formation and data on inclusion study." (E.R.)

SHAPOSHNIKOV, A.A. and KHETCHIKOV, L.N., 1970, Influence of concentration of solutions on the temperature of homogenization of gas-liquid inclusions in quartz: VNIISIMS, Geology and Experimental Studies, v. 12, p. 100-103 (in Russian).

Inclusions in (synthetic) quartz with high salinities have higher homogenization temperatures, approaching the temperature of formation, so the salinity must be considered in homogenization studies. (ER).

SHCHERBA, G.N., 1968, Greisens, chap. 6 of Genesis of Endogenetic Ore Deposits: Moscow, "Nedra" Press, 720 pp. (in Russian); partial translation, part 1, of p. 378-420, in Internat. Geol. Rev., v. 12, no.2, p. 114-150, 1970.

A review of greisen processes, including the evidence from fluid inclusion study (ER).

SHEPPARD, S.M.F., NIELSEN, R.L. and TAYLOR, H.P., Jr., 1969, Oxygen and hydrogen isotope ratios of clay minerals from porphyry copper deposits: Econ. Geol., v. 64, p. 755-777.

An extensive study of pertinence to fluid inclusion work in that it results in a model "...that involves the sinking and influx of cool meteoric waters into shallow hot granitic stocks. Heated ground waters (brines?) rise through the periphery ...(and) form kaolinites and montmorillonites at temperatures below about 350°C. Thus the massive hydration of the stocks, and in certain cases at least some transport of base metals, has been produced by recycled meteoric waters rather than solely by deep-seated primary magmatic waters." (ER).

SHILO, N.A., SIDOROV, A.A., GONCHAROV, V.I., and NAIBORODIN, V.I., 1970, The development of the classification of gold-ore deposits on the base of explorations of gas-liquid inclusions (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 252.

In the North-east of the USSR there are singled out the following principal gold-ore formations:

Plutonic	Volcanic
gold-raremetal	gold-argentic
gold-quartz	gold-sulphidic

The formational regime of gold-ore deposits is characterized by temperatures from 450 to 100-50°C and different pressures/from 1500 to 10-12 atm/. The magnitude of pressures affects to a considerable extent the depth of deposits formation. As for the temperatures, practically within the limits of almost each ore formation there can be defined high-, middle- and low-temperature formations.

The formation of plutonic deposits is notable for its consistency and the evolutionary trend of ore process. Pneumatolytic phase of mineral formation is characteristic for the high-temperature deposits, though its role in the ore sedimentation is insignificant.

The temperature pulsation fixed in the kind of inter- and even intrastadial temperatures inversions is peculiar for the deposits of gold-argentic formation, which is considered in the paper in detail. The classification of these deposits on the basis of temperature formations of the main mineral parageneses is shown in the figure.

Temperature classification of gold-argentic formation deposits of the North East of the USSR

Groups of deposits according to the temperature of formation	Type of deposits	Temperature interval of minerogenesis, °C	Temperatures of sedimentation of productive associations, °C
High temperature	Gold-argentite (with rhodonite)	410-250	up to 400
Middle temperature	Gold-sulpho-antimonite-argentite	325-130	320-290
	Gold-galenite-sphalerite	360-50	300-210
Low temperature	Gold-argentite (with adular)	240-80	220
	Gold-sulpho-antimonite	270-80	240-220

Thus, the results of thermometric explorations favour the development of the genetic classification of deposits on the oreformational basis. (Authors' abstract.)

SHREVE, R.L., 1967, Migration of air bubbles, vapor figures, and brine pockets in ice under a temperature gradient: Jour. of Geophys. Res., v. 72, p. 4093-4100.

Equations are derived for the speed and direction of migration of air-, vapor-, or brine-filled triaxial ellipsoidal cavities of any orientation, and expected velocities are computed for the spherical, cylindrical, and discoidal cases that have been investigated experimentally. In the case of air bubbles agreement is only fair for approximately spherical bubbles trapped during freezing and is somewhat better for drilled cylindrical holes open to the atmosphere. The lack of agreement and the considerable scatter in the data are probably due to uncontrolled variations in pressure and shape and to the slow accumulation of frost. In the case of discoidal vapor figures the agreement is much poorer and the scatter is much greater, probably because of large uncontrolled variations in shape, air content, and temperature of the figures. Calculation of the effect of small size, for which viscous flow of the vapor is important, shows it to be negligle for the figures used in the experiments. For spherical brine pockets at temperatures a few degrees or more below freezing agreement is fairly good, considering the uncertainties in the diffusion coefficient, but at the ice point the predicted speed is about 5 times that observed, probably because the brine concentration in the pockets at this temperature was not in fact zero as required by the theory (Author's abstract).

SILLITOE, R.H. and SAWKINS, F.J., 1970, Geologic, mineralogic and fluid inclusion studies of copper-bearing tourmaline breccia pipes, Chile, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 134.

In north and central Chile, groups of tourmaline breccia pipes are located in a 2000 km long, north-south-trending belt. The pipes cut small, granitic, epizonal plutons of Lower Tertiary age. Individual pipes, cicular to elliptical in plan, approximately vertical, and bounded by closely spaced vertical fractures, contain angular to sub-rounded fragments of the host rock. Small bodies of porphyritic-aphanitic textured granitic rock were intruded with close spatial and temporal relation to the brecciation.

The hydrothermal mineralization of the pipes may be divided into an early replacement stage, followed by open-space filling. Initial fragment replacement produced aggregates of quartz-sericite, and was succeeded by silification and tourmalinization, accompanied by specularite. The filling stage resulted in tourmaline, followed principally by euhedral quartz, scheelite, chalcopyrite, pyrite, molybdenite, galena, and finally rare anhydrite, baryte and carbonates.

The pipes are interpreted as hydrothermal collapse breccias, formed during the removal of rock by the corrosive action of hydrothermal fluids, which subsequently mineralized the columns of breccia. This proposal is analogous to the "mineralization stoping" mechanism of Locke (Econ. Geol., 21, 431, 1926).

Studies of primary and pseudo-secondary fluid inclusions in quartz crystals indicate that quartz precipitation occurred over the temperature range of approximately 450-300°C. Certain inclusions also indicate that both sub- and supercritical fluids were present at times during quartz deposition, and that strong salinity variations occurred. Many inclusions contain no daughter minerals, especially those with filling temperatures in the 360-300°C range. Many of the inclusions that homogenize at temperatures over 400°C contain complex daughter mineral assemblages including cubes of sodium chloride and several birefringent mineral phases.

The geologic, mineralogic and fluid inclusion data suggest a close genetic relationship between the breccia pipes and the associated intrusive rocks.

SKINNER, B.J. and PECK, D.L., 1969, An immiscible sulfide melt from Hawaii, in Magmatic Ore Deposits, H.D.B. Wilson, ed.: Econ. Geology Monograph 4, p. 310-322 .

The basaltic lava trapped in Alae pit crater from the August 1963 eruption of Kilauea volcano, Hawaii, produced an immiscible sulfide melt during a late stage of the cooling of the lava. A differentiated siliceous liquid confined within interstices of the upper crust of the lava lake became saturated with respect to sulfide sulfur at a temperature of 1,065°C and a sulfur content of 0.038% S by weight. Precipitation of two sulfide-rich phases, one an immiscible sulfide-rich liquid, the other a copper-rich pyrrhotite solid solution, followed.

The sulfur-rich liquid, which quenched to a mixture of pyrrhotite, chalcopyrite, and magnetite, is estimated to have a composition of approximately 61% Fe, 4% Cu, 31% S, and 4% O by weight. The copper-rich solid sulfide that coexisted with the sulfide liquid has an estimated composition of 53% Fe, 9% Cu, 3% Ni, and 35% S by weight.

The basaltic liquid from which the sulfide-rich phases precipitated does not contain abnormally high contents of either Cu or Ni. The important conclusions to be drawn from the samples are:

1) Immiscible sulfide-rich liquids separating from basic magmas are always FeS-rich and always contain a significant oxygen content, an important factor in depressing the sulfide liquidus surface. The oxygen content will appear as an iron oxide, generally magnetite in the cooled and crystallized sulfide mass, and all ores formed in this manner should therefore contain significant amounts of an iron oxide.

2) The compositions of most sulfide-rich liquids are such that the first phase to crystallize is a copper- and nickel-rich pyrrhotite solid

solution, leaving the remaining liquid progressively enriched in oxygen and depleted in Cu and Ni until its composition reaches a cotectic between pyrrhotite and magnetite, when a pyrrhotite-magnetite mixture in the approximate ratio 2:1 will crystallize.

3) The pyrrhotite solid solutions crystallizing from and coexisting with the immiscible sulfide melts preferentially concentrate copper and nickel, so the early formed phases in a crystallizing immiscible sulfide melt will form the richest ore pockets. Authors' abstract. (Ed.'s note: This is of pertinence to many studies of silicate melt inclusions in magmatic minerals, both terrestrial and lunar, where such immiscible sulfides separate out either before or after trapping.)

SLIVKO, M. M., 1969, See Translations Section

SMIRNOV, V.I., 1968, Pyritic deposits. (Part II, Conclusions), chapt.X of Genesis of Endogenic Ore Deposits: Moscow, "Nedra" Press, 720 p. (in Russian); translated in Internat. Geol. Rev.,v.12,no.9,p.1039-1058, 1970.

A review of this type of deposit, including evidence from fluid inclusions as to T,P and X of the ore fluids. (ER).

SOBOLEV, V.S., 1970, The origin of leucitic rocks: Akad. Nauk SSSR Doklady, v. 194, no. 4, p. 922-925 (in Russian); translated in Doklady, Acad. Sci. USSR, Earth Sci. Sects., v. 194, p. 166-168 (1970).

Author expresses some doubt as to the extremely high homogenization temperatures (>1600°C) reported by Bazarova and Dmitriyev (Dokl. Akad. Nauk SSSR, v. 177, no. 1, 1967) (ER).

SOBOLEV, V.S. BAZAROVA, T.Yu., SHUGUROVA, N.A., BAZAROV, L. Sh., DOLGOV, Yu.A. and SØRENSEN, H., 1970, A preliminary examination of fluid inclusions in nepheline, sorensenite, tugtupite and chkalovite from the Ilímaussaq alkaline intrusion, South Greenland: Meddel. Grønland, v. 181, no. 11, p. 1-32, plus 4 plates.

A preliminary examination has been undertaken of fluid inclusions in four minerals from the Ilímaussaq alkaline intrusion. The apparatus used in the study has been developed in the Institute of Geology and Geophysics of the Siberian Branch of the Academy of Sciences, Novosibirsk.

Primary three-phase inclusions (liquid-gas-crystals) in nepheline from naujaite homogenize in the liquid phase at 850-1040°C. The gas phase in one analyzed inclusion is dominated by CO_2. Primary gas-liquid inclusions in nepheline from green lujavrite homogenize at 910-970°C in the liquid phase. These temperatures are in agreement with temperatures obtained on nephelines from Lovozero, Miask and Synnur and with data from fusion experiments on the rocks in question.

Primary gas-liquid inclusions in sorensenite and tugtupite from late analcime-albite veins homogenize at 400-460°C. The liquid phase of fluid inclusions in tugtupite contains 21 weight per cent of salts - sodium chloride is assumed to be predominant. The gas phase in one primary inclusion in tugtupite is dominated by CO_2. Secondary fluid inclusions in the two minerals homogenize at 350-100°C. The temperatures obtained are in agreement with those estimated from mineralogical evidence.

A big crystal of chkalovite from an ussingite-analcime vein contains several generations of fluid inclusions. The primary liquid-gas-crystal inclusions homogenize at 860-980°C. The solid phase is dissolved at 330-360°C, two immiscible liquids appear at 700-800°C. Half of the ca. 250 fluid inclusions examined belong to this category.

The several generations of secondary inclusions which embrace liquid-gas-crystal inclusions, gas-liquid inclusions and gas inclusions homogenize in several groups between 760°C and 100°C.

The liquid phase of the high temperature inclusions contains 40-44 weight per cent NaCl. The pressure at the temperature of homogenization is estimated to be higher than 1000 atm. The gas phase is dominated by CO_2 and N_2+inert gases.

The unexpectedly high temperature of homogenization of the primary inclusions of the chkalovite is difficult to explain. A detailed study of this problem is in preparation. (Authors' abstract).

SOKOLOV, S. V., 1970, Possible application of decrepitation methods to minerals having perfect cleavage: Eksp. Issled. Protsessov Mineraloobrazov, 1970, 121-125 (in Russian). Edited by Ovchinnikov, L. N.: Moscow, Izd. "Nauka".

Homogenization of gas-liquid inclusions in minerals having perfect cleavages (carbonates, fluorite, barite, sphalerite, and galena) is studied by decrepitation methods. Decrepitographs of calcites from rare-metal carbonatites show a peak at 500°. A relationship is established between the intensity of decrepitation and the type of cleavages. C.A., v. 74, no. 4 (1971).

SØRENSEN, Henning, 1970, Internal structures and geological setting of the three agpaitic intrusions - Khibina and Lovozero of the Kola peninsula and Ilímaussaq, South Greenland: The Canadian Mineralogist, v. 10, pt. 3, p. 299-334.

The sites of the three largest intrusions of agpaitic nepheline syemites, Ilímaussaq, South Greenland (ca. 1000 m.y.) and Khibina and Lovozero, Kola Peninsula (ca. 300m.y.) are first of all determined by intersecting fault systems and by discordances separating peneplaned Precambrian metamorphic complexes from overlying penecontemporaneous supracrustal rocks, including lavas. Ilímaussaq is associated with a rift zone. The three massifs represent the latest stages of intrusive activity in the two alkaline provinces, which explains their character as products of consolidation of residual melts derived from primary alkali basaltic magmas. The intrusions are of permitted discordant type. Khibina is a ring intrusion, Lovozero and Ilímaussaq are stratified intrusions, which were at least partly emplaced by stoping. All three intrusions are composite, the individual complexes often display rhythmic layering. The intrusions are mineralogically, petrologically and geochemically related. The three intrusions may be interpreted as representatives of three stages of evolution of an agpaitic magma with Khibina representing the first stage, Ilímaussaq the second and Lovozero the third, (Author's abstract). (Ed. note: Pertinent here is that there are extensive inclusion studies of all three of these intrusives, and this comparison is hence exceedingly useful).

SØRENSEN, H., LEONARDSEN, E.S. and PETERSEN, O.V., 1979, Trona and thermonatrite from the Ilímaussaq alkaline intrusion, South Greenland: Geol. Soc. Denmark, Bull., v. 20, p. 1-19 (in English).

Powdery trona and thermonatrite have been found as crusts on the walls of cavities in ussingite in a drill core in the northern part of the Ilímaussaq intrusion. The ussingite forms the core in a thin vein intersecting naujaite enriched in villiaumite.

The optical and X-ray data of the two minerals are identical to those of trona and thermonatrite from saline deposits. The aggregates of sodium carbonate contain a few grains of ussingite, villiaumite, tugtupite, analcime, sodalite (?) and natrolite(?).

The sodium carbonates are considered to have been deposited at low temperature from strongly saline "brines" trapped in cavities in ussingite. The villiaumite was formed at higher temperatures and appears to be ealier than the ussingite.

The drill core in question, like all other villiaumite-bearing drill cores from Ilímaussaq, is covered by an efflorescense of sodium acetate trihydrate which also is associated with the sodium carbonates. This substance was clearly formed after the collecting of the drill core. (Authors' abstract).

STALDER, H.A. and TOURAY, J.C., 1970, "Fensterquarz" with methane-bearing inclusions from the western part of the northern sedimentary Swiss Alps: Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 109-130 (in German).

Quartz crystals are found in several fissures in the northern sedimentary part of the Swiss Alps. Two main groups of different forms can be distinguished: Normal, prismatic crystals, and small bipyramidal quartz crystals with more or less skeletal habit. This latter crystal habit occurs as individuals or in aggregates. When they overgrow the normal rock crystals, they form sceptre quartz. The two quartz generations have different fluid inclusions. The first generation shows normal aqueous, two-phase inclusions. Under the crushing microscope stage gas under pressure escapes. In the second quartz generation always two sorts of inclusions are detectable: One-phase inclusions with a gas under pressure and normal two-phase aqueous inclusions. According to the determination in a mass spectrometer the gas is nearly pure methane. All arguments support the assumption of a phase-separation of the mineral forming solution during the crystallization. And it seems that the phase-separation is always in relation with the change of the quartz habit.

A map shows the distribution of the methane-bearing quartz and two diagrams of mass spectrometic analysis after extraction by heating are given. Data from cryometric and heating stage investigations complete this study. (H.A. Stalder)

STAROSTIN, V.I., 1969, Bor and Majdpanpek copper deposits in Yugoslavia: Moskovskogo Unita, Vestnik, 1969, no. 3, p. 24-37, (in Russian); translated in Internat. Geol. Rev., v. 12, no. 4, p. 370-380.

Decrepitation data are presented for enargite, pyrite, covellite, chalcopyrite, and chalcocite from Bor, and for chalcopyrite from Majdpanpek. (ER).

SUSHCHEVSKAYA, T.M., 1970, The chemical composition of high-temperature hydrothermal solutions, forming the deposits of tin (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 260.

I. The results of studies of natural and artificial minerals show that gaseous-liquid inclusions can be used for estimation not only of the temperature and pressure of hydrothermal solutions but also of their chemical composition. The hydrothermal tin deposits have as the most high-temperature interval of their formation 450-150°C, and for cassiterite deposition 450-300°C. The formation of cassiterite and wolframite in the deposits of quartz-cassiterite type, genetically connected with albitized and greisenised granites is accompanied by crystallization of muscovite, topaz, fluorite, K-feldspar. In the deposition of cassiterite-sulfide and cassiterite-silicate type, usually associated with granitoid hybrid intrusions, the precipitation of cassiterite is closely associated with deposition of various sulfides, and tourmalines, chlorites, carbonates.

The composition of the inclusions of some typical tin deposits has been studied for the determination of chemical composition of the tin-bearing solutions. Analytical data have been obtained by the water extraction method, described in the previous work. Special attention has been paid to ways of elimination of various errors, which can appear at different stages of the analysis.

II. Sodium, potassium and calcium were found to be the major components among the cations and chlorine and bicarbonate - among the anions in the investigated solutions. The average concentrations of the major components are close to: Na -0.5 mol/l, K - 0.14 mol/l, Ca - 0.06 mol/l, Cl - 0.45 mol/l, HCO_3 - 0.30 mol/l. The ratios of these components in the ore-forming solutions do not correlate with the mineral composition of ore deposits and their evolution with temperature decrease can be different. Magnesium and such important for metal transport components as fluorine and sulfur are always present in the solutions. For both groups of tin deposits, the concentration of fluorine is rather high and is approximately 0.1 mol/l. The content of sulfur, usually present in such solutions in the sulfide form, is slightly less, but sometimes reaches 0.1 mol/l.

III. Comparatively little information on minor elements in tin-bearing hydrothermal solutions is avalable. Lithium was found to be one of the typical minor components. Its concentration lies in the range 10-100 mg/l, but sometimes can increase up to 1.5 g/l. In such cases lithium becomes one of the major cations, and results in crystallization Li-micas instead of muscovite. The minimum concentration of boron in the solutions, forming quartz-cassiterite-wolframite ores with tourmaline, redeposited from previously formed tourmaline from wall-rock metasomatites, is near to several mg/l (Na/B and Cl/B 100). The same order of concentration was found for the ammonia-ion. It was possible to determine the concentration of some ore elements by carefully controlled studies. The contents of Pb, Cu and Ag are 10^{-3} mol/l (before the precipitation of metal) and 10^{-5} mol/l (after precipitation of metal).

IV. Tin-bearing hydrothermal solutions are characterized by a such high average of carbon dioxide as 1-2 mol/l, sometimes it reaches 8-9 mol/l, so it is quite possible to consider the high-temperature solutions as carbon dioxide-water-salt systems. The pH-values, estimated from analytical concentrations of CO_2 and HCO_3 of the solutions in the inclusions and from data on the dissociation constants of carbonic acid and ionic production of water at elevated temperatures lie in the slightly alkaline, near neutral field.

Y. The average mineralization of the solution in the inclusions (without the contents of such components, whose concentrations can not be correctly determined by water extraction method, as Si, Al, Fe) vary from 30 g/l to 70 g/l. This is the most typical value for the majority of the hydrothermal deposits. (Author's abstract.)

SUSHCHEVSKAYA, T.M., SINYAKOVA, S.I. and MARKOVA, I.V., 1970, Experimental data on the concentrations of certain ore elements in hydrothermal solutions: Geokhimiya, 1970, no. 6, p.693-700, (in Russian); translated in Geochem. Internat., v. 7, no. 3, p. 483-489.

Polarography with accumulation has been used to determine the contents of Pb, Cu, and Ag in water extracts from inclusions in quartz from tin-sulfide and polymetallic deposits. Concentration limits for these elements that correspond to the initial and final stages of formation of the ore mineralization were determined (from fluid inclusions) to be in the range of 1 to 100 mg/l (ppm). (Authors' abstract, extended.)

TAKENOUCHI, Sukune, 1970a, Fluid inclusion study by means of heating-stage and freezing-stage microscope: Mining Geology (Japan), v. 20, no. 103, p. 31-40 (in Japanese with English abstract) (alternate pagination - p. 345-354).

Fluid inclusions in quartz, sphalerite and cassiterite from various types of post-magmatic ore deposits were studied by means of the heating-stage and freezing stage microscope. The cooling medium used was alcohol cooled by dry ice. Thus it was possible to maintain the temperature of the stage as low as -50°C. The salinity of fluids was inferred from the melting point of ice in the inclusions.

From the results of the investigation, it was found that the measured salinity of inclusions in ore minerals was higher than that of quartz. The filling temperature and the salinity of inclusion fluids in quartz from hypothermal molybdenite-quartz veins in granite were the highest among the measured samples of quartz. Also a direct correlation between the filling temperature and the salinity was recognized in this sample.

Generally speaking, the salinity of the inclusions which were considered to be related to the mineralization at several ore deposits was in a range between 5 to 10 wt. % in NaCl equivalent concentration at various filling temperatures. However, some quartz crystals from vuggy druses in skarn and granite showed a wide variation of the filling temperature, but a constant low salinity. (Author's abstract).

TAKENOUCHI, S., 1970b-Fluid inclusions in minerals from the Takatori Mine, Ibaragi Prefecture: Jour. Soc. Mining Geol. Japan, v. 20, (99), p. 54 (in Japanese) (Author at Dept. Mineral Development Engineering, Univ. of Tokyo).

The Takatori mine is located about 30km to the northwest of Mito city. The ore deposit belongs to the hypothermal wolframite-quartz veins which were formed in Paleozoic rocks striking N45°E and dipping 30°-60° NW. The veins are classified into two types, i. e., steep veins which strike N45°W, dipping steeply, and flat veins which dip very gently. Stocks of granite rock are found to the northeast of the mine about 4km apart. Inclusions in quartz, cassiterite, fluorite, and topaz collected from the major vein of the mine were studied by means of the microscope heating stage and freezing stage. The filling temperature of inclusions in cassiterite was between 250°C and 280°C, and the NaCl equivalent concentration was in the range of 8~10 weight percent, whereas the filling temperature of topaz was 265°~280°C and the concentration was 2.5~3.5 wt. %. In the case of fluorite, the filling temperature was between 170°C and 220°C, and the concentration was 6~7 wt. %. The filling temperature and the concentration of inclusions in quartz varied in the range of 170°~260°C and of 1~9 wt. %, respectively. When the inclusions in quartz are cooled to a temperature lower than room temperature, solid CO_2 gas hydrate formed along the boundary between the gas and liquid phases. This fact indicates that the ore-forming solution contained a certain amount of CO_2. (H. Imai).

TAKENOUCHI, S. and IMAI, H., 1970, Fluid inclusion study of some tungsten-quartz veins in Japan, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 243.

Fluid inclusions from the Takatori mine, Ibaragi Prefecture, and from the Ohtani mine, Kyoto, of Japan were studied by means of the heating stage and freezing stage microscopes.

The quartz veins of the Takatori mine are found in the Paleozoic formation which consists mainly of chert and sandstone, whereas the ore deposit of the Ohtani mine is composed of quartz veins which have been formed in the late Cretaceous or early Tertiary granitic rocks. The main ore mineral of the Takatori mine is wolframite and that of the Ohtani mine is scheelite. These ore deposits contain a small amounts of cassiterite and sulfide minerals.

The filling temperature and freezing temperature of fluid inclusions in quartz, cassiterite, topaz and fluorite from the Takatori mine, and in quartz, cassiterite and scheelite from the Ohtani mine are shown in the following table.

Takatori mine		quartz	cassiterite	topaz	fluorite
Filling temp.	°C	225-320	300-350	330-350	215-270
Freezing temp.	°C	-0.5~-5.7	-5.3~-6.4	-1.1~-2.3	-3.6~-4.3
NaCl Equi. conc.	wt.%	1.0~9.0	8.5~10.0	2.0~4.0	6.0~7.0

Ohtani Mine		quartz	cassiterite	scheelite
Filling temp.	°C	225-360	285-340	270-330
Freezing temp.	°C	-2.3~-3.9	-3.0~-5.7	-3.6~-5.3
NaCl equi. conc.	wt.%	4.0~6.5	5.1~9.0	6.0~8.5

The filling temperature of inclusions in cassiterite, scheelite, and topaz was generally high, whereas that of fluorite was low. Meanwhile, the freezing temperature of inclusions in cassiterite and scheelite was low, but that of topaz was fairly high. The filling and freezing temperatures of inclusions in quartz were various.

In a considerable number of fluid inclusions in quartz from these ore deposits, the CO_2 gas hydrate formed along the boundary between the gas and liquid phases, when the inclusions were cooled to temperatures lower than 10°C. The volume of the gas hydrate formed in the inclusions was not large and, in general, liquid CO_2 was not visible when the gas hydrate disappeared. From the phase diagram of the H_2O-CO_2 system, it inferred that the total concentration of CO_2 in the inclusions is less than several weight percent. Some inclusions in rock crystals from druses, however, formed liquid CO_2 around the gas bubble at temperatures lower than 31°C. In most of these inclusions, the liquid CO_2 phase homogenized to the gas phase at a temperature lower than 31°C, but in some of them the gas phase homogenized to the liquid CO_2 phase.

From the results of the investigation, it is concluded that the temperature and the concentration of the ore-forming solutions which have formed these ore deposits, were almost the same in spite of the different geological setting, and that CO_2 would have been an important gas component at the formation of these ore deposits. (Authors' abstract) (Ed. note: The filling temperatures given here are new, revised data, and not as printed in the cited reference.)

TAYLOR, H.P., Jr., 1970, Oxygen isotope evidence for large-scale interaction between meteoric ground waters and Tertiary diorite intrusions, Western Cascade Range, Oregon (abst.): Amer. Geophys. Union, Trans. (EOS), v. 51, no. 4, p. 453.

Extensive analyses show that convective circulation of ground waters in the vicinity of the stocks must have occurred throughout a large part of their crystallization and cooling history. The amounts of H_2O involved are estimated to be about equal in volume to that of the exchanged rock. Hence, much so-called "deuteric" hydrothermal activity is probably caused by such heated ground waters rather than by H_2O released during magmatic crystallization. (Author's abstract, shortened).

TAYLOR, L.A., 1970, Smythite, $Fe_{3+x}S_4$, and associated minerals from the Silverfields mine, Cobalt, Ontario; Amer. Min. v. 55, p. 1650-1658.

Most of the fluid inclusions in the calcite and quartz containing the smythite contain brine, a large crystal of halite, and no bubble. Others contain small bubbles, homogenizing between 40° and 120°C. These low temperatures (and possibly high pressures) are compatible with other data on the stability of smythite. (E.R)

TENDER, O.V., 1967, Gas-liquid inclusions in calcium carbonate crystals from mercury deposits in northern Caucasus: Geologiya Razvedka, 1967, no. 7, p. 46-49 (in Russian), translated in Internat. Geol. Review, v. 12, no. 8, 1970, p. 930-932.

Liquid inclusions were studied in calcite crystals associated with cinnabar, pyrite, marcasite, quartz, barite, goethite, limonite, and kaolin, rare galena and chalcopyrite. The main vein mineral is quartz, and the cinnabar mineralization is confined to the quartz-dickite ("kaolin"?) stage.

Calcite crystals containing inclusions (and cinnabar) were ground in vacuo, and the evolved gases analyzed for CO_2, H_2, CH_4, and N_2, using a "type VGSCh-2 gas analysis device." Results are CO_2-7.0 to 13.2; CH_4-2.2 to 2.4; H_2-0.1 to 0.3; and N_2-24.2-27.2 cm³/kg. Optical examination showed single-phase, 2-phase (liquid + crystals or liquid CO_2 and water solution), and rare 3-phase (liq., gas, and crystal). Most (2-phase?) inclusions homogenized between 90-100 and 180-200°C, in the liquid phase (E.R.)

THIJSSEN, H.A.C., VORSTMAN, M.A.G. and ROELS, J.A., 1968, Heterogeneous primary nucleation of ice in water and aqueous solutions: Jour. of Crystal Growth, v. 3, no. 4, p. 355-359.

The effect of the volume of the liquid sample, the degree of turbulence in the liquid, and the rate of cooling upon the probability of nucleation has been studied for water and aqueous solutions. Nucleation rates were measured for droplets nearly instantaneously cooled to a predetermined temperature. Also threshold temperatures for nucleation were determined in stirred externally cooled vessels.

The liquids studied (tap water, distilled water, and orange juice) did not contain particles causing nucleation at supercoolings less than 6°C. Nucleation at smaller supercoolings is attributed to the nucleative action of surface irregularities of the vessel walls. Provided no air bubbles are dispersed in the liquid, the rate of stirring (degree of turbulence) appeared to have no influence upon the nucleation.

The experimental results are inconsistent with the stochastic hypothesis of Bigg[7]), the singular hypothesis of Langham and Mason[8]) and the pseudo-singular hypothesis of Vali and Stansbury[10]). They could, including those reported in literature[7,8,10]) be explained by the assumption of three distinct probabilities of nucleation; namely, the probability per unit time that a particular particle can cause nucleation at equilibrium conditions; the probability per unit time that equilibrium is established; and the probability that a particle with characteristic properties is present in the sample (Authors' abstract).

TOKUNAGA, M., MIYAZAWA, T., HONMA, H., and PARK, H, 1970, Formation temperature of some black ore deposits in Akita Prefecture, Japan (abst.): in Collected Abstracts, IMA-IAGOD Meetings 1970: Tokyo, Science Council of Japan, p. 246.

Many black ore deposits occur in the Green tuff region of the northern part of Akita Pref. Geology and mineralogy of the ore deposits have already been reported by many authors in the last ten years. However the data concerning the formation temperature of the ore deposits are only a few.

Concerning black ore deposits such as those of the Shakanai, Kosaka, Furutobe and Ainai mines, an estimation on the temperature of mineral formation was done through the measurements of filling temperature of fluid inclusions in the minerals, using a microscope equipped with heating stage. Minerals used for the measurements were quartz, barite, fluorite and sphalerite.

The result is that the formation of the ore deposits of these mines is assumed to have taken place in a temperature range from 290° to 80°C, i.e. around 290° to 180°C for siliceous ore, 290° to 220°C for yellow ore and 200° to 80°C for black ore. Judging from the modes of occurrence of the ore deposits, etc., these values may be considered reasonable as to their formation temperature. (Authors' abstract.) (Ed. note: Misprint in original data corrected here.)

TOURAY, J.C., 1970a, Thermal and optical analysis of families of inclusions in salt deposits (mainly halite): Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 67-79 (in French).

The reasons of inconsistent thermometric behavior of fluid inclusions seemingly belonging to the same (primary) family are investigated. Homogenization is defined in two ways: Ts, disappearance of the solid phase, and Tb, disappearance of the vapor phase. When Ts is lower than Tb, we are dealing with undersaturated brines and thus need freezing data for the equivalent NaCl content. When Ts is higher than Tb we are dealing with saturated solutions and can use the temperature difference for pressure estimations. Once inconsistencies in single groups of inclusions due to secondary phenomena (leakage and necking down) are ruled out, primary differences should be due to pressure and temperature gradients. An example of constant pressure and decreasing temperature is provided by fluorite from a salt deposit near El Hamman (Morocco). Salinity remained constant: 30% NaCl; T droppped from 180-190°C to 110-120°C, and P remained at 300-400 bars. An example of increasing T and constant P is provided by inclusions in halite (containing sylvite and carnallite) from a geothermal area near Dallol (Ethiopia). Saturated solutions + crystals at 45°C were heated (Ts=Tb) to 100°C and became unsaturated between 100 and 150°C. Inclusions in albites from Rock

Tourné (France) indicate high initial pressures: 2.2 - 3.0 Kb at 360°C, dropping to 1.5 - 1.7 Kb at 300°C, the Ts-Tb values vary from 200° to 140°C. (P.J.M. Ypma).

TOURAY, J.C., 1970b, Freezing stage analysis of gas rich inclusions in "window quartz"; examples of homogenization around the critical temperature of methane (-82.5°C): Compt. Rend. Acad. Sci., Paris, v. 270, Ser. D, p. 2613-2615 (in French).

Secondary inclusions, homogeneous at room temperature and containing only constituents of a very low boiling point revealed their content by freezing to -100°C, and subsequent heating between -89° and -79°C, a temperature range close to the critical temperature of methane. The density is also close to the critical one because of variable homogenization (either in vapor or liquid phase). The results are compatible with mass-spectrometer data. (P.J.M. Ypma).

TOURAY, J.C., 1970c, Lunar glassy inclusions: La Recherche, v.1, no. 7, p. 681 (in French).

A short popular review of the nature and significance of silicate melt inclusions in lunar samples (ER).

TOURAY, J.C., 1970d, Deep origin CO_2 trapped by healed cracks in epigenetic Tunisian fluorites (abst.), in Collected Abstracts, IMA-IAGOD Meetings 1970: Tokyo, Science Council of Japan, p. 247.

In Northern Tunisia, near Zaghouan, epigenetic fluorite deposits are known. They are either stratiform ore-bodies (e.g., Jbel Sta and Hamman Zriba) or veins resulting from redeposition in open fractures (e.g., Jbel Mecella and Djebilet el Kohol). A first investigation of fluid inclusions in fluorites from Hamman Zriba and Djebilet el Kohol (Touray and Yajima, Mineralium Deposita, 2, pp. 286-290, 1967) has shown that the fluorite crystallized in two distinct environments. The second stage forming fluid was an emulsion of petroleum and saline water.

The samples discussed in this paper come from Jbel Sta (J.S.) and Jbel Mecella (J.M.). They contain two-phase primary inclusions (J.S. and J.M.) and sometimes three-phase petroleum-bearing primary inclusions (J.S. only). Both samples contain secondary petroleum-bearing inclusions and heterogeneous groups: in one hand aqueous inclusions and in the other CO_2-bearing inclusions, both of secondary origin, and associated in the same healed cracks.

Mass-spectrometric analysis of the gases evolved after step by step heating indicate a CO_2/H_2O molar ratio = 1.2±0.3 for a chip (J.M.) containing only one healed crack and a minor amount of primary inclusions. This implies that in gaseous inclusions, the CO_2/H_2O molar ratio falls in the bracket 2.3 - 3.5; CH_4/CO_2 =0.020±0.003, other gases are absent or in trace amount.

Primary inclusions (J.S.) homogenize in the ranges of 40°-90°C (petroleum-bearing inclusions) and 140°-180°C. This second set of data is supported by homogenization temperatures of pseudo-secondary inclusions (165°-175°C) -- 130 measurements. Primary inclusions (J.M.) homogenize in the range of 100° - 140° -- 10 measurements.

Secondary aqueous inclusions (J.S) homogenize, from crack to crack, in the wide range of 40° - 190°C -- 90 measurements. The associated CO_2 inclusions exhibit a nearly constant density: 0.17-0.20. Secondary petroleum-bearing inclusions (J.M) homogenize in the range of 84° - 117°C -- 44 measurements. CO_2-bearing secondary inclusions (J.M) have a nonconstant density from crack to crack (0.10-0.85) -- 49 measurements. No data for aqueous secondary inclusions (J.M) and very scarce petroleum-bearing secondary inclusions in J.S.

Geological interpretation: the presence, in healed cracks, of secondary CO_2-rich fluid inclusions results from the trapping at shallow depth of an immiscible fluid proceeding from the mixing of a deep-origin hot CO_2 (t° ≥200°C) and supergene solutions. (Author's abstract.)

TOURAY, J.C. and SABOURAUD, C., 1970, Metastable inclusion brines in fluorite from Ouezzane: Econ. Geol., v. 65, p. 216-219.

Inclusions originally containing NaCl crystals, brine and vapor, brine and vapor, NaCl crystals and brine, or only brine, are described. The NaCl bubbles dissolve at higher temperatures than the disappearance of the vapor bubble. The several inclusion types are in part due to metastability, as evidenced by different phase assemblages after freezing. (ER).

TOURAY, J.C., VOGLER, M. and STALDER, H.A., 1970, Inclusion of liquified hydrocarbons in quartz of Zingel/Seewen (Switzerland): Schweiz. Mineralog. Petrog. Mitt., v. 50, pt. 1, p. 131-139 (in French).

The clear quartz crystals (quartz-diamonds) of Zingel/Seewen are analogous to the methane-bearing skeleton quartz of the Limestone Alps. Their fluid inclusion content varies as follows:

1. Water-rich two-phase inclusions homogenizing into a liquid phase at 150°C.

2. Liquid-vapor inclusions with a liquid of very strong thermal expansion, homogenizing between 30 and 100°C into the liquid phase (liquid hydrocarbon).

3. Vapor-liquid inclusions homogenizing into the vapor phase between 20° and 100°C. Possibly containing a heavy hydrocarbon compound.

4. Single phase gas inclusions, which become two-phase only upon cooling to -10 or -30°C.

Homogenization temperatures in the order of +30 +50°C are frequent and due to a mixture of methane and heavier liquified hydrocarbons, often with critical density. Such an inclusion would be indistinguishable from liquid CO_2. The methane/ethane ratio is fairly constant at 20 and independent of the homogenization temperatures. (P.J.M. Ypma).

TROSHIN, Yu.P., BOIKO, S.M., MARKOVA, M.E., MIKHEYEVA, Z.I., ALEXEYEVA, N.N., and KURDIN, O.V., 1970, Details of composition of primary fluid inclusions and trace element composition of minerals at the Khapcheranginsky ore region, Paper 2: Acad. Sci. USSR, Siberian Division, Institute of Geochemistry, Irkutsk, Yearbook 1969, p. 172-176 (in Russian with English abstract). (See Translations Section)

TRUFANOV, V.N., KURSHEV, S.A., MAISKY, U.G., and USHAK, A.T., 1970, Heterogenous phase balances in the natural quartz-forming solutions at extremal conditions (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 268.

There are polycomponent fluid-inclusions in the typomorphic varieties of the quartz from pegmatitic, hydrothermal, skarn and others endogenous ore deposits. In these natural microautoclavs - closed physical-chemical systems - at the same time with ordinary phase transformations under heating the complicated heterogenous balances may be established.

These equilibriums show the peculiarities of the aggregate state and structure of quartz-forming solutions at high temperatures and pressures.

According to results of the investigation of high-temperature gas-solid and gas-solid-water inclusions the heterogenous "as-melt" and "liquid-liquid" equilibriums were settled in the temperature interval 600-750°C.

The gradual heating of the crystal-fluid inclusions causes the sublimating of the "prisoner-minerals" and foliation of the appearing upper-dense fluid on two phases at 550-600°C. In this case the heterogenous "fluid-fluid" phase balance is settled.

The analogous "fluid-fluid" equilibriums were discovered also in the specific carbon dioxide-water inclusions with "prisoner-minerals" by heating from room temperature up to 600°C.

These results showed that heterogenous phase balances have been taking place in natural quartz-forming solutions. They cause the form of silica educement and influence on the character of the distribution of useful components in the endogenous ore deposits. (Authors' abstract, sic.)

TSUSUE, A., 1970a, Mineralization at the Ryûjima Mine, Nagano perfecture, (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 141.

The epithermal manganese deposit at Ryûjima was formed principally as fissure fillings. The major vein minerals were precipitated during a single period of mineralization in four stages: quartz, rhodochrosite, magnesian kutnahorite - manganoan dolomite (locally Ca-rich dolomite), and finally calcite. The chemical composition of these carbonates is approximately expressed in terms of $CaCO_3$, $MgCO_3$, and $MnCO_3$. Fluid inclusion studies were made on quartz and carbonates. The fluid inclusions in quartz suitable for filling-temperature determination homogenized at 230° to 260°C, and those in carbonates homogenized at approximately 200°C (Tsusue, Amer. Mineral., 52, 1751-1761, 1967). Author's abstract, reduced.

TSUSUE, Akio, 1970b, The coprecipitation of calcium with rhodochrosite at elevated temperatures, in Volcanism and Ore Genesis, ed. T. Tatsumi,: Tokyo, Univ, Tokyo Press, p. 309-322 (in English).

In addition to the experimental part, T lists homogenization data on fluid inclusions from a manganese deposit at Ryujima, Nagano Prefecture, Japan (Tsusue, Amer. Min., v. 52, p. 1751-1761, 1967) (ER).

TUGARINOV, A.I. and NAUMOV, V.B., 1969, Thermobaric conditions of formation of hydrothermal uranium deposits: Geokhimiya, 1969, no. 2, p. 131-146, (in Russian; translated in Geochem. Internat., v. 6, no. 1, p. 89-103, 1969).

Pressures and temperatures of formation of hydrothermal uranium deposit have been determined by the methods of homogenization and decrepitation of gaseous-liquid inclusions. It has been established that pressures during the formation of the deposits can substantially exceed the value of lithostatic load of overlying rocks. Ore stages of uranium deposits may form in a wide temperature range - at least from 350 to 50°, however, different forms of uranium compounds correspond to different temperatures. At temperatures above 250°, uranium mineralization is represented by uranite or brannerite. For all studied deposits where the chief ore mineral is pitchblende the temperatures of ore stages did not exceed 200-220°. (Authors' abstract).

TUGARINOV, A.I., and NAUMOV, V.B., 1970, Dependence of the temperature of decrepitation on the composition of gas-liquid inclusions and on the strength of the mineral: Akad. Nauk SSSR Doklady, v. 195, p. 182-184 (in Russian) (see Translation Section).

VAKHRUSHEV, V.A. and KUTOLIN, V.A., 1970, Sulfides in ultramafic inclusions from diatremes of the north Minusinsk depression: Akad. Nauk SSSR Doklady, v. 192, no. 5, p. 1130-1133 (in Russian); translated in Doklady Acad. Sci. USSR, v. 192, 1970, p. 157-160, dated 1971.

Spherical inclusions of mixed sulfides (pyrrhotite, chalcopyrite, pentlandite, and pyrite) occur in the minerals of these nodules. The authors interpret them as trapped liquid droplets. (E.R.).

VASIL'EVA, M.S., 1970, Temperature conditions of mineralization in Iceland spar deposits: Vyssh. Ucheb. Zaved., Izv., Geol. Razved. 1970, V. 13, No. 2, p. 49-54 (in Russian).

Fluid inclusions in calcite and associated minerals from two large deposits of Iceland spar from Lower Triassic basalts were studied by various techniques. Homogenization temperatures (50-200°C); water leaches (5), and analysis for K, Na, Mg, Ca, Si, Cl, F, SO_4, HCO_3; and gas analyses for CO_2, O_2, and N_2 (E.R.)

VASQUEZ, J.C., 1970, Inclusiones liquidas como geotermómetros: Sociedad Venezolana de Geólogos Boletin, v. V, no. 1, p. 3-23.

A review with 3 references (ER).

WILCOX, W.R., 1970, The influence of a temperature gradient on crystal faceting: Jour. of Crystal Growth, v. 7, p. 203-208.

Crystals which grow in a faceted manner in an isothermal environment will grow nonfaceted in the presence of a sufficiently large temperature gradient. This behavior is viewed from several different standpoints. From equilibrium considerations one predicts faceting in a temperature gradient only if the edge energy is taken into account in addition to the bulk free energy and the surface energy. The surface energy versus orientation concept is used to examine the stability of a facet in a temperature gradient. An examination of the kinetic effects reveals that faceting is favored by anisotropic growth kinetics and rapid growth, (Author's abstract; of possible pertinence to the mechanism of trapping of inclusions).

YAJIMA, J., and KOMATSU, M., Studies on solid inclusions in the phenocrysts of some volcanic rocks (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 269.

Microscopic observations, thermometry and chemical analyses of two- or three-phase solid inclusions in the phenocrysts such as olivines, pyroxenes, feldspars and quartz occurred in various volcanic rocks are presented.

Three types of solid inclusions are observed, e.g. (1)silicate crystal + glass + bubble(s), (2) glass + bubble(s), (3) devitrified glass + bubble. Type (1) is common in olivines and pyroxenes, meanwhile type (2) is abundant in feldspars and quartz. In olivines, spinel is often observed as a solid inclusion or as a crystal phase in a glass inclusion. Thus, the spinel may be considered as a crystal which had been formed before olivine crystallized. Solid inclusions are always primary ones and any secondary inclusions are hardly seen.

Chemical compositions of these glass inclusions were determined by an electron probe microanalyser. Specimens mounted in plastic are polished on one surface. The grain which contains glass inclusion just on the polished surface is selected under binocular microscope and is analysed. A few examples of the results are given in Table 1.

Glass in olivine is composed mainly of silica, alumina, lime and small amount of Fe and Mg. When plotted on the silica-alkali and MgO-Total FeO-alkali diagrams, glass in olivine of the tholeiitic basalts falls in the tholeiitic field and that of alkali basalts in alkali basaltic field. The ratio $(Mg/Mg+Fe)_{Ol}/(Mg/Mg+Fe)_{glass}$ in the present case range between 2 and 3, whereas the same ratio in some Hawaiian basalts are 1.3-1.4. From this difference as well as the chemical composition of the glass inclusions represent the residual liquids after the crystallization of olivine.

Glass in hypersthene in dacite (Showa-shinzan) which contains abundant silica and alumina with minor alkali has same composition as groundmass of the host dacite (Oba, 1967).

Glass in quartz is also very rich in silica and alumina, showing the nature of the residual liquid when all phenocrysts had crystallized.

Table 1. Chemical compositions of glass inclusions.

	1	2	3	4	5	6
SiO_2	59.45	48.66	51.65	57.02	78.27	75.10
TiO_2	0.19	1.37	2.72	2.43	-	-
Al_2O_3	24.42	19.26	19.25	16.85	13.51	12.78
Total FeO	1.40	7.31	7.61	6.09	0.93	0.86
MgO	0.14	4.94	6.11	2.88	0.07	0.16
CaO	7.77	11.37	10.58	11.58	1.46	0.53
Na_2O	2.9	2.3	1.9	2.5	5.0	2.9
K_2O	1.4	2.2	0.3	0.4	0.2	5.5
Total	97.67	97.41	100.08	99.75	99.44	97.83

Samples 1 Olivine in picrite (Sado, Japan)
2 Olivine in olivine basalt (Oshima-oshima, Japan)

3 Olivine in olivine basalt (Kilauea, Hawaii)
4 Olivine in olivine basalt (Mauna Loa, Hawaii)
5 Hypersthene in dacite (Showa-shinzan, Japan)
6 Quartz in quartz porphyry (Jozankei, Japan)

(Authors' abstract.)

YAJIMA, J. and TOURAY, J.C., 1970, Thermometric analysis of the deposit of fluorite at El Hammam (Morocco), from the study of inclusion fluids: Mineral. Deposita, v. 5, p. 23-28 (in French).

This vein, located in the metamorphic district of Achemèche, central Morrocco, is made of three successive parageneses: Calcite I and fluorite; Sulfides, quartz and calcite II; Dolomite. Microscopic investigations of fluorite and calcite I show two-phase-inclusions supersaturated with respect to NaCl, normal two-phase-inclusions and mainly three-phase-inclusions (gas-saturated solution-halite). Thermometric studies show that the beginning of crystallization occurred around 200°C for calcite I and fluorite (pressure correction estimation: 20-30°C) in a highly concentrated brine containing about 30% of NaCl. The main part of sulfides and the quartz (containing single-phased liquid inclusions) crystallized probably at temperatures below 100°C. (Authors' abstract).

YUN, Suckew, and RHEE, Chun Woo, 1970, The temperatures of formation of the fluorites in the Hin-Po Mine, South Korea (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 251.

The Shin-Po Mine, located near Chun-chon, Kangwon-do, is a principal producer of fluorite in South Korea. The deposit is a fissure vein which strikes N75°E, dips 80°SE, in the Precambrian crystalline schist and granitic gneiss. The vein is one meter in average thickness, about 1000 meters in total length and nearly 400 meters in depth. The bulk of the vein materials consist of quartz gangue, and through this a few narrow veins of the desired fluorite run parallel with the strike of the whole vein. They show a well crustified structure enhanced by the associated chalcedonic layers.

Two-phase fluid inclusions suitable for the homogenization method using the heating stage microscope were found in the fluorite crystals. Their shapes are tetrahedral, dodecahedral, wedge-shaped, rectangular, trapezoidal, ellipsoidal, rounded-tubular, and irregular. It is considered that the tetrahedral inclusions, the most conspicuous, were formed as a negative crystal caused by the sealing of an octahedral facet by a hexagonal corner. The maximum diameter of the inclusions is 0.5 mm and the minimum, 0.03 mm. Most of the diameters range from 0.2 mm to 0.8 mm (sic.). The volume ratios of gas and liquid in each inclusion show low value, ranging from 1/10-1/15. The homogenization temperatures obtained from the test are 147-135°C in greenish, 140-125°C in bluish, 138-125°C in violet, 137-121°C in light grayish blue, 133-116 in colorless and 128-106°C in pinkish fluorites. Isothermal lines were drawn on a longtitudinal section of the underground map from the data of the homogenization test. According to the results, the central and lower parts of the ore shoot in the west ore body show the higher temperature of 138-130°C and the peripheral and upper parts of it show the lower temperatures of 128-108°C. It seems that the isothermal trend roughly coincides with the pitch of the ore shoot. Most of the fluid inclusions are primary in origin and mainly composed of a liquid phase associated with a minor gas phase. The range of formation temperatures of the fluorites is 147-106°C. Therefore, the fluorite deposits of the Shin-Po mine are considered to be of low temperature hydrothermal origin. (Authors' abstract.) (Editor's note: this abstract may contain typographical errors, as the original printing was partly illegible.)

ZAKHARCHENKO, A.I., 1968, The nature of granite-aplite, aplite, and aplitic zones of pegmatites, in Papers on experimental and geological-mineralogical studies of the processes of ore formation, vyp. 1; Vsesoiuznyi nauchno-issledovatel'skii geologicheskii institut Trudy, novaia seriaa, v. 162, 1968, p. 5-59 (in Russian).

An extensive review (69 references) of the work of Z. and his colleagues on the geology, mineralogy, petrology, chemistry, and fluid inclusions in various granite, aplite, and pegmatite samples. Losses and gains at contacts, estimates of water content, pressure and temperature of formation, etc., are made on the basis of these data. (ER).

ZAKHARCHENKO, A. I., 1970a, The formation of mineralizing and ore-bearing solutions related to granites, in Internat. Union Geol. Sciences Series A, No. 2., Problems of hydrothermal ore deposition, eds. Zdenek Pouba and Miroslav Stemprok: Stuttgart, E. Schweizerbart'sche Verlags., p. 27-30 (in English)

A short review of Z's extensive work on the geology and inclusions of numerous granite massifs of Kazakhstan, Tien-Shan, Transbaikal, etc. Includes a discussion of the evolution and composition of fluids from granitic magmas, as evidenced by the fluid inclusions, from early silicate melts (as silicate melt inclusions) to aqueous solutions. (E.R.)

ZAKHARCHENKO, A. I., 1970b, Phase condition and composition of successive magmatogene fluids related to granites and their role in mineral and ore formation (abst.), in Collected Abstracts, IMA-IAGOD Meetings 1970: Tokyo, Science Council of Japan, p. 245.

The sequence of segreations and changes of magmatogene fluids can be most fully traced with the aid of their primary inclusions in minerals of postorogenic hypabyssal granite massifs, and orebodies related to them- especially chamber pegmatites, as well as greisens, skarns, quartz veins, etc. Because of the rise and quiescence of formation, there is observed here, expecially in the apical parts of massifs, the accumulation of volatiles (up to tens-hundreds of cm^3/kg) and parallel with it the successive specialization of rocks and orebodies.

In the successive formation there is observed the alteration of phase composition of primary inclusions - from gas-solidified remains of former melts (in granites, aplites, graphic pegmatite zones), through gas remains of former pneumatolites (in internal zones of pegmatites, early minerals of skarns, greisens), to essentially liquid inclusions of hydrotherms (in minerals of cavities in pegmatites, basic (chief) minerals of greisens, skarns, ore veins). The fluidity of solutions, their concentration and composition change accordingly.

The earliest gas-solidified inclusions in late granites contain 70-80% of readily fusible minerals, semi-crystallized glasses, and 20-30% of aggressive gases. They start melting at 720-750°C and melt completely at 850-900°C, bubble-filled glasses forming on quenching. Gas inclusions consist mainly of H_2, N_2, CO_2, H_2S, inert gases, sometimes CO_2, and, judging by the abundance of halogenide salts - a great role was played by the halogenides. The role of acid gases and aqueous solutions increases with the decrease of temperature. An abundance of H_2 and CO_2 is characterised by the appearance of hydrocarbons and even bitumens. The leading role in early inclusions of aqueous solutions was played by halogenide compounds, while sulphate and hydrocarbonate ones were important in subsequent inclusions.

The changes in the nature of solutions had an important effect on the composition of transported substances. First, the accumulating and segregating solutions facilitated the intense differentiation and specialization of melts and granitoid rocks in formation. Furthermore, during the pneumatolitic stage, active reducers (H_2, N_2) intensively transported the petrogenic components, but not heavy metals. With the increase of the role of water, the essentially halogenide hydrothermal solutions intensely transported the heavy metals, the early fluoride ones transporting predominantly rare metals, and the subsequent chloride and sulphate-hydrocarbonate ones-polymetals, etc. (Author's abstract.)

ZAKHARCHENKO, A.I., LEVITSKI, Yu.F., and MOSKALYUK, A.A., 1970, Magmatogene solutions forming the rare-metal deposits (abst.), in Collected Abstracts, IMA-IAGOD Meetings '70: Tokyo, Science Council of Japan, p. 263.

The rare-metal deposits, especially of the greisen-quartz vein type, and their parent granite complexes, are highly favourable for fruitful studies of almost all the evolution of the nature and ore-forming action of magmatogene solutions. This is explained by the accumulation in them of melts and solutions in the form of gas-solidified and gas-liquid inclusions due to their hypabyssal development in relatively quiescent conditions.

In the successive phases of granites there is observed their gradual enrichment in readily fusible components, and parallel with in rare metals (specialization), but in a dispersed form. Among late- and postmagmatic formations there usually occur: I-early (750-450°C) small barren (pre-ore) schlieren pegmatites, feldspar veins, then 2-(450-200°C) larger rare-metal feldspar-quartz veins (with Mo), greisen-quartz-vein bodies especially rich in Sn, W, Mo, etc., and 3-in the end (below 200-150°C) again barren (post-ore) quartz-fluorite, quartz-carbonate, and other veins. Thus, rare-metal deposits are not formed directly after granites.

Primary inclusions of former melts and solutions allow to decipher the principal conditions of the formation of rare-metal deposits.

1. Gas-solidified inclusions in parent granites, aplites, marginal zones of pegmatites allow to trace to enrichment of the successive portions of melts (and granites) with readily volatiles(especially F), fluxing (Li, Rb), readily fusible components, i.e. the emanational differentiation which is paralleled by rare-metal specialization.

2. Then, in pre-ore bodies (750-450°) primary inclusions are the gas ones of the remains of pneumatolites, with gradual disappearance of solidified phases and an increase of aqueous solutions and readily soluble salts. They contain, among halogenides, etc., favourable for the transportation of rare metals, also abundant highly unfavourable reducers (H_2), which caused the absence of emanational removal and deposition of rare metals during the pneumatolitic stage.

3. Still later, in the ore-bearing proper (450-250°C) and post-ore (below 200°C) veins the primary are essentially liquid inclusions of the remains of hydrotherms. At the early stage (450-300°C) such hydrotherms were highly favourable for the mobilization and deposition of rare metals (rich in F, Cl, K, Li, Rb, etc.). Below 300°C they were gradually replaced with sulphate and hydrocarbonate solutions, more alkali-earth ones, less favourable for the mobilization of rare metals, which ceased depositing below 200-150°C.

4. Formation of deposits was accompanied by frequent adiabatic processes. At high pressures rare metals were mobilized, while during adiabatic drops they were deposited, this having caused their characteristic distribution in veins.

5. The revealed peculiarities will explain the regularities of formation and emplacement of rare-metal deposits, this being important for the choice of prospecting directions for them. (Authors' abstract.)

ZAREMBO, Yu.G., TROFIMOVA, A.B. and FIRSOVA, S.O., 1970, Use of decrepitation method for determination of ore-formation temperature in the Muruntau deposit, central Kyzyl-Kum: Tsent. Nauchno-Issled. Gornorazved. Inst. Tr. 1970, no. 93, p. 116-122 (in Russian).

Decrepitation studies on quartz from various stages of this quartz-Au deposit showed temperatures ranging from 400 to 240°C (ER).

ZHABIN, A.G., ed., 1970, Ontogeny methods of investigation of minerals: Moscow, Izdatel'stvo "Nauka", 224 pp. (in Russian).

A series of 24 articles, many of which are of value to anyone trying to relate given inclusions to given growth zones in a single crystal or to a specific stage in a complex paragenesis. (E.R.)

ZHARIKOV, V.A., 1968, Part III, Conclusions, of Skarn source fields of ores, Chapt. IV. of Genesis of Endogenetic Ore Deposits: Moscow, "Nedra" Press, 1968, 719 pp., in Russian. Translation of p. 280-302, in Internat.Geol. Review v. 12, no. 7, p. 760-775.

Gives comparative data on the temperatures of homogenization of inclusions, of decrepitation of inclusions, and of experimental synthesis for 15 minerals from various skarns (his figure 138) (ER)

ZIMMERMAN, J.L. and POTY, B., 1970, Mass-spectrometrical investigations of the fluid composition of Alpine vug minerals of the Mont Blanc Massif: Scweiz. Mineralog. Petrog. Mitt. v. 50, pt. 1, p. 99-108 (in French).

Analysis of the volatile content of fluid inclusions in quartz from the Mont Blanc Massif has been executed by decrepitation (gradual to 300°C) and mass-spectrometer analysis. Because of overlapping mass spectra of the volatile constituents: $H-CH_4-O_2-C_2H_6-N_2-H_2O-CO-CO_2-H_2S$, fractionated injection into the mass-spectrometer was used: below and above -195°C. H^+ , CH_4 and CO were double checked by oxidation to H_2O+; $CO_2 + H_2O$ and CO_2. Gas volumes were determined manometrically. At 300°C essentially all water has been released. CO_2 continues to be released up to 1000°C. H_2 is released from quartz seemingly free from inclusions (above 600°C).

Quartz from the fluorite paragenesis contains largely organic materials: 4 wt % H_2O, 26.5% CO_2, 17.3% H_2, 2.2% CH_4, 9% N_2, 10% CO and 30% hydrocarbons at a decrepitation temperature of 420°C. Amethyst yielded high CO_2 contents: 76 wt %, less water: 16%, and minor quantities of other gases at 300°C decrepitation. CO_2/H_2O ratios, from crushing stage and heating data are compatible with the mass-spectrometer data, although water determinations are considered to be most susceptible to errors (10% relative). (P.J.M. Ypma).

TRANSLATIONS SECTION

Items presented here are selected on the basis of 1) availability of translation, 2) significance to inclusion research, 3) lack of publication elsewhere, and 4) date of publication. Some older items are thus included where particularly significant. Photographs do not reproduce well and are not included, but the photo caption translations are given. (Ed.)

ARKHIPCHUK, R.Z. and ROSIKHINA, A.I., 1969, Conditions of formation of the fluorite mineralization of western Transbaikal from data of mineral thermometry: Geol. Rudnykh Mestorozhndenii v. 11, no. 5, p. 110-113 (in Russian).

The studied fluorite deposits and ore showings of western Transbaikal are associated with the Dzhida-Udinsk fluorite-bearing zone, located in a region of Caledonian folding, activated in Mesozoic time. The geological structure, brief characterization of the ore bodies, and some problems of the genesis of the most important ore deposits and ore showings have been discussed by Gusel'nikov (1961-1962), Shcheglov (1961), Yakzhin (1962), and Ochirov (1964). In most deposits the fluorite and accompanying minerals fill open fissures, forming ore bodies of vein form. The principal minerals, fluorite and quartz, are accompanied by calcite, barite, rare stilbite, gearksutite, albite, pyrite, and galena.

In mineralogical composition, the deposits are of four types: fluorite, quartz-fluorite, barite-quartz-fluorite, and carbonate-quartz-fluorite. Deposits of the quartz-fluorite type are sharply predominant quantitatively.

Deposits of the carbonate-quartz-fluorite type are localized amidst limestones or at small distances from them, the quartz-fluorite type in granitic rocks, and the deposits or their separate veins of adularia-quartz-fluorite composition occur amidst syenites, subalkalic effusives, rarely in granites.

For deposits occurring in similar geological settings, there is characteristically an approximately uniform sequence of deposition of the minerals. Very early formations are chalcedonic quartz, often with fluorite (Burun-Ul'sk, Kharasun, and others); the deposition of the main mass of fluorite occurred later. The process was completed by the deposition of porcelain-like quartz, sometimes with vugs and microscopic disseminations of fluorite, rarely of kaolinite.

In deposits occurring amidst limestones, in the late, concluding stages of mineralization, calcite is deposited in considerable amounts, and quartz to a lesser degree (Darkhin and Barun-Altsak showings).

In the study of the conditions of formation of the fluorite mineralization of western Transbaikal by the mineral-thermometric method, the authors have obtained new data, supplementing ideas on the genesis of the fluorite deposits of this region.

In the fluorite and calcite of all generations, and also in some generations of quartz only liquid two-phase inclusions were found, which belong according to the volume ratio of the phases, to the gas-liquid type according to Ermakov's classification (1950). In them at room temperature, 8-12% of the volume is occupied by the gas phase, 88-92% by aqueous solutions. When heated, all the inclusions studied homogenized in the liquid phase. Daughter phases were not found in the inclusions, permitting one to assume a low concentration of the solution.

The results of thermometric study (see Table) show that in most of the deposits studied, separated from one another by considerable distances, the formation of fluorite and its associated minerals began at uniform or very similar temperatures (180-160°)[1], except for the Ivolginsk and Povorotinsk deposits and the Ubur-Tashirsk ore showing. The identity of the temperature conditions of mineral formation in most of the deposits is seen even more clearly on comparison of the temperature intervals of the main phases, when most of the fluorite crystallized, forming commercial accumulations of ore. For them there has been found universally a rather narrow range (20-40°) of the temperature of mineral formation. A greater spread has been found for the upper temperature interval. The minimum temperatures record the temperatures of formation of the latest generation of fluorite or calcite (Barun-Altsak showing, southern area).

In plates of porcellainous quartz, concluding the hydrothermal process, suitable inclusions were not found and the temperature conditions of its formation are not known. It is most probable that they are lower than the lowest temperature indicated in the table.

It is interesting that many showings (Darkhinsk, Aro-Tashirsk, Barun-Altsak), occurring in different geological settings and separated from one another by considerable distances (90-120 km), are characterized by practically the same temperature conditions of formation, similar mineralogical composition of the ore, general sequence of deposition of minerals, and often also the morphology of the ore bodies. For example, the vein body of the Aro-Tashirsk deposit, occurring amidst granites and at the contact of a syenite-porphyry dike, was formed in the same temperature interval (170-95°) as ore bodies localized amidst Cambrian limestones (Barun-Altsak and Darkhinsk showings). The noted deviations of temperature are unimportant and the genetic community of the studied deposits is not in doubt.

The features of the fluorite deposits are such that each successive mineralization was formed at a lower temperature than the preceding. This indicates that all parts of the mineral-forming solutions came from the same hearth and nearly continuously.

It has been found that fluorites from different deposits differ notably in the frequency of occurrence of inclusions and their size. In some cases (Kharasun deposit) in 1 sq. cm. of a plate 1-2 mm. thick up to 30 primary inclusions occur; in others (Burun-Ul'sk deposit) a total of 1-2 inclusions. Fluorites of different generations from a single deposit also differ sharply in frequency, size, and morphology of inclusions. As a rule, the largest (0.03-0.08 mm.) inclusions are characteristic of the early generations of fluorite. They often have irregular "fringed" form (Burun-Ula, Kharasun). For fluorite of late generations small (0.01-0.03 mm.) inclusions are typical, often in the form of smoothly bounded tetrahedral prisms, parallelopipeds, cubes. Their frequency of occurrence is 1-2 per sq. cm. of a plate 2 mm. thick.

Determination of the pH of the solution, both by the method of aqueous extracts from fluorite (see Table) and also by microcolorimetric analysis on opening individual large inclusions showed that fluorites of all the studied deposits formed in an acid medium, independent of the mineralogical type of deposit and the composition of the country rock. Usually the pH of the liquid inclusions vary from 5.3 to 6.6 (Arkhipchuk and Lokerman, 1966).

Complex inclusions with liquid CO_2 were found in only one case, in blue-green fluorite from the Manyatsk showing. Three-phase inclusions with liquid CO_2 are small ovals (0.01-0.02 mm.), and form grouped accumulations. Under usual conditions the ratios of the phases

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[1] The temperature of formation is taken as the temperature of homogenization of inclusions without correction for pressure.

Table (p. 111).--Comparison of mineral-thermometric data on fluorite deposits of western Transbaikal.

Deposits and ore showings	Minerals studied	Homogenization measurements, in °C						pH of aqueous extracts from fluorite	Mineralization type
		Number of Meas.	Temp. of Formation Start	Temp. of Formation End	Temp. interval	Temp. main phase	Interval of main phase		
Barun-Altsak	Fluorite, quartz calcite	70	160	95	65	140÷115	25	6.20	Calcite-calcite-fluorite
Darkhinsk	Fluorite	26	160	95	65	160-120	40		
Burun-Ulsk	" , calcite	400	190	118	72	150-120	30	5.50-6.12	
Uchastok Yuzhnyi	" "	120	165	75	90	150-120	30	6.01	
Upper Toreisk	"	15	180	150	30	165-150	15		Quartz-fluorite
Manyatsk	"	40	165	115	40	160-130	30	6.80	
Central	" , calcite	10	160	135	25	160-140	10		
Povorotinsk	"	30	220	135	85	180-140	40		
Manzhinsk	"	120	187	130	57	175-145	30	6.12	
Ivolginsk	"	150	250	115	135	200-160	40		
Pervomaisk	"	45	180	145	35	175-150	25		
Oninoborsk I,II	"	32	168	128	40	165-140	25		
Aro-Tashirsk	"	125	170	95	85	150-120	30	6.66	Barite-quartz-fluorite
Ubur-Tashirsk	"	10	200	170	30	190-170	20		Fluorite

In them vary in a narrow interval. Usually the aqueous phase in them constitutes, by visual determination, 2-5% of the volume of the vacuole, the gas phase 0-4%, the remainder of the volume being liquid CO_2. When heated, the partial homogenization of the CO_2 occurs in the liquid phase at a temperature of +26.1°. The density of the liquid CO_2 in the inclusions, with introduction of a 5% correction for the aqueous phase, is 0.63 g/cu.cm. Gas-liquid pseudosecondary inclusions without CO_2 in the same fluorite homgenize in the liquid phase at 160-

140°. According to reference data on the P-T diagram of CO_2 (Kalyuzhnyi, 1960), the pressure existing during mineral formation equals 400-440 atm. Such a pressure is apparently a maximum for this group of deposits.

Because the temperature regime of formation of the deposits does not depend on the composition of the country rock, including intrusive formations of the Dzhida complex, there is no doubt that they were expelled from magmatic sources at considerable distances.

Literature

Arkhipchuk, R.Z. and Lokerman, A.A., New data on the dependence of form of fluorite crystals on the conditions of formation: Mineralog. Sbornik L'vov Univ. no. 20 (1966).

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Ochirov, Ts.O., Geology of the Gusin-Ivolginsk part of Buryat: Buryat. Knizhn. Izdat., Ulan-Ude, 1964.

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GIGASHVILI, G.M., 1969, Primary solid-gas inclusions in quartz from Volhynian pegmatites: L'vov. Gos. Univ. Mineralog. Sbornik, v. 23, no. 4, p. 398-404 (in Russian) (Author at L'vov. Inst. Geology and Geochemistry, Acad. Sci. Ukr. S.S.R.).

Primary gas-solid differently filled inclusions disposed in zones of rhombohedral growth in quartz are described. The solid phase is formed from hydromica, albite, topaz, alunite,+lepidolite in different quantitative correlations. The pressure of the gas phase in the inclusions at 20° is lower than atmospheric. The different quantitative correlations of minerals indicate their xenogenic origin. Gas blebs in the inclusions are relics of the gas phase of the mineral-forming medium. (Author's abstract).

In crystals of morion from the zone of silification, underlying cavities, we have observed primary gas-solid inclusions. The morion is developed along fractures and weakened zones in radiating-fibrous form, replacing microline-perthite, also replaced by protolithionite* and by albite. The degree of silification increases with approach to the cavity up to complete replacement by drusy morion, the size of separate individuals of which on L_3 is 1-3 cm. Large zoned crystals of the cavity are in contact with drusy morion of seven zones, also an inner, a honeycomb, and a morion (Figs. 1,2). In the outer zones of the drusy morion are observed primary gas-solid inclusions

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* Present in accessory amounts in Volhynian pegmatites.

Fig. 1 (p. 398). Relations of the morion zone, containing primary gas-solid inclusions, with other generations of quartz: (1) honeycomb quartz; (2) area of honeycomb quartz with a large amount of xenogenic crystalline phases in the inclusions; (3) a series of primary gas-solid inclusions; (4) leaflets and plates of mica; (5) relicts of albitized microcline; (6) intensively colored morion.

Fig.2 (opp. p. 398; omitted here). Relations of different generations of quartz.

(1) zoned crystals of morion from cavities; (2) drusy morion with mica from the zone of silification; M_k= albitized microcline. x2.

0.01-0.04 mm. in size, arranged along the rhombohedral growth zones (Fig. 3), and also randomly oriented dark-brown crystals of

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Fig. 3 (opp. p. 398; omitted here). Primary gas-solid inclusions; (a) ordered series of primary gas-solid inclusions. To the right upper honeycomb quartz, morion single crystal growing out into a cavity. X 5; (b) one of a series of primary gas-solid inclusions. Plate 11 L_g of quartz. X 500. T = topaz, Ab = albite, g = gas phase.

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protolithionite, which in places are cut by fractures, and at the contact grains of morion are replaced by hydromica. In some crystals of morion there is a paler core or irregular form, full of honeycomb fractures, also containing mica.

Most of the inclusions have a form approximating that of a negative hexagonal bipyramid. The solid phases grow as if in the quartz and the observed outlines of the vacuoles in these areas are determined by the boundaries of the solid phases, and in the areas of gas phase the wall of the vacuole has a crystallographic boundary. The boundary of the gas phase within the inclusion has, on the whole, subordinate form of the crystalline phases, in which one can separate the following components.

1. Clotted accumulations of micro-foliated silver-white mica with indices of refraction $n_g = 1.560$, $n_p = 1.544$. From electron

diffraction data (analyst N.A. Mikolaichuk) and optical constants, this is close to hydromica (7).

I	d/n
	4.43
60	2.544
20	2.181
30	(1.631)
80	1.482
50	1.276

2. Platy crystallites of lepidolite, $n_g = 1.561$, $n_p = 1.537$, 2V=-32°, occurs very.rarely.

3. Small long-prismatic crystals of topaz, n_g=1.626, n_p=1.617.

4. Porous isometric grains of albite: n_g=1.539, n_p=1.532.

5. Platy grains of alunite (?), n_g=1.602, n_p=1.584, uniaxial, positive (6).

6. Acicular crystals of an unidentified mineral, n_g=1.604, n_p=1.587, parallel extinction, elongation positive.

The ns in all cases were determined by the rotating needle method. The immersion liquid in the process of measurement was checked on the IRF-22 refractometer. The accuracy of measurement is ±0.002. The minerals listed occur in crystals in arbitrary proportions. Topaz, alunite (?), lepidolite, and the acicular mineral are absent in many inclusions. The ratios of albite and mica, which are the main components of the crystalline phases, also vary within wide limits. Besides the gaseous and crystalline phases, the presence of a solution is possible, but in such small amounts that it is not observed by microscopic study. One can assume that the microgranular lumps of mica core are saturated with solution and therefore transparent in transmitted light, and the gas phase within the inclusions sometimes has rather smooth outlines. There are, however, a large number of inclusions which are almost non-translucent in transmitted light, but which, after being opened in glycerol with elimination of the gas, have crystalline phases that are transparent.

The ratio of gas to crystalline phases is not constant in the described type of inclusion. The gas phase constitutes on the average 15-25% of the volume of the vacuole in the inclusions. Heating the inclusions in the high-temperature thermochamber (2) to 960°C leads to the fusion of most of the crystalline phases, which gives the possibility of determining accurately the filling of the inclusions.

Phase transformation begins at 700°C. In the interval 700-720°C albite, and somewhat later mica (750-780°C) begins to melt, and the gas phase, reduced in volume, acquires rounded outlines. The inclusions, the solid phases of which are entirely grains of albite and hydromica, become two-phase with inconstant ratio of melt and gas (melt 70-98% and gas 30-2%). Inclusions with a gas phase of about 10-25% predominate. Further heating leads to a small shrinking of the gas bubbles (or of some gas bubbles, fig. 4a). And only in individual inclusions, in which at 720°C the gas is 5% or less is the shrinkage of the bubbles

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Fig. 4 (opp. p. 400; omitted here). Melting of gas-solid inclusions (a) some gas bubbles (g) in glass (c), X 230; (b) acicular crystals (K) and gas bubbles in glass, X 400; (c) inclusion with two glasses, outer (C_1) with n=1.528, inner (C_2) with n=1.481, X 140; (d) differently filled syngenetic inclusions after melting. Inclusion 2 differs in the large number of very fine bubbles, originating at the walls during cooling. This inclusion homogenized in the melt at 920°. X 500.

more notable, and they disappear completely at 930°C. On cooling the bubbles again appear, increasing to the size they had at 720°C. The ratio of the phases on subsequent rather rapid cooling (500° in 30 minutes) remains nearly unchanged, and only in the cold melt do very fine bubbles of gas separate on the walls of the inclusion. In most inclusions, when heated to 960°C, the gas bubbles do not disappear, but only diminish somewhat (time of heating from 400 to 960°C--4 hours, time held at 960°--30 minutes). Phase transformations in the interval 700-960°C were observed over 10° intervals directly in the chamber with an objective of X 20.

The crystallites of topaz and of the acicular crystals melt easily; besides, in many inclusions there is formed a new acicular mineral, forming accumulations immersed in the melt (Fig. 4, b). It is characteristic that in the inclusions with incompletely fused crystalline phases, the gas bubbles are usually larger (sometimes up to 40-50% of the volume), but the number of separated gas bubbles on the walls of the inclusions on cooling is far less or they are completely absent. This may indicate a different viscosity of the melt in the inclusions, caused by differences in their chemical composition. In some inclusions there was observed immiscibility of the melt, which was recorded on cooling by two glasses of different indices of refraction (Fig. 4c); the central part of the inclusion is occupied by glass with $\underline{n}$=1.481, the peripheral part by glass with $\underline{n}$= 1.528. The indices of refraction of other glasses obtained by fusion of inclusions varied from 1.475 to 1.489 (in 10 inclusions). There was no exact dependence between the primary composition of the inclusion and the index of refraction of the glass, which in turn is explained by the difficulty or nearly complete impossibility of diagnostics of all the mineral components of the crystalline phases without opening the inclusions. However, it has been noted that inclusions in which albite predominates give glasses with lower $\underline{ns}$ (1.477-1.481), and inclusions with considerable amounts of mica and topaz give glasses with $\underline{ns}$ 1.480-1.489. For the latter the absence of small bubbles of gas on the walls of the vacuole on rapid cooling is also characteristic.

It has been noted that there is more rapid melting of the small inclusions (0.001-0.004 mm.) and they are completely homogenized as compared with larger ones (0.01-0.1 mm.). This, as has already been noted (8), may be explained by the fact that in comparatively rapid heating, equilibrium at any given temperature is more easily and rapidly reached in smaller than in larger inclusions, especially in the case of a viscous, glassy system. However, we have observed a series of syngenetic inclusions of uniform size, one of which homogenized in the melt at 930°C and others of which retained a gas phase (10-15%) and at 960°C (Fig. 4). According to this difference (?) for inclusions of the same size, one can speak of differences in their filling in the case that this was not established without question before the heating.

Attempts were made to analyze the composition of the gas in separate primary gas-solid inclusions by a volumetric method. But on opening the inclusions in distilled glycerol the gas phase immediately contracted several fold and in many inclusions diasppeared completely. All this, considering the small sizes of the inclusions--from 0.01 to 0.005 mm.-- and the small percentage of gas phase in them (15-25%), makes it impossible to do the manipulations needed for a gas analysis. The observations indicate that the pressure of the gas in the inclusions is lower than atmospheric at room temperature. For comparison there were opened in the same way inclusions from the honeycomb zone of the morion crystal (L=30%). The gas phase increased 50-60 times when the inclusions were opened.

The importance of primary inclusions is that they re-establish the temperature, pressure, and phase composition of the mineral-forming medium in which were formed the zones of minerals containing these inclusions. The gas-solid inclusions described cannot completely fill this function. Especially one cannot, from them, establish the minimum temperature, and consequently also the pressure of mineral formation, because the crystalline phase in them has a xenolithic character, which is shown by their different degrees of filling and arbitrary quantitative ratios of individual minerals, as especially distinctly shown during melting. The temperatures of homogenization, which for individual inclusions is 930-950°C, is not a minimum temperature of mineral formation, but simply the temperature of homogenization of a system consisting of crystals trapped in accidental proportions by growing quartz together with relict gas of the mineral-forming medium. The true state and composition of the mineral-forming medium cannot be judged from data on the inclusions without additional criteria.

Here it is necessary to decide in detail the relations of the morion zone containing primary gas-solid inclusions to the earlier generations of quartz. As already mentioned, the central part of the morion individuals from the zone of silification is a paler variety, with honeycomb inclusions. The zone of honeycomb quartz of width 2-3 cm. to 2-4 mm. is observed also within large crystals of morion from cavities, directly in contact with drusy morion. But between them there is an essential difference: in the drusy morion there is noted mica, consisting of protolithionite, in large part replaced by muscovite and hydromica, but mica is absent from the single crystals from cavities. It is evident that the quartz is labelled by mica, metasomatically developed after microcline of radiating-fibrous form, underlying the cavity. The inert alumina under these conditions is fixed in the mica. Relicts of the mineral-forming medium, referred to this period, have not been found, but the processes proceeded in the pre-inversion stage (above 575°C), because the quartz with mica is infested with honeycomb fractures.

Interesting is the presence in the system of honeycombs of two sharply differing types of inclusions.

1. Liquid-gas inclusions with the form of negative hexagonal bipyramids 0.1 to 0.05 mm. in size. They are uniformly distributed in planes of healed fractures. The filling L of these inclusions= 25-30%; the crystalline phase of most is 0.5-1%, but in areas of large crystals, in contact with drusy morion, i.e. at the bottom of cavities, and also in the central parts of drusy morion in honeycomb inclusions, a considerable number (up to 50-70%) was observed of xenogenic phases, consisting of topaz, mica, and albite. The ratio of gas phase and solution of these inclusions was the same as in all the liquid-gas honeycomb inclusions, i.e. 25-30%. The pH of the honeycomb inclusions, according to measurements by the microcolormetric method (3) was 7.2-7.5; the temperature of homogenization in the gas phase 380-390°C (the xenogenic crystalline phases remained unchanged).

2. Small (0.001-0.005 mm.) gas-solid inclusions, located in rows ("channels"), flowing around the larger inclusions of the first type (Fig. 5). They are observed along all zones of the honeycomb quartz. These gas-solid inclusions, when heated to 960°C, behave

Fig. 5 (p. 402; omitted here). Two types of inclusions in the system of honeycomb fractures (X187). (a) liquid-gas, (b) gas-solid.

like the described primary inclusions. Some of them are homogenized in the melt; in some the gas phase at this temperature, 15-20%, and besides retains the very small unmelted crystallites. The pressure of the gas phase in these inclusions at room temperature could not be determined.

The conditions of entrapment of the primary gas-solid inclusions, the causes of their similarity to the gas-solid inclusions in the honeycomb quartz, and also the specific differences of degree of filling of the inclusions of the honeycomb and their characteristic arrangement in the plane of healing of the fractures in many remain unclarified. One of the hypotheses explaining these phenomena may be presented in the following form.

The formation of the honeycomb fracturing is connected with a sharp decrease of pressure and temperature as the result of adiabatic increase of free volume in the plane of the cavities (1). But in our case, the decrease was not as strong, so that it affects the fracturing of the preinversion quartz, especially of large crystals of cavities at great depth. (4,5). Thereby in the crystals there are observed not very thick zones of honeycomb quartz (Fig. 1,2), formed in places of the most rapid removal of the hot fluid. Part of these fluids, together with turbid crystallites of mica, albite, topaz, etc., which are to a considerable degree products of the metasomatic reaction products of microcline, are fixed in the honeycomb fractures. Comparitively large crystallites (up to 0.1-0.05 mm.) are jammed (filtered) in narrow fissures; small (0.001+0.005 mm.) are distributed with fluid in the whole system of honeycomb fractures.

It is difficult to suggest any specific mechanism for the origin of two different syngenetic types of inclusions during the healing of honeycomb fissures without arranging special experiments. It is evident that the phenomenon is associated with heterogenization, the boiling of a fluid during a sharp decrease of pressure and temperature in the cavity.

In quartz affected by honeycombs, there is an overgrowth of a new generation of quartz from solution, which is very poor in the gas component as a result of its escape from the system while it is open. The solutions fill defects of the volume formed previously during the metasomatic replacement of microcline by quartz and mica. In these cavities a large number of small crystals collect, at the boundaries of which with the solution bubbles form, consisting mainly of steam, separated from the boiling solution. The specific conditions of growth of the quartz aid the entrapment only of crystals with gas phase without mother solution. The low pressure of the gas in the inclusions, determined by opening them in glycerol, can be explained by the low pressure of water vapor at room temperature. And the amount of condensed moisture locked into the inclusion during its cooling to room temperature is small: not more than 5-10%. Otherwise the solution could be observed under the microscope. This corresponds on the P-T diagram of pure water to the isochore with specific volume 20-10 cu.cm./g. Hence it appears that the temperature of the mineral-forming medium, if it is considered to be a slightly mineralized boiling aqueous solution, does not exceed 300-350°C and the pressure 180 atm. In the case of more concentrated solutions, P and T are higher.

On the zone of morion with primary gas-solid inclusions there is overgrown a more intensely colored zone of morion devoid of inclusions, evidently syngenetic with the morion that is overgrown on the outer zone of crystals of the cavity.

Thus, the different degrees of filling and the different composition of the crystalline phases do not permit one to consider the gas-solid inclusions as relicts of recrystallized melt. The too low pressure of the gas phase and the low density create doubt as to its capability of being a mineral-forming medium, providing quick growth of quartz, aiding the entrapment of a large number of primary inclusions. Thereby it is assumed that quartz with primary gas-solid inclusions crystallized from boiling aqueous solution with many xenogenic crystallites, to which bubbles of steam adhered.

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KHETCHIKOV, L.N. and SAMOILOVICH, L.A., 1970b, The possibilities of the decrepitation method in mineral thermometry: Akad. Nauk S.S.S.R., Izvest., Ser. Geol., 1970, no. 7, p. 92-98.

In recent years a considerable number of papers have appeared on techniques of study and determination of temperature of mineral formation by the method of decrepitation of gas-liquid inclusions in minerals (Dolgov, 1954, 1965; Ermakov, 1950, 1965; Komarov and Parshin, 1966; Kostyleva and Lebuntsov, 1958; Naumov, 1965; Naumov and others, 1966; Ingerson, 1955; Roedder, 1954, and others). Regrettably, for many investigators using this method, there has been an inadequate laboratory set-up for the experiment itself and also incorrect interpretation of the results obtained. Of course, the temperature of rupture of inclusions can be determined by many factors, part of which are not directly related to the conditions of formation of the inclusion (number, size, form , and distribution of the inclusions in the grains, the (size) fraction of the grain, the stability of the mineral, etc.). Therefore in the interpretation of the temperature of mineral formation on the basis of data on decrepitation one must take into account differentially the contribution of each factor.

In our paper we consider some aspects of the decrepitation method: (1) the relations between the original temperature of growth and the temperature of homogenization and decrepitation of inclusions (using synthetic quartz as an example); (2) the possibility of determination of the original temperature of growth of the crystal by the decrepitation method; (3) the possibility of determination of the relative temperatures of growth of crystals by the decrepitation method.

To solve the tasks formulated above, we used the temperatures of homogenization and decrepitation of samples of synthetic quartz containing gas-liquid inclusions, and also the P-F-T relations (pressure-degree of fill-temperature; Ed.) of mineral-forming solutions, the compositions of which were similar to the compositions of the solutions contained in the inclusions. The temperature of growth of the quartz was varied in the range 300-375°C, and the pressure from 100 to 2000 atm. Inclusions in the quartz were predominantly of cylindrical form with axial lengths 0.5-0.8 mm., and with filling by liquid phase in the interval 0.65-0.85.

Decrepitation of the inclusions was carried out in the apparatus built at Moscow Gos. Univ. by G.N. Nefedov, under the direction of N.P. Ermakov, and also on the apparatus with piezo-pickup, made in G.E.O.Kh.I. by V.B. Naumov. The speed of heating the sample was in all experiments 5°C per minute. Quartz with inclusions was crushed to grain size 0.5-1.0 mm.

We took as the temperature of decrepitation the temperature of massive bursting. In our opinion, estimating the temperature of decrepita-tion by the beginning of massive bursting has one very important advantage compared to estimating it by the maximum of bursting. The fact is that the temperature of the beginning of massive bursting refers to the temperature of bursting of inclusions closest to the surface and does not depend on the size fraction of the grain, whereas the position of maximum bursting depends on the size fraction. This fact was experimentally demonstrated by V.B. Naumov. Theoretically this can be shown by considering the grain with inclusions as a hollow sphere with external radius R_1 and internal R_2 under the condition that the pressure P is acting within the sphere. For such a brittle mineral as quartz, one can assume the equilibrium theory of elasticity along the fracture, because the region of plastic deformation is absent in brittle minerals (Landau and Livshits, 1965).

The equation of deformation in this case will have the form ∇ div U=0, where U is the tensor of deformation. The solution of this equation in spherical coordinates under boundary conditions $\sigma_{rr}=-P$, where $r=R$, and the thickness of the wall of the inclusion $h=R_1-R_2 \ll R$ gives (Landau and Livshits, 1965) for a tangential pressure

$$\sigma_{\phi\phi} = \frac{PR_2}{h} \qquad (1)$$

and for radial

$$\sigma_{rr} = \frac{P}{2} \qquad (2)$$

Because $R_2/h > 1$, $\sigma_{\phi\phi} > \sigma_{rr}$, i.e. the greatest pressure will be tangential. From formula (2), one can estimate the pressure at which there occurs rupture of a spherical inclusion of radius R_2 at wall thickness h:

$$P_{rupture} = \frac{\sigma_{\phi\phi\ rupture} \times 2h}{R_2} \qquad (3).$$

As seen from formula (3), the pressure at which rupture of the inclusion occurs, does not depend on the size of the grain, but is determined by the magnitude of $\sigma_{\phi\phi}$ and the ratio of the wall thickness of the inclusion to its size h/R. Consequently the temperature of decrepitation is better taken as the temperature of the beginning of massive bursting of the inclusions.

Homogenization of gas-liquid inclusions in quartz was carried out in the thermal chamber constructed by Yu.A. Dolgov and L. Sh. Bazarov. The rate of heating was 3-5° per minute. Knowing the coefficient of filling of the inclusion F (in our case the corresponding coefficient of filling of the steel autoclave in which the quartz was grown), and also the experimentally determined temperature of homogenization ($T_{hom.}$) and of decrepitation ($T_{decr.}$), we have determined the pressure at which massive bursting of the grain occurred. The calculation was made by the empirical formula revealed by study of the P-F-T dependence for salt solutions: $P=P_{hom.}+(30F-10.7)(T_{decr.}-T_{hom.})$. Calculations showed that in the studied range of parameters, independent of the magnitudes P, F, and T during growth, the pressure at the moment of rupture of the inclusions is constant and equals 800± 30 atm. (Khetchikov and others, 1968). Plotting this region of rupture of inclusions on the P-F-T diagram for Na_2CO_3 solutions, we can determine the quantitative relations of temperature of decrepitation and homogenization. Thereby it is entirely evident that the absolute magnitudes of temperatures of decrepitation depend mainly on two factors: (a) the stability properties of the mineral (i.e. the location of the region of bursting of inclusions on the P-F-T diagram of the mineral-forming solution; (b) the coefficients of filling of the inclusions' liquid phase.

The dependence of the temperatures of decrepitation and homogenization and of the magnitude $\Delta T=T_{decrep.}-T_{hom.}$ on the coefficients of filling of the inclusions' liquid phase are shown for synthetic quartz on Fig. 1.

Fig. 1 (p. 94). Dependence of temperatures of homogenization (1), decrepitation (2) and the magnitude $\Delta T=T_{decrep.}-T_{hom.}$ (3) on the coefficient of filling of inclusions in synthetic quartz.

As seen from these data, all three curves increase continuously with decreasing coefficients of filling. In order to determine the true temperature of growth, it is insufficient to know one temperature of decrepitation. Only in such cases where the pressure during mineral formation is approximately equal to the pressure during the opening of the inclusions is the temperature of decrepitation equal to the temperature of growth of the mineral. On the whole, as also in the method of homogenization of inclusions, it is necessary, in order to establish the true temperature of growth, to introduce corrections for pressure (Naumov and others, 1966; Khetchikov and others, 1968). However, in contrast with the temperature of homogenization, which gives always only the lower temperature limit of mineral formation (and consequently the sign of the temperature correction is always positive in this case), the correction to the temperature of decrepitation can be either positive or negative.

In our case the correction to the temperature of decrepitation for two coefficients of filling of inclusions with liquid phase, 0.6 and 0.9, is given for various pressures in Fig. 2. As seen from the graph, if the

Fig. 2 (p. 94). Dependence of correction to temperature of decrepitation of inclusions in synthetic quartz at F=0.6 and 0.9 P.

pressure of the mineral-forming solution is less than 800 atm., then with increasing P, the correction, having a negative sign, decreases linearly. If the pressure of mineral formation is greater than 800 atm., the correction to the temperature of decrepitation has a positive sign and increases linearly with increase of pressure. The dependence of the magnitude of the correction at a fixed pressure on the coefficient of filling is single-valued over the whole range of pressures: the smaller the coefficient of filling, the higher is the correction. For example, at F=0.6 and 0.9 at P=400 atm., the corrections are, respectively, -54° and -26°. Thus, in order to establish the true temperature of growth of the crystal from the temperature of decrepitation, it is necessary: (1) to know the pressure of mineral formation; (2) to know the pressure during rupture of the inclusion. If one plots a curve of stability towards rupture in the coordinates P-T, the pressure during rupture is determined by the ordinate of the point of intersection of the isotherm $T\text{-}T_{decr.}$ with the curve $P_{rupture}=F(T)$; (3) on the P-F-T diagram of the mineral-forming solution (as a first approximation one can use the P-F-T diagram for pure water) one draws the isobar P=P of mineral formation also through the points $T_{decr.}$ and $P_{decr.}$ -the corresponding isochore. The abscissa of the point of intersection of this isochore with the isobar P=P mineral formation gives the true temperature of growth (Fig. 3).

Fig. 3 (p. 95). Drawing illustrating the graphic determination of the temperature of growth of a mineral.

Establishing the true temperature of crystallization is impossible without taking account of these factors, which influence the relations of the temperature of growth of the crystal and that of decrepitation of the inclusions. The accuracy of estimation of the true temperature of mineral formation will depend, besides errors of the decrepitation method itself, on the accuracy of the determination of the pressure. If the absolute error of determining the the pressure is ±100 atm., the absolute error in the determination of the temperature of mineral formation for essentially liquid inclusions with filling of the liquid phase of 0.9-0.6 is approximately 6-14°C. Thereby, and also for the method of homogenization, gas-liquid inclusions with the greatest degree of filling are more suitable as geological thermometers than those with less degree of filling.

To clarify a series of problems on the genesis of hydrothermal deposits, relative temperatures of mineral formation could have specific value. At present it is stated that the sequence of changes of temperatures of crystallization of minerals ought to correspond with the sequence of changes of temperatures of decrepitation (Kostyleva, 1965; Malinko, 1966; Puzanov and Kudakova, 1966; Trufanov, 1966). In other words, higher temperatures of decrepitation ought to correspond to higher temperature generations of minerals, and vice versa.

For graphical representation of the further discussion, let us consider three possible cases of crystallization of a mineral from homogeneous liquid solutions of various densitites (Fig. 4,a,b,c). In all cases the region of bursting of the inclusion is plotted in the coordinates

Fig. 4 (p. 95). Different cases of relations of temperature of growth of mineral and temperature of decrepitation of inclusion.

P-T by two lines parallel to the temperature axis.

1. Suppose the parameters of the points C_1 and C_2 correspond to the conditions of growth of the mineral in which $P_{c1}=P_{c2}$, $T_{c1}<T_{c2}$, and $F_1>F_2$. From 4a, it is seen that the temperature of decrepitation of the inclusions formed at the parameters of point C_1 is less than for inclusions formed at the parameters of point C_2, i.e. the high-temperature crystallization corresponds to a higher temperature of decrepitation. If the parameters of mineral formation will correspond to parameters of points lying on a single isochore (C_1 and C_1^1, C_2 and C_2^1), then the temperature of decrepitation will remain constant, independent of P and T, and is determined solely by the magnitude of F.

2. Suppose the inclusions compared were formed under conditions of different pressure, temperature, and density of solutions. Thereby $P_{c1}<P_{c2}$, $F_1>F_2$, $T_{c1}<T_{c2}$ (Fig. 4B). Under these conditions, as in the first case, there ought to be correspondence of the relative temperatures of growth and decrepitation.

3. Suppose the inclusions were formed under conditions of different pressure, temperature, and density (Fig. 4c). But, in distinction from the second case, $P_{c1}>P_{c2}$, $F_1>F_2$, $T_{c1}>T_{c2}$. Then the higher-temperature crystallization will correspond to the lower temperature of decrepitation, $T_{D1}<T_{D2}$.

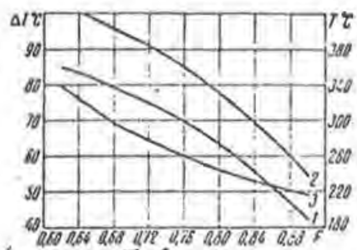

Fig. 1

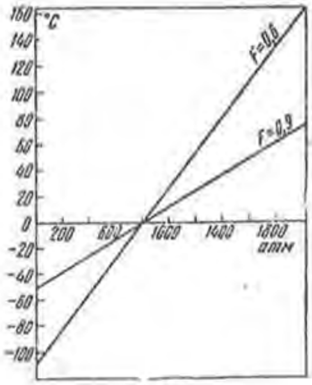

Fig 2

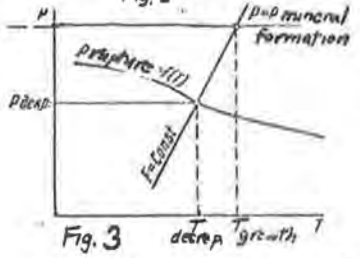

Fig. 3

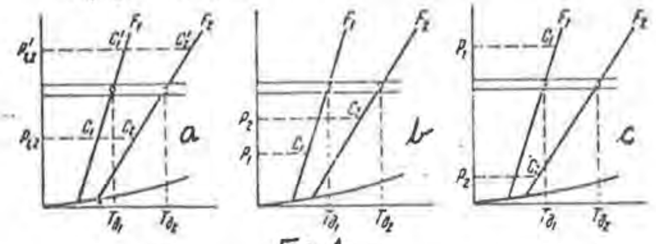

Fig. 4

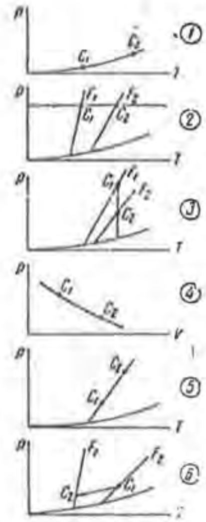

Fig. 5

In a more general view, different cases of the relations of the temperatures of decrepitation and of mineral formation, applicable to processes, the thermodynamic parameters of which are connected by specific regularities, are given below in a table.

Higher temperatures of decrepitation will correspond to relatively high temperatures of mineral formation, if the formation of the inclusions occurred during the formation of the mineral from a heterogeneous system on the line of saturated vapor, or from homogeneous systems characterized by different magnitudes of parameters T and F, but nearly uniform presures (Table, 1 and 2). This same correspondence of temperatures of crystallization and decrepitation will be observed if the process of growth of the crystal occurs in a regime of decrease (also increase in the general case) of the parameters P and T and simultaneous increase (decrease) of F (table, 6).

The evolution of the parameters of growth of crystals for different stages of mineral formation under natural conditions is very diverse and can be described only to a first approximation by specific thermodynamic rules. The most widespread regimes of crystallization during changes of parameters are noted in the table (1 and 6). Possible also is the formation of the inclusions during adiabatic expansion of the cavity-crystallizer with decrease of the temperature and of the density of the mineral-forming solution. In the latter case, relatively high temperature of growth will correspond to low-temperature of decrepitation, and conversely, relatively low temperature of decrepitation will correspond with relatively high temperature of growth of the mineral. Isobaric and isothermal regimes of crystallization are not characteristic of processes of natural mineral formation.

Nevertheless, one can assume short-lived periods of isobaric and isothermal conditions in the formation of some deposits. As seen from the graphs of Fig. 5(2 and 3), one cannot judge the relative temperatures of

Fig. 5 (p. 96). Graphical representation of processes with regularly associated thermodynamic parameters.

growth of the crystal by the decrepitation of the inclusions formed in them. This lack of correspondence of the relative temperatures of growth and decrepitation of inclusions has often been observed by us during study of minerals grown under synthetic conditions at uniform temperatures and pressures, but with varying densities of solutions (Khetchikov and others, 1968).

Thus the studies carried out show that temperatures of decrepitation do not always correspond to temperatures of growth of crystals. Depending on the features of the process of mineral formation and the character of the changes of thermodynamic parameters of this process, the temperature of decrepitation can be higher, lower, or approximately equal to the temperature of crystallization. Thereby, in order to estimate even relative temperatures of growth of crystals from the decrepitation of inclusions, one must consider the possible effects of various factors, determined by the changes of the process of mineral formation.

Table (p. 97)

No.	[illegible] of parameters of mineral formation of the objects compared	Relations among parameters	[illegible] in direction of change of T [illegible]. and T decr.
1	Crystallization from a heterogeneous [illegible] [illegible], [illegible] lines of saturated water)	$T_1 > T_2$ $P_1 < P_2$ $T_{decr_1} < T_{decr_2}$	No
2	Crystallization from a homogeneous [illegible] and [illegible], but uniform [illegible] (sic!), should be uniform P. [illegible].)	$T_1 > T_2$ $P_1 < P_2$ $T_{decr_1} < T_{decr_2}$	No
3	Crystallization from a homogeneous system, characterized by different [illegible] and [illegible], but uniform T	$T_1 > T_2$ [illegible] = [illegible] = const. $T_{decr_1} < T_{decr_2}$	No
4	Crystallization from a heterogeneous system, under conditions of [illegible] (or. reaction) of system	$T_1 > T_2$ $P_1 > P_2$ $T_{decr_1} < T_{decr_2}$	No
5	Crystallization from homogeneous system characterized by different [illegible], but [illegible]	$T_1 = T_2 = const.$ $P_1 < P_2$ $T_{decr_1} = T_{decr_2} = const.$	No
6	Crystallization from homogeneous [illegible] and [illegible] rise ([illegible]) of [illegible]	$T_1 > T_2$ $P_1 > P_2$ $T_{decr_1} > T_{decr_2}$	Yes

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KRENDELEV, F.P., ZOZULENKO, L.B. and ORLOVA, L.M., Temperature of homogenization and composition of gases in gas-fluid inclusions in pebbles from ancient conglomerates of sulphide type (Authors at Institute of Geology and Geophysics, Novosibirsk, USSR) (Paper for presentation at 1972 Montreal COFFI symposia, received too late for inclusion in symposia programs in previous issue of COFFI; Ed.)

The most important uranium-gold concentrations among all found in the Earth are associated with Precambrian conglomerates. Throughout the whole of mankind's history about 75-80,000 t of gold were mined, two-thirds of this amount being mined from South Africa's conglomerates during the past eighty years. Because of this fact the problem of mineralization in conglomerates attracts great attention by numerous scientists. In discussing this problem geologists usually regard the ores from Witwatersrand, Blind River, Serra de Jacobina, Tarkwa, Mounana, Koli and other deposits as belonging to one common type. This concept must be revised because at present some different ore-forming minerals were discovered, in addition to uranium and gold contained in conglomerates (fig. 1). They contain copper, mercury, tin, rare earths and nonmetalliferous ores such as barite, fluorite, semiprecious stones etc. Oil is also extracted from conglomerates (Austria). It is necessary, therefore, in treating the problem of genesis of ores in conglomerates, to include all elements and define the place of gold-uranium bearing ores among them.

The ores of U, Au, Cu, Pb, Zn, Sn, Hg and other metals localize not only in conglomerates, but in gravels, sandstones and siltstones too. In many cases the ores spread from conglomerates to sandstones and/or siltstones within the boundary of one and the same ore body.

According their age, metalliferous conglomerates vary from Archean to the pebble rocks of the modern beaches and streams. The existence of modern placer deposits indicates that the concentrations of detrital minerals could have been forming in ancient sediments. It is clear that we can't apply the same measure to the Archean and Quaternary sediments. Both the possibility of formation of ore concentrations and the probability of its conservation must have been realized during their geological history.

Ancient conglomerates may be found in different geological structures such as the large geosynclinal fore deep structures in platforms or shields, the rift valleys, fault depressions, fore deeps, intermountaine basins, and within the Alpine geosynclinal folding zone and molasses series.

Conglomerates are distinguished either by their genesis, or by the genesis of their mineralization, or the grade of metamorphism of their matrix, etc.

We can get information by examination of the newly-formed minerals in the matrix of conglomerates. As likely as not, all the matrix-minerals contained in the Precambrian sulphide conglomerates are newly formed. The only exceptions are the accessory minerals of rounded shape. Even quartz pebbles are often fully recrystallized. In essence they are quartz pseudomorphs replaced over the original quartzite pebbles or vein quartz. Such pebbles are frequently of bluish, pinkish, or lilac color. In the quarternary pebbles only clay minerals such as kaolinite, montmorillonite, and limonite can be considered as newly-formed minerals. In this case this may be applied to the placer deposits only entering into stages of transformation. As an example we take the Tertiary and Quaternary conglomerates of Japan and California and show that kaolinization, argillitization and sericitization of feldspars proceeds along with formation of sulphides. It must be stressed that in the Ninge-Toge deposits formation of U-minerals is related to acid rocks, while formation of Au-ferrous sulphide with placer deposits from California is related to basic rocks, overlying the placers. These are separate links in the process, which are distorted and masked in Precambrian rock series by later processes of different duration and diversity. The source of solutions resulting in formation of the new minerals are also diverse. In Japan one has solfataric thermal waters of the final stage of volcanism. In California one has down-flowing ground waters. The clear hypogenic nature of sulphides is probably connected with the displacement of the ore material by solutions. Hypogenic sulphides may be encountered in the recent as well as Paleozoic and Precambrian conglomerates.

The newly formed mineral assemblages show a clear order in all the groups of minerals (newly formed matrix minerals, sulphides, oxide minerals, the radioactive minerals and gold). Order in the deposits reflects the sequence of assemblages from high-temperature minerals, that is well-known from the hydrothermal deposits of vein, stockwork, and other morphological types.

We can distinguish all the stages of metamorphism by the assemblages of newly-formed matrix minerals, starting with granulites, via staurolite, kyanite, garnet+pyroxene, amphibolite, epidote and green-schist facies to finish with the rocks in which clay minerals such as kaolinite, montmorillonite etc. were conserved. A set of minerals is characteristic of each of the assemblages of the newly-formed minerals.
We can find gold in each of the assemblages but its maximum concentrations may be found in connection with quartz-sericite-chlorite-pyrite association (sometimes pyrophyllite, fuchsite and other sulphides).
It must be indicated that Au-U-bearing sulphide conglomerates are positioned in the field of green-schist facies metamorphism.

The appearance of newly-formed minerals are impossible without an influence of solutions. The important problem is to determine the parameters of these solutions.

The newly-formed minerals have a certain temperature of formation and fields of stability, but there is only approximate information about these. The only evidence of real solutions are gas-fluid inclusions (GFI). For this reason we have investigated the temperature of homogenization (tH) and composition of gas-phase of gas-fluid inclusions (GFI) from quartz pebbles of conglomerates of different ages and useful components. In table 1 all investigated conglomerates are arranged in order of decreasing metamorphic stage.

We have used the method of determination of tH worked out by N.P. Ermakov (1) and the thermochamber suggested by L. Sh. Bazarov and Yu. A. Dolgov (2). For determination of chemical composition of individual GFI we used the method and apparatus worked out by N.A. Shugurova (3).

All the GFI may be divided into two groups. The primary GFI are located nonsystematically in quartz of pebbles; the secondary GFI - along the fissures and/or in the newly-formed minerals of the matrix. The results of determinations tH of two classes of GFI are given in fig. 2.

According to tH of primary GFI (fig. 1,A) all conglomerates may be divided into two groups: 1) Precambrian (samples 1-11), range of tH from 70 to 570°C; there are deposits of deep structures in platforms or shields; 2) Paleozoic and Mezozoic conglomerates (samples 12-17) from young folded structures, range of tH from 150 to 400°C.

The tH of secondary GFI may vary from high-temperature gas-saturated pneumatolites (570°C) to low-temperature thermal waters (70°C).

From fig. 2 it is obvious: a) secondary GFI are contained in quartz pebbles from all conglomerates with different contents and ages. Otherwise, the pebble is not a closed system, preserving primary fluids. The latter are altered (metamorphosed) constantly, and GFI are formed in such pebbles along the microscopic cracks, fissures, and fracture cleavages. Sometimes there is complete recrystallization of pebbles, forming pseudomorphous amethyst or quartz by replacement.

There are three-phase GFI (gas+fluid+crystal of NaCl) in the pebbles from the red/colored conglomerates of Khuzir (sample 17). We would remind that Motskaja suite have the vend-age and contents of salt-thickness (sic.). Consequently, the quartz-pebbles are metamorphosed by interstratal brines too. The three-phase GFI homogenized at temperatures of 140-180°C and the NaCl dissolved below 160°C.

We can observe a border of calcite around the quartz-pebbles of conglomerates from Laba. GFI are in this calcite too. The secondary GFI from quartz-pebbles (sample 14) and GFI from calcite (sample 15) homogenize at the same time. Comsequently, the time of forming GFI and the time of matrix metamorphism are synchronous.

b) The classification of conglomerates on the basis to the tH of secondary GFI and by asemblages of newly-formed minerals coincide. The characteristics listed below coincide with each other:
1) the temperature of homogenization of the exsolution structures of chalcopyrite-bornite solid-solution (sample 11);
2) tH of GFI in newly-formed minerals from matrix (sample 14, 15);
3) tH of secondary GFI from quartz-pebbles. Most probably the sulphide ore-formation and metamorphism of conglomerates are caused by an integrated process.

c) Homogenization into the gas-phase takes place only for conglomerates from Karelia (sample 3) subjected to high-temperature metamorphism. One-phase inclusions occur in conglomerates containing fluorite, barite, and carbonates as newly-formed matrix minerals. Possible these minerals are formed from cold-water solutions with temperatures about 50°C.

There are determinations of temperature ore-formation for other minerals from ancient conglomerates: cinnabar from Khakassia (fig. 1) - 70-180°C (4), and ningoite from Ninge-Toge - 70-30°C (5). Consequently, there is a visible evolution of temperatures of hydrothermal solutions in the course of geological time. The wide interval tH for every sample demonstrates also the evolution of temperature for solutions which took part in the forming of a specific ore body in conglomerates. This implies that the ores in conglomerates may be divided into following classes: hypo-, epi-, and meso-thermal deposits, as for vein deposits, localized in the cleavage zones or open cavities.

The composition of the gases were determined in 16 GFI, all > 0.1 mm in diameter, with the results shown in table 2. Having considered the matter we arrived at definite conclusions.

Acid gases (mainly NH_3) predominates in conglomerates from Rand (samples 6,9) and were found in samples from Ural (samples 1, 19) and Karelia (samples 3,5). Analogous results are shown for Jatullian quartzites from Karelia (6). CO_2 and O_2 contents are low in all GFI from all types of conglomerates. The high content of acid gases in GFI (for instance the Rand sample) is a result of the influence of a deficient GFI-volume. On opening the gas-bubbles are absorbed rapidly by the neutral castor oil and this distorted the results. However this fact allows us to propose that the main acid gas is NH_3. This is confirmed by the drop reaction of Nessler. Sulfur bearing gases are not absorbed by castor oil during 20-30 min.

The tH of GFI and their gas-content from vein quartz cutting the ore zone (Ural, samples 19,20) correspond with secondary GFI from the quartz-pebbles (samples 1,2). The GFI characteristic of the quartz from the veins cutting the spread thick layer only (sic.) are similar to those of primary GFI in the pebbles.

Primary and secondary GFI from quartz-pebbles are readily distinguished by their gas contents. The higher temperature hydrothermal solutions (700-400°C) have a greater percentage of acid gases (to 79%), and vice versa; lower temperature may lead not to a decrease in quantity of acid gases but to an increase in the quantity of CO_2. GFI from quartz, tourmaline, fluorite (tH about 200-400°C) have no acid gases. There are anomalously high percentages of H_2 in all GFI, except conglomerates from Rand. Maximum quantities of H_2 are contained in the GFI of quartz of veins and secondary GFI from pebbles.

In such a manner gold and uraniferous ores in Precambrian conglomerates of sulphide type are formed owing to the activity of solutions with temperatures about 220-400°C and containing acid gases, CO_2 and oxygen.

Under a temperature of about 300°C the correction for pressure is small and it may be ignored.

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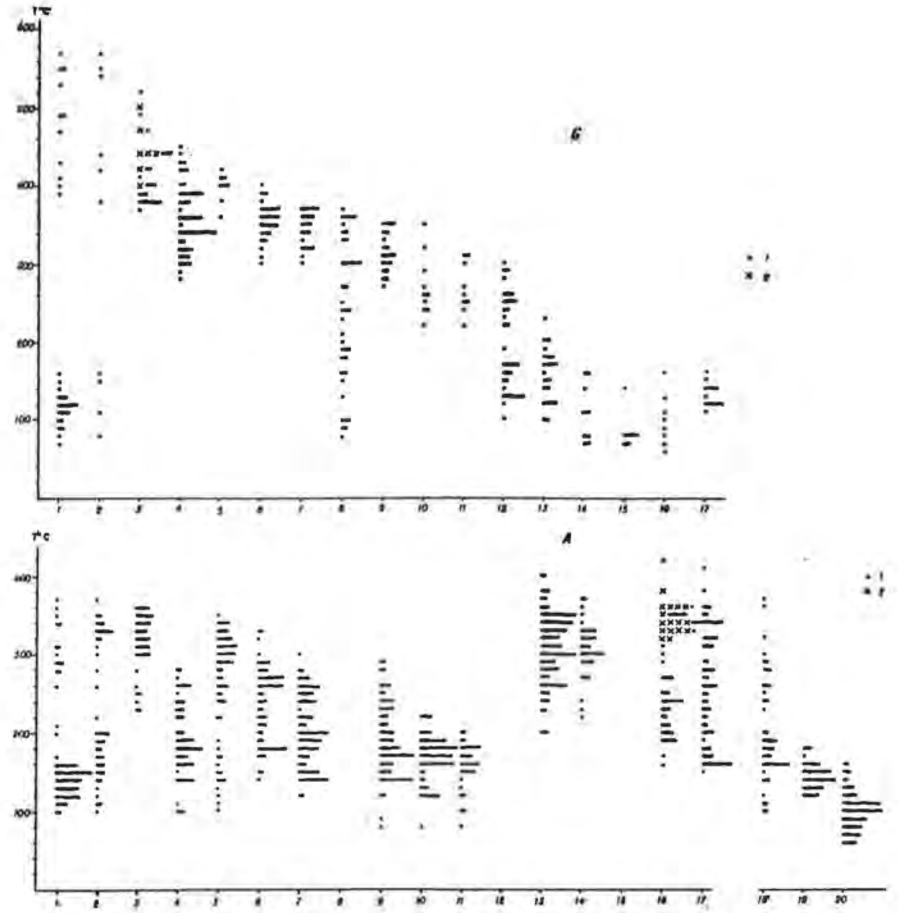
(Translation provided by the authors)

List of figures

Fig. 1 - Principal localities for ore-bearing conglomerates of world. The useful components: 1-Au+U; 2-U; 3-Au; 4-Cu; 5-Pb+Zn; 6-TR; 7-SnO_2; 8-Fe; 9-mica+feldspars; 10-Hg.
Deposits: Africa: 1-Witwatersrand; 2-Orange Free State; 3-Eldorado-Banket; 4-Denny-Delton; 5-Pangolla; 6-Tarkwa Goldfield; 7-Mounana; 8-D'Arlit; 9-Assongo; 10-Sekenke; 11-Zamfara; 12-Bou-Sellam; North America: 1-Blind-River; 2-Houmstack (sic); 3-Leeds; 4-Silver Reef; 5-White Pine(?); 6-Iron-Hill; 7-Lake Padlli; 8-Otish Mountains; 9-Forrest Hill; South America: 1-Serra de Jacobina; 2-Los Adobes, Huemuel; Europe: 1-Koli; 2-Westerwick; Australia: 1-Westmoreland; 2-Mountain Morgan; 3-Bonny Doon; 4-Guolgoong, Asia: 1-Ninge-Toge; 2-Mizunami and other; 3-China; 4-Chikmagaluru; 5-Travankohr; USSR: 1-Antoshkin kljutcn; 2-East slope of Ural; 3-Rjabinka; 4-Kurusay; 5-Terlig-Haja; 6-Laba, Caucasus; 7-Baley; 8-Khara-Su; 9-Omsutchan; 10-Huzir; 11-Timan (sic).

Fig. 2 - Diagram of temperature of homogenization of primary (A) and secondary (B) GFI. Every point - one determination: 1-homogenization into the fluid; 2-into the gas. Number by abscissa - the deposit from table 1.



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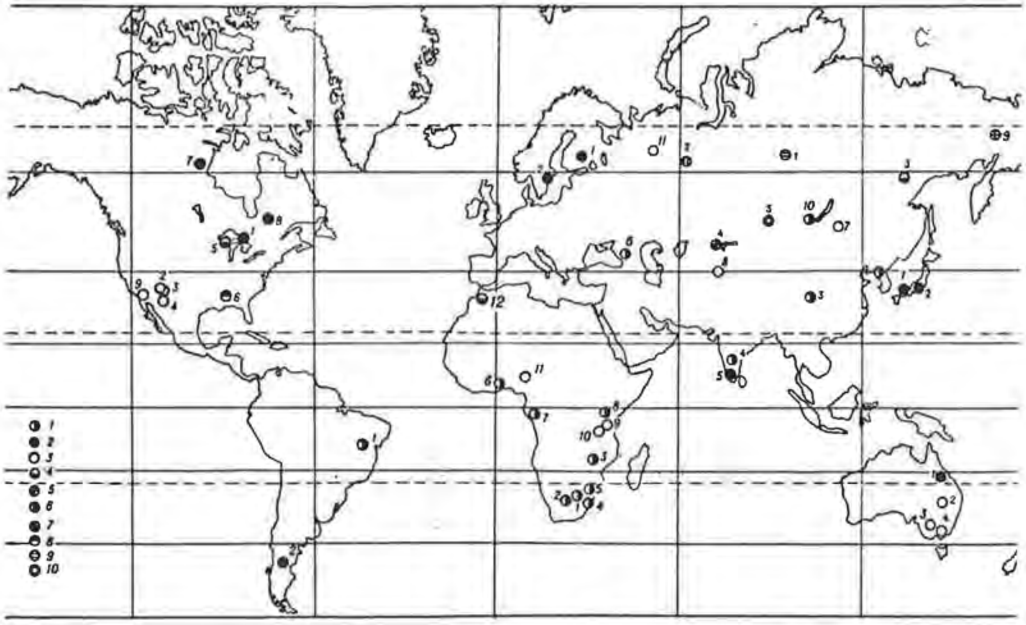

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Brief list of conglomerates (investigated from various regions) Table 1

N	Locality	Age	Useful Compo- nents	Pebbles[1)]	Newly-formed minerals of matrix of conglomerates [1)]
1	Ural, Chobeinskaja suite	Cm_1	TR	q^{+},hl[2)],sh	fe, ga, bi, mu, ser, chl
2	In the same place, gravels	Cm_1	TR	q^{+}	fe, q, bi, ga, mu, ser, chl
3	Karelian, Sarioli	Pt_1	Au?	q^{+}	q, ser, py, ep
4	Enissey ridge, Taseevskaja suite	PCm_3	Mica	q^{+},qu,ap	fe, q, bi, mu, ser, chl
5	Karelian, Jatulli	Pt_3	Au	q^{+}	q, ser, chl
6	Rand, Dominion-reef	PCm_1	U+Au	q^{+},qu	q, ser, chl, pl, mu, py, pr
7	Rand, Mein-reef	PCm_2	U+Au	q^{+}	q, ser, py, chl
8	KMA, Kurskaja suite	K_1	Au?	q^{+}	q, ser, fuc, py
9	Rand, Basal-reef	PCm_3	Au+U	q^{+},qu	q, ser, he, py, chl
10	Enissey Ridge, Lopatinskaja suite	V	Au?	q^{+},sh	q, ser, ca, py, he
11	Aldan, Rjabinka, Omachtinskaja suite	R_3	Cu	q^{+},ja	q, ser, chl, ca, ch, bo
12	Uch-Kulatch, Uzbekistan	Pz	Pb+Zn	ef,tf	ca, ba^{+}, ga, sp
13	Khakassia, Samochvalskaja suite	C_1	CaF_2	q,in,se	flu^{+}, fl, cl
14	Laba, Caucasus	P_1	Au	q^{+},in,se	ca, fl, li
15	Matrix of sample 14	P_1	Au	q,qu,fl	ca^{+}
16	Narin-river, Uzbekistan	Tr	Au	q^{+},qu,fl ja,to	ka
17	Khuzir, Motskaja suite	V	Au	q^{+},qu,ja,sh	cl, li

Quartz from veins (Ural , region of sample N1 and 2)

18 Quartz-microcline vein from granites of base of series q^{+}

19 Large zonal crystal of quartz from sample N18 q^{+}

20 Milk-white quartz from vein-filling which cuts the conglomerate

Note:

1) in order of decreasing (metamorphism).

2) minerals which contain gas-fluid inclusions.

Abbreviations:

ap-aplite; ba-barite; bi-biotite; bo-biotite; ca-carbonate rocks; ch-chalcopyrite; chl-chlorite; cl-clay minerals; ga-galena; gn-garnet; gr-granites; ef-effusive rocks; ep-epidote; fe-feldspars; fl-flint; flu-fluorite; fuc-fuchsite; he-hematite ; ja-jasper; in-intrusive rocks in general; ka-kaolinite; li-limonite; mu-muscovite; pl-pyrophyllite; pr-pyrrhotite; py-pyrite; q-quartz; qu-quartzite; se-sedimentary rocks; sec-sericite; sh-shale; sp-sphalerite; tf-tuff; to-tourmaline

Composition of gases in GFI in quartz-pebbles from ancient conglomerates

Table 2

Sample	tH °C	Diameter mm	Volume percentage				
			H_2S, SO_2, NH_3	CO_2	O_2	CO	Remainder+
1	150	0.00279	18.9	8.4	7.2	0.0	65.5
	150	0.0288	21.9	18.0	6.4	0.0	53.7
		0.0450	18.1	16.7	5.8	0.0	59.4
	120		0.0	17.1	10.2	0.0	72.7
	120	0.0444	0.0	17.1	5.2	0.0	77.7
4	180	0.0264	20.5	11.5	12.3	0.0	55.7
	380	0.0138	0.0	47.3	19.5	0.0	33.2
5	385	0.0384	0.0	17.5	11.7	0.0	70.8
	410	0.0268	0.0	12.0	8.3	0.0	79.7
6	295	0.0156	68.6	18.3	9.5	-	3.6
	200	0.0198	56.1	11.9	5.2	7.3	19.5
9	140	0.0168	57.0	27.5	-	-	15.5
19	160-140	0.0402	32.5	9.0	6.0	20.0	32.5
	160-140	0.0198	19.5	16.0	6.5	19.4	39.6
20	115	0.0384	0.0	13.3	12.0	0.0	74.7
	115	0.0312	0.0	18.8	9.6	0.0	71.6

+ Includes H_2, N_2, C_nH_m and rare gases

MALYSHEV, A.G., 1970, On determining the possibility of rock-crystal in pegmatites and quartz veins with the help of chemical analysis of water leachates from quartz, in Geology and Experimental Studies (subtitle: Geology of deposits of piezoresources and experimental study of processes of mineral formation), Ministry of Geol. USSR, All-Union Research Institute for the Synthesis of Mineral Resources (VNIISIMS) Trudy, v. 12, p. 14-21, "Nedra" Press, Moscow. Translation by A. Lahiry.

During the study of fluid inclusions it was found that the growth of crystals of quartz takes place in a wide range of temperature and pressure in rock crystal-bearing druses from hydrothermal or pneumatolytic solutions. Since the formation of rock crystal is dependent on the composition of the solutions, the course of the crystallization processes which depend upon the concentration of certain elements present in the hydrothermal solutions can be understood.

The qualitative and quantitative composition of the solutions in the fluid inclusions can be approximated by the chemical analysis of water leachates of different minerals. Since varying quantities of solutions are contained in different samples it is necessary to represent the results of the analyses in milligram equivalents so that they can be quantitatively compared. For example 100g of quartz sample rich in fluid inclusions contains more solution than that from 100g of quartz with fluid inclusions that have leaked out or been destroyed. In one 100 g sample, for example, 3 mg Na^+ was found and in another 100g sample 1g Na was obtained, although in both samples the same concentration of Na^+ was present.

For the comparison of the leachates the ion content in the solutions is usually given in relative weight percentage or in percent equivalents of individual anions and cations. Further the results of the chemical analysis for all most common ions, found in major amounts, such as K^+, Na^+, Mg^{2+}, Ca^{2+}, Cl^-, F^-, SO_4^{2-}, HCO_3^-, are presented in % equiv. From the sum of the milligram equivalent which is taken equal to 100% equiv., the % equiv. for every ion can be easily calculated. (Table 1). In the text the mean value of % equiv. from quartz of individual deposits and provinces are given. (Table 2).

The study of the role played by individual elements in the process of formation of crystals revealed that out of the eight ions (K^+, Na^+, Mg^{2+}, Ca^{2+}, Cl^-, F^-, SO_4^{2-}, HCO_3^-) only Na^+ and K^+ take active part in the solubility of quartz (Butuzov and Bryatov, 1957; Khitarov, 1952); according to I.G. Ganeev (1963), silicic acid is maintained in the solution by the Cl^- and F^- ions. In the pegmatites, quartz crystals of good quality are formed mainly from NaCl solutions (Ermakov, 1960; Zakharchenko, 1960). An increase in the CaO concentration in the solutions strongly reduces the concentration of silicic acid (Babuskin, Matveev and Mchedlov-Petrosyan, 1965); the presence of Ca and also Mg and some other elements reduces the ability of the hydrothermal solutions to form crystals.

Two coefficients, K_1 and K_2, result from the above facts as characteristics of the crystallization of the quartz veins. Coefficient K_1 is the ratio between the sum of the % equiv. of the Mg^{2+} and Ca^{2+} ions and the sum of the % equiv. of the anions:

$$K_1 = \frac{\%\ \text{Equiv. } Mg^{2+} + \%\ \text{Equiv. } Ca^{2+}}{\%\ \text{Equiv. } Cl^- + \%\ \text{Equiv. } F^- + \%\text{Equiv } SO_4^{2-} + \%\ \text{Equiv. } HCO_3^-}$$

This coefficient characterizes the qualitative mutual relation of Mg and Ca with the anions and the effects on the formation of rock crystals. It expresses the ability of the hydrothermal solution to form rock crystals. The best possibility for the formation of quartz crystals under natural conditions is given at lower values of K_1, since in this case K+ and Na+ are easily removed by the adjoining rocks and the silicic acid remains in the solution.

Coefficient K_2 is the sum of the % equiv. of alkali metal ions and the anions Cl^- and F^-; $K_2 = \%\ \text{Equiv. } K^+ + \%\ \text{Equiv. } Na^+ + \%\ \text{Equiv. } Cl^- + \%\ \text{Equiv. } F^-$. The values of these factors show the relative contents of the introduced ions in the solution during the formation of crystal (solution and re-precipitation of silicic acid). The coefficient K_2 is therefore an indispensable factor for the formation of rock crystals.

It should be noted that with the calculated coefficients, only the relative condition of the hydrothermal solutions for the formation of the crystals and the possible duration of these processes can be determined, because the geological-structural conditions, the magnitude of the hydrothermal activity and the thermodynamic conditions during the formation of the pegmatites and quartz veins are not considered.

Before we compare the coefficients of the different deposits, the values of the coefficients K_1 and K_2 of the druse pegmatite of west Tarbogat will be compared.

In the diagrammatic representation (fig. 1) the drop in coefficient K_2 during the crystallization of the pegmatite genetically connected with the granitoid of the main phase is shown against the crystallization of the pegmatites related to the later leucocratic granites. Extensive geological work confirms the conclusion derived from the K_1 and K_2 coefficients. A sharp change in the value of K_1 occurs between the rich and the lean rock crystal-bearing pegmatites which are connected genetically with the leucocratic granites and not with porphyrites. The pegmatite rich in rock crystals represents the immediate continuation of a granite apophysis. The pegmatite poor in rock crystals is completely in porphyrite and cuts across a thin vein-like granite body. This underlines the fact that by the K_1 and K_2 coefficients the effects of the adjoinging rocks on the nature of the hydrothermal solutions during the formation of crystals can also be recognized.

The lower values of K_1 for vein quartz and for quartz crystals are typical of the pegmatites of west Tarbogat, Kent, Maidantal and quartz veins of Ural. (See Table 2, fig. 2). The values for K_1 on the points A1 and a1 were calculated from the analyses of water leachates of quartz from crystal-bearing pegmatites. Still better results are obtained from the same analysis (point A_2 and a_2) for K_2.

The values of the coefficients for core quartz and for quartz crystals show that the solutions were identical during the growth of the quartz crystals in druses and during the formation of core quartz.

A distinct difference exists between the values of the coefficients for rock crystals (point B_1 and b_1, fig. 2) which is less distinct in the crystal-bearing and massive quartz veins of the Ural. Significant variations in the values for K_1 and K_2 were observed in the vein quartz and quartz crystals. Apparently the character of the hydrothermal solutions changes, after the formation of rock crystal-bearing veins, as a result of intake of Ca and Mg from the neighboring country rocks.

Characteristic for the quartz veins of west Kazakstan are multiple stages of formation, recrystallization of earlier quartz and formation of crystal-bearing druses in the last phase. This is confirmed by the coefficients K_1 and K_2. For example the late quartz, in comparison with earlier quartz, is marked by considerably lower values for K1 and higher values for K_2. Consequently such changes in the values of the coefficients can be evidences for overlapping or addition of new hydrothermal solution.

In fig. 2 the coefficients K_1 and K_2 for quartz of a few polymetallic deposits of north Caucasus are represented. According to the values obtained for the coefficients (for quartz crystals: $K_1 = 0.94$; $K_2 = 19$; for vein quartz: $K_1 = 1.25$; $K_2 = 34$), it was determined that the capacity (or ability) of the hydrothermal solutions to form rock crystals is very little or weak.

The coefficients for quartz crystals from Volyn pegmatites are similar: $K_1 = 0.66$ and 0.86 and $K_2 = 23$ and 41 (See Table 2 and fig. 2). Most probably the analyzed sample consisted essentially of secondary fluid inclusions. According to the description of the inclusions (Prikazchikov, 1966) the inclusions were of large dimension (up to 20 mm long) and were on healed fractures. The coefficients K_1 and K_2 for the late quartz crystals from the pegmatites of Kent, Maidantal, Bektau-Ata and west Tarbogat are equal to 1.23 and 42. This confirms the fact that the solutions in the inclusions of quartz crystals from Volyn are similar in composition to those present during the end phase of growth of crystals of quartz.

The suggested method makes possible, after the conversion of analyses and calculation of K_1 and K_2, the estimation of the potential capacity (ability) of the hydrothermal solutions to form rock crystals during the formation of quartz veins and pegmatites. For a full elucidation of the formation of rock crystals in particular pegmatites or quartz bodies or groups it is necessary to take into account all the effects and factors involved in the formation of rock crystals.

The data obtained permit the following conclusions: the formation of rock crystals in quartz veins and pegmatites takes place (under suitable available conditions) when the mineral-forming solutions are characterized by low values of K_1 and high values of K_2. The chemical analyses of the water leachates of quartz crystals show that for most of the deposits K_1 is not much larger than 0.7 and K_2, as a rule, is more than 50. From this it follows that with the help of the coefficients, the origin of hydrothermal solutions (rest solutions or new additions) and their effect on the adjoining rocks can be determined.

The coefficients K_1 and K_2 were calculated from the mean values of the chemical analyses of water leachates of quartz from individual deposits. This increases the reliability. As rightly remarked by D.N. Khitarov (1965) the accuracy of the methods of chemical analyses must be improved for reliable comparison of the chemical analyses of water leachates. Of particular importance is that the solutions from primary and secondary inclusions should be separately studied (Khodakovsky, 1965).

The chemical analyses permit an objective characterization of natural mineral-forming solutions in the various stages and conditions of formation of rock crystal-bearing bodies.

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Table 1 (p.15)

Calculation of micro-chemical analysis of samples from quartz veins of Ural

Content	K^{1+}	Na^{1+}	Mg^{2+}	Ca^{2+}	Cl^{1-}	F^{1-}	SO_4^{2-}	HCO_3^{1-}	Sum
mg/100g	1.53	11.29	-	2.04	21.3	0.72	0.18	-	
mg. equiv.x1000	39.1	491	-	102	602	37.9	2.8	-	127
% equiv.	3.1	38.5	-	8.0	47.2	3.0	0.2	-	100

Table 2 (p. 16-17)

Mean values of percent equivalent of chemical analysis of solutions from macro-inclusions and water leachates and the values of coefficients K_1 and K_2.

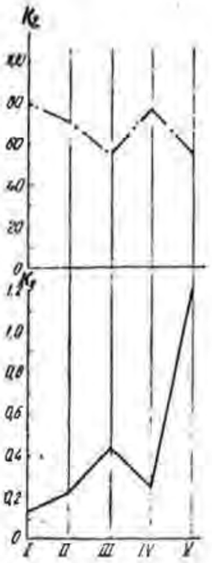
Location of samples	Samples	% Equiv of ions									Coefficients	
		K^{1-}	Na^{1+}	Mg^{2+}	Ca^{2+}	Cl^{1-}	F^{1-}	SO_4^{2-}	HCO_3^{1-}	Sum	K_1	K_2
Pegmatites of Ukraine	Crystals of quartz (macro-inclusion)	0.4	27.2	2.9	25.8	13.9	-	10.8	19.0	100	0.66	41
Pegmatites of Ukraine	Crystals of quartz	0.2	7.6	5.5	36.8	15.4	0.1	14.7	19.7	100	0.86	23
	Core quartz	2.4	33.8	3.7	12.6	22.1	2.1	10.2	13.1	100	0.34	60
Pegmatites of granite massive of Kent	Crystals of quartz	6.0	29.0	1.6	14.6	38.7	0.1	3.4	6.6	100	0.33	74
	Core quartz	8.7	32.1	0.4	11.4	41.0	0.4	3.7	2.3	100	0.25	82
Pegmatites of western Tarbagat	Quartz crystal from crystal-bearing peg.	2.0	36.9	-	9.0	39.9	0.1	4.4	7.7	100	0.17	79
	Core quartz from crystal bearing pegmatites	0.6	38.9	0.3	9.7	39.6	-	3.6	7.3	100	0.2	79
	Crystals of quartz from all groups of pegmatites	0.7	36.8	0.5	17.6	27.0	1.6	7.5	8.3	100	0.41	66
	Core quartz	0.2	29.1	0.7	22.2	23.5	0.9	11.2	12.2	100	0.48	54
Peg. of Maidantal	Crystals of quartz	0.8	33.4	0.1	14.2	38.7	2.0	2.0	7.9	100	0.28	76
	Core quartz	-	42.4	-	10.0	41.9	-	1.6	4.1	100	0.3	84
Quartz-feldspar veins of Maidantal	Crystals of quartz	-	25.1	-	29.3	22.0	13.0	1.8	8.8	100	0.64	60
	Vein quartz	-	29.7	-	26.3	23.7	-	3.8	16.5	100	0.6	53
Peg. of massif Kenkol	Crystals of quartz	1.9	17.2	0.2	29.5	40.6	-	2.4	8.2	100	0.58	60
	Core quartz	1.0	19.7	0.4	29.0	45.8	-	1.2	2.9	100	0.59	66
Peg. of Kaib	Crystals of quartz	1.8	22.4	0.3	28.1	29.7	0.1	9.3	8.3	100	0.6	54
	Core quartz	1.0	26.7	2.2	19.2	28.0	7.3	7.1	8.5	100	0.42	62
Peg. of Katbar	Crystals of quartz	-	12.5	14.8	16.2	-	17.0	21.0	18.5	100	0.55	30
Peg. from massif of Bektau-Ata	Crystals of quartz	0.2	2.4	-	52.2	18.9	3.2	23.1	-	100	1.16	25
	Core quartz	-	-	-	73.7	19.8	2.0	4.5	-	100	2.8	22
Quartz veins of Ural I	Crystals of quartz from vein	4.4	25.0	4.1	22.5	27.2	0.7	7.3	8.8	100	0.6	57

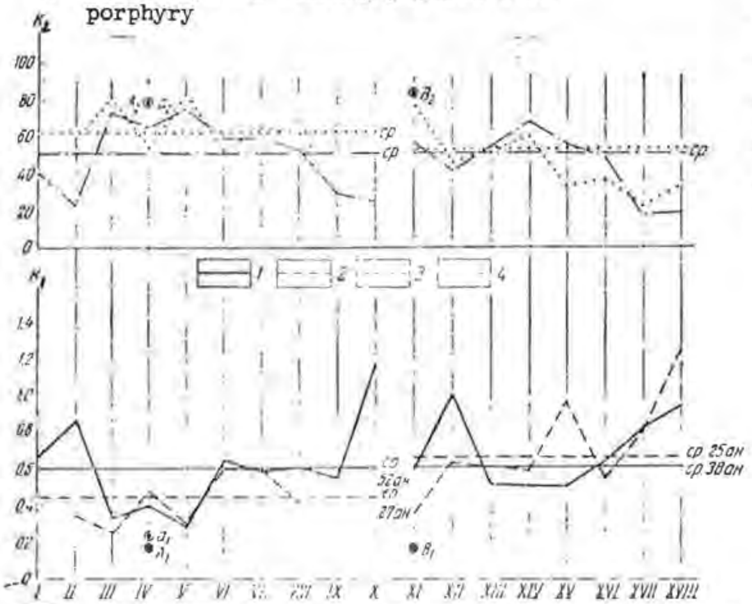
	Crystals of quartz from crystal-bearing vein	3.7	40.8	0.1	7.3	37.8	2.1	1.4	6.8	100	0.16	84
	Qz from vein in plagiogranite	1.8	39.8	0.4	14.7	34.4	0.7	2.8	5.4	100	0.35	77
Qz veins of Ural I	Crystals of quartz	4.7	19.2	11.5	26.7	18.2	-	11.5	8.2	100	1.01	42
	Vein qz. from less-crystal bearing and noncrystal bearing veins	2.2	19.9	2.8	27.6	22.7	2.3	5.0	17.5	100	0.64	47
Oz veins of Ural II	Crystals of quartz	0.5	22.7	-	26.4	30.8	-	-	19.6	100	0.52	54
Qz veins of eastern Siberia	Crystals of quartz	0.7	24.3	-	25.4	41.9	1.5	1.0	5.2	100	0.51	68
	Vein quartz	2.3	21.7	-	28.2	33.7	3.0	2.7	8.4	100	0.59	61
Qz veins of western Kazakstan	Crystals of quartz	2.0	21.8	6.6	18.9	33.3	-	0.5	16.9	100	0.51	57
	Vein quartz	1.0	19.5	5.4	33.7	13.7	-	9.0	17.7	100	0.96	34
Qz veins of Verkhnye-Buryeinsk rayon	Crystals of quartz	7.2	24.1	19.5	7.2	18.0	-	7.1	16.9	100	0.64	49
	Vein quartz	9.0	11.5	21.1	7.2	16.5	-	10.4	24.3	100	0.55	37
Qz veins of Verkhoyan	Crystals of quartz	-	10.8	6.7	33.5	6.8	-	-	42.2	100	0.82	18
	Vein quartz	-	13.7	-	38.6	9.0	-	7.4	31.3	100	0.81	23
Polymetallic ore deposit of NW Causasus	Crystals of quartz	-	4.4	10.9	35.3	3.8	-	8.1	37.5	100	0.94	19
	Vein quartz	-	23.2	14.0	28.7	10.7	-	5.5	17.9	100	1.25	34
Peg. and qz. veins of above mentioned deposits	Crystals of quartz from pegmatites	1.3	23.6	1.7	26.3	25.0	1.5	9.6	11.0	100	0.6	51
	Crystals of quartz from quartz veins	2.8	21.8	5.9	23.5	26.5	0.3	4.6	14.6	100	0.64	51
	Crystals of quartz from peg. and quartz veins	1.9	22.8	3.5	25.2	25.7	1.0	7.4	12.5	100	0.62	51
	Core qz from peg.	2.5	29.4	1.3	19.4	29.1	1.8	7.6	8.9	100	0.44	63
	Vein qz from quartz vein	2.2	24.2	3.5	25.5	25.1	1.1	5.6	12.8	100	0.65	53
	Core qz. and vein qz. from pegmatite and qz vein	2.4	26.8	2.5	22.3	27.2	1.5	6.5	10.8	100	0.54	58

Note: Chemical analyses taken from the works of U.N. Anufriyev., V.C. Aplonov, L. Sh. Bazarov, V.C. Balitskov, V.I. Berger, C.N. Venedictov, M.G. Guryevich, A.I. Zakharchenko, Y.D. Inshin, V.A. Kalyuzny, A.E. Lisitsin, V.N. Lyubofyev, A.A. Moskalyuk, I.M. Ovchinnikov, V.C. Polykovsky, L.A. Prikazchikov, L.C. Puzanov, V.A. Smirinov, Ya.N. Sokolov, V.N. Trufanov.

Fig. 1 (p. 18) Values of coefficients K_1 and K_2 for quartz crystals of pegmatites of western Tarbagat.

I. - rich-crystal bearing pegmatites in leucocratic granites.
II. - poor-crystal bearing pegmatites in leucocratic granites.
III. crystal bearing pegmatites in grandiorites
IV. -rich-crystal bearing pegmatite in porphyry
V. - poor-crystal bearing pegmatite in porphyry





1 - K_1 for crystals of quartz; 2 - K_2 for vein quartz and core quartz;
3 - K_2 for crystals of quartz; 4-K_1 for vein quartz and core quartz.
Cp. = content; aH = anorthite (?)

Fig 2. Values of coefficients K_1 and K_2 for quartz from different deposits of rock crystal.

Pegmatites: I. Ukraine (analyses of solutions from macro-inclusions).
II. Ukraine (analyses of water leachates),
III. Kent massive (Central Kazakstan),
IV. Western Tarbagat (eastern Kazakstan),
V. Maidantal (Kirgiz),
VI. Quartz-feldspar veins of Maidantal,
Pegmatites: VII. Kenkol massif
VIII. Kaiba (central Kazakstan),
IX Katbar massive (Central Kazakstan)
X Bektau-Ata massif (Central Kazakstan)
Quartz veins: XI. in Plagiogranites (Ural)
XII in gneisses, sandstones, different schists (Ural)
XIII. of Ural
XIV. of Aldana,
XV from western Kazakstan
XVI from Rayon of Verkhnye-Burensky
XVII. of Verkhoyan
XVIII. Quartz from polymetallic deposits of northwestern Caucasus.

POKROVSKIY, P.V. and PURTOV, V.K., The main regularities in the formation of quartz veins of crystal-bearing and tungsten deposits of the Urals (Authors at A.N. Zavaritsky Institute of Geology and Geochemistry of the Urals Scientific Centre of the Academy of Sciences of the USSR) (Paper for presentation at 1972 Montreal COFFI Symposia, received too late for inclusion in symposia programs in previous issue of COFFI; Ed.).

Spatially discrete groups of crystal-bearing and tungsten deposits under review are situated within the Eastern Urals uplift in the region of metamorphic volcanic-sedimentary Paleozoic rocks and granitoids of the Djabik-Karagai and Shilovo-Konyovo massives.

The area of crystal-bearing deposits includes non-crystal-bearing and crystal-bearing quartz veins. These are monomineralic deposits consisting of quartz mainly. There are distinguished two stages of quartz vein formation in the vicinity of the deposits (Anufriyev, 1962, 1969, etc.). In the beginning the formation of quartz veins proper took place accompanied by silicification of the enclosing rocks. The appearance of crystal manifested itself at the late stages in residual cavities and newly formed fissures and was followed by the enrichment of solutions in alkalies and silica extraction from the enclosing rocks (Neikur, 1971).

Tungsten deposits of the Boyevka-Biktimirovskoye group include the early non-tungsten-bearing veins of the P'yankovo and South Konyovo deposits, the supposedly early tungsten-bearing veins with feldspar of the Karasi deposit and quartz veins of the Boyevka, South Konyovo, Porokhovskoye and Biktimirovskoye deposits. Tungsten-bearing veins of the Karasi deposit differ from those of the others belonging to this group by the absence of scheelite, fluorite and carbonate typical of the other deposits.

Circumvein alteration of enclosing rocks is evident in the formation of metasomatic rims and muscovite fringes in vein gouge. Metasomatic processes preceded or outstripped quartz vein formation and were accompanied by silica extraction from the enclosing rocks and their enrichment in potassium and aluminum.

The method of gas-liquid inclusions was used for revealing the conditions of quartz vein formation. Abundance ratios of H_2O and CO_2, CO_2(CO_2; mole % CO_2) concentrations and the total density of solutions of inclusions (D) were determined by way of calculation on the basis of tabulated H_2O and CO_2 densities of the known volumes of aqueous (Vaq) and carbon dioxide (VCO_2) phases of inclusions (Dolgov, Bazarov, and Bakumenko, 1968). Concentrations of salts in solutions were estimated according to freezing temperatures of the aqueous phase of inclusions. Crystallization temperatures of quartz were determined from homogenization temperatures of solutions. Several methods were used to estimate pressure as a function of phase volumes: from the P-T-X diagram of the H_2O - CO_2 system and from the P-T-Y one for CO_2. The resulting temperature and pressure values were checked on the basis of equilibrium CO_2 concentrations calculated in liquid and gaseous phases of the H_2O - CO_2 system (Purtov, 1970).

Conditions of quartz vein formation of crystal-bearing deposits of the Middle Urals.

The study involved inclusions in vein quartz and quartz crystals from the Akmullinskiy, Zapadniy and Astaf'yevka deposits. Quartz of veins occurring within the Akmullinskiy and Zapadniy deposits is characterized by the presence of inclusions which are three-phase at room temperatures or when cooling: aqueous solutions + liquid CO_2 + gaseous CO_2. Inclusions in quartz of the Astaf'yevka deposit contain additional solid phases. "Aqueous" and "carbon dioxide" inclusions corresponding to different phases of the primary heterogenous hydrothermal solution are singled out depending on Vaq and V_{CO_2} ratios and the type of complete homogenization.

The Akmullinskiy deposit. Here occur inclusions with phase volumes reaching 30-40 ("aqueous") - 70-80% ("carbon dioxide"). "Carbon dioxide" inclusions and inclusions containing both phases of the heterogenous hydrothermal solution at the moment of trapping are the most abundant. Partial homogenization takes place within the liquid (20-31°) and gaseous (31-27°) phases. Vein quartz inclusions have the lowest temperatures of partial homogenization (Th_{CO_2}) in the liquid phase. The lowest Th_{CO_2} values in the gaseous phase are registered in the apices of quartz crystals. Complete homogenization of "aqueous" inclusions proceeds at 300-310°, while that of the "carbon dioxide" ones - at temperatures 2-7° higher. Homogenization temperature variations are explained largely by the slight compositional difference between inclusions and pure phases of heterogenous solutions due to the intake of a small quantity of another phase by the inclusion.

The determination of parameters of the hydrothermal solutions was made with the help of large (0.1-0.4mm) primary inclusions of tubular form (Table I). In connection with the low salt concentration (about 2 weight per cent) calculations were carried out to fit the requirements of the bicomponent H_2O - CO_2 system. Temperature and pressure values estimated in a number of ways are quite similar. The results obtained show a considerable decrease in pressure, CO_2 concentration in aqueous solutions and their density during quartz crystallization.

Phase relations and complete homogenization temperatures of primary inclusions and inclusions of healed fissures are in perfect analogy. There is a small difference in Th_{CO_2} (1-2°) only. The similarity of properties typical of inclusions suggests that the formation of fissures and their healing proceeded in the course of crystallization or just after its termination.

The Zapadniy deposit. Primary inclusions are revealed here in the outer zone of two quartz crystals. "Aqueous": V_{CO_2} - 33-37%, Th_{CO_2} in the gaseous phase 30.5°, Th - 260-263°; "carbon dioxide": V_{CO_2} - 76-80%, Th_{CO_2} in the liquid phase 16.0°, Th - 260-275°. Concentration of salts in solutions does not exceed 3 weight per cent (Table 1).

Considerable disparity between pressures measured by different methods can be explained by errors brought about when determining abundance ratios of H_2O and CO_2 due to small dimensions of "carbon dioxide" inclusions (±50-100 bars), which result from peculiarities of the P-T-X diagram of the H_2O - CO_2 system within this pressure range.

Most inclusions are confined to healed fissures. There are distinguished two groups of healed fissures: the most numerous early fissures containing "aqueous" and "carbon dioxide" inclusions with Th amounting to 240-280° and much rarer late fissures with inclusions of aqueous solutions only, free of CO_2, whose complete homogenization takes place at 160-240°.

The Astaf'yevskiy deposit. A regular change in temperatures of partial homogenization is established in "aqueous" (V_{CO_2} -20-30%) and "carbon dioxide" (V_{CO_2} - 85-95%) inclusions when approaching crystal-bearing nests together with the compositional change of prisoner-minerals in "aqueous" solutions. In connection with the intensive splitting of inclusions during heating there is recognized only the most possible Th range of inclusions equal to 260-320° (Table 2).

The results of investigations indicate the decrease in pressure, CO_2 concentration, density of solutions and the increase in salt content (C) of solutions during the formation of quartz veins of the deposit. A similar character of the change in salt composition of solutions is revealed according to the data obtained when analyzing solutions of inclusions by the water-extract method (Anufriyev, 1966). Numerous healed fissures contain multi-phase aqueous inclusions with low (less than 20°) temperatures of partial homogenization into the aqueous phase. The volume of solid phases reaches here 20% (halite-15% and sylvite - 3-5%).

The study of inclusions in quartz of three crystal-bearing deposits permits drawing the following conclusions:

Table 1. Peculiarities of inclusions in quartz of crystal-bearing deposits.

"Aqueous" inclusions					Carbon dioxide inclusions					Inclusions of both types	
Th_{CO_2}, °C	Th, °C	N_{CO_2} mole %	D, g/cm^3	P, bar	Th_{CO_2}, °C	Th, °C	N_{CO_2} mole %	D, g/cm^3	P bar	T, °C	P, bar
THE AKMULLINSKIY DEPOSIT											
Vein quartz.											
24.0L	300	16	0.92	540	23.0L	300	38	0.84	590		
The lower zone of crystals.											
29.5L	300	14	0.87	515	30.0L	305	38	0.72	490		
29.8L	302	14	0.87	505	30.5L	310	37	0.71	480		
The middle zone of crystals.											
30.0L	305	14	0.87	490	30.8L	310	39	0.68	470	293-302	485-530
30.8L	305	13	0.85	480	30.7L	305	39	0.68	465		
31.0L	305	12	0.84	470	30.8L	307	40	0.68	475		
30.5L	307	13	0.86	475	30.7L	307	40	0.68	475		
30.0L	305	14	0.87	490							
30.0G	302	10	0.77	435	31.1L	302	43	0.60	430	295-302	430-470
30.1G	302	10	0.75	450	31.2L	302	42	0.60	420		
30.0G	302	11	0.74	456	31.2L	302	44	0.60	433		
					31.2L	302	42	0.60	425		
The upper zone of crystals.											
27.0G	310	8	0.74	380	31.0G	315	39	0.56	380	307-312	380-400
27.0G	310	9	0.74	385	31.0G	315	40	0.56	385		
27.0G	310	9	0.72	390	31.0G	315	40	0.56	385		
27.0G	310	9	0.72	395	31.1G	315	40	0.56	395		
27.0G	310	9	0.71	400							
THE "ZAPADNIY" DEPOSIT											
The outer zones of crystals.											
30.5G	260	9	0.80	625	16.0L	262	59	0.86	840	247-272	500-875
30.5G	263	9	0.80	675	16.0L	260	59	0.86	825		
30.5G	260	10	0.77	700	16.0L	262	56	0.86	790		
					21.0L	275	54	0.82	715		
					21.0L	270	51	0.83	700		

Note: G - homogenization in the gaseous phase
L - homogenization in the liquid phase

Table 2. Properties of inclusions of the Astaf'yevsk crystal-bearing deposit.

"Aqueous" inclusions								Carbon dioxide inclusions	
Th_{CO_2}, °C	Properties of solid phases			Th, °C	C (by NaCl), weight %	N_{CO_2}, mole %	D, g/cm^3	Th_{CO_2}, °C	P, bars
	number	Prisoner minerals	Vol., %						
Massive vein quartz									
20-26	-	Absent	-	-	-	-	-	-	-
Circumnest vein quartz and the inner zones of crystals									
28-29L	0-2	Sylvite Halite	0-5 0-1	260-320	30	7	1.12	7-12	1550-1115
The outer zones of crystals									
28-29G	2	Halite Sylvite	10-12 3-5	260-320	40	3	1.09	18-24	1170-800

1. The formation of crystal-bearing quartz veins proceeds from hydrothermal heterogenous solutions with high density (more than 0.7 g/cm^3) containing different salt concentrations(from 2 to 40 weight per cent) and considerable amounts of dissolved CO_2 (up to 16 mole %).

2. At each deposit the formation of vein quartz around the vug, and quartz crystals, took place at small temperature variations (10-60°) and

more significant pressure fluctuations (up to 175-750 bars). Considering the duration of processes, it is possible to speak about crystallization under practically isothermic conditions during a gradual pressure decrease.

3. The decrease in pressure was accompanied by a drop in CO_2 solubility in aqueous solutions and in their density, while at the Astaf'yevskiy deposit - by the additional increase of the degree of mineralization of the solutions.

Conditions of quartz vein formation of tungsten deposits of the Middle Urals.

Vein quartz of tungsten deposits contains three-phase inclusions with CO_2. Inclusions of heterogenous solutions - both "aqueous" and "carbon dioxide" - are known in the columnar vein quartz and cloudy quartz crystals of the Biktimirovskoye deposit. "Aqueous" inclusions resulting from homogenous solutions are present in massive vein quartz of other deposits. Inclusions are located within healed fissures and interfissure sections. The rows of early and late quartz veins recognized according to the geological data are distinguished by the peculiarities of gas-liquid incluions (Table 3; fig. 1). The early non-tungsten-bearing veins of the P'yankovo, South Konyovo deposits and the tungsten-bearing ones of the Karasi deposit contain inclusions with higher V_{CO_2} and Th values as compared to those of other deposits. There are also established some differences in Th_{CO_2} pointing to the lower CO_2 density in inclusions of the early veins against the later ones.

CO_2 concentrations in inclusions of quartz of the early and late veins are almost the same, their average values for the deposits being 8 - 12 mole % (fig. 1). Densities of solutions in inclusions amount to 0.6-0.9 g/cm^3 in early veins and 0.8-1.0 g/cm^3 in the late ones. The difference in densities indicates a possible density increase in hydrothermal solutions in the course of quartz vein formation. Density changes of solutions can result from pressure increase. Reasoning from experimental data on CO_2 solubility in H_2O (Takenouchi and Kennedy, 1964), the moment of homogenization is accompanied within the established temperature range in inclusions by the development of pressure amounting to 300-480 bars in quartz of the early veins and 420-1500 bars in that of the late ones.

Table 3. Properties of inclusions in quartz of tungsten deposits.

Deposit	Sample number	V_{CO_2}, %	Th_{CO_2}, °C		Th, °C
			liquid phase	gaseous phase	
		Tungsten-bearing veins			
Boyovka	4	15-25	2-28	-	200 - 260
	2	20-30	25-31	-	240 - 260
	1	25-30	30-31	31-28	250 - 270
Karasi	1	30-40	30-31	31-20	320 - 360
	2	30-50	—	31-20	320 - 360
South Konyovo	1	15-25	20-28	-	200 - 240
	2	20-30	30-31	31-28	240 - 280
Porokhovskoye	2	15-20	16-30	-	200 - 240
	2	15-20	20-31	31-25	200 - 250
Biktimirovskoye	1	20-30	24-31	31-30	220 - 260
		60-70	20-30	-	260 - 280
		Non-tungsten-bearing veins			
P'yankovo	1	30-40	28-31	31-25	220 - 260
	1	30-40	-	31-20	285 - 315
	3	30-50	-	31-20	310 - 360
South Konyovo	2	30-40	30-31	31-20	320 - 340
	1	40-50	-	31-20	330 - 350

It should be particularly emphasized that the position of the Karasi deposit among the other deposits of the Boyovka-Biktimirovskoye group is quite exceptional. There can be singled out two stages in the formation of mineralization for all deposits - hübnerite crystallization and further progress of its scheelitization accompanied by crystallization of fluorite and carbonate. In veins of the Karasi deposit this second stage is not displayed. The most intensive tectonic study of the Karasi ore field suggests that its specific features are governed not by the formation that takes place earlier, but by the formation proceeding at quite another level and further vertical displacement within the structure of the ore zone.

Some peculiarities of quartz crystallization from carbon dioxide - aqueous hydrothermal solutions.

Peculiarities of quartz crystallization in veins of crystal-bearing and tungsten-bearing deposits are determined not only be temperature and pressure changes, but also by the related changes in CO_2 regime, salt composition and pH of hydrothermal solutions.

The decrease in dissolved CO_2 concentration due to its transition to the gaseous phase causes an increase of silica solubility (Morey, 1957). Calculations show that at 300° the decrease in pressure from 500 to 400 bars (SiO_2 solubility decrease by 22-27%) is compensated completely by the opposite influence of the decrease in dissolved CO_2 content from 13 to 8 mole % (the increase in SiO_2 solubility by 27%).

The decrease in dissolved CO_2 concentration causes the increase in the solubility of salts (Smith, 1968) intensifying the ability of hydrothermal solutions to extract the components of the enclosing rocks. It is precisely this fact that explains the rise in the content of chlorides of alkaline metals in solution with the decrease in dissolved CO_2 concentration and pressure traced in inclusions in quartz at the Astaf'yevsk deposit.

The reduction of pressure and dissolved CO_2 concentration causes the decrease in the degree of carbonic acid dissociation, the increase in the degree of HCO_3^- ion hydrolysis and the decrease in the ratio of dissolved CO_2 concentration to HCO_3^- ion activity causing the pH shift to higher values (Ryzhenko, 1965). The additional pH rise is related to the increase of alkaline metal cations in solution.

The whole complex of indicated factors decreases the degree of supersaturation of solutions with silica and promotes the extraction of SiO_2 from the enclosing rocks, the vein quartz recrystallization, and the formation of crystal-bearing cavities. In this case CO_2 separation-dissolution compensates possible pressure fluctuations and provides for a stability of both the degree of supersaturation of solutions with silica and the rate of quartz crystallization.

The drop in temperature or the rise in pressure at constant CO_2 concentration established for processes of quartz crystallization of tungsten deposits had to cause the increase in the degree of carbonic acid dissociation, the decrease in hydrolysis of its ions and, therefore, the alkalinity decrease (acidity increase) of hydrothermal solutions. The primary alkaline nature of the solutions is confirmed by the gain-loss balance of components during near-fissure metasomatism accompanying tungsten-bearing vein formation (Pokrovskiy and Grabezhev, 1971).

The order of pH changes in solutions adequately explains the extraction of silica from enclosing rocks near tungsten-bearing quartz veins at the early stage of their formation, while in the proximity of crystal-bearing ones at the closing stages of the process, during the formation of crystal-bearing nests.

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(Translation provided by the authors)

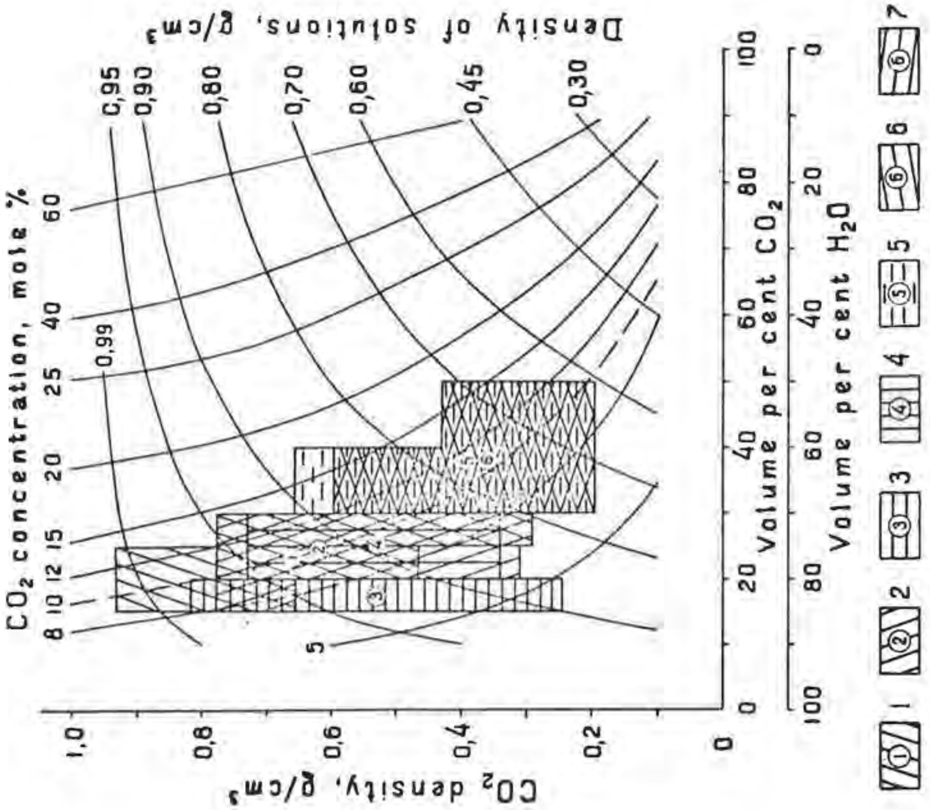

Fig. 1: Variations of volume relations of phases, CO_2 densities and concentrations and total densities of solutions of inclusions in quartz of the late tungsten-bearing veins of the Boyovka (1), South Konyovo (2), Porokhovskoy (3), Biktimirovskoy (4) deposits and the early veins of the P'yankovo (5), Karasi (6) and South Konyovo (7) deposits of the Boyovka-Biktimirovskoye group.

The position of average values for separate deposits is shown by circles. (Average values calculated for the early veins of the Karasi and South Konyovo deposits coincide) - 6).

SLIVKO, M. M., 1969, Liquid CO_2 - aqueous inclusions in tourmalines from pegmatites of the Mama region: L'vov. Gos. Univ. Mineralog. Sbornik v. 23, p. 295-301 (in Russian). (Author at L'vov. Gos. Univ., L'vov, USSR.)

"Primary carbon dioxide-aqueous inclusions in growth defects along L_3 and in the pyramid (10$\bar{1}$1) have been established in schorl crystals. The temperatures of homogenization (from beginning of growth) of the primary inclusions are the following: 340--330°C; 310--295°C; 275-260°C; 203-195°C. The inclusions homogenize in the liquid phase. The pressure in contrast to temperature changed approximately from 450 to 800 bars (maximum during growth of pyramid zone). All primary inclusions in the tourmaline crystals are characterized by a high content of carbon dioxide." (Author's abstract).

Inclusions of mineral-forming solutions in some minerals of pegmatites of the Mama region are rich in CO_2 (2, 4, 11). In papers by the author (15, 16), it was noted that CO_2-aqueous inclusions are also characteristic for crystals of tourmaline from these pegmatites. In this paper results are given of the study of inclusions in tourmalines of the Mama pegmatites and the problem is touched on the state of the mineral-forming medium during the crystallization of tourmaline.

Tourmaline is an important mineral, although minor in abundance (1, 19), of the pegmatites of the Mama region, forming accumulations of large crystals in individual pegmatite bodies. Despite the fact that four generations of tourmaline have been distinguished in these pegmatites (19), it consists here only of the iron variety, schorl. The inclusions were studied in crystals from the zones of quartz replacement and albitization. All the crystals studied had clearly shown idiomorphism with bounded terminations, predominantly with form determined by the main pyramid {10$\bar{1}$1}. Comparatively small crystals are homogeneous in outward structure, large ones, as a rule, have blocky structure (the result of splitting during growth).

To study the inclusions there were prepared polished plates of thickness up to 1 mm., parallel to the axis of three-fold order of the crystals. Survey of more than 100 preparations, about 40 of which were prepared from different areas of large, split crystals, is shown schematically in Fig. 1. The distribution of the inclusions in individual most interesting sections was recorded by means of a sample driver and a coordinate net that permitted the construction of a family of "topographic maps" of the distribution of the inclusions. One of such maps is shown in Fig. 1b. Main emphasis was on the cryothermometry and thermometry of primary inclusions, formed in places of defects of growth along an axis of third order (splitting, intergrowth of blocks) and in pyramids of growth of the crowning faces of the cap, for which clearly shown zonal coloring is especially characteristic in the final stages of crystallization of tourmaline.

Typical secondary inclusions in crystals of Mama tourmaline are comparatively rare, according to our observations, because fractures occurring at the surface of the crystal are generally dry. Most of the inclusions in the crystals of tourmaline studied fall into the categories of primary and pseudosecondary inclusions (6).

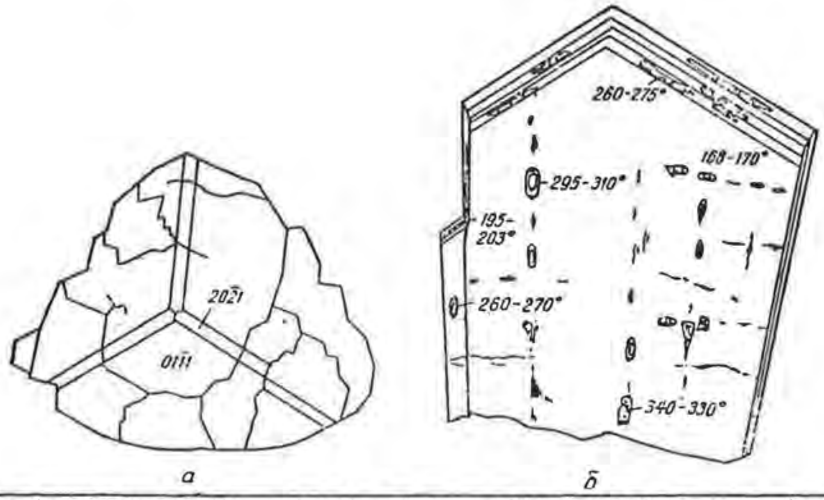

Fig. 1 (p. 296). Split crystals of tourmaline, half natural size. (a) orthogonal projection; (b) section along L_3.

The primary inclusions, formed in places of defects of growth of the crystals along principal axes, differ according to the morphology of the vacuoles (Fig. 2). They have features characteristic of common crystals of tourmaline: vicinal striations on the prismatic faces, limited opposite to the end of the vacuole, etc. It is evident that these attest to the great crystallizing strength of tourmaline. During the origin of local defects, there are formed chains of inclusions elongated along L_3. The vacuoles of such inclusions are "negatively" idiomorphic, and the chains are always curved, which confirms displacement (wandering) of early incipient defects.

An unusual band originates during "non-compact" overgrowth of blocks of split crystals. The surfaces of such bands are covered by sculptured elements, characteristic of crystals of tourmaline. On the surfaces, in which accumulations of such bands are observed, the crystal is easily split into separate blocks. Bands (of vacuoles) of this type very rarely preserve primary solution; usually they are open or are healed at the expense of later tourmaline-forming solutions.

A group of inclusions of solutions, formed at the place of defects of the crystal along an axis of the third order (considering the predominant growth of the crystal of tourmaline in this direction, and also the tendency of this mineral to splitting), contain the most interesting information, both on the character of the changes in the state of the medium at the time of the growth of the crystal of tourmaline, and also on the overall regime of its crystallization.

According to the composition and state, such inclusions in the crystals studied were comparatively similar. They consist of liquid CO_2 -aqueous inclusions with ratios of phases 52-55% aqueous solution and 45-48% liquid CO_2. A third phase occurs very rarely (only in large inclusions) and occupies a very small part of the volume of the vacuole (Fig. 2b). Partial homogenization (phases Ly + Gy) (CO_2 liq. + vap., Ed.) occurs in the liquid phase at temperatures 10.5-18°C. Obtaining magnitudes of temperature for complete homogenization is connected with difficulties: the large inclusions decrepitate at temperatures not above 250°. The data given below were obtained for comparison on small inclusions (0.03 mm and less).

Fig. 2 (opposite p. 285; omitted here). Primary inclusions of CO_2-aqueous inclusions, originating in places of defects of growth along L_3. (a) X 560, (b) X 208, (c) X 1250, (d) X 420.

Homogenization of the phases $L_y + L_y$ occurs by means of the solution of CO_2 in the aqueous solution in two temperature intervals: 340-330°

and 310-295°C. It must be noted that in the crystals represented in Fig. 1 there are observed along the axis of third order some variations both of the degrees of filling of the vacuoles by CO_2 and also of the temperatures of partial and complete homogenization. The inclusions in the "tail" part of the crystal have more stable ratios of phases, temperatures of homogenization $L_y + G_y$ lying in the range 10.5-12.5°C, $L_y + G_y$ - 340-310°C. As one approaches the cap of the crystal, the phases $L_y + G$ are homogenized at 12.5-18°C, and complete homogenization occurs at 330-295°C.

An interesting group of primary inclusions is formed at the end of the growth of the crystals in the pyramids of face $\{10\bar{1}1\}$ (Figs. 1b, 3). Distribution of such inclusions is controlled by zonal colors (Fig. 3, between p. 284-285), which makes it possible to refer them as being primary at the conclusion of the growth of the crystals. The vacuoles of the inclusions are also filled by aqueous solutions and liquid CO_2. Solid phases were not found. It is very difficult to measure accurately the ratios of phases in inclusions of this type, but observations show that the contents in them of CO_2 are lower than in the inclusions previously described.

Fig. 3 (opp. p. 285; omitted here). Inclusions in the zone of growth of the pyramid $\{10\bar{1}1\}$. X175.

Homogenization of CO_2 occurs in the liquid phase at temperatures 14-18.5°, and complete homogenization (solution of CO_2 in the aqueous solution) lies in the range 260-275°C. Similar inclusions are also found in oriented overgrowths on prismatic faces of sub—individuals (Fig. 1), which grew together with the growth of the last zones of the main crystal. However, inclusions analogous to those described above are found only in the "tail" parts of sub-individuals; in the caps CO_2-aqueous inclusions, formed in zones of growth of the pyramid $\{10\bar{1}1\}$, contain less CO_2, have lower density (as a rule $L_y < G_y$), and the complete homogenization of these inclusions occurs in the liquid phase (aqueous solution) at 195-203°C. Evidently deposition of related material from these solutions occurred also at the caps of the crystals, but the zone of such tourmaline obtained very little development. Rather they formed during the healing of open cracks--fissures to the boundaries of growth of blocks in the late stages of formation of the tourmaline crystal.

Finally, in some crystals there is observed still another set of inclusions, the formation of which is most probably associated with the healing of late fractures or uncovered fissures between blocks of the crystals. These are, as a rule, essentially liquid inclusions without notable contents of CO_2 (at -4°, CO_2 is not found). In individual crystals are found groups of inclusions of this type with different degrees of filling. The usual, essentially liquid inclusions (Fig. 4) homogenize in a narrow interval of temperature (168-170°C).

In the primary CO_2-aqueous inclusions the pH was determined as 7.3± 0.2 (analyst D.K. Voznyak). The results of analyses of aqueous extracts, made in correspondence with the recommendations of Khitarov (18), are given in the table. The sample of 100 g. weight was taken from the base of the crystal (Fig. 1).

Fig. 4 (opp. p. 285; omitted here). Inclusions of aqueous solution along fractures in tourmaline. X350.

The data given permit one to draw some conclusions on the conditions of crystallization of tourmaline in the Mama pegmatites.

1. The variation of the temperature of homogenization of primary inclusions indicates that the crystallization of tourmaline occurred in a regime of gradually decreasing temperature: from the beginning to

the end of growth of the crystals, the course of change of temperature of homogenization of primary inclusions appears thus: 340-330°; 310-295°; 275-260°; 203-195°C. In conjunction with this it is interesting to note that the temperature of homogenization of inclusions located on cleavage planes and fractures in kyanite of the enclosing crystalline schists and pegmatites (4), varied within the range 240-280°, and the primary inclusions in the minerals of the pegmatites (quartz, apatite, garnet, albite, etc.) homogenize at temperatures of 260-380° (11).

On the basis of the ratios of the phases and the type and temperatures of homogenization (partial and complete) of the CO_2-aqueous inclusion, using the literature (3,6,21), one can judge the magnitude of the pressure at the moment of homogenization of the inclusion. Calculations show that the pressure varied approximately in the range 450-800 atm.; thereby in the course of its variation (in contrast to the temperature) a maximum will be observed, recorded by inclusions in the zone of growth of the pyramid $\{1011\}$ (see Figs. 1b and 3), after the formation of which, the pressure evidently decreased (appearance in subindividuals of CO_2-aqueous inclusions with partial homogenization in the gas phase).

2. It must be emphasized that all the clearly primary inclusions in the studied crystals of tourmaline homogenize in the liquid phase. Dolgov (5), quoting (10), states the opinion that "toumaline as a rule is always pneumatolytic, although, no doubt, some small part of it crystallized from liquid solutions" (5, p. 61). There is not complete agreement with this statement. Conversely, the results of study of inclusions in tourmaline of different types of pegmatites and their separate zones (22, 14, 12, 16), and in tourmalines of other genetic types (for example 8, 20, and unpublished data of the author) indicate that all satisfactorily verified primary inclusions in crystals of this mineral homogenize in the liquid phase. This, thanks to recently known facts (7), is a rather weighty indication of the hydrothermal genesis of most tourmaline in the studied part of the Earth's crust.

3. The mineral-forming solutions in the process of crystallization of tourmaline in the pegmatites of the Mama region were saturated by CO_2. This is indicated both by the behavior of individual inclusions on cooling and heating, and also by the composition of the aqueous extracts, according to which the ratio $(HCO_3^- + CO_3^{-2}) : (F^- + Cl^-) = 20:1$. The high saturation by CO_2 of the solution forming pegmatites of the Mama region is noted in papers (4,2,15,11,16), and the presence of CO_2 in inclusions in Mama muscovites in (13).

4. The origin of the pegmatites is closely associated with the formation of the metamorphic complex. Korzhinskii (9) and Sobolev (17) assumed a large role of CO_2 in metamorphic processes. The first direct confirmation of this position is a paper (4), in which are described inclusions of kyanite in kyanite-garnet--two-mica and kyanite-garnet-muscovite crystalline schists and plagioclase pegmatites of the Mama region. The high saturation by CO_2 of the inclusions in post-magmatic minerals of the Mama pegmatites emphasizes the significant role of this component in the formation of the metamorphic complex and is one more (geochemical) confirmation of the interelationship between processes of metamorphism and pegmatite formation in old metamorphic strata.

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Translated by Michael Fleischer.

Table (p. 298)

Analysis of aqueous extracts from tourmaline

Components	mg/250 ml				mg-equiv/ 250 ml
	I*	II*	III*	Σ**	
Na^+	8.57	2.38	2.0	6.95	0.302
K^+	0.38	0.22	0.25	0.10	0.003
Li^+	0.30	0.01	0.01	0.29	0.042
Ca^{++}	1.20	3.75	2.40	0.15	0.007
Mg^{++}	0.29	0.21	0.05	0.40	0.032
Fe^{++}	0.04	0.02	0.02	--	--
Mn^{++}	not found	not found	not found	--	--
ΣK (cations)					0.386
HCO_3^-	18.96	7.39	5.29	15.77	0.258
CO_3^{--}	4.06	not found	not found	4.06	0.135
Cl^-	0.60	0.13	0.16	0.41	0.011
F^-	0.55	0.12	0.24	0.19	0.010
SO_4^{--}	not found	not found	not found	--	--
$HSiO_3^-$	2.11	2.05	1.79	0.58	0.008
ΣA (anions)					0.422
Weight	100g.	99.64g.	99.22g.		
pH doubly distilled H_2O	5.45	5.04	4.56		
pH extract	8.31	8.24	7.64		

* I, II, III - 3 consecutive leaches

** Sum of (I-III) + (II-III). Analyst G.F. Rudenko.

TROSHIN, Yu.P., BOIKO, S.M., MARKOVA, M.E., MIKHEYEVA, Z.I., ALEXEYEVA, N.N., and KURDIN, O.V., 1970, On the composition particularities of primary fluid inclusions and trace element composition of minerals at the Khapcheranginsky ore region: in L.V. Tauson, ed., Yearbook for 1969 of The Acad. Sci., USSR, Siberian Division, Institute of Geochemistry, Irkutz (published 1970), p. 172-176, (in Russian, English abstract). The phyllite series which are of almost uniform composition occur north and south of the Tarbalzyesky fault zone and are characterized by considerable variations in the grade of metamorphism due to the intrusion of Khapcheranginsky pluton. The displacement of the rocks along the fault and the tectonic stress during the formation of phyllites caused, particularly in the vicinity of the fault, plastic flow of material and release of silica from the country rocks and redeposition of quartz as flat lenses and veinlets which occur parallel to the phyllite layers. The formation of quartz is earliest in the area and NaCl-type solutions took part in its formation. (Table 1). The metamorphism in the zone of disturbance is shown by the decomposition (or alteration) of certain minerals in the rocks (which contain up to 10% biotite), and by silicification. The metamorphic solutions of NaCl-type acquired increased amounts of potassium and fluorine. Such solutions are of an intermediate type which are responsible for the formation of gold-quartz veins. The mineralization is connected with the E-W striking fractures. These represent the earliest ore veins of this area and formed before or during the intrusion of the granite pluton, The heat of the intrusion caused the mobilization and separation of ore minerals. In comparison with the minerals of the Khapcheranginsky region it is noteworthy that ore minerals from such deposits which are connected with faults have a higher content of gold (Table 2).

All tin, zinc, and lead deposits, which formed after the intrusion and are genetically associated with it show partly horizontal and partly vertical zoning. In all ore deposits, the fluid inclusions in quartz of earliest stage of ore deposition are characterized by a higher acidity and higher content of potassium, whereas in Tarbalzyesky the quartz-cassiterite stockwork is rich in fluorine. In the latter case the content of KF is double that of NaCl.

The greisen deposit of Granitnyi and the Tarbalzyesky stockwork are similar both in regard to the mineral composition (quartz, fluorite, arsenopyrite, cassiterite etc.) and to the composition of fluid inclusions in quartz (except the F/Cl ratio and the pH value). The quartz from Tarbalzyesky fault zone is distinguished by its higher content of Li and F in fluid inclusions than that in the quartz of Khapcheranginsky ore region. On considering the ore minerals in the above ore deposits it is noted that the ores of the Tarbalzyesky, Kurultyei, and Kurultuikena are richer in iron than the ones of Granitnyi and Khapcheranginsky.

The cassiterite from Khapcheranginsky differs from the cassiterite of Granitnyi in that it is richer in such elements which could have come from phyllites (Fe, Ga, Sc) and besides it has a higher indium content, In the cassiterite of greisen-type deposit of Granitnyi the Nb, typical of pneumatolysis, is enriched. The decrease in the content of Fe, Ga, and In in cassiterite from cassiterite-sulphide veins of Khapcheranginsky, in comparison to the griesen deposits, is explained by the intake of these elements in the sulphides. The lowering of the Nb and Sc content is defintiely connected with the evolution of the composition of the solutions.

Sphalerite and galena from those deposits connected with the fault differ from the sphalerite and galena from Khapcheranginsky due to their higher F content and partly K, Ga, Tl, and Fe contents in the inclusions.

Finally the genetic relationship and similarity between all the Sn-Zn and Pb deposits of the investigated area, with respect to the main features of the mineral composition, the association of ore and gangue minerals and their inclusions may be pointed out. The partly existing differences are due to the fact that ores and gangue minerals (and their inclusions) from deposits associated with deep fracture zones, are enriched with elements which, most probably, have been released due to the decomposition of minerals of the country rocks (particularly biotite) from the fracture zone.

Translation by Asoke Lahiry.

Mean values of the parameters of leachates of fluid inclusions from minerals of Khapcheranginsky ore region

Table I

Tin-polymetallic and polymetallic ore deps.

Locality of samples	Quartz						Sphalerite				Galena			
	pH	Na/K	Li/Na	Li/K	F/Cl	no. of samples	pH	Na/K	F/Cl	no. of samples	pH	Na/K	F/Cl	no. of samples
Quartz lenses in phyllite	7.6	5.6	0.020	0.053	0.018	19								
Gold quartz veins	8.25	1.8	0.033	0.067	0.060	19								
Tabalzyesky fault (Qz. without mineralization	8.0	1.2	0.022	0.028	0.30	63								
I. Tabalzyci	7.5	0.57	0.10	0.033	2.3	4								
Kurultyei	8.2	1.4	0.20	0.22	0.45	3								
II. Kurultuiken 5 ore bodies	8.9	0.43	0.23	0.19	0.33	13	5.7	0.62	0.81	2	6.1	0.70	0.57	3
Kurultuiken 4 ore bodies	9.0	2.1	0.39	0.18	0.36	5					6.2	1.1	0.21	3
Kurultuiken I and 2 ore bodies	9.15	1.85	0.15	0.15	0.15	38	7.0	0.68	0.21	9	6.9	0.75	0.15	9
III Granitnyi	8.7	0.57	0.10	0.062	0.47	14								
Khapcheranginsky (veins with SnO2 and RS)	9.15	1.8	0.044	0.044	0.024	21	7.4	0.73	0.25	5	6.0	0.93	0.07	5
Khapcheranginsky (v eins with Zns and PbS)	9.25	1.4	0.030	0.054	0.27	34	7.8	1.67	0.09	15	8.0	0.84	0.15	15

Table 2

Content of some (admixture) elements in the ore minerals of Khapcheranginsky ore region (in g/t)

	Ore deposits and ore bodies	Au					Cassiterite						Sphalerite			Galena		
		FeAsS	$CuFeS_2$	FeS_2	ZnS	PbS	Fe	Nb	Sc	Ga	In	no. of samples	Fe,%	Ga	no. of samples	Ga	Tl	no. of samp.
Ore deposits I	Tabalzyei	0.05					9000	170	8	30	190	3						
	Kurultyei		0.06	0.03	0.04	0.04							13.9	30	1	30	1	1
II	Kurultuiken, 5 ore bodies	2.0		0.06	0.04	0.01							11.5	10	3	-	-	5
	Kurultuiken, I&II ore bodies												13.5	5	16	-	1	22
III	Granitnyi	0.01	0.004				7200	2000	-	3	80	8	9.15	-	1	1	3	4
	Khapcheranginsky (veins with SnO_2 and RS)	0.008	0.05	0.004	0.02	0.007	5500	-	14	-	16	14	11.7	2	33	-	-	16
	Khapcheranginsky (veins with ZnS and PbS)			0.005	0.003	0.01							7.6	1	123	-	-	98

TUGARINOV, A.I., and NAUMOV, V.B., 1970, Dependence of the temperature of decrepitation on the composition of gas-liquid inclusions and on the strength of the mineral: Akad. Nauk SSSR Doklady, v. 195, p. 182-184, (in Russian).

In recent years ever broader studies of inclusions of mineral-forming media have been undertaken to clarify the physico-chemical conditions of mineral formation. Thus, of the 1450 papers published in 150 years with data on inclusions in minerals, 1050 papers (70%) were completed during the last ten years. Inclusions in minerals are used most successfully in thermobarometry, although it must be noted that even yet the results obtained are given arbitrary interpretations in connection with inadequate treatment of the basis of the method, expecially in the application of the method of decrepitation of inclusions.

Previously, in studies of gas-liquid inclusions in crystals of synthetic quartz, grown from aqueous solutions of Na_2CO_3 and NaOH, the relations were established between the temperatures of homogenization and decrepitation of inclusions (1-4). The temperatures of the beginning of massive decrepitation of inclusions were always higher than the temperatures of homogenization by 45-65° (depending on the densities of the solutions). Besides corrections were determined for the pressure for the transition from the temperature of decrepitation to the temperature of formation of the mineral. Nevertheless, as was shown by the results of studies of inclusions in minerals of various ore deposits, there are contained very often in hydrothermal solutions significant amounts of volatile components, mainly CO_2, and for such solutions, naturally, the corrections ought to be different. We therefore tried to show the dependence of the temperature of decrepitation of gas-liquid inclusions on the content of CO_2 in them.

The results, obtained by the method of (5), are given in Table 1. It is seen clearly that there is a tendency for a decrease of the temperature of decrepitation as the concentration of CO_2 increases, for all the minerals studied. If one compares two samples of quartz, no. 1 (without CO_2) and no. 6 (with the maximum amount of it), they show nearly the same temperatures of homogenization, but the difference in temperatures of decrepitation (350° and 150°, respectively) is 200°! Using only data on the temperatures of decrepitation for sample no. 6 (quartz 150°, wolframite 110°) one could be led to an incorrect conclusion as to the low-temperature conditions of formation of these minerals. Hence it becomes perfectly clear that to use single determinations of the temperature of decrepitation to judge the temperature of formation of a mineral without using the method of homogenization or determining the composition of the inclusion is impossible in any case. Only complex study of gas-liquid inclusions permits obtaining reliable information on the physico-chemical conditions of formation of minerals.

Thus, the joint use of the methods of homogenization and decrepitation makes it possible to determine the pressure at the moment of the homogenization of inclusions (6). The method was checked on samples of quartz, because only for this are there data on the pressure at the moment of the beginning of massive decrepitation (850 ± 50 atm.)(1). At present such data have been obtained by us for nine minerals of different stability (Table 2).

Because in our work it is impossible to pause for each of the minerals listed in the table, we give as an example only one of them, wolframite. Several samples were studied, in which quartz and wolframite crystallized simultaneously, according to mineralogical indications. Analyses of the content of CO_2 in inclusions of these minerals confirmed the analogous composition of the solutions (Table 1, samples nos. 5 and 6). Measuring the temperatures of decrepitation of quartz and wolframite in these samples and using the graphical method of determination of pressure (6), we obtain a pressure at the moment of decrepitation at the moment of the beginning of decrepitation of the inclusions in wolframite as 575±50 atm.

On examining Table 2, it is clearly seen that the greater the hardness of the mineral, the greater the pressure necessary to burst the inclusions. Because increase of the pressure in gas-liquid inclusions is connected with increasing temperature, one must assume that for stronger minerals the temperatures of decrepitation will be higher. In other words, even if two minerals crystallize simultaneously from the same solution at the same temperature and pressure, but they are of different tenacity (for example, quartz and molybdenite), then inevitably the temperaturas of decrepitation ought to be different. However, the magnitudes of these differences for two minerals will not be the same in all cases, because they also depend, as Table 1 shows, on the composition of the solution.

From the results given in Table 2, yet another conclusion follows: for minerals with hardness in the range from 1.5 to 7, the pressure of decrepitation increases about 100-120 atm. per unit. Such a correlation between hardness and pressure permits one to estimate approximately the pressure during decrepitation of inclusions also for some other minerals, such as molybdenite (150±50 atm.), galena (250±50 atm.), etc. Of course these data will be made more accurate in the future.

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Translated by Michael Fleisher.

Table 1 (p. 182)

Dependence of the temperature of decrepitation (T_D) of gas-liquid inclusions on their content of CO_2

Mineral	No.	CO_2 wt. %	T_H** ±2°C	T_D ±5°C	Mineral	No.	CO_2 wt. %	T_H** ±2°C	T_D ±5°C
Quartz	1	0.0	298-300	350	Fluorite	11	5.8	125-137	150
	2	11.5±0.1*	265-276	270		12	25.2	220-245	70
	3	22.1	288-302	240	Stibnite	13	2.1	-	120
	4	21.8	279-292	220		14	7.6	-	100
	5	23.8	290-305	180		12	24.8	-	40
	6	27.6±1.7*	278-285	150	Quartz	15	0.6	146-160	200
Wolframite	7	3.7	-	340		16	14.6±0.2*	188-203	155
	8	7.3	-	320					
	9	10.0	-	260					
	10	20.5±0.6	-	160					
	5	24.6	-	120					
	6	26.4±0.8*	-	110					

*Arithmetic average of 2 samples

**Temperature of homogenization

Table 2 (p. 182)

Pressure at the moment of the beginning of massive decrepitation of gas-liquid inclusions for various minerals ($P_{decrep.}$)

No.	Mineral	Hardness on the Mohs scale	P_{decrep} ±50 atm.
1	Orpiment	1.5-2	175
2	Stibnite	2-2.5	225
3	Wavellite	2.5	225
4	Barite	2.5-3.5	250
5	Calcite	3	350
6	Villiaumite	3.5	450
7	Sphalerite	3-4	450
8	Fluorite	4	450
9	Wolframite	5-5.5	575
10	Quartz	7	850

INDEXES TO VOLUMES I, II, and III

The user should keep in mind the following features of these indexes. The volume is given by Roman numeral, the page by Arabic numerals; 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: Only first authors are listed.

Subject Index: Only data in the title and abstract are indexed, and then only if they appear to be of more than incidental mention. Misleading or erroneous translations may well result in occasional incorrect or omitted entries. Some pertinent entries are included under a given subject even though the index word does not occur in the abstract. The deposit type is indexed only where known to the Editor without research, and hence some may be incorrect. The type terms such as porphyry copper and Mississippi Valley are used loosely. Analyses for specific elements are indexed only when they are particularly 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 pages (such as Homogenization, Quartz) are omitted.

Deposit Index: 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.

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