Harvey Belkin

FLUID INCLUSION RESEARCH

PROCEEDINGS OF COFFI

VOLUME 2, 1969

REPRINT

FLUID INCLUSION RESEARCH - PROCEEDINGS OF COFFI, VOL. 2, 1969

(Reprint)

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Washington, D.C. 1969

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. Subscriptions U.S. $3.00 per year. A very limited number of press overruns of the 1968 volume are still availabe at $3.00. Make checks payable to COFFI and address all correspondence to:

Edwin Roedder, Editor of COFFI
U.S. Geological Survey
959 National Center
Reston, Virginia 22092

NOTICE TO SUBSCRIBERS

Publication of this issue of Fluid Inclusion Research - Proceedings of COFFI, as with the previous issue, has been unfortunately delayed by a series of circumstances. Most of the material for the issues for 1970 and 1971 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 the translation of abstracts. All subscribers can help by cutting down time-consuming and unnecessary correspondence and billing procedures by (1) requesting standing orders and (2) 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, recording subscriptions, banking, addressing, and mailing, etc., that now occupy his spare time.

EDITOR'S PREFACE

Fluid Inclusion Research - Proceedings of COFFI was started in 1968 as an offshoot of the Commission on Ore-Froming Fluids in Inclusions (COFFI) of the International Association on the Genesis of Ore Deposits (IAGOD). Although closely connected with COFFI and IAGOD, the publication of the Proceedings is independently arranged, 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.

The previous issue was dominated by the large number of papers from the 2nd and 3rd All-Union Conferences on Mineralogical Thermometry and Barometry in the USSR. In this issue an attempt is made to cover the world literature for 1969, and to catch some of the more important papers missed previously. There are two fluid inclusion symposia planned by COFFI and scheduled in connection with the August, 1972, meeting of the I.G.C. Abstracts of most of the papers to be given there (including all that were available to the Editor at press time) are included here. As a result, not all important papers from the literature for 1969 could be included in this issue, as it was thought best to expedite publication of the volume before the I.G.C. meeting; the omitted works will be covered in the next issue.

Although each abstract is duly credited, 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, as 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. The Board of Associate Editors kindly provided translations of 13 abstracts, as acknowledged individually. 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 issue 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 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 10R. Expressions of interest in participation, and titles of prospective papers papers should be sent by November 1972, and abstracts (not more than two typewritten pages) by February 1, 1973, to:

Prof. N.P. Ermakov, Geological Faculty, Moscow State Univ.
Moscow 117234, U.S.S.R.

The following excursions are planned:

Pre-Congress - by steamer on the Don and Sea of Azov to historic sites and mariupolites (2 days)

Post-Congress - Ore deposits of the northern Caucasus, with examination of the laccoliths at Pyatigorsk and Mt. Elbrus (5 days).

NOTICE OF NEW INSTRUMENTS

Dr. A.R. Groshenko of the Geological Faculty, Univ. of Moscow, Moscow V-234, USSR, has sent three brochures, issued by the Academy of Sciences of the USSR, in which he describes three new patented instruments that he has designed. Plans are underway to manufacture these three instruments in the USSR for sale. They are (1) a decrepitator, (2) a microscope heating stage, and (3) a universal microscope heating stage. (Translation by D.C. Alverson).

(1) Decrepitator

The instrument is intended for the study of the decrepitation of inclusions in minerals of ores and rocks during heating (decrepitation method).

The decrepitator consists of a block of sensors (sound and temperature) and a heating element in a decrepitation apparatus, which also has an electronic amplifier, impulse recorder, and other units.

The decrepitator is equipped with a special piezoelectric microphone with a membrane that can be brought into the heated area. The material to be investigated (crystals, mineral and rock grains) is placed directly on the membrane, which increases the sensitivity of the instrument to the weak sound signals of the exploding untramicroscopic inclusions in the minerals.

To lower energy losses from the sound signals, the membrane and sound conductor are made as one solid part, and to provide for the possibility of heating the material to a high temperature without overheating the piezoelement, they are made from quartz glass. The efficient thermal insulation (porous refractory) and the position of the electric coil in the closed inner cavity of the decrepitator make it possible to heat to >1200°C. The special design of the heating element (electric coils suspended on refractory rods) lower internal sound interference to the minimum, as does the soft suspension of the decrepitator in the external sound insulating screening chamber.

Design characteristics of the sound sensor and the efficient protection of useful signals from internal and external interference make it possible to increase the sensitivity of the instrument and the precision of investigations, as well as their productivity and thrift.

The instrument was created in the K.I. Satpayev Institute of Geol. Sciences of the Kazakh SSR Academy of Sciences by A.R. Grosh'henko

Fig. 1. Block diagram of decrepitation apparatus

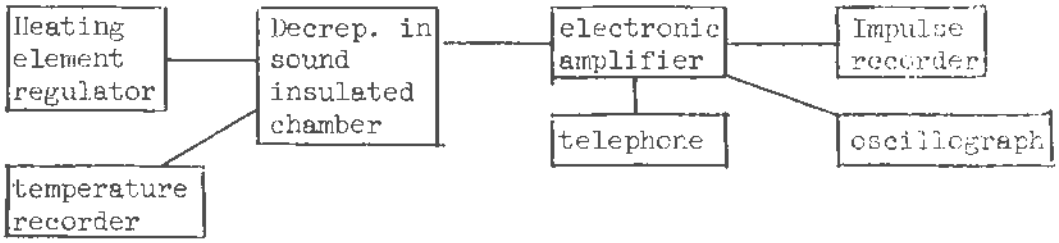


Fig. 2. Decrepitator disassembled (not included here).

Fig. 3. Schematic section thru decrepitator. (See p. 7)

1,2,3 - housing, middle ring, and cover of thermally-insulated material with refractory insert; 4 - thermocouple; 5 - membrane-cup of microphone; 6 - handles on cover; 7 - electric coil of heating elements; 8 - refractory ring; 9 - arms of middle ring; 10 - hooks for "soft" suspension of decrepitator; 11 - needle of sound conductor; 12 - piezoelement; 13 - metal screening box; 14 -"Porolon" shock absorber (probably a styrofoam-like material).

(2) Microscope Heating Stage.

The instrument is intended for heating preparations under the microscope in transmitted light.

The object glass with the preparation being studied (crystals, mineral grains, etc.) is placed in contact with the electric coil of a miniature heating element, which makes it possible to heat the preparation to 1000°C. Temperature measurement is with a thermocouple, which is made into the form of a ring near the junction to provide maximal illumination of the preparation, which is inside the ring. The stage is equipped with a special heat disseminating plate, which prevents the microscope objective from overheating, and makes it possible if necessary to bring it closer, at minimal distance, to the preparation.

The listed characteristics of the stage make it possible to study, in a broad interval of temperatures, even such difficult material as micro-inclusions in vein and rock-forming minerals.

The instrument was created in the K.I. Satpayev Inst. of Geol. Sciences of the Kazakh SSR Academy of Sciences by A.R. Groshenko.

Fig. 1. Schematic section of heating stage. (See p 7)

1 - plastic base ring; 2 - thermocouple; 3 - heat dispersing plate; 4 - ring of heat-insulating material; 5-6 -refractory rings; 7 - electrical heating coil; 8,9,10 - quartz glasses.

Universal Microscope Heating Stage

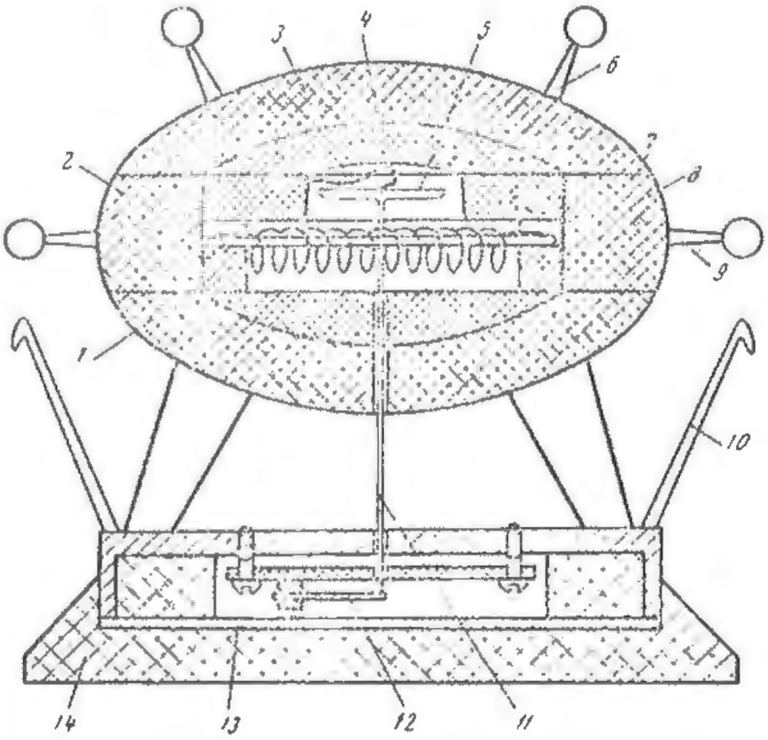
Intended for the study of preparations under the microscope, with changes in their orientation during the process of heating.

The instrument is equipped with an orientation apparatus, in which a miniature object stage is fastened on a thermocouple, but in such a way as to remain mobile (near the junction). The thermocouple acts as an axis. This makes it possible, without lowering the precision of measurement of temperature, to change the angle of inclination of the preparation from 0 to 20°. Efficient thermal insulation made of porous refractories, and the location of the electric coil in air in the inner chamber of the thermal stage, provide for heating the preparation up to 900°C. The ease of detaching the instrument increases the productivity of research, decreasing time spent on cooling in the intervals between experiments. Use of a heat disseminating plate prevents overheating of the microscope's optical system.

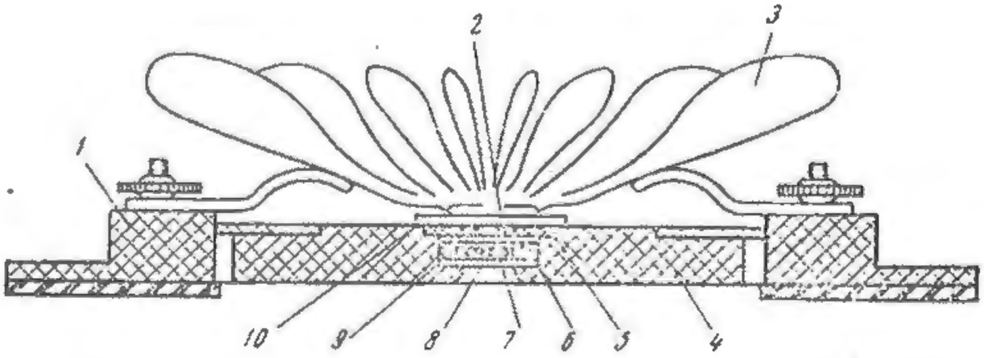
Design characteristics of the thermal stage make it possible to conduct new kinds of investigations, such as the study of micro-objects which change their shape, structure, aggregate state, color and other properties on heating. For example, the study of microinclusions in minerals of complex shape or arranged at an angle to the surface of the plate, daughter minerals, structure of internal surfaces of vacuoles, etc.

The instrument was created in the K.I. Satpayev Institute of Geol. Sciences of the Kazakh SSR Academy of Sciences by A.R. Groshenko.

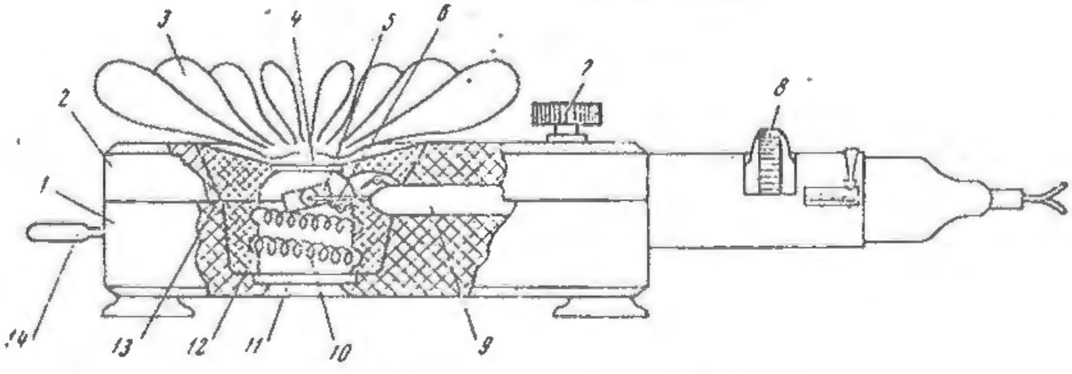
Fig. Schematic section of universal heating stage. (see p 7)
1,2 - body and cover of porous heat-insulating material; 3 - heat disseminator; 4 - quartz glass; 5 - object glass; 6 - thermocouple; 7,8 - screws for changing orientation of preparation; 9 - 3-hole porcelain rod; 10 - electric-heating coil; 11 - quartz glass; 12,13 - refractory inserts; 14- electric connections.



Decrepitator



Microscope heating stage



Universal microscope heating stage

REPORT OF THE COMMISSION ON ORE-FORMING FLUIDS IN INCLUSIONS (COFFI) OF THE INTERNATIONAL ASSOCIATION ON THE GENESIS OF ORE DEPOSITS (IAGOD)

by N.P. Ermakov, Chairman of COFFI

I. A business meeting of the bureau of COFFI, consisting of N.P. Ermakov, E. Roedder, H. Imai, and G. Deicha took place in Kyoto, Japan 29-30 August, 1970. Also present were some of the chairmen of national sections of COFFI. The following accomplishments can be reported for the 2-year period August 1968, to August, 1970.

A. National sections of COFFI were established in USSR, USA, France, Japan, India, Mongolia, Czechoslovakia, Bulgaria, Roumania, Holland, Belgium, England, Ukrain, Byelorussia, Canada, and Morocco. Contacts with the scientific groups of China and Greece was lost. With the help of zonal leaders of COFFI in eastern Asia and Australia (Imai), America (Roedder), eastern Europe and western Asia (Ermakov), and western Europe and Africa (Deicha), groups of investigators from the following countries were added to COFFI: Brazil, Australia, South Korea, Poland, G.F.R., Algeria, Tunisia, Italy, Spain, Argentina, (Tasmania), Venezuela, and Turkey. Thus at present the Commission unites the sections and groups of investigators from 28 countries (not including Greece and China).

B. Some results of the scientific work were summed up in three international meetings during this period that were organized and presented by COFFI: 1968 in Prague, Czechoslovakia; 1968 in Alexandrov, USSR; and 1969 in Bern, Switzerland. Titles and/or abstracts of the papers from the two 1968 meetings were published in the Proceedings of COFFI for 1968 (Ed's. note: additional translated abstracts will be found in this issue as well), and the papers from the 1969 meeting were collected in a special issue of "Schweiz. Mineralog. u. Petrog. Mitt.," v. 50, no. 1, 1970.

C. The participation of COFFI at the 1970 IMA-IAGOD meetings included the collection and selection of abstracts for presentation at the COFFI Symposium (Kyoto). Particular thanks are due to H. Imai and S. Takenouchi for this work.

D. Publication of the complete bibliography of Russian fluid inclusion work for the last 100 years (N.P. Ermakov, ed.)

E. Considerable expansion of inclusion work in Japan was reported by the Japanese national section.

II. The following plans for the future were discussed:

A. The participation of COFFI at the 24th Internat. Geological Congress was planned, with representatives of IAGOD and R.W. Boyle for the IGC.

B. Plans were discussed for the publication of future issues of Fluid Inclusion Research - Proceedings of COFFI, with Roedder as Editor.

C. Plans were discussed for publication, in the USSR, of a photo-atlas for the identification of inclusions in minerals, with Ermakov as Editor.

D. Zonal libraries on inclusions were created in Moscow, Washington, Paris, and Tokyo, via an obligation on the part of each national section to send all publications to all four zonal libraries.

E. Exchange of microphotos and sample preparations was encouraged.

F. Distribution of a motion picture film by Dr. F.P. Melnikov (USSR) on the changes occurring on freezing and heating inclusions under the microscope was discussed. It may be possible to buy copies of this film.

G. The eight most profitable directions for future research on inclusions of applicability to the search for hidden ore bodies and to aid in mineral synthesis were selected and approved.

H. The title "Thermobarogeochemistry of endogenous processes of mineral formation" was recommended to all national sections, as it consolidates all types of investigations based on various tests and analyses of inclusions of solutions and melts.

N.P. Ermakov

NOTICE OF THIRD INTERNATIONAL COFFI SYMPOSIUM ON FLUID INCLUSIONS

The third international symposium on fluid inclusions, sponsored by the Commission on Ore-Forming Fluids in Inclusions ("COFFI"), will be held on Aug. 22 and 23, 1972, in Montreal, in connection with the 24th International Geological Congress. These two sessions will each be held at 1400 hours so they will not conflict with any regular IGC sessions. Although sponsored by COFFI, these will not be limited to studies of inclusions of ore-forming fluids, but will also include papers on instrumentation, and the interpretation of data for magmatic (silicate melt), metamorphic, and sedimentary inclusions as well, and are open to all.

The titles of all formal papers are given below, in their probable sequence of presentation (approximately 15 minutes per paper), followed by those author's abstracts that were available to the Editor at presstime (arranged alphabetically). Late abstracts will be published in the next issue. Please note that this is the only publication of these abstracts, as they are not included in the IGC Abstracts volume. It is hoped that there will be time for short informal communications as well.

Session 1 Aug 22 1400 hours Duluth room, Queen Elizabeth Hotel.

Chairmen G. Deicha and N.P. Ermakov.

Inclusions in igneous and metamorphic rocks and higher temperature ore deposits

Takenouchi, Sukune, Glass inclusions in quartz of volcanic rocks from mining areas.

Anderson, A.T., Sulfur and chlorine contents of glass inclusions in phenocrysts and basaltic host glasses.

Roedder, Edwin, Interpretation of silicate melt inclusions in lunar, terrestrial, and meteoritic minerals.

Ernst, Th., Mages, G., and Schwab, R.G., Liquid-CO_2 inclusions in olivine bombs--generated by decomposition of "orthocarbonates"?

Poty, B. and Weisbrod, A., Equilibria between minerals and solutions in the Mayres pegmatite (Cévennes médianes, French Massif Central).

Kozlowski, Andrzej and Karwowski, Lukasz, Bromine in gaseous-liquid inclusions in postmagmatic minerals from Lower Silesia.

Takenouchi, Sukune, Ore-forming fluids at the Takatori tungsten-quartz veins in Japan.

Pokrovskiy, P.V. and Purtov, V.K., The main regularities in the formation of quartz veins at crystal-bearing and tungsten deposits of the Urals.

Logsdon, Mark J., A fluid inclusion study of the porphyry copper deposits at Ray and San Manuel, Arizona.

Andrusenko, N.I., Timofeevsky, D.A., Grebenchikov, A.M. and Andrianova, S.I., The temperature of formation of the gold deposits in the U.S.S.R. (by inclusions in minerals).

Drake, W. and Ypma, P.J.M., Fluid inclusion study of the Mineral Park porphyry copper deposit, Kingman, Arizona.

Trufanov, V.N., Kurshev, S.A., Maisky, U.G. and Ushak, A.T., Experimental investigation of thermal metamorphism of the fluid inclusions in minerals.

Ypma, P.J.M., Fluid composition and P-T relations in fluid inclusions.

Sawkins, F.J. and Landis, Gary, Fluid inclusion studies of Andean ore deposits

Session 2 Aug.23 1400 hours Duluth room, Queen Elizabeth Hotel.
Chairmen E. Roedder and H. Imai

Significance and use of inclusions in lower temperature environments

Barnes, H.L., Lusk, L., and Potter, R.W., Compositions of fluid inclusions.

Ermakov, N.P., Geochemical classification of inclusions in minerals.

Imai, Hideki and Takenouchi, Sukune, Fluid inclusions in quartz in granitic rocks and associated vein-type deposits.

Rasumny, J., À propos de la rapidité de coalescense des bulles dans les inclusions fluides soumises à la retroebullition.

Mogarovsky, V.V., Morosov, S.A., Novoseltsev, Y.A., Faysiev, A.R., Blochina, N.A. Alidodov, B.A., Ishan-Sho, G.A., Shulikovskja, Y.A., Alchasov, V.V. Kotelnikov, G.V., Gurevich, Ya.A. and Besugliy, M.M., Thermodynamic and chemical conditions of formation of endogenic deposits in Tajikistan.

Dejonghe, Léon, Les inclusions aqueuses de la gangue du gîte de RAVANDJE (Iran); étude de la morphologie de leurs cavités au microscope à balayage .

Manutcharjants, B.O., On the conditions of formation of Hg-Sb deposits of jasperoid type.

Deicha, Georges, Investigation des cavités intraminérales par microscopie électronique à balayage.

Faugere, J.C., Application de l'étude des inclusions à un matériel sédimentaire du Dogger du DJEBEL ZERHOUM (Maroc).

Ermakov, N.P. and Kusnetsov, A.G., The application of thermobarogeochemistry methods in searching for hidden ore deposits.

Currie, J.B. and Nwachukwu, S.O., Fluid inclusions in fracture-fillings of petroleum resevoir rocks.

Krendelev, E.P., Zozulenko, L.B. and Orlova, L.M., Temperature of homogenization and composition of gases in gas-fluid inclusions in quartz pebbles from sulphide conglomerates.

Benešová, Z and Čadek, Josef, Temperature of homogenization of inclusions in fluorite deposits of Czechoslovakia.

Petrovic, Radomir, Coalescence and removal of fluid inclusions from minerals exposed to confining pressure greater than the fluid pressure in inclusions.

Barker, Colin, Volatiles in fluid inclusions-analysis and interpretation.

End of Symposium

Abstracts of papers to be presented at the Third International COFFI Symposium on Fluid Inclusions, Montreal, Aug. 22-23, 1972

ANDERSON, A.T., Sulfur and chlorine contents of glass inclusions in phenocrysts and basaltic host glasses, (Department of Geophysical Sciences, The University of Chicago, Chicago, Illinois, 60637).

Representative electron microprobe analyses of sulfur, chlorine and potash in basaltic host glasses and glasses included in phenocrysts from the same lava are (in weight percent):

		Inclusion			Host glass		
Lava	Phenocrysts	S	Cl	K_2O	S	Cl	K_2O
IKI122	Olivine	0.11	0.018	0.48	0.018	0.016	0.53
HK1955AG	Olivine	0.148		0.79	0.012		1.3
HK1955AG	Ilmenite	0.129		0.41	0.019		1.25
HK1955AG	Magnetite	0.135		0.70	0.018		1.05
HK-K4	Ilmenite	0.038		0.7-1.1	0.008		1.0-1.4
HK1697					0.061		
Hippo Butte	Olivine	0.093	0.035	1.08	0.004	0.049	2.16
Black Crater	Olivine	0.095	0.015	0.18	0.041	0.01	0.45
Hat Creek 5	Olivene	0.075	0.013	0.45	0.006	0.009	0.5

The lavas mentioned are basalts from Kilauea, Hawaii 1959 (IKI22), 1955 (HK1955AG), prehistoric Kamakaia (HK-K4), submarine (HK1697), and basalts from Northern California (Hippo Butte, Black Crater and Hat Creek 5). Host glasses have 0.5 to 0.1 times the sulfur content of glasses included in phenocrysts. One sparsely vesicular submarine specimen (HK 1697) has a comparatively high S content in the host glass in agreement with independent results of Moore and Fabbi. Estimates of the SO_2 fugacity in the 1955 Kilauea lavas at 1120°C range from 50 atmospheres inside oxide phenocrysts to 10 atmospheres in the host glass. These results indicate that SO_2 is lost from subaerial lavas during the final stages of eruption. Cl apparently is not lost and shows fair coherence with K_2O in individual eruptions. The estimated juvenile S/Cl ratio in basalts is about 8 and ranges from 4 to 10 in comparison with Kilauean gases (S/Cl=4) and Rubey's excess volatiles (S/Cl = 0.07).

BARKER, Colin, Volatiles in fluid inclusions -- analysis and interpretation (Dept. of Chemistry, Univ. of Tulsa, Tulsa, Okla. 74104).

The volatiles in two-phase fluid inclusions in minerals from hydrothermal ore deposits have been analyzed using a volumetric method for water (determined as water vapor) and mass spectrometry for the other components. The volatiles were released either by heating or crushing in vacuum. For the fluorites, quartz, sphalerites and galenas analyzed water accounted for well over 95% of the volatiles. The balance was mainly carbon dioxide with minor amounts of hydrogen, methane, nitrogen, argon and carbon monoxide. Carbon monoxide was very low, or absent, in the volatiles released by crushing. Two methods were used for distinguishing between volatiles from primary and secondary inclusions. Heating ruptures the secondaries at lower temperatures than the primaries and can be used to remove the secondary inclusions from the sample so that the primaries can be analyzed separately. The alternative approach is sequential crushing which appears to break open secondary inclusions preferentially, probably because they lie along rehealed cracks and these form planes of weakness in the crystal. Sequential crushing for two generations of fluorite from Groverake Mine, N. Pennines showed that the H_2O/CO_2 ratio was 50 in the primary inclusions of the first generation, 300 in the primary inclusions of the second generation and greater than 600 for the secondary inclusions. Thus the partial pressure of carbon dioxide fell during this part of the mineralization. The partial pressure of hydrogen, nitrogen, and methane also fell. Since the water determined experimentally was present in the inclusions as liquid water the volume of the inclusions ruptured can be calculated if the liquid/bubble ratio is known. But this is the volume initially occupied by the carbon dioxide (and other gases) so partial pressures follow directly. Values for the N. Pennine orefield were found to lie in the range from 0.2 atm to 22 atm for carbon dioxide but were lower for the other gases.

BARNES, H.L., LUSK, J., and POTTER, R.W., Composition of Fluid Inclusions, (Ore Deposits Research Section, The Penn. State Univ., Univ. Park, Penn., and Dept. of Geology, Macquarie Univ., North Ryde, New South Wales, Australia).

Fractionation between parent and fluid inclusion solutions was investigated by synthesizing inclusion-rich overgrowths of sphalerite on natural seed crystals. Overgrowths formed experimentally within sealed gold tubes when nutrient ZnS was transported about 10 cm. down a 15°C gradient in 0.3-6.0 m NaOH solutions to deposit at 325 to 375°C, between 0.27 and 1.0 kilobar. Inclusions, typically 0.05-2.0 mm long, formed only in valleys on the surface of the acid-etched seed crystals, and not within the overgrowths despite attempte using variations in temperature during growth; this suggests that corroded mineral surfaces are natural loci for the formation of fluid inclusions.

Composition of the parent and inclusion solutions were determined by measuring freezing temperatures using liquid N_2-cooled nitrogen gas to control the temperature of a microscope freezing stage. The fluids in 106 synthesized inclusions were found to be more dilute than the parent solution, the difference in molality being nearly constant at 0.2±.03 for concentrations from about 1-6 molal in NaOH. This difference suggests that natural processes forming inclusions are complex and do not necessarily trap samples representative of the parent solution. Other ranges of pressures and temperatures and other solutions require investigation.

BENESOVA, Zdenka and CADEK, Josef: Temperature of homogenization of inclusions in fluorite deposits of Czechoslovakia (Authors at Geological Survey of Czechoslovakia, Prague).

The studied samples of fluorite were collected from economically significant fluorite deposits and their indications. The results of the temperature measurements in the table below represent the ranges of homogenization temperatures:

Jilove u Decina	110-150°C
Harrachov	115-175°C
Hradiste	95-145°C
Krizany	95-130°C
Moldava	125-160°C (1st generation) and 105-130°C (2nd generation)
Vrchoslav	115-160°C (1st generation) and 110-145°C (2nd generation)
Vys. Sneznik	155-190°C
Javorka	125-160°C
Teplice	70-95°C

The temperature ranges of the studied samples from Czechoslovakia fluorite deposits are comparable with the values published by Roedder for Mississippi Valley type stratiform ore deposits. They are also within the range given by Naumov and Kodakowski for fluorite deposits.

Experimental data on fluorite solubility suggest that there is a significant temperature interval from about 100 to 200°C, suitable for transport of fluorine as well as for precipitation of fluorite.

Freezing temperature measurements and the presence of halite in the inclusions of some samples indicate that at least some of these fluorine deposits were formed from concentrated saline waters. The formation of MgF^+, NaF^+, and CaF^+ complexes in fluorine-bearing solutions was obviously responsible for the transport of fluorine. The decomposition of these complexes with decreasing temperature resulted in the precipitation of fluorite.

CURRIE, J.B., and NWACHUKWU, S.O., Fluid Inclusions in Fracture-fillings of Petroleum Resevoir Rocks, (Dept. Geology, Univ. of Toronto, Toronto 181, Canada)

In assessing the origin of fracture porosity, a question arises as to depths at which the fractures may develop and become openings that conduct fluid flow. Information bearing on this question can be gained from determination of the homogenization temperature for fluid inclusions in the filling material which now occupies some of these fracture openings. Samples are obtainable both from outcrops and from subsurface cores.

Two examples are reported, one from the Ram River - Ricinus area of central Alberta foothills, the other from the Beaver River area of northeastern British Columbia. Homogenization temperatures in the former area lie near 100°C and 50°C for primary and secondary inclusions in quartz that fills microfractures in sandstone of the Cardium formation. These data are combined with other geological evidence to determine the depths at which fractures must have been opened and their filling material deposited. In the Beaver River area, two separate homogenization temperature ranges are also evident for fluid inclusions in the Middle Devonian carbonates comprising the resevoir rock there. These ranges are around 165°C and 100°C for primary and secondary inclusions respectively.

DEICHA, Georges, Investigation des cavities intraminerales par microscopie électronique a balayage, (Directeur de Recherche, Centre d'Etudes des Inclusions, Tour 16, (5ème étage) 9, quai Saint-Bernard. 75-Paris, France).

La miniaturisation actuelle des recherches sur les inclusions (Gas und Flüssigkeits Einschlüsse in Mineralien. Schweizerische mineralogische und petrographische Mitteilungen, 1971, Band 50, Heft 1) se trouve encore accélérée par le recours à la fractographie électronique par balayage. Grâce au service spécialisé du Muséum National d'Histoire Naturelle (Laboratoire de Géologie) cette technique a pu être utilisée depuis un an par le Centre d'Etudes des Inclusions (Université de Paris VI). A cette écrelle d'observation, les petites cavités microscopiques (10 à 1 microns) et surtout les cavités submicroscopiques (inférieures à un micron) prennent le pas sur les inclusions de plus grande taille. Les résultats obtenus obligent à reconsidérer les rapports entre les inclusions syngénétiques et épigénétiques. Les variations de la morphologie, de l'abondance et de la répartition des cavités conduisent également à envisager leur rôle dans la distribution des éléments traces et dans le réadjustment des rapports isotopiques.

DEJONGHE, Léon, Les inclusions aqueuses de la gangue du gîte de Ravandje (Iran). Etude de la morphologie de leurs cavities au microscope à balayage, (Laboratoire de Géologie appliquée, Univ. de Bruxelles).

In order to determine the temperature of crystallization of the paragenesis of the ores of Ravandje, the fluid inclusions of baryte have been watched by optical microscopy in transmitted light The monophase nature of the water filling has been confirmed under the crushing stage and by decrepitoscopy.

Further information under the electronic scanning microscope has shown the genetical conclusions which can be deduced from the morphology of the cavities and their mutual relationships.

DRAKE, William E. & YPMA, Peter J. M., Fluid inclusion study of the Mineral Park porphyry copper deposit, Kingman, Arizona, (Authors at Dept. of Geology, Columbia University, New York, N.Y. 10027.)

Disseminated chalcopyrite and minor molybdenite mineralization, brecciation and alteration zones in a concentric arrangement around a monzonite stock denominate the Mineral Park deposit as a typical porphyry copper deposit. Atypical is an extensive base metal vein mineralization NE and SW of the porphyry deposit. Fluid inclusion studies have demonstrated continuity between disseminated copper mineralization and base metal vein mineralization. The mineralization sequence occurs in several stages: I - Pegmatitic quartz pods confined to the stock, II - Quartz-molybdenite veinlets, III - Chalcopyrite-pyrite veinlets, IV - Extensive quartz-chalcopyrite-sphalerite-galena veins. Both II and III occur in the immediate vicinity or within the stock. The sequence II to IV is one of decreasing average temperatures: 450° to 230° and decreasing salinity: 10 to 3 wt% equivalent NaCl. The veins show temperature zoning concentric with regard to the stock: from 360° to 230°. Pressures inferred from fluid inclusions and boiling conditions during the chalcopyrite stage point to equal pressures for the whole sequence: 400-550 bar. The primary nature of the inclusions is difficult to establish. Large variations in the CO_2/H_2O ratios -- with a slight tendency of decreasing (7-2 mol%) CO_2 content towards the low temperature deposits -- indicate mixing of solutions of different sources.

The early pegmatic quartz inclusions are discontinuous with regard to the mineralization. They have lower salinity (6 eq. wt% NaCl), lower CO_2 content (4 mol%), and higher temperatures 450-500° at equal pressure.

A model is proposed in which the porphyritic solutions represent an almost sterile magmatic stage, followed by convection circulation of solution of non--or only partly hypogene origin, which increased with time and depth in salinity but became disrupted by later magmatic fluid release. The multiplicity of the intrusive event -- so characteristic for porphyry copper deposits -- becomes a major factor in this model triggering the mineral deposition.

ERMAKOV, N.P., -See p. 18

[illegible], [illegible], [illegible], G. and [illegible], A.G., Liquid CO_2-inclusions in olivine bombs - generated by decomposition of "orthocarbonates"? (Mineralogisches Institut der Universität Erlangen-Nürnberg, 852 Erlangen, Schlossgarten 5, Germany).

Already in 1869 and 1870 a paper on "Inclusions of liquid carbon dioxide in olivines" was published by H. Vogelsang and F. Zirkel. The detailed microscopical investigation of lherzolitic olivine bombs shows that such inclusions are present in all of them.

However, it was the merit of E. Roedder to point out the importance of these inclusions for the origin of olivine bombs as well as for basaltic magmas. In order to find out the relations between inclusions and host olivines on one hand and bombs and basalts surrounding them on the other hand, it seemed necessary to get exact analyses of the included gases at first. These analyses were performed by mass spectrography. Moreover the oxygen fugacities of the bombs and of their basalts were determined.

The investigations by mass spectrography revealed that the inclusions mainly consist of C,H,O - compounds, especially of carbon dioxide and of carbon monoxide. If the possible adulteration of gas composition through the analytical procedure is taken into account an average CO_2/CO ratio of 60-200 will be found at room temperature and at 1 atm. The CO_2/CO ratio defines a certain oxygen fugacity which may be compared with the respective fugacities in olivine bombs and basalts. The very surprising result is:
Inclusions and olivine bombs are in redox equilibrium over a wide range of temperature whereas the bombs and basalts surrounding them do not. This is demonstrated in fig. 1.
The different oxygen fugacities in olivine bombs and basalts show that the olivines cannot have crystallized from the melt, at least not in the middle or upper parts of the crust. Most probably their place of origin may be found in the upper parts of the Earth's mantle. The inclusions, mainly consisting of CO_2 and CO, may be explained as an exsolution product of the host olivine during its ascent. The carbon monoxide was created by redox reactions of the separating carbon dioxide with the ferrous iron of olivine. This process led to the formation of brown spinel, widespread in the inclusions, and possibly diamond in certain cases.
This is contrary to the conception of E. Roedder, who believes that the gases were taken up from the magma during the crystallization of the olivine or later.

The most probable interpretation for our results is that in mantle silicates a certain amount of Si^{4+} may be replaced by C^{4+} under the respective p,-T- conditions. At pressure release during ascent these "ortho-carbonates" are decomposed with liberation of molecular carbon dioxide which then can react with the ferrous iron of the silicates.

Literature:

FUDALI R.F. (1965): Oxygen fugacities of basaltic and andesitic magmas, Geochim. Cosmochim. Acta 29, 1063-1075.

ROEDDER, E. 91965): Liquid CO$_2$ inclusions in olivine-bearing nodules and phenocrysts from basalts. Am.Min. 50, 1746-1782.

Vogelsang, H. (1869): Nachtrag zu der Abhandlung "Über Flüssigkeitsseinschlüsse im Gestein", Ann. Physik Chemie 137, 257-271.

Zirkel, F. (1870): Untersuchungen über die mikroskopische Zusammensetzung und Struktur der Basaltgesteine, Adolf Marcus, Bonn.

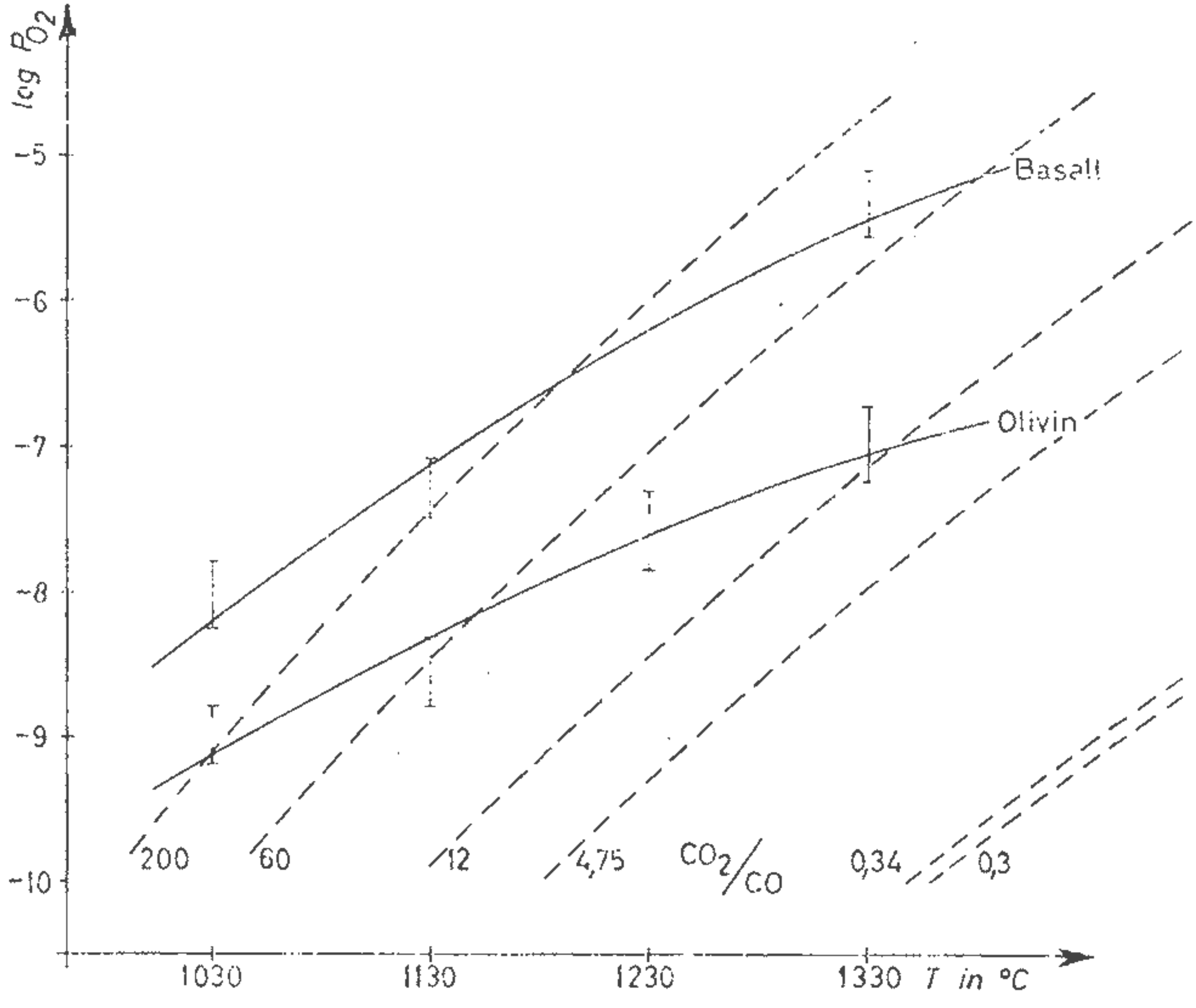


fig. I : oxygen-fugacities of olivine, surrounding basalt and different CO$_2$/CO - mixtures.

ERMAKOV, N.P., Geochemical classification of inclusions in minerals,
(M. V. Lomonosov State University, Moscow, USSR).

I. Geoendogenous and metamorphogenous

I. Magmatic
(solidified melts)
- I) Amorphous (silicate glasses)
- 2) Crystalline (crystal-granular aggregates)
- 3) Crystal-fluidal (residual melts and brines)

2. Pneumatolytie
(gas mixtures)
- 4) Air-exhalational (single-phase-gaseous)
- 5) Essential gaseous (two-phase, low density, hypogene)
- 6) Fluidal (juvenile dense gases; two- and multiphase)

3. Hydrothermal
(aqueous-liquid solutions)
- 7) Ionic-molecular (true salt solutions)
- 8) Colloidal-aqueous (syneretical liquids)
- 9) Aqueous-carbonaceous and boiling solutions

4. Metamorphic
(in solid media)
- 10) Metamorphosed (superdense liquids and condensed gases)
- 11) Metamorphic (hydrocarbons)
- 12 Metamorphosed (recrystallized glasses)

II. Geoexogenic (and biogenic).

5. Cold-water
(in aqueous minerals single phase liquid)
- 13) Authigenic-marine-subsaline-aqueous
- 14) Halogenic (lagoon-limnetic brines)
- 15) Infiltrationic-aqueous solutions

6. Liptcbiogenic
(inclusions in fossil pitches)
- 16) Paleoatmospheric (air bubbles)
- 17) Paleohydrogenous (secondary preservation of marine water)

III. Cosmogenic and selenogenic.

7. Selenomagmogenic
(in effusive and regolith of Moon)
- 18) Amorphous-crystal-gaseous (glass, daughter minerals, gas)
- 19) Gas-volcanic (single-phase, unsaturated gases)

8. Cosmogenic
(asteroid and cometogenous)
- 20) Meteoric (glass-gaseous and carbonaceous)
- 21) Tektite (lechatelierite and gas-vacuum)

IMAI, Hideki, and TAKENOUCHI, Sukune, Fluid inclusions in quartz in granitic rocks and associated vein-type deposits. (Dept. of Mineral Development Engineering, Univ. of Tokyo, Tokyo 113, Japan).

In the study of fluid inclusions in quartz from the Taishu mine of western Japan, a mesothermal zinc and lead vein deposit, we observed under the microscope that highly saline inclusions occur in the quartz of the granite. These correspond to the ore-forming fluid, concentrated in a limited part of the granite mass. It migrated along the vein-fissures and deposited the vein-materials. In the course of migration, the fluid was gradually diluted by the meteoric or connate water. This is recognized by the study of fluid inclusions in the vein-quartz from the various parts of the veins.

In the Ohtani mine of the central Japan, hypothermal tungsten and tin veins occur in the granodiorite. The granodiorite suffered greisenization around the veins. In greisen and granite, two-phase fluid inclusions are recognized. The filling temperatures of inclusions of both rocks are nearly the same, i.e., 275-355°C. The ore-forming fluid was not supplied from this grandiorite itself and the source of the fluid must exist in the deeper part of this area.

In the Kumano district of central Japan, many mesothermal or epithermal copper veins exist around masses of granite porphyry. Highly saline inclusions are found in the quartz phenocrysts of granite porphyry in the Onigajyo area, though no copper vein is found in this area.

In central Hokkaido, gold-silver veins as well as zinc-lead veins are genetically related to an intrusion of quartz porphyry. Highly saline secondary inclusions in the quartz phenocrysts of the quartz porphyry are recognized near the Tokuryu mine.

Though the existence of highly saline inclusions in the constituent quartz of granitic rocks or quartz porphyry does not necessarily indicate the presence of ore deposits, it is possibly expected in an area which has produced ore deposits.

KOZŁOWSKI, Andrzej and KARWOWSKI, Łukasz, Bromine in gaseous-liquid inclusions in postmagmatic minerals from Lower Silesia. (Institute of Geochemistry, Mineralogy and Petrography, Dept. of Geology, Warsaw Univ., Warsaw 22, al. Zwirki i Wigury 93, Poland).

This paper reports a preliminary investigation of bromine geochemistry in hydrothermal environments. The concentrations of Br^- in aqueous extracts from a number of minerals were determined. Higher concentrations of Br^- were found in samples from lower-temperature solutions. The ratio Cl/Br varies from 1200 to 39. The concentrations of Br^- found, in ppm of mineral, are as follows: albite 0.11-0.96; pegmatitic and drusy quartz - 0.18-2.9; vein quartz - 0.22-1.7; fluorite - about 6; epidote - about 0.6; stilbite - about 2.7; and calcite - about 4. The average concentration of Br^- in the inclusion fluid itself varies from 0.015% to about 0.2%. Part of the postmagmatic solution was trapped in intergranular spaces and as secondary inclusions in granite. This is evident from the fact that higher concentrations of Br^- were found in extracts from granite containing numerous hydrothermal and pegmatitic bodies, in comparison with those which contain neither pegmatites nor hydrothermal veins. The concentrations (in ppm) of Br^- in granites are 0.58-1.05; aplites - 0.36-0.66; and pegmatites as a whole - 0.21-1.1.

The average concentrations of Li+, Na+, K+ in the inclusion fluids were determined by analyses of aqueous extracts.

The samples were mainly from the area of the Strzegom, Strzelin, and Karkonosze massifs, and the Izera area.

MOGHDON, M.J., A Fluid Inclusion Study of the Porphyry Copper Deposits at Ray and San Manuel, Arizona, (Princeton University, Department of Geological and Geophysical Sciences, Guyot Hall, Princeton, N.J. 08540).

The porphyry copper deposits at Ray and San Manuel are associated, both spatially and temporally, with Laramide granitic rocks which intrude Precambrian quartz monzonite ± Precambrian and Paleozoic sedimentary rocks.

Quartz grains in samples from the K-feldspar - biotite and the quartz - sericite alteration zones show five types of fluid inclusions. Type I inclusions have liquid + small bubble ± opaque daughter mineral; Type II inclusions have liquid + large bubble ± opaque daughter mineral. Type III inclusions have liquid + small bubble + multiple daughter phases. Type IV inclusions have two liquids + vapor + solids; Type V inclusions contain three fluid phases only. Halite, sylvite, and hematite have been definitely identified; anhydrite may also be present. The fluids are H_2O and CO_2.

The wide range of homogenization temperatures (200°->450°C), and the differences in density, salinity, and ratio of H_2O to CO_2 indicate that the inclusions were trapped at or near the two - phase boundary of the system NaCl - KCl - H_2O - CO_2 It is proposed that boiling, quite typical for the fluids of porphyry coppers, was achieved by a sudden pressure release due to massive fracturing

PETROVIC, Radomir, Coalescence of fluid inclusions and their removal from minerals exposed to confining pressure greater than the pressure of the fluid in inclusions.(Author at Department of Geology and Geophysics, Yale University, New Haven, Connecticut 06520).

When the pressure of the fluid in fluid inclusions is lower than the pressure acting on the outside of the host crystal, fluid inclusions perturb the stress field in their vicinity in such a way as to attract one another and to be attracted to grain boundaries. However, the corresponding gradients in molar Gibbs free energy of the host substance are too low for migration of fluid inclusions that do not intersect at least one dislocation with a screw component. Fluid inclusions located on such dislocations should migrate, but the rate of migration of one fluid inclusion towards another should be inversely proportional to the 15th power of the distance between the centers of inclusions (assumed spherical), and it appears that the migration should not be significant when that distance exceeds the sum of inclusion radii by more than a few percent.

POTY,B. and WEISBROD,A., Equilbria between minerals and solutions in the Mayres pegmatite (Cévennes médianes, French Massif Central), (Centre de Recherches Pétrographiques et Géochimiques, CNRS, Case Officielle No. 1, 54-Vandoeuvre, Nancy, France).

The pegmatite of Mayres is interbedded in biotite-sillimanite-orthoclase augen-gneisses which belong to the catazonal part of a low pressure metamorphism. It lies a bit above the upper front of a regional granitization and is overlain by lenses of a biotite-rich basic rock.

The mineralogy consists of:

I. Quartz - orthoclase - albite - biotite -(cordierite)
II Quartz - orthoclase - (albite) - andalusite - tourmaline
III Quartz - albite - muscovite - tourmaline
IV Quartz - orthoclase - chlorite.

Fluid inclusions have been studied for stages III and IV. They consist mainly of a low density fluid (homogenization temperature from 400 to 200°C with evidence of evolution close to the boiling curve) and a rather low salinity (freezing temperature around -4°C). Analyses of leachates of crushed quartz give very low K/Na at. ratios (around 0.05).

From petrology and fluid inclusions we can infer the following characteristics for the genesis of this pegmatite:

1) beginning of growth deduced from experimental curves must have occurred near 650°C and 3.5 Kb.
2) growth of andalusite in presence of orthoclase suggests during stage II a sudden decrease of pressure against a nearly constant temperature.
3) one of the most interesting features results in the amazingly low K/Na ratio which shows the lack of chemical equilibrium between solutions and 2 feldspars + muscovite. The solutions behave as if the most important mineral in volume of the pegmatite, i.e. K-spar, was totally absent.

RASUMNY, J., A Propos de la Rapidite de Coalescence des Bulles dans les Inclusions Fluides Soumises a la Rétroébullition, (Geologie Structurale et Appliquèe - Bat no. 504, Faculté des Sciences, 91 , Orsay, France).

La coexistence de bulles dans les milieux critallo génétiques pose de multiples problèmes. Il est loisible d'en expérimenter les possibilités en observant la rétroébullition dans des inclusions: sur l'exemple d'un film réalisé par J. Painlevé (Institut de Cinématographie Scientifique) sur un échantillon de C. Taddei (Bellinzona, Tessin). Il est montré que la "durée de vie" des bulles de CO_2 gazeux as sein de CO_2 liquide est souvent limitée à une fraction de seconde Dans les expériences réalisées sur des exemples analogues cette durée de vie n'a pas excédé quelques minutes. Des études micro-cinématographiques analogues sur les inclusions aqueuses sont suggérées. On sait par contre (G. Deicha - Les Lacunes des cristaux, Paris, 1955, Masson édit., p. 85) que des bulles peuvent persister indéfiniment dans les reliquats magmatiques (R. Clocchiatti, Schw. Min. Petr. Mitt., 1970, B 50, H. 1, pp. 159-166).

ROEDDER, Edwin, Interpretation of silicate melt inclusions in lunar, terrestrial, and meteoritic minerals, (U.S. Geological Survey, Washingron, D.C. 20242, U.S.A.).

Melt inclusions, common in most igneous rocks from lunar, terrestrial and meteoritic minerals, are analogous to the aqueous ("fluid") inclusions of terrestrial samples, but the nature of melts limits the analogy and may cause erroneous interpretation of the inclusion data.

With the exception of interstitial melt inclusions, the mechanisms of trapping are similar. In contrast to aqueous inclusions, compositional gradients in the melt away from a rapidly growing face may result in trapping of nonrepresentative melt. Errors from this feature can be minimized by using several different host minerals and by laboratory reheating.

Crystallization of rock-forming minerals after trapping causes the major differences between aqueous and melt inclusions. It permits placing relative or absolute limits on the cooling history (both time and temperature) since trapping. The sequence and temperatures of nucleation and growth of the various phases can sometimes be determined. Such data are valuable in interpreting differentiation trends if equilibrium can be verified in the experimental runs.

Crystallization of the host mineral on the walls of the inclusion has several important consequences:(1)coeval inclusions in different host minerals may have grossly different compositions, none identical to the original melt; (2) large volume decreases on crystallization of major amounts of the inclusion contents (as from a nearly monomineralic melt) can yield a large percentage of shrinkage volume, easily misinterpreted as primary gas inclusions; (3) if the trapped melt consists of two major constituents, one of which is the host crystal, nearly monomineralic crystal inclusions may form, each with a shrinkage cavity.

SAWKINS, F.J. and LANDIS, G., Fluid Inclusion Studies of Andean Ore Deposits, (Dept. of Geology and Geophysics, Univ. of Minn.)

Detailed fluid inclusion data are available from several Andean metal deposits and reconnaissance data have been gathered from others

The available data from Andean porphyry coppers, copper-bearing tourmaline breccia pipes, and vein deposits of tin, tungsten, copper-lead-zinc and silver demonstrate in general a decrease in temperature of ore deposition and average salinity of ore fluids from porphyry deposits, to breccia pipe deposits, to vein deposits. Furthermore, there is a general decrease in temperature and salinity of ore fluids with time during the deposition of individual deposits.

The presence of ore fluids containing >40 wt. % chloride salts is indicated by fluid inclusions containing NaCl daughter minerals in all the higher temperature (>350°C) deposits. The wide geographic area over which such deposits occur, and the paucity of major evaporite horizons in the Andean stratigraphic column strongly suggest that the chlorides contained in these ore fluids were of primary magmatic derivation. Pressure estimates based on fluid inclusion data imply that in all cases mineralization occurred at shallow depth (<2 km from the surface).

In the few instances where stable isotope data on inclusion fluids and hydrothermal minerals are available a derivation of the bulk of the ore constituents and fluids from magmatic sources is indicated. Finally, the large range of formation temperatures indicated for many of the deposits, and the relatively high temperatures obtained from silver veins of low temperature aspect, demonstrate that the terms hydrothermal, mesothermal and epithermal, as defined by Lindgren and used by many workers, are of little utility.

TAKENOUCHI, Sukune, Ore-forming fluids at the Takatori tungsten-quartz veins in Japan, (Department of Mineral Development Engineering, University of Tokyo, Tokyo 113, Japan).

Fluid inclusions in quartz, cassiterite, topaz, fluorite and rhodochrosite from the Takatori tungsten mine were studied by means of the heating-stage, freezing-stage and crushing-stage methods. From the results of the investigation, it is concluded that the temperature of the ore-forming solutions was in the range of 200° to 360°C and the salinity was 0 to 10 weight percent NaCl equivalent.

Of the inclusions from the Takatori mine, those of topaz were characteristic. The filling temperature of the inclusions in topaz concentrated in the range of 330° to 360°C, which corresponds to the higher part of the temperature distribution, while the salinity was in the range of 2.0 to 4.0 weight percent NaCl equivalent, which is the lower concentration for the ore-forming solutions at the Takatori mine. The investigation by the crushing-stage revealed that the internal pressure of fluid inclusions was in the range of 4 to 60 atm at room temperature. CO_2-rich inclusions were found in drusy quartz These inclusions were mostly secondary. Two types of CO_2-rich inclusions were recognized and the CO_2 concentration was estimated from the freezing data and from the volumetric ratio of each phase in inclusions as 5 to 15 weight percent CO_2 for the high density solutions and 30 to 60 weight percent CO_2 for the low density phase. It is inferred that CO_2 concentrated at the late stage of the mineralization owing to the separation of the gas and liquid phases. From the P-T diagram of the H_2O-CO_2 system, the separation of the two phases would have occurred at about 270°C and 230 bars.

TAKENOUCHI, Sukune, Glass inclusions in quartz of volcanic rocks from mining areas. (Department of Mineral Development Engineering, Faculty of Engineering, University of Tokyo, Tokyo 113, Japan)

Glass inclusions in quartz crystals of volcanic and pyroclastic rocks, from several mining areas, were studied by means of microscopic observation, heating experiments, laser-probe and electron-probe microanalysis. They were classified into 8 types according to their constituent phases. Heating experiments revealed that the homogenization temperatures of glass inclusions ranged from 900°C to 1,200°C. The composition determined by electron-probe microanalysis was generally rich in SiO_2, Al_2O_3, Na_2O and K_2O, and poor in CaO, FeO and MgO. Laser-probe microanalysis revealed the presence of Cu, Ag and Zn in some inclusions. The various states of glass inclusions would generally reflect the thermal environment of host minerals during cooling.

YPMA, Peter J.M., The analysis and significance of volatile constituents in fluid inclusions and their P-T relations. (Author at Dept. of Geology, Columbia University, New York, N.Y. 10027)

The analysis of fluid inclusion content raises problems of contamination, extraction techniques and the large differences -- several orders of magnitude -- between minor and major constituents. The last problem is overcome by gas chromatographic analysis using an exponential dilution flask and three columns: one for water, a second for CO_2 and H_2S, and a third for gases, such as CH_4, H_2, CO, O_2 and N_2. Gas chromatography enables the extraction -- by decreptitation -- to occur in the carrier gas (He) and obviates the problems of ultra high vacuum. Contamination due to absorption is reduced by moderate sequential heating steps (lower than decrepitation temperatures) in a low pressure He-atmosphere, and by monitoring the purge products. The He-ionisation detector is sensitive in the parts per billion range for most common volatile constituents.

Analysis by progressive temperature decrepitation of quartz samples of the Mineral Park porphyry copper deposit near Kingman, Arizona, indicates parallel release curves for CO_2 and H_2O up to 500° and a continued release of CO_2 beyond that temperature. CH_4 only appears around 300° C and runs parallel to H_2O. H_2 appears at 400-500°C and rapidly increases in the higher temperature ranges. The fluids have the following average mol. ratios: $CO_2/H_2O = 0.02 - 0.06$; $CH_4/CO_2 = 0.05 - 0.30$, and $H_2/CO_2 = 0.05 - 0.10$.

Calcuation of the gas-equilibria as minimum free energy gas mixtures from a fixed H:O:C atomic ratio indicate that the compositions represent decrepitation equilibria between 300 and 500° and 100 and 500 bar. In the progressive temperature decrepitation runs CH_4 is consistently lower, and H_2 consistently higher than the calculated ideal values. The excess H_2 is considered to be of lattice-held origin, being released only at the higher temperatures. The lack of CH_4 may be due to the escape of H_2 through the lattice after entrapment, which will drive the reaction $CO_2 + 4H_2 \rightleftharpoons 2H_2O + CH_4$ to the left. A sharp drop in pressure at about equal temperature -- such as with inclusions of low temperature origin and a high degree of filling -- will also drive the equilibrium to the left. These mechanisms explain why mineral deposits of shallow-origin show less CH_4 than one would expect in the inclusions at observation temperatures. The implication of this hydrogen leakage is important for stable isotope studies of fluid inclusion content.

AKHVLEDANI, R.A. and others, 1968, Rock crystal veins of Alpine type in the Greater Caucasus and their tectonics: Soobshch, Akad. Nauk. Gruz. SSR, v.52(1), p.115-120 (in Russian). (Author at Geol. Inst. Tbilisi, U.S.S.R.).

The gas inclusions in quartz of the Alpine veins of rock crystal in the Khdestakali and Shoda deposits were studied to det. the phy.-chem. conditions of the mineralizing solns. The formation temp. was detd. by homogenization with subsequent corrections for pressure. The pressure was calcd. The data on distribution of temp. and pressure during vein formation were interpreted with consideration for sequence of mineral deposition. Prehnite and clinozosite, which according to Sterns, form at 250-350° under 500-4500 atm. pressure were present in the Khdestakali veins cutting diabase. The homogenization in quartz and clinozosite from a selvage part of the veins had the highest value: 275° at 1200 atm. The selvage zones in the Shoda quartz veins contained albite. Max. measured T and P in albites and quartz were 210° at 1000 atm. The veins were formed under dynamic conditions when the rate of quartz crystn. was higher than the rate of fracture openings. The main mass of SiO_2 was deposited evidently at 250-260° and 1000-1200 atm. for the Khdestakali and 185-90° and 900-1000 atm. for the Shoda deposits. Chem. anal. of aq. ext. from quartz indicated their chloride-bicarbonate character. Na, Ca, and Mg with small amts. of K predominated among the cations. The Mg/Cl ratio in these deposits as well as total mineral content of mineralizing solns. (2.7-16 and 4.6-22.4 g./l. for the Khdestakali and Shoda veins, resp.) included similarity of mineralizing soln. with brines typical of saliferous and sea basins. This substantiated the metamorphic character of both soln. and veins in the Khdestakali and Shoda deposits. CA v. 70 (7) 125, 1969.

AMIGO, Jose Maria and FONT-ALTABA, Manuel, 1968, Thermal behavior (decoloration, decrepitometry) of several fluorite, galena, and sphalerite specimens from the Osor deposit (Gerone): Bol. Real Soc. Espan. Hist. Natur., Secc. Geol., vol. 66 (1) p. 53-59 (in Spanish).

Decrepitation temperatures of 380-400°C (fluorite), 400-420°C (galena), and 440-480° (sphalerite). All fluorites lost their color at 400°C. (E.R.)

ANDERSON, A.T., JR. and GOTTFRIED, D. 1972, Hat Creek basalt, California: Similarity to continental- and oceanic-type basalts: Amer. Geophys. Union Trans. (EOS), v. 53, p. 547.

The Holocene Hat Creek high-alumina, olivine tholeiite north of Lassen Peak consists of early flow units (E) that are chemically distinct from the later flow units (L):

Flow units	K_2O(%)*	K_2O/TiO_2	Ba(ppm)	Sr(ppm)	V(ppm)	Zr(ppm)	Nb (ppm)
Early (E)	0.35-0.58	0.33-0.39	160	490	[illegible]	70	7
Late(L)	0.19-0.36	0.15-0.25	90	280	[illegible]	60	2

*Range for glass inclusions in olivine phenocrysts, host glass, and bulk lava.

Transition between E and L is sharp; L is compositionally more variable than E and has rare olivine xenocrysts containing glass inclusions with E compositions. Some differentiates (segregation veins) of L are similar to E in terms of K_2O, Ba, Sr, V, Nb, but not TiO_2, Zr, and other elements. L is similar in many chemical characterisitics to "oceanic-type" basalts, e.g., those dredged from Juan da Fuca Ridge; E is chemically more akin to"continental-type" basalts. Chemical differences between E and L are explained by crystallization-differentiation coupled with vapor phase transport of volatile elements in a high-level magma chamber. Caution is indicated in using chemistry to infer tectonic setting of basaltic lavas. The Hat Creek Basalt was first described by C.A. Anderson in 1940. (Authors' abstract)

ANDRUSENKO, N.I. and KIEVLENKO, E.Ya., 1968, Multiphase liquid inclusions in Iceland spar from Kirghiz granitic pegmatites, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 190-196 (in Russian).

The inclusions homogenized at temperatures up to 200°C, and the daughter crystals recrystallized on cooling. Identified daughter phases include halite, sylvite, rutile, and hematite. The composition of the fluids (up to 440 g/l of chlorides of Na, K and Ca) is hence not like those from other types of Iceland spar (i.e., the deposits in trap rock). (ER)

ANDRUSENKO, N.I., and MEL'NIKOV, F.P., 1968, Cryometric studies of liquid inclusions in Iceland spar from USSR deposits, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v. 2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 141-148 (in Russian)

Inclusions in calcite from several geologically different types of Iceland spar deposits in U.S.S.R. differ in their behavior on the freezing stage (an indication of differences in solution salinity). Freezing temperatures of -25 to -64°C are recorded . (ER)

ANDRUSENKO, N.I. and VASILYEVA, M.S., 1968, On liquid inclusion in apaphylite: L'vov Univ. Min. Sbornik v. 21, no. 1, p. 47-53 (in Russian).

Two types of inclusions were found: two-phase (liquid plus about 40% vapor), in equant crystals, and "one-phase" (liquid plus $\lesssim$5% vapor), in tabular crystals of apophylite from Siberian basalts. The two-phase inclusions lose their liquid on heating to about 130° without breaking. The freezing points range from -24 to -57°C (mainly near the latter) but change with experimentation. (ER).

APLONOV, V.S., 1969, Thermal conditions in the formation of crystal quartz veins of the northern Verkhoyansk area: Uch. Zap. Nauch.-Issled. Inst. Geol. Arktiki, Reg. Geol, 1969, no. 14, p. 45- 50 (in Russian).

ARKHIPCHUK, R.Z. and LYSAK, G.I., 1968. (See Translations Section)

ARKHIPCHUK, R.Z. and ROSIKHINA, A.I., 1969, Conditions of formation of the fluorite mineralization of western Transbaikal from data on mineral thermometry: Geol. Rudnykh Mestorozhdenii v. 11, no. 5, p. 110-113 (Translation to appear in next issue)

ARNOLD, R.G., and RUTHERFORD, M.J., 1969, Data for brine and carbon dioxide filled liquid inclusions in quartz veins from the Coronation mine, in A.R. Byers, ed., Symposium on the geology of the Coronation mine, Saskatchewan: Ottawa, Geological Survey of Canada Paper 68·5, no. 10, p. 213-228.

Liquid inclusions assumed to be primary occur in quartz veins cutting the ore bodies in Coronation mine. Hand specimens collected from seven levels contain liquid inclusions of three general types - brine-gas (most common); brine-CO_2 fluid-gas, and CO_2 fluid-gas (all with or without crystals, presumably NaCl.) Analyses were made of electrolytically cleaned quartz samples for CO_2 and H_2O by combustion at 1200°C and absorption. Additional samples were crushed, electrodialyzed, and analyzed for K, Na, Mg and Ca. The ratios found were both $Na > Ca \gg K > Mg$. On heating the NaCl daughter crystals dissolve by 140° to 300°C; the bubble disappears below about 250°C. The CO_2 phases homogenize in the liquid phase at temperatures between -16 and +29°C. The three-phase inclusions homogenize as high as 400°C "Freezing temperatures" (specific phase changes not stated) were found to be -19 to -50°C. Pressures, calculated from homogenization temperatures for CO_2 and brine inclusions, range from 1640 to 2830 bars, (ER).

AVAKOV, K.R., 1968, Geological-geochemical and thermometric study of a Ural quartz deposit: Sb. Nauch. Stud. Obshchest., Geol. Fak., Mosk. Gos. Univ. 1968, No. 6, 187-200 (in Russian).

Mainly a study of the movement of elements, in and near quartz veins, with some thermometry (ER)

BAKUMENKO, I.T., KAZANSKII, Yu. P. and SHUGUROVA, N.A., 1969, Determining the composition of the ancient atmosphere from the gas phase in individual inclusions in minerals: Paleogeogr. Litol.-Fatsii Issled. SSSR, 1969, p. 27-28 (in Russian).

Accuracy of the method (checked with synthetic standards) was $\sim\pm 20\%$ for bubbles $\sim 50 \mu m$. Analyses of gases from samples of Precambrian sediments and Hereynian ore deposits are presented. Referativ. Zhur. Geol. v. 1969, abst. No. 9 V649. (ER)

BAKUMENKO, I.T., LAPUKHOV, A.S. and SHUGUROVA, N.A., 1969, Crystalline inclusions in quartz from paleotype rocks: Akad. Nauk SSSR, Doklady, v. 185 p. 1137-1140 (in Russian). Translated in Doklady Acad. Sci. USSR, Earth Sci. sec., v. 185, p. 139-142. (Authors at Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, USSR).

Primary melt inclusions in quartz phenocrysts from the Salair ore field are now mainly opaque crystalline masses, without visible bubbles. Homogenization studies (mainly on the smaller inclusions that do not leak as often) show melting at 900° and homgenization (after stabilization) at 1125-1150°C. Considerable metastability occurred on cooling. The authors take exception to the interpretation of melt inclusions by A.V. Gromov, (1968; incorrectly listed as 1967; see Proc. of COFFI, 1968.) Gases from the bubbles in 7 inclusions were analyzed. N_2 and CO_2 were the major constituents, with minor acid gases and no O_2, CO, or H_2 . (ER)

BAKUMENKO, I.T., and LYSAKOV, V.S., 1965, Relation of growth conditions and subsequent history of quartz from different pegmatite

zones to specific thermofluorescence [thermoluminescence]: Akad. Nauk SSSR Doklady, v. 166, no. 3, p. 680-683 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. Sec., v. 165, p. 124-127, [illegible]
The thermoluminescence of quartz samples is compared with the homogenization temperatures of inclusions in the same samples. (ER)

BALITSKII, V.S., SAMOILOVICH, M.I., NOVOZHILOV, A.I., and CHUPAKOV, G.P., 1966, On the influence of the temperature conditions of formation of quartz on the content of the structural aluminum impurity: Mineralog. Sbornik L'vov Gosudarst Univ. v. 20, p. 430-434 (in Russian). Temperatures of homogenization of inclusions are compared with the electron paramagnetic resonance of the host quartz. (ER). (See Translations, this issue).

BARABANOV, V.F., 1969, Lectures on genetic mineralogy. vol-I: Leningrad, Leningrad Univ. Press 181pp. (in Russian)
Occasional references to data from fluid inclusion studies (e.g., Lecture 8) (ER).

BARTHOLOMÉ, P., 1966, Les inclusions fluides des mineraux et leurs enseignements en métallogénie: Revue Universelle des Mines, 1966, p. 171-178. A review with 6 figures and 15 references. (ER).

BARTOSHINSKY, Z.V., MATKOVSKY, O.I., PAVLISHIN, V.I., and PEREGUDA, A.I., 1967, Siderite and Calcite in Pegmatites of the Volhyn: L'vov. Univ. Min. Sbornik, v. 21, no. 3, p. 246-257 (in Russian, English abstract). Carbonates in pegmatites of the Volhyn are represented by siderite and calcite. Siderite is attached to a pegmatoid zone and to a zone of hydrothermal alteration and recrystallization, where it fills cavities as separate crystals, druses, and compact radial aggregates. On many crystals figures of both growth and solution are fixed. Homogenization data on inclusions show that the formation of siderite took place at comparatively low pressures(110-140atm) in the hydrothermal stage of alteration and recrystallization of pegmatites. The source of iron was the femic minerals.
Calcite, together with quartz, forms little druses in cracks of metasomatically altered granites, enriched in dark minerals. It is represented by scalenohedral crystals overfilled with solid inclusions. (Part of abstract, revised by ER)

BAZAROV, L. Sh., 1966, A device for freezing inclusions in minerals, in Materialy po genetischeskoi i eksperimental'noi mineralogii, V. 4: Novosibirsk, Akad. Nauk SSSR Sibirskoye Otdeleniye Inst. Geologii i Geofiziki, p. 231-234 (in Russian, English abs.). The device consists of a cooling stage on the microscope, a Dewar vessel for liquid nitrogen, and an arrangement for supplying a regulated flow of nitrogen to the stage (through the Dewar). Temperatures are read with a thermocouple and can be controlled down to -180°C. (Author's abstact revised by ER)

BAZAROV, L.Sh., 1968, A micro thermal chamber for high-temperature studies of inclusions in minerals: Geol. Geofiz. 1968, no. 8, p. 140-142 (in Russian).
An electrically-heated high temperature stage, for use up to

1650°C, with stated accuracy up to ±10° at 145-°C is described. This stage has been used to obtain the data in numerous published papers.(ER).

BAZAROV, L. Sh., and MOTORINA, I.V., 1967, Determination of the composition of solutions of individual multiphase inclusions by the method of freezing; Acad. Sci. SSSR Doklady, v. 176, no. 6, p. 1385-1387 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 176, p. 145-148, 1968.

Composition of solid phases (NaCl, KCl) in gas-liquid inclusions in quartz and fluorite, and total dissolved salts, are ascertained qualitatively on the basis of behavior of the inclusions at freezing temperatures, by comparisons with the known properties of such salts at such temperatures. (Authors' abstract).

duBERGER, REYNALD, 1967, Étude des minéraux de la ville de Québec: Bachelor of Science thesis, Univ. of Laval, 48pp. (in French).

The quartz crystals of the area contain much black organic matter (anthraxolite?), as well as yellow liquid inclusions that fluoresce under ultraviolet illumination. X-ray diffraction and infrared spectra were obtained on the anthraxolite. Decrepitation of the samples occurred over the range 55°-100°C. Loss on ignition varied from 0.31 to 6.82% (See also Bureau, 1958) (ER)

BILLINGS, Gale K., KESLER, Stephen E. and JACKSON, Stewart A., 1969, Relation of zinc-rich formation waters, northern Alberta, to the Pine Point ore deposit: Economic Geology, vol. 64, pp. 385-391.

Brine samples collected from Middle Devonian carbonate units about 350 km southwest and downdip from the Pine Point ore body (which is also in Middle Devonian rocks) show a close compositional similarity to analyzed inclusion fluids from other Mississippi Valley type deposits. Furthermore, bottom-hole temperatures in the brine collection zone are approximately the same as filling temperatures observed for Mississippi Valley type fluid inclusions, and the brines appear to be flowing from the collection zone toward Pine Point and appear to now contain sufficient Zn to produce another deposit about half the volume of Pine Point. These features suggest that the brines represent the fluid that formed the Pine Point ore. (Authors' abstract, shortened.)

BIRKELAND, Tore, and CARSTENS, Harald, 1969, Decoration of dislocations in quartz: Norges Geol. Undersokelse no. 258, p. 372-374.

Heat treatment of synthetic and natural quartz crystals may reveal dislocations, twin boundaries and microfractures. The decorating particles are believed to be tiny bubbles of water. It is shown that imperfections in metamorphic quartz commonly are decorated naturally. (Authors' abstract)

BLOUNT, C.W. and DICKSON, F.W., 1969, The solubility of anhydrite ($CaSO_4$) in $NaCl-H_2O$ from 100 to 450°C and 1 to 1000 bars: Geochem. Cosmoch. Acta, v. 33, p. 227-245.

The change in solubility for anhydrite from retrograde (at low salinities and temperatures) to prograde (at high salinities and temperatures) is of use in the interpretation of daughter mineral behavior(ER)

BOCHKAREV, A.I., 1969, Source of silica for the formation of rock crystal vugs in carbonate rocks : Geologiya i Razvedka, 1969, no. 10, p. 56-59 (in Russian, translated in Int. Geol. Review, v. 12, no. 9, p. 1018-1021, 1970).

Includes some data on decrepitation of quartz (ER).

BOCHKAREV, A.I. and MOSKALYUK, A.A., 1968, Formation temperature of quartz bodies and rock crystal vugs in a Ural deposit situated in carbonate rocks: Vses. Nauch.-Issled. Geol. Inst. Trudy, v. 162, p. 70-73, (in Russian). (Collected papers on experimental and geological-mineralogical studies of the process of ore formation).

Thermometry (both by homogenization and decrepitation) on aqueous inclusions (some with liq. CO_2) in various generations of quartz. (ER)

BOGOMOLOV, G.V.,+ KRASOVSKII, V.F., 1968, Inclusions of mineralizing solutions in endogenic rocks, and their effect on the composition of interstitial- and subsurface waters: Porovye Rastvory Metody Ikh Izuch. p. 104-108. Edited by Bogomolov, G.V., Izd. "Nauka Tekhnika": Minsk, USSR (in Russian).

Water leaches from crushed samples of quartz and fluorite of several granitic massifs and pegmatites were analyzed. If such fluids are released to ground waters (on crushing or weathering), they will affect their composition (ER).

BONEV, I., 1969, Liquid inclusions in galena: Comp. Rendus Acad. bulgare des Sciences, v. 22, no. 11, p. 1289-1292 (in English).

Huge inclusions (> 8mm) near the surface of galena crystals from various Bulgarian ore deposits form shallow indentations in the surface,which B believes represents natural deformation of the galena into the cavity when internal pressure decreased, NaCl and KCl (in the ratio of approx. 3 to 5) occur in the fluids, and they have a pH of 6.7 (microcolorimetric). The inclusions may be formed originally by skeletal growth. (ER).

BORCOȘ, MIRCEA, 1966, Some considerations of the determination of the thermodynamical conditions of formation of some hydrothermal veins and deposits in the Metalliferous Mountains region: Rev. Roumaine Géologie, Géophysique, et Géographie, Sér. Geol., v. 10, no. 1, p. 99-113 (in English). Homogenization (and decrepitation) temperatures of the principal gold and silver-bearing veins and deposits, sometimes highly polymetallic in depth, localized in the Almaș-Stănija area (Alba district), provides new data on Neogene volcanic ore formation in the Western Carpathians. Primary liquid inclusions (1153) in quartz, calcite and dolomite crystals from the Haneș, Fata Bàii, Muncăceasca East, Brádișor, Stnáija and Muncăceasca West deposits were measured. Homogenization temperatures ranged from 220°C to >357°C, and yielded a geothermal gradient of 10°C/100m for the hydrothermal fluids in these deposits (ER).

BORCOȘ, M., 1967, Geothermometric study of mineralization in the Neogene subvolcanic massif of Toroiaga-Tiganul, Maramures: [România] Com. Geol. Dări Seamă Șed., v. 53 (1965-66), pt. 2, p. 219-240 (in Romanian with French and English summ.).

The postmagmatic manifestations of hydrothermal origin exerted along some fractures associated probably genetically with the last arrivals of more acid magma consolidated in the subvolcanic mass, have determined the accumulation of some considerable ore bodies, showing a vein system. The mineralization of polymetallic nature, especially cupriferous, with a very low Au and Ag contents, was formed on account of a monoascendent hydrothermal activity. Based on former studies it is admitted that the forming temperature of the ore bodies corresponds to an epithermal or mesothermal stage up to 300°C. The results acquired from the investigations carried out during the study of the primary liquid inclusions show that the mineralization of the Toroiaga and Tiganul district was formed in conditions of a hypo-mesothermal stage with a slow and gradual decrease of the forming temperatures of the mineral generations deposited during the hydrothermal activity. In the main veins of the Toroiaga deposits a variation of the forming temperature both in vertical and horizontal direction, at the level of the chalcopyrite generation, is observed. (Author's abstract)

BORCOŞ, M., 1969, Le controle thermodynamique dans la métallogenèse associée au volcanisme Néogène des Monts Métallifères de la Transylvanie: Annales de la Société Géologique de Belgique, v. 92, pt. II, p. 307-320.
A review with 16 references. (ER)

BORCOŞ, Mircea, 1969, Les inclusions des minéraux et les enseignments en tirés dans les domaine du métamorphisme: Acta Geol. Acad. Sci. Hungaricae, v. 13, p. 125-130 (in French, Russian abstract). A review of the potential of inclusion studies in metamorphics (E.R.).

BOTSARIS, G.T., and seven others, 1969, Crystallization (a review in three parts): Ind. Eng. Chem. v. 61, no. 10, p. 86-113; no. 11, p. 92-101; and no. 12, p. 65-79.
A very thorough review (1949 references listed in 26 subject categories) of transport phenomena of nucleation and crystal growth, crystallization processes, and various particular systems. Much of this is pertinent to problems of inclusion trapping mechanisms. (ER)

BOYER, Francois, TOURAY, Jean-Claude, and VOGLER, Michel, 1967, Présence of liquid CO_2 inclusions in quartz from the auriferous district of Salsigne: Acad. sci. [Paris] Comptes rendus, ser. D, v. 265, no. 1, p. 11-13 (in French).
CO_2 verified by microscopy and mass spectrometry. (ER)

BOYLE, R.W., 1961, The geology, geochemistry, and origin of the gold deposits of the Yellowknife district: Geol. Survey Can. Mon., 310, 193 pp.

The distribution of solid and liquid inclusions (discussed on p. 41-49) in quartz of the veins is used to help understand the origin of the various epochs of quartz. Some daughter crystals. Quotes Boyle (1954) for decrepitation results. (ER)

BRADSHAW, P.M.D., and STOYEL, A.J., 1968, Exploration for blind orebodies in southwest England by the use of geochemistry and fluid inclusions; Inst. Min. Metal. Trans. Sect. B v. 77, p. B-144-152.

Examples are given that demonstrate the applicability of stream sediment and soil geochemistry to mineral exploration in Southwest England; they are in agreement with work carried out by others. Many of the anomalies located, however, will be related to sub-economic mineralization at surface which could be associated with (1) concealed economic mineralization; (2) mineralization which existed at a shallower depth, and since eroded; or (3) a vein system devoid of economic mineralization. In an attempt to provide criteria for assessing the potential of surface anomalies an examination of metal dispersion in the wallrock, and filling temperatures of fluid inclusions, was undertaken.

The former proved to be of very limited value. Results of a preliminary study of fluid inclusions in vein material are, however, more promising. They demonstrate that the metals which characterize the established zonal arrangement have well defined filling temperature ranges and the application of filling temperature data to mineral exploration is postulated (Authors' abstract)

BRADSHAW, R.L. and SANCHEZ, Florentino, 1969, Migration of brine cavities in rock salt: J. Geophy. Research v. 74, p. 4209-4212 (Authors at Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 37830).

Small quantities of brine trapped in 'negative crystals' (cavities) exist in most rock salt (halite) and have been found to migrate toward a heat source. The theory of Hoekstra and others on the migration of liquid inclusions in ice crystals was modified for predicting the migration rates of brine cavities in salt. The driving force for the migration is the difference in solubility between the warm and colder sides of the brine cavity. The theoretical model indicates that the migration rate is a function of temperature and is directly proportional to the temperature gradient. Calculated cavity migration rates for a 1°C/cm gradient ranged from about 0 at 20°C to 7.7 cm/yr at 300°C. The theoretical predictions were found to be in reasonable agreement with migration rates measured in the laboratory, although there was considerable spread in the experimental data. Specimens consisted of relatively pure salt crystals from Hutchinson, Kansas, mine, about 2 ½ cm on a side, containing brine cavities between 2 and 10 mm in maximum dimension. Thirty-one rate measurements (on twelve separate cavities) were obtained, covering the temperature range of 75°-244°C, with gradients ranging from 4 to 34°C/cm. Migration periods varied from about 20 to 358 hours, and the observed distances of migration ranged from 0.8 to 8 mm. The theoretical predictions also tended to confirm the approximate (but difficult to measure) rates of brine migration into a number of heated holes (salt wall temperatures up to 200°C) located in the Kansas mine. (Authors' abstract)
(Ed. note - Although this work was done for an entirely different purpose, it is pertinent to the problem of the possible downward-migration of fluid inclusions in halite resulting from the geothermal gradient.)

BRATUS, M.D., 1969, Gas-liquid inclusions in apophyllite crystals: Akad. Nauk. Ukr. SSR, v.31, pt. 3 (series B) p. 195-198 (in Ukrainian).

Homogenization of large (0.4mm) primary inclusions occurred in range 65-130°C. On opening they were found to be strongly alkaline (pH- 9.0-9.5). (ER).

BRATUS', M.D., STASYUK, Z.V., and PANCHISHIN, R.S., 1968, Determination of the composition of gases of individual inclusions in quartz from pegmatite by the omegatron mass-spectrometer: Akad. Nauk SSSR Doklady, v. 183, no. 4, p. 928-930 (in Russian). Translated in Geochemistry, 1968, p. 185-187.

A very brief but important paper on a powerful technique. (ER)

BROOKS, Richard, HORTON, A.T. and TORGESEN, J.L., 1968, Occlusion of mother liquor in solution-grown crystals, Journal of Crystal Growth v.2, p. 279-283 (authors at National Bureau of Standards, Washington, D.C. 20234, U.S.A.).

Mother-liquor inclusions, major defects in solution-grown crystals, sometimes form when the level of supersaturation increases. A change in supersaturation, even when relatively slight, can cause irregular growth particularly on fast growing faces, and inclusions can form by overgrowth of irregularities by contiguous faces or, if supersaturation is diminshed, by redevelopment of the face originally present. In ammonium dihydrogen phosphate and sodium chlorate, grown with habits characterized by several forms, fast-growing faces provide primary sites for occlusion of mother liquor.

Results can be explained if formation of growth centers is sensitive to supersaturation and their location is dictated by solute supply if supersaturation exceeds a limiting value. (Authors' abstract).

BRUNNER, G.O., WONDRATSCHEK, H., and LAVES, F., 1961, Ultrarotuntersuchungen über den Einbau von H in natürlichem Quarz: Zeitschr. Electrochemie, v. 65, p. 735-750 (in German)

The IR absorption apectra of various quartz crystals have been investigated; besides the vibrations due to the SiO_2- lattice, there are bands in the 7000, 5000, 3000 and 900 cm^{-1} regions which are due to lattice imperfections. Variations in intensity of several powers of ten have been observed from one crystal to another and occasionally within the same crystal. The half-width of the bands is strongly temperature dependent, H-D- exchange experiments(from which a self-diffusion coefficient of approx. 10^{-7} cm^2/ sec. at 950°C has been obtained) show, that several bands in the 3000 cm^{-1} region are due to OH vibrations. Further experiments indicate that all bands observed here, other than those of the SiO_2-structure, are related to H-containing defects. Annealing at temperatures above 650°C causes permanent changes in the IR-spectrum, which are apparently related to positional exchanges. On electrolysis, H from atmospheric H_2O can enter and replace the alkali ions, which have been deposited on the cathode. The behavior of quartz defects after different irradiation treatment has been studied. From the IR spectrum the H-concentration can be evaluated; values of about 10^{18} H/cm^3 are frequently found for clear quartz crystals, while all natural smoky quartzes as yet examined show a low H content (approx. 10^{17} H/cm^3). Different types of H-defects which might be responsible for the appearance of the bands are discussed. H_2O molecules in considerable amounts are apparent only in milky quartzes and in d-l- twinned quartzes with lamellae (these include most of the amethysts) (Author's abstract).

BULGAKOVA, Ye.N., 1969, Investigation of inclusions of molten matter in rock-forming minerals of the Mount Chernaya intrusion, Noril'sk district: Akad. Nauk SSSR, v. 185, p. 423-426 (in Russian). Translated in Doklady Acad. Sci. USSR, Earth Sci. Sec. v. 185, p. 132-135, 1969. (Author at Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, USSR).

Primary melt inclusions in various trap rock minerals are now glass ± solid phases and vapor. The vapor bubble (originally distorted) begins to move at about 50° below the homogenization temperature. Many primary inclusions in pyroxene homogenized at 1210-1270°C, the temperature varying with the rock type. (ER)

BUREAU, RENÉ, 1958, Les "diamants" de Québec: Naturaliste Canadien, v. 85, p229-238 (in French)
A review (12 references) of the early records on the discovery and study of clear to black quartz crystals containing inclusions of "bitumen" and/or petroleum. A decrepitation temperature of 75°C (from F.G. Smith, personal communication) is quoted. (See also duBerger, 1967) (ER)

BURNHAM, C.Wayne, HOLLOWAY, J.R. and DAVIS, N.F., 1969, The specific volume of water in the range 1000 to 8900 bars, 20° to 900°C: American Journal of Science, Schairer vol., 267-A, p. 70-95. (Authors at Dept. of Geochemistry and Mineralogy, The Pennsylvania State University, University Park, Pennsylvania 16802).

Basic data of value to any study of aqueous inclusions (ER).

BUSECK, P.R., 1966, Contact metasomatism and ore deposition-Concepcion del Oro, Mexico: Econ. Geology, v. 61, p. 97-136. This large copper deposit, disseminated in skarn, contains post-ore quartz with primary inclusions (p. 124-126). The freezing temperatures (2 inclusions) are -5 and -8°C; homogenization determinations ranged from 315 to 330 ±25°C. (ER).

CARSTENS, HARALD, 1966, Deformation in vein genesis: Norsk Geol. Tidsskrift, v. 46, pt. 3, p. 299-307. It is shown that the formation of veins in metamorphic psammitic rocks is closely related to creep, involving fracturing, subgrain development, stress-induced diffusion, syntectonic-recrystallization, and chemical replacement. The veins are easily subjected to annealing recrystallization and grain growth resulting in equilibrium disposition of grain boundaries and a general coarsening of the vein fabric, (Author's abstract). (This is pertinent to the problems of the origin of inclusions in any such veins - ER).

CARSTENS, Harald, 1969a, Dislocation structures in pyropes from Norwegian and Czech garnet peridotites: Contr. Mineral. and Petrol., v.24, p. 348-353 (author at Norges geologiske undersøkelse, Trondhein, Norway.)

The dislocations described in this and the following two entries are important to studies of leakage of inclusions, and in some cases are spatially related to the inclusions (E.R.).

CARSTENS, Harald, 1969b, Arrays of dislocations associated with healed fractures in natural quartz : Norges Geologiske Undersøkelse Nr 258: P. 368-369.

CARSTENS, Harald, 1969c, Dislocation-free quartz crystals: ibid, p. 370-371.

CHAIGNEAU, Marcel, 1967b, Sur la relation entre l'aspect enfumé des quartz et leur tenure en hydrocarbures: Acad. sci. [Paris] Comptes rendus, ser. D, v. 265, no. 20, p. 1444-1447.

Gases released by heating were analyzed by various methods for HCl, SO_2, CO_2, H_2, CH_4, C_2 hydrocarbons, C_3 and C_4 hydrocarbons, CS_2, CSO, and N_2 (+ rare gases). Small amounts of ethane, propane, ethylene, propylene, and butylene were also reported. (ER).

CHEMLA, M., TOURAY, J.C., BROUSSE, R. and CAUSSE, C., 1968, Abondance relative des gaz inclus dans quelques minéraux magmatiques d'origine profonde, in Origin and distribution of the elements, L.H. Ahrens, ed.: New York, Pergamon Press, p. 971-979.

Among a set of sixty comagmatic xenoliths of basalts and trachytes coming from the French "Massif Central", the samples richest in included gases have been selected with a crushing super-stage,

Their minerals have been separated, studied under the microscope and, in the end, vacuum crushed. The gases, thus extracted, have been analyzed with the mass spectrometer.

The results of twenty-two analyses are presented. They show that CO_2 is the major fluid constituent of the inclusions of very deep origin minerals. The geochemical implications of this fact are debated (Authors' absract).

CHERNOKOLEV, N., 1969, Mineralogical-thermometric study of quartz from the Gradishte lead-zinc deposit in Madan ore field: Izd. Geol. Inst., Bulg. Akad. Nauk., Ser. Geokhim., Mineral. Petrogr., v. 18, p. 145-152 (in Bulgarian).

Homogenization of inclusions showed a drop of temperature with the various stages, from a maximum of 360°. (ER)

CLOCCHIATTI, R., 1968, Note on the morphology of glass inclusions in quartz phenocrysts from acid lavas from the Northern Vosges: Compt. Rend. Acad. Sci. Paris, v. 267, Serie D, p. 2257-2259,

The acid lavas from the Vosges mountains in France contain quartz phenocrysts, that show glass inclusions of different degrees of devitrification (proceeding with age: Permian to Devonian) and a void of shrinkage occasionally filled with gas under pressure. Bi-pyramidal negative crystal outlines of the cavities reveal high temperatures of formation. (P.J.M. Ypma.)

DAVIDENKO, N.M., 1968, The practical importance of the study of microinclusions in minerals of western part of Chukotka (abst.): Abstracts of Reports of Third All-Union Conference on Mineralogical Thermobarometry, Moscow, Sept. 9-15, 1968, p. 148. Author at SVKNII, Magadan.

Primary and secondary polyphase microinclusions suitable for homogenization studies are present in the minerals of veins in western Chukotka. The inclusions are particularly numerous in quartz, scheelite, and calcite. The gold-bearing quartz veins differ markedly in the composition of mineral-forming solutions present in inclusions from those of unmineralized quartz veins. With the help of primary polyphase microinclusions in gangue minerals found in the gold placers of Chukotka region, the location of the source rocks of these gold placers can be traced. Primary micro-inclusions in the quartz from the lighter fraction of panning (western Chukotka) characterize the quartz as the associate gangue mineral of gold. This fact increases the applicability of panning as an exploration method for gold deposits much farther. Translated by Asoke Lahiry.

DAVIDENKO, N.M. and VALPETER, A.P., 1969, Microinclusions in minerals of gold-bearing and barren veins in Western Chukotka: Kolyma, 1969, no. 6, p. 44-45 (in Russian).

Primary inclusions in Au-bearing veins were multiphase, whereas the barren veins were simple gas-liquid. From Referat. Zhur., Geol., 1970, abstract 2V227. (ER).

DENBIGH, K.G., and WHITE, E.T., 1966, Studies on liquid inclusions in crystals: Chem. Eng. Science, v.21, p. 739-754. Studies have been made on the formation of liquid inclusions in certain crystals, especially those of hexamethylene tetramine. This substance, which belongs to the cubic system, when grown from aqueous solution gives rise to crystals with inclusions in a highly symmetrical dodecahedral pattern of 12 members. The inner dimension of this pattern has been shown to be almost invariably 65±10u and it appears that this is a critical size below which inclusions are not formed. Evidence has been obtained that there may also be a critical growth rate (of about 12u/min) such that inclusions are formed if this rate is exceeded when the crystals are larger than 65u. The drying out of mother liquor from the inclusions once they have been formed, has been shown to be impracticable under industrial conditions. Other methods of formation of inclusions are described as at the corners of crystals previously rounded by solution (p.741); considerable overheating of hexamine crystals without decrepitation was found; the patterns of inclusion distribution in hexamine crystals are remarkably similar to those the Editor has seen in some leucite (ER).

DICKEY, Parke A., 1969, Increasing concentration of subsurface brines with depth: Chem. Geol. v. 4, p. 361-370.

Many fluid inclusions in low-temperature environments may represent such fluids (ER).

DIMITROV, D.K., [illegible] Formation temperatures of fluorite deposits in the central Rhodope massif, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., 1968. v. 2, Moscow: "Nauka" Press, p. 277-85. (in Russian)

Various color fluorites, from a series of deposits in the area, yield homogenization temperatures of 150-250°C. Daughter minerals are almost absent (ER).

DMITRIEV, L.K. and LYAKHOV, Y.V., 1969, Character of temperature conditions of mineralization changes in time and space in the Darasun Deposit (East Transbaikalia): L'vov Gos. Univ. Mineral Sbornik., v. 23, p. 408-413 (in Russian).

The Darasun gold ore deposit is a high temperature pneumatolytic-hydrothermal deposit. Its first stage developed at temperatures of 450-275°C, the second, the hydrothermal stage, at 280-50°C. The ore body vertical temperature gradient is 22-21°C/100 m and horizontally is 10-12°C to 4°C/100 m. The increase in ore formation temperatures in the direction of the plagiogranite-porphyry boss testifies a connection of mineralization with that intrusion. (Authors' abstract)

DOLGOV, Yu.A., 1968, Pressures and temperatures in the process of formation of chambered pegmatites: Doklady Akad. Nauk S.S.S.R., v. 178, p. 1171-1174 (in Russian). See Translations Section.

DOLGOV, Yu.A., BAZAROV, L. Sh. and BAKUMENKO, I.T., 1968, Determining the pressure in inclusions by simultaneous use of homogenization and cryometry, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v. 2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 9-17 (in Russian).

Flat inclusions in topaz were used for detn. of pressure during mineral formation. The temp. of homogenization of inclusions, the vol. of inclusions, vol. of liq. soln., vol. of CO_2, vol. of gases, cryohydrate point, and concn. of solns. were detd. All detns. were made by using values measured by planimeter from enlarged photomicrographs. The freezing of inclusions proved to be the most convenient. The accuracy of pressure detns. was controlled by the accuracy of measured data. This was a reason of selection of flat inclusions or inclusions with geometrically regular shape. The method is simple and does not require complex apps. The cryometric app., described by L.S. Bazarov (1966), is inexpensive and easy to operate. It provides for freezing of inclusions and measurements down to -180° to ± 0.05°. The cooling rate is easily controlled and freezing can be stopped at a given temp. The transformations of inclusions during their cooling in cryometric app. are registered photographically. Photometric and crystaloptical observation provides sufficient data to det. the relative vols. of phases, their nature, and temps. of phase transformations. Compn. of inclusions were calcd. from these data. The pressure in inclusion is detd. from phase diagrams. For example, an inclusion containing NaCl solution that melts at -6.5° is a 10% NaCl soln. Homogenization of liq. phase occurred at 360°. According to the diagram of Sturikovich and Khaibulin (1956), homogenization into liq. phase of this systen occurs under 160-165 kg./cm.^{2} pressure. According to the tables of Sourirajan and Kennedy the homogenization under these conditions occurred at 166 bars. Detn. of CO_2 was made from measuring of volumetric ratios below the freezing point of aq. phase. The formation pressures were detd. for 40 inclusions in topaz, quartz, and beryl from molar % of CO_2 and homogenization temp. by using corresponding diagrams. (modified,from Chemical Abstracts)

DOLGOV, Yu.A., MAKAGON, V.M., and SOBOLEV, V.S., 1967, Liquid inclusions in kyanite from metamorphic rocks and pegmatites of the Mamsk region (north-eastern Transbaikal): Akad. Nauk SSSR Doklady, v. 175, no. 2, p. 444-447 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 175, p. 164-166, 1967.

DOLGOV, Yu.A. SHUGUROVA, N.A., and POGREBNYAK, Yu.F., 1969, Gas inclusions in tektites (moldavites): Doklady Akad. Nauk SSSR, Doklady, v. 184, no. 6, p. 1405-1408.

A series of analyses of the gases in bubbles in tektite glass show major CO_2 and H_2, minor N_2 and acid gases, and no O_2 and CO. (ER).

DOLOMANOVA, E.I., KOROLEV, N.V., and RUCHIN, V.V., 1969, A method for microspectral determination of the composition of gas liquid inclusions in quartz: Akad. Nauk SSSR, Izvestia, v. 1969, no. 7, p. 72-84 (in Russian).

Inclusions are opened and the fluid transferred to an electrode in a visual grating spectroscope. Twenty-nine qualitative analyses are presented, for Cl, F, B, S, Na, K, Ca, Mg, Al, Be, Fe, Cr, and Mn, in inclusions in various samples of quartz. (ER)

DOLOMANOVA, E.I., LIDER, V.V., ROZHANSKII, V.N., and ELINSON, M.M., 1966, Composition of solids in some gas-liquid inclusions in morion according to data of X-ray spectral point=analyses [electron microprobe]: Akad. Nauk SSSR Doklady, v. 167, p. 176-179 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 167, p. 116-119, 1966.

This is the first use of the electron microprobe, to detect the elements present in daughter crystals on the walls of <u>unopened</u> fluid inclusions in quartz (ER).

DOLOMANOVA, E.I., LIDER, V.V., ROZHANSKII, V.N., and ELINSON, M.M., 1968, X-ray spectral study of the element composition of the ultramicrocrystalline phase of gas-liquid inclusions in quartz, <u>in</u> Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., 1968, v. 1, p. 281-90 Moscow: "Nauka" Press, (in Russian)

Electron microprobe analyses were made of daughter crystals in inclusions in morion crystals from Transbaikalia. (The sample was polished down to very near the inclusion, thus permitting excitation of daughter crystals by the electron beam through the walls of <u>unopened</u> inclusions - personal communication from Dr. Dolomanova). Major amounts of Fe and Cr indicate possible chromite as one daughter crystal. Smaller amounts of Zn, Cu, Ti, and Ca were also detected. Two analyses of evolved gases showed CO_2, H_2S and H_2, plus minor CH_4.(ER)

DOROSHENKO, Yu.P., 1966, Crystallomorphological peculiarities and barite-forming temperatures from fluorite deposits of Transbaikal: L'vov. Gos. Univ. Mineralog. Sbornik., v. 20, no. 3, p. 458-459 (in Russian).

The barite in the fluorite deposits of Transbaikal is represented by two morphological types of crystals (tabular and elongated). The data received on the study of gaseous-liquid inclusions in the barite established that the tabular barite formed from hydrothermal solutions at a temperature from 165 to 115°C; the elongated barite at a temperature from 110 to 80°C. A graph is given of the dependence of crystallomorphological peculiarities of the barite on the temperature of formation.(Author's abstract).

DORSHENKO, Yu.P., IVANOV, V.N., PATRUSHEVA, M.A., and CHUMACHENKO, N.M., 1969, Apophyllite from the Savinskoye No. 5 complex ore deposit in Eastern Transbaikalia: L'vov Gos. Univ. Min. Sborn. v. 23, no. 4, p. 424-

428 (in Russian).

A study of the first apophyllite occurrence in Transbaikal polymetallic deposits show that it is β-apophyllite (according to V.J. Vernadsky). Mineral thermobarometric research gives formation temperature 156-148°C and pressure 50-90 atm. - which are of great genetic significance. (Authors' abstract, modified by ER).

DORSHENKO, Yu.P., KOMLEVA, Zh.A., LYAKHOV, Yu.V., MYAZ, N.I., PIZNYUR, A.V., and RUDENKO, A.F., 1968, Aqueous extracts from inclusions of hydrothermal solutions in minerals of genetically different types of deposits, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., 1968, v. 1, Moscow: "Nauka" Press, p. 308-18 (in Russian)

Report 18 analyses of water leaches of inclusions from fluorite, from various stages of mineralization, for Na, K, Li, Ca, Mg, HCO_3, Cl, F, and $HSiO_3$ (ER).

DOROSHENKO, Yu.P., and KUZEMKO, V.N., 1966, Some peculiarities of fluorite mineralization of the Mikhailovsk ore field (Eastern Transbaikal): L'vov Gos. Univ. Vestnik, Geol. Series, v. 4, p. 75-78 (in Russian, English abstract)

Fluorite ores in the Mikhailovsk field occur on a crush zone in carbonate rocks of the Bystrinskaya group. Ore deposition took place during two stages: the quartz fluorite state (inclusion homogenization temperatures 180-140°C) - mainly by means of a metasomatic replacement of carbonate rocks, and the fluorite-quartz stage (150-115°C) - mainly by means of cavity filling. Secondary dispersion halos obtained by spectrophotometry aid in determining ore bodies hidden by 5-7 meters of overburden. (Authors' abstract, revised by E.R.)

DUNNING, G.E. and COOPER, J.F., 1969, A second occurrence of antarcticite, from Bristol Dry Lake, California: Amer. Mineral, v. 54, p. 1018-1025.

This compound, $CaCl_2 \cdot 6H_2O$, is optically uniaxial negative, with indices 1.550 and 1.490. (Ed. note - this phase probably occurs as a daughter mineral, and certainly forms as one on freezing inclusions). (ER)

ELINSON, M.M., 1968, Studying the composition of gases in small samples of minerals and rocks, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., 1968, v. 2, p. 251-5 (in Russian): Moscow, "Nauka" Press.

An app., in which a microdegaser was used together with a gas chromatograph, or low-temp. gas analyzer for acid gases, was used for study of gases from small samples (0.1-1.0 g.). The gas anal. for CO_2, H_2S, O_2, CH_4, He, Ar, and N_2 was made from 0.1-0.002/cc. of gases. The extn. of gases from samples was made by disintegration of sample in a microdegaser in Ar atm. or in vacuum. Special tests proved applicability of the method and good reproducibility of av. results obtained during study of several 0.2-1.0 g. samples made from a single sample in the app. with microdegaser and compared with data obtained during detn. of gas content in the same rock samples weighing 100 g. and ground in the vacuum ball mill. The sensitivity of chromatographic detn. was 0.5·% at min. vol. of gas of

200 mm^3. The sensitivity of detn. in low-temp. gas analyzer for acid gases at -195° with subsequent absorption of CO_2, H_2S, SO_2, and Cl_2 by solid absorbers, was 0.05% at the same vol. of gas. The accuracy of detn. increased at large gas volumes (C.A.)

Eds. note: Dr. Elinson (personal communication in Russian, translated by M. Fleischer) gives the following details on the absorbents she uses in gas analyses:

H_2S - Porcelain powder impregnated by a solution of lead acetate in 2% acetic acid with addition of barium chloride.
SO_2 - Porcelain powder impregnated with a $ZnCl_2$ solution in 10% HCl with addition of Na nitroprusside and urotropine.
CO_2 - Silica gel impregnated with 0.1% solution (alcoholic) of basic fuchsine mixed with hydrazine hydrate and an aqueous solution: 42% $SrCl_2$ and 2% hydrazine sulfate.
Cl_2 - Silica gel impregnated with a solution of KBr and Na carbonate, with the addition of fluorescein.

ELINSON, M.M. and POLYKOVSKII, V.S., 1967, On the gaseous composition of solutions which participated in the formation of rock crystal-bearing veins in skarns: Geokhimiya, 1967, no. 2, p. 170-177 (in Russian, English abs.); translated in Geochemistry Internat., no.1, p. 108-114, 1967.

ELLIS, A.J., 1967, Partial molal volumes of $MgCl_2$, $CaCl_2$, $SrCl_2$, and $BaCl_2$ in aqueous solution to 200°: Jour. Chem. Soc., Sec. A, Inorg., Phys., and Theor. Chemistry, 1967, p. 660-664.

ELLIS, A.J., and MAHON, W.A.J., 1967, Natural hydrothermal systems and experimental hot water/rock interactions (Part II): Geochim. et Cosmochim. Acta, v. 31, no. 4, p. 519-538.

A study was made of the reaction of volcanic rocks from the Taupo Volcanic Zone of New Zealand, and a greywacke, with water at temperatures 400 and 600°C. From analysis of the resultant solutions it was established that most solutes (K^+, Rb^+, Ca^{2+}, Mg^{2+}, F^-, SO_4^{2-}, SiO_2 and NH_3) are controlled in concentration by mineral solubility or ion exchange equilibria. Values of the atomic ratio Na/K in solution in contact with rhyolitic rocks ranged from 10 to 15 at 250° to 4 at 600°. Other features of the reaction solutions were their acidity when cooled, their extremely low concentration of magnesium, and their concentration of a large proportion of the chloride, boron, and caesium from the original rocks. (Authors abstract)

ENJYOJI, M. and MIYAZAWA, T., 1969, Formation temperatures of the fluorite deposits in Japan and Korea: Jour. Soc. Mining Geol. Japan, v. 19, p. 73 (in Japanese) (Authors at Dept. of Geol., Tokyo Univ. of Education).

The Hiraiwa fluorite deposit in Japan belongs to the vein type, occurring in Paleozoic clayslate and granite porphyry. The Chuncheon Shin Po mine in Korea is also a vein type deposit in Precambrian biotite gneiss. The Ku Mi mine in Korea is a replacement deposit in Carboniferous limstone. The filling temperatures of the fluid inclusions in fluorites were measured by means of a heating stage. They are as follows;

Hiraiwa 86°-151°C (42 samples).
Chuncheon Shin Po 102°-130°C (14 samples)
Ku Mi 79°-143°C (5 samples) (H. Imai)

EVZIKOVA, N.Z., and MOSFALVUK, A.A., 1964, Gas-liquid inclusions in carbonates from carbonatites : Akad. Nauk SSSR Dokl., v. 159, p. 98-101 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec. v. 159, p. 108-111.

One of the very few papers on inclusions in carbonatites. They found solid matter and an unknown phase, made homogenization dterminations, and made four analyses of water leaches(ER).

FORD, T.D., 1967, Some mineral deposits of the Carboniferous limestone of Derbyshire, in Geological Excursions in the Sheffield Region; R. Neves and C. Downie, eds.: Sheffield, Univ. of Sheffield, p. 53-75.

A good summary of the geology and mineralogy of these deposits, that contain many organic fluid inclusions (ER).

FORD, T.D., 1969, The stratiform ore deposits of Derbyshire, in C.H. James, Ed., 15th Inter-Univ. Geol. Congr., 1967, Univ. of Leicester, England, p. 73-96 (published in 1969).

Quotes(p. 86) some previously unpublished freezing data from Roedder on fluorite from the Derbyshire deposits (-15 to -22°C, corresponding to 20-30 weight percent salts in solution, in primary inclusions, and lower concentrations in later inclusions). Homogenization temperatures (p. 87, also from Roedder) of 70-90°C are also reported (for primary aqueous inclusions), and 130-140°C for late primary and pseudosecondary inclusions of oil (ER)

FRIEDLANDER, C. G. I., 1969, Brownian movement in quartz (abst.): Canadian Mineralogist, v. 10, pt. 1, p. 132 (Author at Dept. Geology, Dalhousie Univ., Halifax, Nova Scotia.)

Quartz from mineralized specimens taken at the dumps of the Dunbrack Prospect, Musquodoboit River, Halifax Country, Nova Scotia, contain fairly plentiful liquid inclusions. Some of these liquid inclusions show, at moderately high magnification, moving gas bubbles. The diameter of the moving gas bubbles is in the order of 1μ. A film has been made by the Audio Visual Department, Dalhousie University (D. A. Gibson, D. Pike) of two such observations. The diameter of the bubble in the first frame (6804) is approximately 0.7μ. In the second frame (6817), a number of moving bubbles appear successively on different levels of the thin section. The diameter of these bubbles lies between 0.7 and 0.2μ. The mobility of the smaller bubbles is distinctly greater than that of the larger bubbles. The communication consists essentially in the presentation of the film. (Author's abstract.)

FUNKHOUSER, J.G. and NAUGHTON, J.J., 1968, Radiogenic helium and argon in ultramafic inclusions from Hawaii, Journal of Geophysical Research, vol. 73, no. 14, p. 4601-4607 (Authors at Chemistry Dept. and Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii 96822).

Isotopic studies have been made of the inert gases present in ultramafic xenoliths from two sites in Hawaii, the 1800-1801 Kaupulehu flow (Hualalai Volcano, Hawaii) and Salt Lake Crater (Oahu). Apparent ages calculated from the measurement of radiogenic argon and helium have very high values. The ratio of radiogenic helium to argon relative to natural gases and to the value expected from generation in situ is low. From gas extraction by crushing and decrepitation, it is shown that the inert gases occur in fluid and gaseous inclusions in the minerals of the nodules. The gases are believed to be representative of the magmatic environment, with the low helium-to-argon ratio resulting either from preferential loss of helium or from generation of the gas from a source similar to a chrondritic composition. The inert gas 'ages,' then, are of uncertain significance for these samples (Authors' abstract)

GALIMOV, E.M., and PETERSIL'E, I.A., 1967, Isotopic composition of carbon from hydrocarbon gases and CO_2 held in alkalic igneous rocks of the Khibiny, Lovozero and Ilimaussaq plutons: Akad. Nauk SSSR Doklady, v. 176, p. 914-917 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 176, p. 200-203, 1968.

A significant anomalous impoverishment of the light-weight isotope in the hydrocarbons makes them resemble CO_2 in the isotopic composition of C and is a supplementary evidence of their abiogenic origin, possibly from the graphitic substance of the mantle. (Auth. abstract)

GAL-OR, Benjamin, KLINZING, G.E., and TAVLARIDES, L.L., 1969, Bubble and drop phenomena: Ind. Eng. Chem. v. 61, no. 2, p. 21-34.

This is a very extensive review, with 618 references arranged into 14 subject areas, several of which are of considerable interest to inclusion studies (ER).

GIGASHVILI, G.M., 1969, Primary solid-gas inclusions in quartz from Volhynian megmatites: 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.)(Translation to appear in next issue)

GIGASHVILI, G.M., 1969, Metasomatism of microcline from a Volynian pegmatite: L'vov. Gos. Univ. Mineralog. Sborn. v. 23, no. 2, p. 160-169 (in Russian).

The greisenization of microcline crystals in the chambered ("zanorysh") pegmatites is of two varieties, 1) quartz-topaz and 2) quartz-muscovite-fluorite. Homogenization temperatures for type 1 were 330°C. Gases in solution are mainly CO_2 and N_2 (E.R.).

GIGASHVILI, G.M., and KALYUZHNYI, V.A., 1969, Black opal from the pegmatites of Volyn containing organic substances: Akad. Nauk SSSR Doklady, v. 186, p. 1154-1157 (in Russian).

Late black opal in these pegmatites contains organic matter that yields a wide variety of organic compounds upon pyrolysis in a mass spectrometer. (ER.)

GNATENKO, G.I., KUZNETSOVA, S.V., and SKARZHINSKII, V.I., 1969, Conditions of formation of high-temperature mineralization in breccias of salt-dome structures in the northwestern Donets basin: Dopov. Akad. Nauk Ukr. RSR, Ser. B, v. 31, no. 11, p. 963-968 (in Ukrainian).

High-temp. endogenic mineralization was detected during study of Hg and complex ore occurrences in the Bantishevsk and Novo-Dmitrievsk structures. The high-temp. assocn. of minerals was localized in the breccia overlying salt domes in the structures. It consisted of scapolite, tremolite, albite, muscovite, phlogopite, tourmaline, topaz, rutile, sphene, rock crystal, and pyrite and was accompanied by recrystn. of carbonates in breccia, regeneration of terrigenous quartz grains, and change in textural-structural characteristics of the breccia. The high-temp. mineralization in breccias was formed under low depth conditions by ascending local hydrothermal solns. contg. numerous volatile components. The max. formation temp. of these minerals was detd. by homogenization of gas-liq. inclusions in apatite and decrepitation of scapólite and pyrite. It was 375°. The gas components in primary and secondary inclusions in apatite were detd. as (H_2S, SO_2, NH_3, HCl, and HF) 0.0 and 2.35; CO_2 8.0 and 97.65; O_2 8.6 and 0; and N_2 + rare gases 73.4 and 0.0%, resp. (Chemical Abstracts).

GRIGGS, DAVID, 1967, Hydrolytic weakening of quartz and other silicates: Geophys. Jour. Royal. Astrom. Soc., v. 14, p.19-31 (Also reprinted 1968 in D.C. Tozer, Ed., Non-elastic processes in the mantle, London, Hodgson and Son, Ltd.)

Shearing of quartz crystals containing 0.0015 to 0.13 weight percent H_2O (100-9000 H/10^6Si, as inferred from $3\mu m$ IR absorption) results from intracrystalline gliding and yields many dislocations. These latter anneal out in 24 hours at 1 atm. and 300°C to form "bubbles" of H_2O $\sim 0.2\mu m$, from breakdown of $Si(OH)_4$ to form SiO_2 and H_2O. (ER)

GRIGOREV, D.P., BUKANOV, V.V., and MARKOVA, G.A., 1969, Synchronization of the process of crystallization in zoned crystals: Akad. Nauk SSSR Doklady, v. 185, p. 1129-1132 (in Russian).

The zones in multiply-zoned crystals of quartz are correlated from one crystal to another by comparison of their absorption spectra traverses. This might be useful in correlating inclusion ages. (ER).

GRITTI, C. and SOULIÉ, M., 1969, La barytine du Burc et sa position par rapport à la fluorine: Bull. Soc. D'Hist. Natur. de Toulouse, v. 105, p. 227-233.

Describe heating stage and decrepitoscope studies on barite from Burc (E.R.)

GROMOV, A.V. and KRESTIN, Ye.M., 1967, Magmatic inclusions in rock-forming minerals of nickel-bearing trap rock intrusions: Akad. Nauk SSSR Doklady, v. 175, no. 2, p. 441-443 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 175, p. 161-163, 1967.

GROVES, D.I. and SOLOMON, M., 1969, Fluid inclusion studies at Mount Bischoff, Tasmania; Inst. Mining and Metal. Bull. 747, Sect. B; Trans. v. 78, p. B1-B11.

A study of fluid inclusions in fluorite and quartz from a cassiterite-sulphide replacement deposit at Mount Bischoff, Tasmania, substantiates the presence of temperature variations in time and space during ore deposition. These had previously been suspected for mineralogical zoning and variation in elemental composition of sulphides. Fluorite of the same generation was deposited over the temperature range 200-580°C. Fluorite and quartz from later (?) fissure veins were deposited over the temperature range 170-380°C, although most deposition occurred between 200 and 250°C. The density of the CO_2 inclusions in fluorite from one orebody indicates a pressure of 750 atm. The salinity of inclusions varies considerably within one locality, but there is a general positive correlation between average salinity and temperature of formation between localities. Low Na/K and Na/Li ratios of fluid inclusions from the central area of the replacement deposit are probably a result of addition of K and Li from hydrothermal alteration of the surrounding quartz-feldspar porphyry dykes. Ratios of Na/K and Na/Li are higher for inclusions in the fissure veins of the marginal zone.

The gross distribution and correlation between temperature of formation, salinity and alkali ratios of the fluids may be explained by mixing of initial, hot, saline hydrothermal solutions with low Na/K and Na/Li ratios with cooler, less saline, relatively Na-rich meteoric and connate waters, in conjunction with heat loss by the solutions to the wallrocks. This may be complicated by local sources of hydrothermal solutions, variation of salinity in the initial solutions, and fixation of K in micaceous minerals (Authors' abstract).

GRUSHKIN, G.G., 1969, Composition of gas-liquid inclusions in fluorites from Khingan tin deposits: Zap. Vses. Mineral. Obshchest. v. 98, no. 6, p. 748-752 (in Russian).

Fluorites from the Khingan Sn deposits had numerous gas-liq. inclusions. The satn. of fluorite with inclusions, salts, water, and CO_2 was variable. The set of anions and cations found in the inclusions was quite uniform, but the concn. of salts was higher in early than in late Sn fluorites. This was esp. typical to Na and K, F, C-, and CO_2. The lower concn. of salts, in inclusions in pink fluorite than in green fluorite was caused by a rapid decrease of temp. and changes in the relative amts. of liq. and gas phases in solns. during the formation of these fluorites. Primary inclusions in green and pink fluorites homogenized at 400-35 and 292-333°, resp. In addn. to gas-liq. inclusions, the fluorites contain small crystals of cassiterite, halite, sylvite, chlorite, and an unidentified mineral. The deposit was formed during Cretaceous volcanism in the Khingan-Olonoi depression. No magmatic activity occurred in the area after formation of the deposits. The high temp. of hydrothermal solns. (F-, Cl-, ammonium group, nitrates, and CO_2), which is close to the compn. of volcanic gases, indicate that volcanic gases (mostly their volatile anionic components) played a leading role in formation of hydrothermal solns. (Chem. Abstracts v. 70, no. 8, p. 167, 1970)

GÜBELIN E., 1968, Die Edelsteine der Insel Ceylon, 152 pp, Privately printed in Switzerland. Many excellent plates, some showing 2 and 3-phase inclusions in various gems.(E.R)

GÜBELIN, E., 1969, On the nature of mineral inclusions in gemstones: The Journal of Gemmology, v. 11, no. 5, p. 149-192.

A fairly extensive review, with 49 references and many excellent color photomicrographs. (E.R.).

GUILHAUMOU, N. and OGNAR, S., 1969, Inclusions à CO_2 liquide et dépôts salins dans des cristaux de dolomite de Tunisie. (Inclusions with liquid CO_2 and salts in dolomite crystals from Tunisia:) Compt. Rend. Acad. Sci. Paris, v. 268, Serie D., p. 241-243.

Both primary and secondary inclusions in dolomite show isotropic cubes of different behavior upon heating (NaCl and KCl) and another undetermined isotropic mineral, that does not change in size, a brine and a vapor phase. The vapor phase contains CO_2, homogenizing into a vapor phase or liquid phase near 20°C. Heating to 300° resulted in the disappearance of the small cubes near 150°C and shrinkage of the larger cube and vapor phase. Decrepitation prevented further heating of the contents. The sedimentary dolomite occurs near an effusive igneous rock contact (P.J.M. Ypma).

HAAS, J.L., Jr., 1966, Solubility of iron in solutions coesxisting with pyrite from 25° to 250°C, with geologic implications: University Park, Pennsylvania State University, Ph. D. dissert., 135 p.; abs. in Dissert. Abs. [Ann Arbor, Mich], v. 28, no. 3, 1967.

Various theories of solubility of metals in [illegible] fluids, by a variety of complexes, are adequate to explain the solution and transport of most ore metals but not iron. Haas made experimental measurements of the solubility of iron in a Teflon-lined bomb at temperatures up to 250°C in a wide variety of proposed ore fluids, but all were $<$ 10ppm. Much higher solubilities were found in the presence of NH_3 (aq.), and the solubility is assumed to be from a ferrous tetraamine complex $Fe\ (NH_3)_4^{2+}$. Hence the concentrations of NH_3 and NH_4^+ should be sought in analyses of fluid inclusions. (Author's abstract, shortened).

HALL, W.E., 1967, Genesis of the southern Illinois fluorite-zinc district as viewed from fluid inclusion and light stable isotope studies (abst.): Inst. of Mining and Metal. Trans., v. 76, p. B224. (Author at U.S. Geol. Survey, Menlo Park, Calif. 94025).

Fluid inclusion studies indicate the ores were deposited from a highly concentrated sodium-calcium chloride brine (approximately 150,000 ppm) over a temperature range of 160 to 60°C. Isotopic and chemical analyses of fluid inclusions show that the earliest ore minerals were deposited from a connate water of the same chemical and isotopic composition as that now in the same horizon as the ore deposits. Later ore and gangue minerals were deposited from a less concentrated ore fluid with a lower relative deuterium concentration.

These and other data show that the ore deposits are epigenetic. They were deposited from hydrothermal solutions that initially were connate waters. The abundance of yttrium, gadolinium, dysprosium, europium, thorium and other elements that are commonly associated with alkalic rocks in fluorite in the breccia at Hicks Dome strongly suggest a magmatic contribution to the connate system. The data suggest that a deep convective system involving the connate water was started during the uplift of Hicks Dome, and that the ore was deposited from the rising, heated, essentially connate waters. (Author's abstract, shortened)

HAYAKAWA, N., NAMBU, M. and AOSHIMA, T., 1969, Trial manufacture of a heating stage for use under high pressure: Program , Annual Meeting, Mining and Metallurgical Inst. Japan, 1969, p112-113 (in Japanese) (Authors at Dept. of Mineral Resources, Tohoku Univ., Sendai, Japan).

A high-pressure heating stage, for use up to 280°C and 97 atm. pressure, was made. Fluid inclusions in synthetic quartz crystals, grown at 278°C and 300 atm. pressure, were studied in the apparatus. Filling temperatures were 262°-286°C, nearly coinciding with the formation temperatures. (H. Imai)

HAYAKAWA, N., NAMBU, M., and KOBAYASHI, N., 1967, On the decrepitation apparatus. Jour. Mining Metallurgical Inst. Japan, v. 83, p. 421-423 (in Japanese).

1. A new type of silencer was devised for the sample-heating box.

2. The determination of selection level of peaks and of

wave length of rectangular wave could be adjusted by the indication of the counter.

3. Struggling of decrepitation could be reduced by the change of time constant.

4. Selection of decrepitation having an amplitude larger than the standard level produced good results (H. Imai).

HAYAKAWA, N., NAMBU, M., and OHGOSHI, M., (Authors at Dept. of Mineral Resources, Tohoku Univ., Sendai, Japan): Decrepitation of artificial halite: Jour. Mining Metallurgical Inst. Japan, v.84 (1968), 209-211 (in Japanese).

Decrepitation temperature depends on the pressure, not on the temperature at the time of the crystallization of artificial halite. (H. Imai).

HELZEL, M., 1969, Gas chromatographic analysis of gaseous inclusions in glass: Ceramic Bull., v. 48, no. 3, p. 287-290. (Author at PPG Industries, Inc., Glass Research Center, Pittsburgh, Pa.)

A gas chromatograph of special design provides an accurate, rapid method for the determination of nl ($10^{-3}\mu l$) quantities of CO_2, H_2, O_2, N_2, CH_4, CO and SO_2 found in the blisters normally encountered in glass. Detectability limits approach 0.003-0.005 μl for the gases, except SO_2, for which the instrument sensitivity is less by a factor of ten. The time for a chromatograph scan is 10 min, unless scanning for SO_2; then it is about 18-20 min. These fixed gases have a definite order of elution and retention time when operating parameters are controlled; therefore, qualitative identification is simple. Quantitative measurements are based on standard gases and calculation of peak areas. (Author's abstract).

HEMLEY, J.J., MEYER, C., HODGSON, C.J., and THATCHER, A.B., 1967, Sulfide solubilities in alteration-controlled systems: Science, v. 158, p. 1580-1582.

Solubilities of sphalerite (ZnS) and galena (PbS) were determined at 300° to 500°C and 100 bars total pressure in a chemical environment buffered by silicate mineral equilibria. Chloride solutions and muscovite-bearing assemblages characteristic of hydrothermal wall-rock alteration were used; weak acidities at temperature were therefore involved. The metal concentrations encountered tended to be higher than those observed in high bisulfide—H_2S systems at neutral to weakly basic pH used in most previous experimentation; the chemical conditions of the work, although not completely satisfactory, are geologically more realisitic than previous experimentation done in the basic-pH region. (Authors' abstract.)

HOMMA, H. and MIYAZAWA, T., 1969, Formation temperatures of Kuroko (black ore) deposit in Japan (1) Yunosawa ore body, Furutobe Mine: Jour. Soc. Mining Geol. Japan, v. 19, p.73 (in Japanese) (Authors at Dept. of Geol., Tokyo Univ. of Education).

Yunosawa ore body is mainly composed of Keiko (silicious ore) accompanied by Ohko (yellow ore) and Kuroko (black ore). The filling temperatures of fluid inclusions in minerals as measured by heating stage are as follows:

Barite in silicious ore 99°-211°C (48 samples)

Quartz in silicious ore 117°-190°C (6 samples)
Sphalerite in yellow ore 245°C (1 sample)
Fluorite in yellow ore 159°C (1 sample)
Barite in black ore 116°-212°C (22 samples) (H. Imai)

IANOVICI, V., and six others, 1969, Evolutia geologica a Muntilor Metaliferi (Geological evolution of the Metalliferous Mountains): Bucarest, Roumanian State Publishing House, 741 pp. (in Roumanian with 14-page French summary).

Contains some scattered discussions of fluid inclusion data, mainly geothermometry (ER)

IKORSKII, S.V., 1966. (See Translations Section)

IKORSKII, S.V., 1967, Bitumens in minerals of igneous rocks (as illustrated by eudialyte of the Khibina alkalic massif): Geol. Geokhim. Goryuch. Iskop., no. 9, p. 22-29 (in Russian). Includes IR spectra and fluorescence photographs of inclusions, and some gas analyses. (ER)

IKORSKII, S.V., 1967a, Organic materials in the minerals of igneous rocks, as illustrated by the Khibina alkalic massif: Leningrad, "Nauka" Press, 121 p. (in Russian).

This is a summary of Ikorskii's extensive studies of the geology of the occurrence, and the extraction and chemical and IR analysis of the organic compounds present, and is profusely illustrated with photomicrographs of the inclusions, some taken in UV illumination. (ER)

IMAI, H. and TAKENOUCHI, S., 1968, Fluid inclusion study at the Taishu Mine, Japan, as related to geologic structure: Jour. Geochem. Soc. Japan, V.2, p42-43. (in Japanese) (Authors at Dept. Mineral Development Engineering, Univ. of Tokyo).

The Taishu mine is a zinc and lead deposit belonging to mesothermal vein type. Veins occur in the Paleocene sediments around the granitic mass. The fissures having vein materials are classified into two types. (1) gently dipping reversed bedding faults, (2) strike-slip faults. The ore-forming fluid would move outward and upward from the granite magma along the fissures of type (1), and pour into the fissures of type (2). The deposit reveals the zonal distribution of minerals. The distribution of minerals, from lower to upper part, is barren quartz, pyrrhotite, sphalerite, galrna and barren calcite zone. Fluid inclusions in quartz crystals from some parts of the veins and of the granite mass in the mining area were studied by means of microscope heating stage and freezing stage. Some of the results are shown in the following table. No.3 vein quartz in the table is farther away from the granite mass than No. 2 vein quartz. From these data, is is recognized that the temperature of the ore-forming fluid drops and the salinity of the fluid falls outward and upward from the granite mass (H. Imai).

(See next page)

Kind of quartz	Homogenization temperature (°C)	Phases in inclusions	Freezing point (°C)	Equivalent % NaCl salinity
(1) Quartz from the granite in the mining area	350°-500°C	Liquid, vapor halite, calcite? undetermined opaque mineral		31-50%
(2) Vein quartz from the Shintomi vein, -70mL	350°-370°C		-9.5°C	30-33%
	310°C	same as above	-3°	5-20%
	250°C		-13.6°C	
(3) Vein quartz from the Shirodake vein, 0 mL.	235-250°C	Liquid, vapour, calcite?	-4.5°C	7.2%

KALYUZHNYI, V.A., and KOVALISHIN, Z.I., 1967, Regularities in the distribution of carbon-containing gases in granites around pegmatites and quartz of "zanoryshevykh" pegmatites of the U.K. Sh.: Geol. Geokhim. Goryuch. Iskop., no. 9, p. 5-21 (in Russian). These are the very coarsely crystallized pegmatites with huge control cavities. Includes many gas analyses for 5 constituents. (ER)

KALYUZHNYI, V.A., and PRITULA, Z.S. (Gryn'kiv), 1967, Explanation of structural, thermodynamic, and geochemical conditions of deep solutions of pegmatites of "zanoryshevogo" type (according to relicts of the mineral-forming medium): Geol. Geokhim. Goryuch. Iskop., no.9, p. 33-54 (in Russian). Many analyses of water leaches of inclusions for up to 15 constituents, with an attempt to tie in with the geological features of these vuggy pegmatites (E.R.)

KALYUZHNYI, V.A. and VOZNYAK, D.K., 1967, Thermodynamic and geochemical characteristics of mineral-forming solutions of pegmatites of the "Zanorysh" type (from liquid inclusions in minerals): L'vov Geol. Obshch. Mineralog. Sbornik, v. 21, no. 1, p. 49-61 (in Russian). (Authors at Inst. Geol. Geokhim. Goryuch. Iskop., L'vov, USSR).

The "Zanorysh" (cavernous) pegmatites are situated in the endocontact of rapakivi granites with gabbro-labradorite rocks. The compn. of pegmatites and their transition into country rocks indicated the similar genesis of granites and pegmatites. Pegmatites are in fact products of the final phase of granite melt crystn. Microchem. and thermal-decrepitation studies of inclusions in quartz were made simultaneously with a study of the total compn. of inclusions by water extrn. method and by vacuum extrn. of gas components. Quartz and feldspar were the most common minerals in pegmatites. Quartz was present in all zones: graphic, pegmatitic, block, and cavernous zones. Crystn. of the earliest block quartz was limited to 700-600°. Calcd. conditions of fracture healing are 205-220° and 670-800 atm. The initial pressure during pegmatite segregation should be much higher. The morion crystals formed at temps. < 570-620° and together with metasomatic replacements in underlying granites and pegmatites (silification, albitization, topazitization, and kaolinization). The inversions of pH in quartz-forming solns., which effected inversion in the formation of quartz modifications, consisted in change of regular decrease in soln. alky. The morion was formed from alk. solns. Noticeable increase in the acidity (pH of solns. 5.2-5.6) occurred 1 or 2 times during formation of quartz in cavities. According to the distribution of topaz the solns. acted locally and affected only individual objects. Topaz was present only in some pegmatite bodies. The latest low-temp. solns., the relicts of which were retained in the form of single-phase liq. or essentially liq. inclusions (liq. 96.8%), had relatively high acidity (pH 5-5.5) and large concns. of salts including Na, Ca, Mg, and K chlorides and sulfates. Quartz, leached from underlying rocks and lower parts of the graphic zone was a source of SiO_2 for deposition of block quartz and morion crystals in addn. to residual pegmatite fluid. C.A. 70 (11) 148 (1969).

The authors also report solid daughter crystals of $FeCl_2 \cdot 2H_2O$, and major BO_3^{-3}, Fe^{+2}, and Fe^{+3}, and homogenization temperatures up to 550°C, for inclusions in quartz from pegmatite "A" (their Table 1)(ER)

KARAMYAN, K.A. and MADANYAN, O.G., 1968, Thermometric studies of vein quartz and stage character in the formation of the Kadzharan copper-molybdenum deposit, in Mineral. Thermom. and Barometry, v.2, p. 168-74, (in Russian), Ed. N.P. Ermakov., Izd. "Nauka":Moscow, USSR.

Mineralization of Kadzharan deposit occurred in 10 stages within a wide range of temps.: from high temp. gaseous solns. (temp. > crit. for the water) to low temp. cold solns. ≤80-60°. Inclusions in minerals formed during 1st 2 stages of mineralization (quartz-magnetite and quartz-feldspar) had essentially gas compn. and no liq. Mineralization occurred from dry gases at temp. > 375°. The subsequent quartz-molybdenite stage (3rd) was characterized by typical gas-liq. inclusions of two types. The homogenization temp. for both types of inclusion was the same: 350-315°. The further decrease in temp. and densification of hydrothermal solns. occurred during the 4th quartz-molybdenite-chalcopyrite stage. The temp. of this stage was 270-89°. The subsequent tectonic deformation resulted in further activation of source of mineralization which resulted in an abrupt increase in temp. during 5th (quartz-chalcopyrite) stage. The increase in temp. of soln. was accompanied by increase in amt. of gases. The temp. of the 5th stage was 295-305°. Large decrease in temp. of soln. (220-200°) occurred during 6th (quartz-pyrite) stage. The temp. of soln. decreased to 180° during 7th (quartz-sphalerite-galena) stage. An even sharper decrease in temp. accompanied the 8th (carbonate) stage where the temp. of soln. varied from 150 to 100°. The final 9th and 10th stages of mineralization (chalcedony and anhydrite) were characterized by activity of soln. having temp. ≤ 50-60°.(C.A.)

KARSKII, B.E., and ZORIN, B.I., 1968, Gas-liquid inclusions in muscovite from pegmatites of the Mamsk region, in Mineral. Thermometry and Barometry, v.2, p. 246-7 (in Russian), Ed. N.P. Ermakov, Izd. "Nauka": Moscow, USSR.

Primary inclusions were found containing a variety of daughter minerals. On heating, most inclusions decrepitated before homogenizing (ER).

KAZANSKY, Yu.P., KATAYEVA, V.N., and SHUGUROVA, N.A., 1969, Gas and liquid phases in inclusions as relicts of former atmospheres and hydrospheres: Geologiya i geofizika, 1969, no. 11, p. 39-43, in Russian; trans. in Int. Geol. Review, v. 12, no. 9, p. 1150-1153.

Twelve analyses of gas inclusions in Precambrian siliceous rocks are presented, for N_2, O_2, CO_2, and (H_2S, SO_2, NH_3, HCl, HF), and 8 leach analyses for Na, K, Ca, Mg, Li, and Cl. Other anions (F, SO_4^{-2}, CO_3^{-2}, and HCO_3^{-1}) and NH_4^+ were analyzed qualitatively. (ER)

KHETCHIKOV, L. N. and DOROGOVIN, B. A., 1969, Possible determination of calcite formation temperature by homogenization and decrepitation of gas-liquid inclusions. Tr. Vses. Nauch.-Issled. Inst. Sin. Miner. Syr'ya, v. 10, 144-152 (in Russian).

The title method should be selected and checked with synthetic minerals, grown under various conditions and possessing various phys. before its data on homogenization and decrepitation of gas-liq. inclusions can be used in geothermometry. Small calcite crystals synthesized in an autoclave during 5 sets of expts. were used in the study. All of them contained gas-liq. inclusions. The homogenization of inclusions was done in thermal chambers. 70 inclusions were studied. The temps. of inclusion homogenization hardly differed from the temp. of calcite synthesis. This behavior indicated that homogenization of inclusions can be used for detg. the temp. of natural calcite formation. The decrepitation of gas-liq. inclusions was carried out and decrepitation curves were plotted. The data are given on changes in the no. of explosions in each expt. depending on the sample wt. and grain size of the calcite. The decrepitation method cannot be recommended for detg. the temp. of calcite formation. The most distinct max. on the decrepitation graphs did not correspond to temps. of inclusion explosion but were related to the displacement of calcite grains during heating. (Chem. Abstracts v. 73, no. 5, p. 113, 1970)

KOKORIN, A.M. and KOKORINA, D.K., 1968, Formation temperatures of quartz during productive stages of a tin-ore deposit of the tourmaline type. Mineral. Thermom. and Barometry, v. 2, p. 151-61, (in Russian), Ed. by N.P. Ermakov, Izd. "Nauka": Moscow, USSR.

Both homogenization and decrepitation studies of quartz from the deposit showed a wide temperature range, from 411 to 70°C, varying systematically and generally downward with the various stages of deposition. (ER)

KOLTUN, L.I., and GOLOVCHENKO, N.G., 1962, On mineral formation temperatures at the Nikitovka mercury deposit, determined through inclusions in minerals: L'vov Gos. Univ. Mineralog. Sbornik., v. 16, p. 407-410 (in Russian).

It has been determined that the deposition of ore minerals at the Nikitovka deposit (the Donbas) took place from hydrothermal solutions at low temperatures and pressures. The deposition of quartz and the accompanying arsenopyrite took place at 180-175°C, and probably at a still wider temperature range. The formation of quartz and the accompanying principal minerals, cinnabar and antimonite, took place within a small temperature range (150-100°C.) and at 160-120 atm. pressure (Authors' abstract).

KOPLUS, A.V., KORYTOV, F.Ya., and PUZANOV, L.S., 1968. (See Translations Section)

KORNILOV, V. F., 1969, Mineralogical characteristics and temperature

conditions of the quartz-forming solutions in a Ural deposit: L'vov Gos. Univ. Mineralog. Sborn., v. 22, no. 4, p. 416-420 (in Russian.)

KORZHINSKII, A.F., 1964, Hydrothermal changes of rocks and their significance for understanding ore formation: Kiev, Science Press, 168pp. (in Ukrainian with Russian summary.)

Inclusion studies are referred to rather briefly in several places. (ER)

KOSTER VAN GROOS, A.F. and WYLLIE, P.J., 1969, Melting relationships in the system $NaAlSi_3O_8$-NaCl-H_2O at one kilobar pressure, with petrological applications: Journal of Geology, v. 77, p. 581-605.

Phase relationships in the system $NaAlSi_3O_8$-NaCl-H_2O appear to be ternary between 850°C and 950°C at 1 kbar pressure. A two-phase field containing NaCl-rich liquid and H_2O-rich vapor extends from the system NaCl-H_2O into the ternary system, although this field was not intersected by the joins investigated.

The results contrast with those in the system $NaAlSi_3O_8$-NaF-H_2O and confirm previous conclusions from the systems $NaAlSi_3O_8$-HCl-H_2O and $NaAlSi_3O_8$-HF-H_2O. Whereas fluoride (or NaF) tends to remain in the liquid (magma), chlorine (or NaCl) passes preferentially into the vapor or fluid phase. The solubility of H_2O in a silicate melt increases when a small quantity of chlorine is present. Coexistence of H_2O-rich liquid inclusions and NaCl-rich liquid inclusions in crystalline phases in igneous rocks may indicate low-pressure conditions (< 1 kbar) during capture of the inclusions (Authors' abstract, shortened).

KOSTYLEVA, E.E., 1968., Improvement in thermal-sonic analysis: in Mineralog. Thermometry + Barometry, v.2, p. 46-9 (in Russian). Ed. by N.P. Ermakov, Izd. "Nauka": Moscow, USSR.

The evolution of volatiles during decrepitation is monitored from a separate sample heated simultaneously. This helps in interpreting the decrepigrams. (ER).

KOTOV, E.I., TIMOFEEV, A.V., KHOTEEV, A.D. and PASHKOV, Yu.N., 1968, Determination of relative temperatures of mineral formation in quartz-molybdenite formations by a decrepitation method: in Mineral. Thermometry and Barometry, v. 2, p. 183-90 (in Russian), Ed. by N.P. Ermakov, Izd. "Nauka": Moscow, USSR.

Describes a decrepitometer of improved design, and gives results obtained with it to show temperature zoning in several molybdenum deposits (ER).

KOVALISHIN, Z.I., 1966. (See Translations Section)

KRANZ, Reimar, 1968b, Organic amino compounds in the gas and liquid inclusions of uranium bearing minerals and their importance on transport reactions in hydrothermal solutions, in Advances in Organic Chemistry 1968, Proceedings of the 4th International Meeting on Organic Geochemistry, Amsterdam, Spetember 16 -18, 1968, P.A. Schenck and I. Havenaar, eds.: Oxford, Pergamon Press, p. 543-552 (in German with English abstract).

The remmants 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. One hopes, from the analysis of these inclusions, to gain a new insight into the chemistry of the gases and solutions which are present during mineral formation. The gases and liquids present as inclusions in the crystal lattice of mineral samples were extracted by grindling under vacuum, and finally subjected to gas-chromatographic and mass-spectrometric analysis. While primarily inorganic gases and traces of hydrocarbons were obtained from all minerals, measurable quantities of organic amino-compounds as amines and nitriles of low molecular weight could be detected in uraniferous minerals and in radium bearing feldspar samples. Furthermore in some highly radioactive feldspar samples from the uranium bearing Co-Ni-Ag-veins of Wittichen in the Black Forest, some amino-acids could be found. Always a straight dependence of the appearance of organic matter especially of amino-groups on the uranium, thorium and radium content was detected.

Further discussions will be about the influence of these compounds on the solubility and recrystallization of mineral material. Some model-experiments prove the large 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 determinations by lead-lead and uranium-lead methods will be mentioned. The investigations prove the hypothesis that the organic 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. (Author's abstract)

KRASIL'SHCHIKOVA, O. A., MITROPOL'SKII, A. Yu. and POVARENNYKH, A. S., Relation of the photoluminescence spectra of variously colored fluorites to their formation temperatures: Dopov. Akad. Nauk Ukr. SSR, Ser. B v. 31, no. 7, p. 592-595 (in Ukrainian).

The homogenization temperatures, the luminescence spectra, and the color of various fluorites correlate with various RE concentrations. (ER).

KRAVTSOV, A.I., VOYTOV, G.I., FRIDMAN, A.I., GRECHUKHINA, T.G., LINDE, I.F., and POLYANSKIY, M.N., 1967, Hydrogen content of gas streams in Khibiny: Akad. Nauk SSSR Doklady, v. 177, no. 5, p. 1190-1192 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 177, p. 234-236. (Authors at S. Ordzhonikidze Geological Survey Institute, Moscow)

The gas, flowing from the ijolite-urthites in the walls of the Rasvuchorr railway tunnel, contains 2.8-3.8% H_2 (also up to 1.3% He and 6% Ar). The gas has a stable composition, against a background of fortnightly and semiannual oscillations the amplitudes of which may be expressions of some tectonic and cosmic variables. (V. P. Sokoloff).

KUROVETS, M.I., PIZNUR, A.V., 1961, Conditions of monazite genesis: L'vov Gos. Univ. Mineralog. Sbornik., v. 15, p. 355-359 (in Russian).

Results of a genetic study of monazite are given. It has been determined that monazite, together with albite and other minerals can become a stage of hydrothermal-metasomatic replacement. The temperature of formation of monazite crystals is as follows: the edge zones, 260-270°C; the central parts 320+350°C (Authors' abst.)

KUSHIRO, I., 1969, State of H_2O in the upper mantle, in Problems of petrology and genetic mineralogy, V.S. Sobolev Memorial Volume I: Moscow, "Nauka" Publishing House, p. 21-[illegible] (in Russian with English abstract).

H_2O is probably present in the upper mantle, although its amount may be small. If H_2O is present and H_2O pressure in sufficiently high, hydrous minerals such as amphibole and mica would be expected to form in shallower levels of the upper mantle. However, such hydrous minerals most likely break down into anhydrous, high pressure mineral assemblages plus H_2O with increasing depth even if H_2O pressure is high. In the relatively deep levels of the upper mantle, H_2O may exist in interstices between crystals or as inclusions in the state of a supercritical fluid with specific volume less than 1.0 cc/gm. Such fluid may dissolve considerable amounts of various elements and migrate upwards through the mantle to a layer where hydrous minerals are stable (Author's abstract).

KUZNETSOV, A.G., and KOBILEV, A.G., 1967, Inclusions in quartz of volcanogenic rocks of northen Osetia: Geol. Geokhim. Goryuch. Iskop., no. 9, p. 88-92 (in Russian).

LAZARENKO, E.K., 1967, Honeycomb quartz from the Vikhtorinka district of Volhynia: L'vov Geol. Obshch. Mineralog. Sbornik, v. 21, no.3, p. 283-287, (in Russian).
Honeycomb quartz (i.e., quartz that has a network of planes of inclusions, presumably from alpha-beta inversion (Ed.) from unproductive parts of the pegmatite fields of the Voledarsk-Volynsk area is compared with similar quartz from productive pegmatites. Seven very complete water leach analyses are presented. (ER)

LAZARENKO, E.K., 1968, New data on inclusions in the topaz of the Volyn: L'vov. Gos. Univ. Mineralog. Sbornik. v. 22, no. 1, p. 30-32 (in Russian).

The topazes from the pegmatite of the Victorinka (Volyn) are characterized by small size and are colorless. The topazes contain secondary polyphase and essential gas inclusions. The temperatures of homogenization of these inclusions are 350-360°C, and the pH of the solutions 5.6±0.2. (Author's abstract).

LEBEDEV, L.M. and NIKITINA, I.B., 1968, Chemical properties and ore content of hydrothermal solutions at Cheleken: Akad. Nauk SSSR Doklady v. 183, no. 2, p. 439-441 (in Russian); translated in Doklady Acad. Sci. USSR, v. 183, 1968, p. 180-182.

Gives 11 complete analyses. These heavy-metal-rich saline brines are important as possible examples of active ore solutions(E.R.)

LELEU, M., 1969, Essai d'interprétation thermodynamique en métallogenie: les minéralisations karstiques (du Laurium (Grèce)), Bulletin du B.R.G.M.-Deuxième série - n°4 p. 1-59 + four plates.

Homogenization temperatures of 140-1[illegible]°C are reported for fluorite (p. 24 and 36) (ER).

LEROY, J. and POTY, B., 1969, Recherches préliminaires sur les fluides associés à la genèse des minéralisations en uranium du Limousin (France): Mineral. Deposita v. 4, p. 395-400, (Authors at Centre de Recherches Pétrographiques et Géochimiques - Nancy, France).

Thermometric study of fluid inclusions shows that the fluid phases were rich in CO_2 at high temperature and rather low pressure during the deposition of uranium ores in Limousin. (Author's abstract.)

LÉZIER, J.C., 1969, Étude morphologique des lacunes de cristallization dans la fluorine d'Ouezzane (Rif occidental, Maroc): Notes Service géologique Maroc, v. 29, no. 213, p. 173-179 (in French).

A study of the crystal forms of negative crystal cavities. (ER).

LEZNYAK, V.F., 1964. (See Translations Section)

LHAMSUREN, J., 1968a, New genetic family of liquid inclusions in topaz: Ulaan Baatar, Mongolian State Univ., Sci. Inf. 13, p. 3-9 (in Russian).

LHAMSUREN, J., 1968b, Some interesting examples of deformation of the gas bubble in polyphase inclusions in topaz: Ulaan Baatar, Mongolian State Univ., Sci. Inf. 13, p. 10-14 (in Russian).

LHAMSUREN, J., 1968c, Determination of the temperature of formation of pyrrhotite found in quartz from the granite pegmatite of the Zuun Bayan deposit: Ulaan Baatar, Mongolian State Univ., Sci. Inf. 13, p. 15-18 (in Russian).

LHAMSUREN, J., 1969, Comparison of the processes of pegmatite formation and greisenization in two deposits in Mongolia (with inclusions of mineral-forming solutions): Author's summary for Candidate degree, Moscow State University Press, 1969, 29 p. (in Russian). An extension of the work covered in the three papers above. (ER)

LINDSAY, W.T., Jr., and LIU, C.T., 1968, Vapor pressure lowering of aqueous solutions at elevated temperatures: Office of Saline Water, Research and Development Progress Report No. 347, U.S. Dept of Interior, 235pp.

This provides data on many systems of interest to inclusion studies. (E.R.)

LITVINOVSKII, B.A. and GULETSKAYA, E.S., 1969, Temperature of crystallization and composition of nepheline of some alkaline rocks of the Vitim plateau: Geol. Geofiz., 1969, no. 6, p. 12-16 (in Russian).

Homogenization temperatures of melt inclusions were 800-850°C, very different from that predicted from the isotherms in the synthetic system nepheline-kalsilite-silica (Hamilton), due to impurities in the analyzed nepheline. (ER).

LOFOLI, P., 1969, Examen ultramicroscopique des inclusions des grains de quartz alluvionnaires du Basin du Congo. (Microscopic investigation at high magnifications of inclusions in alluvial quartz grains from the Congo Basin): Compt. Rend. Acad. Sci. Paris, v. 268, Serie D, p. 3149-3152.

A symmetric dark field illumination of the very small fluid inclusions in detrital grains of quartz may help to characterize the origin of sedimentary rocks. Surface pits and unevenness require flakes of the grains to be broken off, in order to make them transparent. (P.J.M. Ypma).

LU, K. I., 1969, Geology and ore deposits of the Uchinotai-Higashi ore deposits, Kosaka mine, Akita Prefecture, with special reference to the environments of ore deposition: PhD dissertation, Univ. of Tokyo, 1969, 116 pp. (in English). (Also referenced as 1970).

This dissertation, on a typical Kuroko ore deposit, includes a section on fluid inclusions (p. 44-57) and 94-1[illegible], in samples of "large" crystals of quartz, barite, and sphalerite (3-5 mm). Homogenization temperatures for selected primary inclusions from all localities (154 dets.) (using pure Bi and Cd as standards) revealed a wide variation: quartz, 225° to 310; sphalerite, 190-245; and barite, 120-300°. Pressure corrections are probably negligible. Freezing temperature determinations ranged from -1.5 to -5.3°, indicating salinities (NaCl equivalents) of <10 wt %. The wide range of homogenization temperatures for barite is interpreted as possibly due to leakage, and the smaller but still appreciable range for quartz as due to trapping of primary gas bubbles. (ER)

LYAKHOV, Yu.V., 1963, Syngenetic inclusions of goethite and hematite in quartz crystals from Volynian pegmatites: L'vov. Gos. Univ. Mineralog. Sbornik, v. 17, p. 210-214 (in Russian).

Goethite forms peculiar ragged inclusions in the outer zones of quartz crystals, developing simultaneously with the host mineral. Here goethite is usually found closely associated with hematite which also forms syngenetic inclusions. The quantitative distribution of these mineral inclusions in the quartz zone points to the decrease of the role of iron in the quartz-forming solution with the growth of the quartz crystal. Judging from the gaseous-liquid inclusions accompanying goethite, its formation took place from liquid solutions at a temperature of about 195°C. (Author's abstract).

LYAKHOV, Yu.V., and MYAZ', N.I., 1966. (See Translations Section)

LYAKHOV, Yu. V., and PIZ'NYUR, A. V., 1969, Unusual discovery of carbon dioxide in fluid inclusions: L'vov. Gos. Univ. Mineral. Sborn., v. 23, no. 2, p. 185-187 (in Russian).

Inclusions in quartz containing both liquid CO_2 and halite daughter crystals homogenize from 310° to 410°, at calculated pressures of 750-1130 atm. CO_2 was also found in inclusions in calcite. (ER)

McAULIFFE, Clayton, 1969, Determination of dissolved hydrocarbons in subsurface brines: Chem. Geol. v. 4, p. 225-233 (author at Chevron Research Company, La Habra, Calif., U.S.A.)

Hydrocarbons dissolved in subsurface waters can be determined by several analytical procedures. The solubility of hydrocarbons in water varies as much as 5-6 orders of magnitude, depending upon the hydrocarbon type and molecular weight within a homologous series. The concentration of dissolved hydrocarbons in subsurface brines varies widely from brine to brine. Marked variations also occur in the relative concentration of the individual hydrocarbons dissolved. Up to 1800 ppb of CH_4; 10,000 of benzene; 5,000 of toluene; and several hundred of ethane and propane. (Author's abstract, modified).

MAIRLOT, H. and GILARD, P., 1967, Setting up a gas chromatograph for the analysis of bubbles in glass, Glass Technology, v. 8, no. 5, October 1967, p. 123- . (Authors at Institut National du Verre, Charleroi, Belgium).

Gas chromatography appears to be particularly suitable for the analysis of gas bubbles in glass.

The paper describes the experience gained by the authors in the use of a chromatograph which has a thermal conductivity cell in a

Wheatstone bridge network as a detector, a column of sebacate on Chromosorb W for the separation of CO_2, SO_2, and H_2S, and a column of 5 A molecular sieve for the other gases.

With this apparatus it is possible to analyze bubbles of about 0.5 mm in diameter. (Authors' abstract)

MAISKII, Yu.G, 1968, Thermometry of inclusions in topaz from pegmatites of the Ikhe-Naratin-Khi[illegible]granite massif (southeastern Mongolia), in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New Methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 244-5 (in Russian).

Primary multiphase inclusions (including daughter crystals and CO_2) homogenized around 450°C. Pseduosecondary and secondary inclusions homogenized at lower temperatures (ER).

MAISKII, Yu.G., and TRUFANOV, V.N., 1967, Carbon-containing inclusions in hydrothermal minerals of quartz-carbonate veins of northwestern Caucasus: Geol. Geokhim. Goryuch, Iskop., no. 9, p. 30-32 (in Russian).

MASLYAKEVICH, Ya.V., 1967, Hydrocarbon-containing inclusions in minerals of post-magmatic formations: Geol. Geokhim. Goryuch. Iskop., no. 9, p.58-69, (in Russian).

MEL'NIKOV, F. P., 1968a, Duplication of (inclusions of) parent solution in daughter crystals within liquid inclusions with changing temperature, in Mineralogical Thermometry and Barometry, N. P. Ermikov, ed., v. 1, Geochemistry of deep mineral-forming solutions: Moscow, "Nauka" Press, p. 103-109 (in Russian).

Twenty different daughter minerals from inclusions are described in terms of their appearance and shape, and thermal characteristics on heating or cooling. Inclusions forming within newly recrystallized daughter crystals on cooling are illustrated. (ER)

MEL'NIKOV, F.P., 1968, Cryometric study of inclusions in samples of a mineral-forming medium, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 56-61 (in Russian).

Expts. on freezing of inclusions in quartz and fluorite were made in a modern app. cooled by liq. N and in the Kofler stage cooled by liq. CO_2. A complete diagram on changes in the aggregate state of solns. in quartz and fluorite inclusions at pos. and neg. temp. was plotted. A gradual decrease in concn. of mineral soln. during growth of fluorite crystals was ascertained by the cryometric method. Homogenization of inclusions in fluorite during their heating occurred only in the liq. phase. The cryohydrate point of solns. increased with decreased coeffs. of inclusion filling at increase in soln. vol. during freezing, reaching 5-10%. The cryometric study of samples of mineralization medium provides data for detn. of relative changes in soln. concn. during crystn. In essentially gas inclusions, the method provides for detn. of CO_2, H_2S and other gases without chem. anal. The observation of processes, occurring during freezing and thawing of inclusions, provides direct or indirect data on chem. compn., concn., and d. of mineralizing solns. (C.A.)

MEL'NIKOV, F.P. and FRATKIN, O.S., 1968, Motion picture method for studying processes occuring in mineral inclusions during temperature changes, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 98-102 (in Russian).

Groups of still photomicrographs are presented from three sequences in a motion picture of cooling and heating of inclusions.(ER)

MERCER, P. D., 1967, Analysis of the gases released on cleaving muscovite mica in ultrahigh vacuum and of gases which remain adsorbed on the freshly cleaved surface: Vacuum, v. 17, no. 5, p. 267-270 (Author at Division of Tribophysics, Commonwealth Scientific and Industrial Research Organization, University of Melbourne, Australia).

The gases released on cleaving mica specimens in ultrahigh vacuum have been analysed mass spectrometrically and found to consist mainly of nitrogen ($\sim$80 per cent) and hydrogen ($\sim$10 per cent). The total amount of gas released was variable and it is concluded that the gas was trapped in pockets or fissures between the silicate layers. On heating the freshly cleaved surface, adsorbed gases, mostly water vapor, were evolved. It is estimated that there was 1 water molecule for every 2 to 5 potassium ions in the cleavage plane. (Author's abstract).

MILLER, J.D., 1969, Fluid inclusion temperature measurements in the East Tennessee zinc district: Econ. Geology, v. 64, p. 109-110.

197 primary inclusions in fluorite were studied. Filling temperatures ranged from 100° to 280°C, with a maximum at about 200°C (E.R.) Note - a correction to these data, invalidating the higher measurements, will be published in Econ. Geology, 1972.

MIROCHNIKOV, I.I., 1968, Determination of the temperature ranges of rock crystal and vein quartz formation by a decrepitation method, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 50-5 (in Russian).

Decrepitation of quartz from a variety of deposits in the USSR. Peaks at high temperatures ($>450°$) are probably due to overshoot of tiny inclusions and the α-β transition. (ER).

MIRONOVA, O.F. and NAUMOV, G.B., 1967, Method of determining the concentration of CO_2 in gas-liquid inclusions; Geokhimiya 1967, No. 10, p. 1121-1123 (in Russian)(Authors at Vernadskii Inst. of Geochemistry and Analytical Chemistry, Acad. Sci. USSR, Moscow). (See Translation Section).

MOROZOV, S.A., 1966. (See Translations Section)

MOTORINA, I.V., 1967, Multiphase inclusions in topazes from the pegmatites of Volyn': Akad. Nauk SSSR Doklady, v. 175, p. 686-688 (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 175, p. 135-137, 1967 (Author at Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, USSR).

Pseudosecondary inclusions homogenize at 465-550°C, and at least 300-400 atm: their dissolved salts are as high as 70% by weight. Primary inclusions homogenize at 540-570°C, in the gaseous phase; the type which homogenizes at 700°C, according to earlier reports, could not be found in the crystals here examined. Homogenization temperatures of secondary inclusions may be as low as 120°C, indicative of a remarkably low temperature range for the possible healing of the crystals.--V.P. Sokoloff.

MOTORINA, I.V. and BAKUMENKO, I.T., 1968, Genesis of tourmalines in pegmatites of Borshchevochnyi ridge, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow "Nauka" Press, p. 196-201 (in Russian).

Varicolored tourmalines show inclusions of hydrothermal fluids homogenizing at 370°C and containing appreciable gas. Eight gas analyses show major H_2S and CO_2, minor O_2 and CO, and 0.0 NO and H_2(ER).

NARSEEV, V.A., BUGAETS, A.N., ABISHEV, V.M., LOPATNIKOV, V.V. and BALGAEV, M.D., 1968, Temperature formation conditions of Kalby pegmatites and hydrothermal rocks (eastern Kazakhstan), in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 213-218 (in Russian).

These pegmatites and associated rare metal ore deposits were studied by decrepitation and thermoluminescence. Very little variation occurred in the temperatures found for either method for several widely different kinds of deposits. (ER).

NAUCHITEL, M.A., 1968, Control of the decrepitation method and use of thermogravimetric analysis for comparing formation conditions of cassiterites, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 255-260 (in Russian).

The author successfully used TGA curves to help interpret the decrepigrams from thermally inert minerals. Sample and heating conditions had to be held relatively constant for the two (different) runs. (ER.)

NAUMOV, V.B., 1968, Determination of mineral formation temperatures by a decrepitation method, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigation of the conditions of ore formation: Moscow, "Nauka" Press, p. 37-43 (in Russian).

Homogenization and decrepitation temperatures (for natural and synthetic crystals) are compared. The agreement is good except for cases of "anomalous decrepitation", which was found in many minerals. In sulfides, it may stem from oxidation. (ER).

NAUMOV, V.B., and IVANOVA, G.F., 1967, Temperatures of formation of tungsten deposits of greisen type in eastern Transbaikal, in Barabanov, V. F., and others, eds., Mineralogy and Geochemistry of wolframite deposits: Leningrad Gos. Univ., p. 153-158 (in Russian).

The authors made both decrepitation and homogenization determinations in quartz and huebnerite. Homogenization of the liquid-gas inclusions (no daughter crystals) was in the liquid, at ≤ 400°. (ER.)

NAUMOV, V.B., and KHODAKOVSKII, I.L., 1968, Formation temperatures of minerals according to data obtained from studying inclusions in mineral-forming media, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of conditions of ore formation: Moscow, "Nauka" Press, p. 136-140 (in Russian).

A statistical review of the inclusion data from the literature on the temperatures of crystallization, proving that most minerals from hydrothermal deposits formed at < 400°C. (ER)

NIKANOROV, A.S., MIKHAILOV, I.I., MOSKALYUK, A.A. and LAZAREVICH, N.S., 1968, Composition and concentration of solutions from microinclusions in quartz of mica-bearing and ceramic pegmatites, in Papers on experimental and geologic-mineralogical investigations of the processes of ore formation, vyp. 1; Vsesoiuznyi nauchno-issledovatel'skii geologicheskii institut Trudy, novaia seriia, v. 162, 1968, p. 60-69

In addition to several decrepigrams, Tables 1 and 2 present nine analyses of aqueous extracts from quartz of the quartz cores (?) and quartz-muscovite complexes of pegmatites, with SiO_2, K, Na Mg, Ca, Cl, F, SO_4, and HCO_3 reported in g/l; $\%H_2O$ in the quartz; and pH of the leachate. Eight additional analyses are given (Tables 3 and 4), for the same constituents, on high- and low-temperature inclusions. (ER)

NIKULIN, N.N., 1967, Distribution of indium, niobium, and scandium in cassiterites of the Khingan deposits: Leningrad Univ. Vestnik, Ser. Geol. Geog., 1967, no. 6, p. 81-87 (in Russian).

In addition to the data on trace elements, the author presents 61 homogenization temperatures for inclusions in quartz, which increase with depth from a minimum of 220°C at 636 m to a maximum of 330° at 1068 m (his table 5) (ER).

OGNAR, S., 1969, Géothermométric des concentrations plombo-zincifères dans le Crétacé de Tunisie centrale: Centre de Recherches de Pau, Bull. v. 3, no. 2, p. 377-399.

Deposits (Plain of Foussana) are peneconcordant, low-temperature, stratiform. Studied decrepitation using Deicha's visual (oil) decrepitoscope. Decrepitation temperatures 50-150°C, with some to 250-300°. Some NaCl daughter crystals and liq. CO_2 seen (ER).

OHMOTO, Hiroshi, 1969, Bluebell mine, British Columbia, Canada. Mineralogy, paragenesis, fluid inclusions, and the isotopes of lead, carbon, oxygen, and hydrogen. Chemistry of the hydrothermal fluids (gases and salts in fluid inclusions): PhD Dissertation, Princeton Univ., 206 pp. Avail. Univ. Microfilms, Ann Arbor, Mich., Order No. 69-14, 424, and Diss. Abstr. Int. B. 1969, 30 (3), 1204.

PANINA, L.I., 1966, On the genesis of nepheline syenites of Borgoi: Akad. Nauk SSSR Sibirskoye Otdeleleniye Geologii i Geofizikii, Trudy, 1966, no. 8, p. 114-115 (in Russian). (See Translations Section).

PAVLISHIN, V.I., VOZNYAK, D.K. and MELNIKOV, V.S., 1968, Syngenetic inclusions of micas in topazes from Ukrainian pegmatites: L'vov Min. Sborn., v. 22, no. 2, p. 175-177 (in Russian).

Inclusions indicated the topaz and mica formed at 380-415°C (E.R.)

PERCHUK, L.L., 1969, Evaluation of temperature and pressure conditions of petrologic processes: Geol. Geofiz., 1969, no. 8, p. 142-146 (in Russian).

A critical review of the validity and application of homogenization temperatures and other geothermometers. (ER)

PERING, Katherine and PONNAPERUMA, Cyril, 1969, Alicyclic hydrocarbons from an unusual deposit in Derbyshire, England - a study in possible diagenesis: Geoch. et Cosmo. Acta v. 33, p. 528-532.

Black brittle rods and gelatinous dark gray-green elastic gums found in veins with sulfides, quartz, calcite, and fluorite in carboniferous limestone may be related in genesis to the lead, zinc and barite deposits of the area. Extractable hydrocarbons in the two types of material show that the two may have had different origins. (Various organic materials are found in the inclusions in fluorite from these deposits as well. Ed.) (ER).

PERNA, Giuliano, 1968, Geotermometria dei minerali di ganga dei giacimenti minerari: Symposium internazionale sui giacimenti minerari delle Alpi, Trento-Mendola 11-18 Sept. 1966, v.4, p. 989-1003. (in Italian with very brief summaries in French, English and German).

A review with 61 references (E.R.)

PETERSIL'E, I.A., ANDREEVA, E.D., and SVESHNIKOVA, E.V., 1965a, The organic matter in the rocks of some alkaline massifs of Siberia: Akad. Nauk. SSSR, Izvestia, Geol. Series, 1965, no. 6, p. 26-37 (in Russian). As this paper deals with the gases and bitumens from samples from other than the thoroughly studied Khibina and Lovozero massifs, it has been translated (See Translation Section). A much shorter version was published elsewhere (see next item).

PETERSIL'E, I.A., ANDREEVA, E.D., and SVESHNIKOV, E.V., 1965b, Hydrocarbonic gases and dispersed bitumens in rocks of certain alkaline massifs of Siberia: Akad. Nauk SSSR Doklady, v.161, p. 670-672, (in Russian); translated in Acad. Sci. U.S.S.R. Doklady, Earth Sci. sec., v. 161, p. 65-67, 1965

PIZNYUR, A.V., 1968a, Pressures during the formation of the Zhireken copper molybdenum deposits (eastern Transbaikal): Akad. Nauk SSSR Doklady, v. 179, no. 5, p. 1186-1188 (in Russian).

Very similar in coverage to that of Piznyur, 1968b (see next abstract) (E.R.)

PIZNYUR, A.V., 1968b, The determination of pressure from multiphase inclusions: L'vov Gos. Univ. Mineral. Sbornik v.22, no.2, p. 168-170 (in Russian).

Inclusions containing daughter crystals of halite may be divided into two groups on the basis of their behavior on heating: 1). those in which the halite dissolves before the gas bubble disappears, and 2) those in which the halite dissolves after the gas bubble disappears. The author used the second group, plus the data of Klertsov and Lemmlein (1959) to define the pressure of trapping. A study of inclusions (from the Zhireken Cu-Mo deposits in Eastern Transbaikal) indicate very high early pressures, the pressure varying drastically with the mineralogy of the ore process involved (early K-feldspathization, later sulfidation, argillic alteration, etc.). (Author's abstract, extended by E.R.)

PIZNYUR, A.V. and SOLOMIN, Yu.S., 1968, The problem of the mineralogy and genesis of molybdenum occurrences: L'vov Gos. Univ. Min. Sbornik, v.22, no.4, p. 378-385 (in Russian with English abstract).

The chemical and physical parameters of rock-forming solutions have naturally been changing in the course of the formation of the Davendin occurrence. The cycle of each stage of the solution development complicated the direct development of the solutions from the beginning up to the end of the rock-forming processes. The formation of minerals occurred over a wide range of temperature (435-80°C). The minerals of the early stages were formed from gaseous solutions, which later on condensed into concentrated hydrothermal solutions. During later stages minerals were formed from solutions. (Authors' abst.)

POLYKOVSKII, V.S., NEKLYUDOV, Yu. V., and IDRISOVA, L.V., 1966, Formation temperature conditions of some fluorite deposits of the eastern Pamirs: Trudy, Sredneaziat. Nauch. -Issled. Inst. Geol. Miner. Syr'ya 1966, No. 7, 130-4 (in Russian).

Homogenization of liquid-gas inclusions in fluorite from various types of occurrences ranged from a maximum of 250° (from quartz - tungsten deposits) to 58° (in veins cutting Triassic carbonate sediments. ER)

POMÎRLEANU, Vasile, 1968a, Die Bedeutung der Flüssigkeitseinschlusse in Scheelitkristallen für die geologische Thermometrie: Chemie der Erde, v. 27, pt.2, p. 178-186

Primary inclusions in scheelite from the Baia Sprie deposit homogenized at 260-327°C. Those in scheelite from Tincova contained CO_2 and required temperatures up to 460°C, yielding formation temperatures up to 500°C (E.R.)

POMÎRLEANU, Vasile, 1968b, Determination of the crystallization temperature of diopside in the Rodna massif of eastern Romanian Carpathia, from homogenization of liquid inclusions, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 272-274.

Homogenization temperatures (66) ranged from 185-240°C; corrected to 326-456° for formation temperature. (ER.)

POMÎRLEANU, V., 1969, Les inclusions fluides dans les cristaux de béryl des pegmatites de Roumanie: Rev. Roum. Géol. Géophys., Géogr.-Sér. Géol., v. 13, pt. 2, p. 117-121 (in French).

Homogenization temperatures for a series of deposits range from 235 to 450°, and are compared with decrepigrams. CO_2 liquid was found in some, and cubes of NaCl in other inclusions. (ER).

POMÎRLEANU, V. and BARBU, A., 1969, Contributions to the study of the occurrences of diopside in the Rebrei and Cormaia Valleys (Rodnei Mtns.): Univ. "Al. I. Cuza" Inst. Pedagog. Commun. Stiin., 1969, p. 331-340 (in Romanian).

Decrepigrams for two generations of diopside (temperatures up to 500°C) and for calcite are presented. (ER)

POMÎRLEANU, VASILE, and MOVILEANU, A., 1966, Geothermometry of sphalerite in the hydrothermal deposit of Capnic: Analele Ştiinţifice Univ. Al. I. Cuza, Iaşa, sect. 2, v. 12, p. 21-26 (in Romanian, with French and Russian abs.)

Inclusions in sphalerite homogenized in the range 243-274° C; quartz 285-303°C (ER).

POMÎRLEANU, A. and MOVILEANU, Aurelia, 1968, Crystallization temperature of muscovite in various pegmatites:Rev. Minelor v. 19(10), p.441-443(in Romanian) .

Liquid inclusions in muscovite from many sources contained liquid and variable gas ± a daughter crystal of calcite (?). Homogenization was generally about 300° (ER).

POMÎRLEANU, Vasile and PETREUS, I., 1968, Geothermometry of calcite and fluorite based on the study of fluid inclusions in the hydrothermal deposit of Capnic (Baia Mare): Analele Stiintifice Univ. "Al. I. Cuza," Iași, sec. 2, v.14, p. 1-5 (in French).

Decrepitation and homogenization temperatures,both $\leq$ 310° for calcite assoc. with fluorite, barite, quartz, chalcopyrite, and rhodochrosite. Primary inclusions in the fluorite homogenized at 130-178°C (E.R.).

POTY, Bernard, 1969, The growth of quartz crystals in quartz, exemplified by "La Gardette" vein (Bourg d'Oisans) and the clefts in the Mont-Blanc massif: PhD dissertation, Univ. Nancy, Sciences de la Terre, Mem. 17, 162 pp. 39 figs., 28 tables and 10 plates; (in French with English abstract).

A thorough study (approx. 250 references) of the relationships between external and internal morphology, impurity content, unit cell size, geological environment and growth conditions, investigated by a variety of techniques. Many fascinating details of growth phenomena are revealed, in particular by a special X-ray technique. The growth conditions are revealed from the study of the geology, wall rock mineralogy and its alteration, vein mineralogy, and the fluid inclusions. Homogenization temperatures, phase studies, freezing temperatures, and mole % CO_2 determinations on the inclusions are recorded. (ER)

PURTOV, V.K., 1969, Determination of mineralization temperature and pressure by calculation of carbon dioxide equilibrium concentration in liquid and gas phases of the water-carbon dioxide binary system: Geol. Polez. Iskop. Urala 1969, No. 1, p. 257-258 (in Russian). From Refer. Zhur., Geol., V. 1969, Abstr. No. 12V640.

RAKHMANOV, A.M., 1968, Formation conditions of quartz crystals in cavities in pegmatite of Mezhdurech'ya Kafiringan-Barzov (Southern Gissar), in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v. 2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 201-212 (in Russian)

Quantities and homogenization temperatures of the CO_2 and the water phases in inclusions are used to calculate pressure variations during and between stages. A leach analysis for Na, Mg, Ca, SO_4, Cl, and HCO_3 is presented, along with pH and spectrographic determination of trace elements.(E.R)

RODZYANKO, N.G., 1969, Mineralogical-thermometric study of skarn formation conditions in the Tyrny-Auz ore field: Probl. Metasomatizma, 1969, p. 401-410 (in Russian). From Referat. Zhur., Geol., v. 1970, Abstr. No. 6V 726.

An improved decrepitometer and decrepitation technique are described and applied to the deposit. Temperatures of 90-700° are recorded. (ER).

ROEDDER, Edwin, 1967a, Fluid inclusions as samples of ore fluids, Chapter 12 of Barnes, H.L., ed., Hydrothermal ore formation: New York, Holt, Rinehart and Winston, p. 515-574.

An extensive review (162 references) of the nature of the data on the ore fluids available from studies of fluid inclusions, how they are obtained, their limitations, and validity. (ER)

ROEDDER, Edwin, 1967b, Metastable superheated ice in liquid-water inclusions under high negative pressure: Science, v. 155, p. 1413-1417.

In some microscopic inclusions (consisting of aqueous liquid and vapor) in minerals, freezing eliminates the vapor phase because of greater volume occupied by the resulting ice. When vapor fails to nucleate again on partial melting, the resulting negative pressure (hydrostatic tension) inside the inclusions permits the existence of ice I crystals under reversible, metastable equilibrium, at temperatures as high as +6.5°C and negative pressures possibly exceeding 1000 bars. (Author's abstract)

ROEDDER, Edwin, 1967c, Environment of deposition of stratiform (Mississippi Valley-type) ore deposits, from studies of fluid inclusions: Econ Geology Mon. 3, p. 349-362.

Fluid inclusions in ore and gangue minerals provide a wealth of data on the conditions of origin of these deposits with respect to density, temperature, rate of movement, salinity, and composition of the fluids that deposited the ores, at the site and time of deposition. Although some assumptions must be made that certainly cannot be strictly valid in every case, the available evidence indicated that, if care is used in inclusion sample selection and experimental technique, the exceptions to these assumptions will be few and of minor significance, and the accuracy of the results adequate for use in discussions of genesis.

From inclusion evidence alone, it is apparent that the ore fluids forming a number of these deposits were slow-moving, hot, dense, Na-Ca-Cl brines, containing abundant organic matter. The most striking feature is the uniformity of temperature, density, chemical composition, and salinity, over a wide range of stratiform-type deposits, inclusing those in the Joplin, Southern Illinois, Southeast Missouri, East Tennessee, Derbyshire, North Pennine, and Santander districts, and in other smaller occurrences.

Although these data do not determine the origin or origins of these deposits, they place severe limitations on the possible mechanisms of ore transport and deposition. Origin by sedimentary-syngenetic, volcanic exhalative, simple magmatic-hydrothermal, and meteoric circulation processes seem to be precluded by the inclusion data; deposition from modified, deep-circulating, heated connate brines in compatible with these data, and is considered to be a satisfactory working hypothesis. (Author's abstract)

ROEDDER, Edwin, 1968a, Environment of deposition of the disseminated lead ores at Laisvall, Sweden, as indicated by fluid inclusions, Internat. Geol. Cong. 23d, Prague 1968, Repts., sec. 7, Endogenous ore deposits, Proc., p. 389-401.

In 1960 and 1967, Erland Grip showed that ore-fluid movement and deposition of highly radiogenic lead ore in Cambrian sandstones and quartzites underlying black alum shales at Laisvall (and many similar deposits along the eastern border of the Caledonides) were strongly controlled by sedimentary features and by tectonic structures formed by imbricate overthrusting toward the southeast.

Although the ore at Laisvall is generally fine grained and the sequence of deposition ambiguous, good inclusions were found in eight samples (fluorite, barite, calcite, quartz, and yellow-brown sphalerite). Presumed primary inclusions in seven samples (> 250) and pseudosecondary or secondary inclusions (several hundred) in the eighth were selected for measurement of homogenization (filling) temperature; freezing temperature (a function of the salinity) was deterined for many of these.

With few exceptions, the inclusion fluids were extremely saline, freezing between -19.7° and -32.5°C. Fluids in three primary inclusions in a late, 10-cm calcite crystal were exceptional in that they were essentially fresh water.

Homogenization temperatures ranged from 83° to 223°C. Four large groups of primary inclusions in three sphalerites had the highest averages: 150°, 160°, 172°, and 185°C. Assuming a depth of 1,000 m, the pressure correction to be added to these temperatures would be approximately +20°C.

The salinity could result from ion filtration through shales, or from hypothetical evaporite beds; the temperature could reflect deep circulation, or added hot metamorphic waters from sediment palingenesis to the west; and the radiogenic lead could originate from either the shales or Precambrian basement rocks. Obviously the inclusion data are not definitive, but they do effectively preclude those modes of ore genesis involving fresh or sea water, at surface temperatures, that have been suggested for such Mississippi Valley-type ores (Author's abstract). Note: The higher temperatures reported here (>150°C) are probably in error. A note to this effect will appear in <u>Econ. Geology</u> in 1972 (E.R.)

ROEDDER, Edwin, 1968b, Temperature, salinity, and origin of the ore-forming fluids at Pine Point, Northwest Territories, Canada, from fluid inclusion studies: Economic Geology, v.63, p. 439-450.

Although the Pine Point ore is relatively poor in useable fluid inclusions, some sphalerite crystals from replacements, vugs, and from "colloform" crusts were found to contain primary or pseudosecondary liquid-gas inclusion adequate for study. Most (132 of 133) of these had low freezing temperatures, indicating exceedingly saline brines. The 112 inclusions suitable for filling-temperature determination homogenized at +51° to +97°C. A very small pressure correction must be added to obtain the trapping temperature.

Dolomite crystal from some of the same vugs contain large numbers of primary inclusions, many of which have leaked. The twenty-three that presumably have not leaked had filling temperatures of 90°-100°C, but somewhat lower salinities. Inclusions in late calcite appeared to have similar gas-liquid ratios, but had still lower salinities.

The significance of these data lies in the limitations they place on the choice of possible mechanisms of origin of these large deposits.

This choice, in turn, may influence the success in prospecting for blind ore bodies. There is general agreement that the deposits are of Mississippi Valley type. Although the high salinities may reflect solution of salts from evaporites, as are now found to the south, the elevated temperatures seem to require deep circulation, perhaps through known faluts in the underlying Precambrian. The densities of these brines, even at their elevated temperatures, are well above that of fresh, cold surface water, thus restricting the possible modes of circulation during ore deposition. (Author's abstract).

ROEDDER, Edwin, 1969, Fluid inclusion evidence on the environment of formation of mineral deposits of the southern Appalachian Valley (abst.): Econ. Geol. v. 64, p. 353.

Approximately 1,000 fluid inclusions were studied in samples of ore and gangue minerals from both massive ore and late-stage vugs from seven small Appalachian deposits and five active mines in the East Tennessee district. Most primary inclusions in sphalerite, fluorite, dolomite, and quartz from East Tennessee homogenized at 82°-149°C. Primary inclusions in fluorite, barite, and sphalerite from the Central Kentucky, Sweetwater barite, and other districts ranged from 72°-132°C. Pressure corrections to be added are probably less than 10°C

Freezing data were obtained as a crude measure of the salinity of inclusion fluids. With few exceptions, all primary inclusions contained very strongly saline brines (mostly $>$20 percent salts), with appreciable amounts of at least some salts other than NaCl. The exceptions include several quartz, fluorite, calcite, and barite samples that contained only moderately saline brines (12-16 percent), and some vug calcite inclusions containing essentially fresh water. Secondary inclusions had lower salinities than adjacent primary inclusions. Eight primaries in the outer millimeter of one Central Kentucky fluorite had low salinity (4.6 percent).

The data indicate that these deposits formed from hot, saline brines. This places severe restrictions on possible modes of origin, and makes deeply circulating connate brines the most probable ore fluids. The data give no information on the cause or direction of fluid circulation, which would be controlled by topography, salinity, and temperature during ore deposition, but they permit wide latitude in the construction of possible models. Other observations, on "colloform" textures, seem to indicate the admixture of at least small amounts of surface waters with the brines. (Author's abstract).

ROEDDER, Edwin and COOMBS, D.S., 1967, Immiscibility in Granitic Melts, Indicated by Fluid Inclusions in Ejected Granitic Blocks from Ascension Island: Journal of Petrology, vol. 8, part 3, 417-51. (Authors at U.S. Geological Survey, Washington, D.C., 20242 and Geology Department, University of Otago, New Zealand).

Quartz and alkali feldspar from vuggy granitic blocks contain up to 10^{10} fluid inclusions per cubic centimeter, of three main compositional types, I-III; the inclusions are presumably the result of the trapping of three discrete, individually homogeneous fluids, plus fewer inclusions of other compositions, including several mixed types. The original fluid trapped in inclusions of type I was a silicate-rich magma; at room temperature it consists of silicate glass, with a small, very low-pressure gas bubble and sometimes a crystal of fluorite(?). The original material trapped in type II was a dense saline fluid with 50-70 weight per cent NaCl; at room temperature it consists of saturated water solution, a large halite crystal (usually with other crystalline phases), and a large gas bubble sontaining some CO_2. The original material trapped in type III was a dense aqueous-rich fluid or steam; at room temperature it consists of a dilute water solution and a very large, high-pressure CO_2 gas bubble.

Type III apparently represents vapor coexisting with type II fluids (i.e. boiling); it occurs both as independent primary inclusions and in intimate association with type II in planes of secondary inclusions.

It is believed that type II represents immiscible globules of dense saline fluid, suspended in silicate magma, and trapped, possibly because of preferential surface wetting during crystal growth. If both types I and II are primary, their random interdistribution implies immiscibility. Regardless of primary or secondary origin, the examples of mixed type I-II inclusions, containing (at room temperature) a saturated water solution, a large halite crystal, a gas bubble, and a variable amount of silicate glass, seem to require simultaneous coexistence of silicate and saline fluids as a heterogeneous mixture, i.e. immiscibility.

Similar inclusions are found in blocks quenched from both above and below the alkali feldspar solvus. Despite the complex geological history of the samples, such inclusions throw light on the chemical nature of the residual fluids produced during crystallization of these granites, and may permit environmental P-T estimates. They should be looked for in other granites. (Authors' abstract).

ROEDDER, Edwin, HEYL, A.V. and CREEL, J.P., 1968, Environment of ore deposition at the Mex-Tex deposits, Hansonburg District, New Mexico, from studies of fluid inclusions, Economic Geology, v.63, pp.336-348.

These deposits, in Pennsylvanian limestone and shale, contain barite, fluorite, low-silver galena with "J-type" lead, and quartz, and only minor amounts of other minerals. Mineralization occurs in veins, in blankets of bedded, rhythmically banded "coontail" ore, and in vuggy, coarsely crystalline open-space fillings in tectonic and solution channels in limestone adjacent to faults. Except for widespread silification, the mineralization is very similar to that of the southern Illinois deposits. The main stages of hypogene mineralization are: 1) sphalerite, pyrite, galena, and chalcopyrite; 2) five easily recognizable substages of fluorite with intermittent quartz and barite; and 3) late calcite.

More than 500 primary and 2,500 pseudosecondary inclusions, mainly from fluorite, were studied on the freezing and heating microscope stages. Some primary inclusions contain organic matter. Gross supercooling indicates slow ore-fluid movement. Recognizable planes of pseudo-secondaries (each containing 20-200 inclusions) yield data essentially identical with coeval primaries, but the few planes of presumed secondaries do not.

The first three substages of fluorite formed from fluids that were essentially constant in temperature at 186°-205°C (assumed pressure correction +10°C), but increased in salinity from approximately 10 up to 15 weight persent salts. Succeeding substages formed at gradually decreasing temperatures (to about 140°C) and increasing salinity (maximum 17%), with breaks marking several individual substages. A few inclusions in an early barite have anomalously low homogenization temperatures. Coarse selenite has primary inclusions full of fresh water and hence is presumed to be supergene.

These data do not prove any given theory or origin for the fluids or the deposits, but they do place some limits on possible mechanisms of origin. (Authors' abstract).

ROEDDER, Edwin and Skinner, Brian J., 1968, Experimental evidence that fluid inclusions do not leak: Economic Geology, v.63, p. 715-730.

The possibility of leakage of fluid into or out of fluid inclusions subjected to large pressure gradients has always been considered a serious problem in the interpretation of inclusion data. As previous experimental evidence on leakage was contradictory, new experiments were performed. Inclusion vapor bubble diameters in twelve quartz crystals ($\leq$ 3mm; 8 localities), not sawn, ground or polished, were measured. The samples were run at P H_2O external $\leq$ 4,000 bars, at T run 100°-410°C, for $\leq$ 17 days total, and remeasured after each run. Similar experiments at $\leq$ 155°C were made on sphalerite and calcite.

Most inclusions in most samples (even those only 5μm under the surface in quartz) showed no change in bubble diameter, hence no leakage. A few exceptions, mainly among inclusions homogenizing at $T \ll$ Trun, had $P_{internal} \gg P_{external}$, hence they ruptured and lost liquid during the 410°C run.

From this work and a review of the literature, we conclude that most inclusions have not suffered major leakage. Some previous experiments indicating leakage may be explained by microfractures introduced during sample preparation. The present work does not, however, preclude the possibility of diffusion of small but chemically significant amounts of substances such as hydrogen in or out of inclusions (Authors' abstract).

ROSENFELD, J.L., 1969, Stress effects around quartz inclusions in almandine and the piezothermometry of coexisting aluminum silicates: Amer. Jour. Sci. v. 267, p. 317-351.
Ed. note: Although not directly pertinent to fluid inclusion study, this method should provide excellent crosschecks on fluid inclusion thermometry and barometry. (ER)

RYABCHIKOV, I.D., 1967, Possible role of concentrated saline solutions for the mobilization of ore components from magma (abst.): Inst. Mining and Metal. Trans., v. 76, sect. B, p. 14. (Author at Institute for Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Moscow, U.S.S.R.).

In many systems of the type silicate-NaCl (including rock-forming silicates), experimental investigations have demonstrated the presence of two-liquid miscibility gaps which continue into the ternary systems silicate-NaCl-H_2O. There is a five-phase non-variant point on the P-T diagram of the system $Na_2Si_2O_5$-NaCl-H_2O, where the following phases coexist: two solids (NaCl and $Na_2Si_2O_5$), two liquids (silicate melt and aqueous chloride melt) and gas.

On cooling the silicate melts of the same initial composition, crystallization at pressures lower than that of the non-variant point will give rise to separation of chloride melt, while if the pressure is higher than that of the non-variant point crystals of NaCl will precipitate. In systems with rock-forming silicate-NaCl-H_2O such non-variant points are absent, and direct crystallization of NaCl from the silicate melt is impossible. This indicates that when an initially homogeneous silicate melt with appropriate NaCl:H_2O ratio is cooled through the crystallization range the second liquid phase (concentrated saline solution) must separate out at a certain stage of the process.

The presence of a liquid immiscibility field at the temperatures of silicate liquidus in the system granite-NaCl-H_2O suggests the possibility of simultaneous separation of gas phase and concentrated aqueous saline liquid solution during the crystallization of granite magma. The reality of this process is confirmed by investigations of fluid inclusions in the minerals of acid rocks (Roedder, Lesnyak). This aqueous saline solution may extract some ore components from residual silicate magma, and thus this concentrated aqueous liquid may play the role of ore-forming fluid. (Author's abstract.)

RYE, Robert O. and HAFFTY, Joseph, 1969, Chemical composition of the hydrothermal fluids responsible for the lead-zinc deposits at Providencia, Zacatecas, Mexico: Economic Geology, v. 64, pp. 629-643.

The chemical composition of 22 samples of primary fluid inclusions in quartz, calcite, and sphalerite from Providencia, Mexico, has been determined. Samples were prepared, crushed, and leached as described by Roedder et al. (1963). Cation analyses of leachates were made by atomic absorption spectroscopy, and the anions were analyzed by a special X-ray fluorescence technique.

The Na, K, Ca, and Cl concentrations show a considerable range that reflects the widespread salinity variations in the hydrothermal fluids observed by Sawkins (1964). The K/Na atomic ratios of most samples range from 0.18 to 0.43 and the ratios tend to increase with the salinity of the inclusions. The temperatures indicated by the K/Na ratios from the published curves of K/Na ratios vs. temperature are mostly at least 100°C greater than corresponding filling temperatures. The Ca/Na atomic ratios of inclusions in sphalerite range from 0.12 to 0.61. The K/Na and Ca/Na data agree well with previous δO^{18} data (Rye, 1966; Rye and O'Neil, 1968) which indicate that the hydrothermal fluids were derived from the magma related to the Providencia granodiorite stock and that the fluids reacted only slightly with the crystalline stock during the late phases of ore deposition. The data also indicate that the salinity variations in the hydrothermal fluids probably occurred at the source of the fluids and may have resulted from boiling in the magma chamber.

Mg concentrations are generally no more than a few hundred parts per million. Most of the Mg in the hydrothermal fluids was evidently removed during the formation of calcium-magnesium silicates in the lower levels of the ore pipes. Mg/Ca atomic ratios are generally less than 0.08 and are consistent with the paucity of dolomite in the area.

Zn and Cu concentrations in water leaches of inclusions in calcite are generally less than 50 ppm. Maximum base-metal concentrations upon cooling and multi-nucleation upon rapid melting of the latter, KCl cubes do not form hydrates. and increase in size while being coole

from water leaches of two samples of inclusions in quartz are 890 ppm Zn and 530 ppm Cu.

Chloride is the major anion in the fluids, and Cl concentrations vary with corresponding cation concentrations. With two exceptions, sulfur concentrations of the inclusions in calcite and quartz, analyzed as SO_4, are below the level of detection. (Authors' abstract)

RYE, R.O. and O'NEIL, J.R., 1968, The O^{18} content of water in primary fluid inclusions from Providencia, North-Central Mexico, Econ. Geol., v.63, pp.232-238.

The water of eight samples of primary fluid inclusions in calcite, quartz, and sphalerite was analyzed for δO^{18} by the technique of O'Neil and Epstein (7). The δO^{18} of inclusions in sphalerite from three different ore bodies ranged from 6.2 to 5.8‰ relative to SMOW. These values are lighter than the 7-9‰ believed to be typical of pristine magmatic waters and have probably resulted from isotopic exchange between the hydrothermal fluids and the crystalline granodiorite through which the fluids passed after they left a magmatic source. The 6.2-5.8‰ values are in reasonable agreement with the previously calculated δO^{18} of 6.0-7.9‰ for the hydrothermal fluids that deposited calcite and quartz at Providencia.

The δO^{18} of water in inclusions in quartz and in calcite indicate that the inclusions have exchanged O^{18} with their host during cooling of the ore deposit but that less than 45 percent of the exchange that is theoretically possible at surface temperatures has occurred.

The δC^{13} of CO_2 in inclusions in sphalerite and in calcite was -7.0 and -11.0‰, respectively, relative to PDB. The sphalerite value is consistent with the value previously inferred for the δC^{13} of the hydrothermal fluid and is believed to be typical of juvenile CO_2. The calcite value reflects about 50 per cent of the possible exchange that could occur between inclusion CO_2 and the host at surface temperatures. (Authors' abstract)

SABOURAUD-ROSSET, C., 1969, Caractères morphologiques des cavités primaires des monocristaux, sur l'exemple du gypse de synthèse. (Morphological characteristics of primary cavities in single crystals, as exemplified by synthetic gypsum); Compt. Rend. Acad. Sci., Paris, v. 268, Serie D, p. 749-751.

Brine-filled cavities are observed in synthetic gypsum, 2 to 300 microns in size. They occur along surfaces of discontinuous growth but also in planes marking stages of continuous growth. The fluid inclusions seem to become more abundant with proceeding crystallization. Similar phenomena are observed in natural gypsum (P.J.M. Ypma).

SABOURAUD-ROSSET, C., 1969, Expériences sur des inclusions hypersalines synthétiques ($NaCl-H_2O$ et $KCl-H_2O$). Diagnose de la halite et de la sylvite intracristallines. (Experiments with hypersaline synthetic inclusions ($NaCl-H_2O$ and $KCl-H_2O$). Recognition of halite and sylvite in cavities): Compt. Rend. Acad. Sci., Paris. v. 268, Serie D, p. 1671-1674. 247 251.

Experiments with brine-filled fluid inclusions in synthetic gypsum indicate that thermal shock (rapid cooling) can overcome supersaturation or retardation of nucleation. NaCl cubes in fluid inclusions can be recognized by the formation of hydrates ($NaCl \cdot 2H_2O$)

upon cooling and multi-nucleation upon rapid melting of the latter, KCl cubes do not form hydrates, and increase in size while being cooled. (P.J.M. Ypma)

SAINSBURY, C.L., 1969, Geology and ore deposits of the Central York Mountains, Western Seward Peninsula, Alaska: U.S. Geol. Survey Bull. 1287, 101 pp.

Brief mention (p. 87) of CO_2-rich inclusions in fluorite-beryllium ores and greisen deposits of the area (ER)

SAMOILOVICH, L.A., 1969, Dependence between pressure and temperature and density of aqueous salt solutions: Moscow, Ministry of Geol. USSR, All-Union Inst. for the Synthesis of Mineral Raw Materials (VNIISIMS), 51 pp., offset printing, paperbound.

Experimental procedures and evaluation of the data on the systems of water with chlorides of Na, K, Li, NH_4, and Ca; Na_2CO_3, NaOH, and K_2CO_3, up to 1500 kg/cm^2 and T from 180°-550°C. 54 references. Data presented graphically in the form of isochores on 18-- P-T plots.(ER)

SAMOYLOVICH, L. A., and KHETCHIKOV, L. N., 1968a, Pressure corrections to the homogenization temperatures of aqueous salt solutions: Geokhimiya, 1968, no. 12, p. 1462-1469 (in Russian); translated in Geochemistry Internat. v. 5, p. 1184-1189.

The authors present a graphical plot of the isochores in the system H_2O plus 2 weight percent $CaCl_2$, at T up to 400°C and P up to 500 kg/cm^2. Data are also presented on the systems with 4 and 10 weight percent LiCl and 2 and 10 weight percent NH_4Cl, but in the form of graphs of the pressure correction for fluid inclusions of known composition and degrees of fill; data on the position of the two-phase boundary (i.e., the homogenization temperatures) for these systems are not given. In this range the pressure correction varies linearly with pressure. (ER)

SAMOYLOVICH, L. A., and KHETCHIKOV, L. N., 1968b, On the correlations between pressure, temperature and density in aqueous solutions of sodium chloride and potassium chloride: Akad. Nauk SSSR Doklady, v. 180, no. 6, p. 1450-1452 (in Russian); translated in Doklady Acad. Sci. USSR, v. 180, p. 155-157. (Authors at All-Union Scientific Research Institute for the Synthesis of Mineral Products, Aleksandrov, USSSR.)

Basic data on the systems NaCl-H_2O and KCl-H_2O, to 1500 kg/cm^2 and 540°C, of interest to all inclusion workers. (ER)

SAVuL, M. and POMÎRLEANU, V., 1965, Indications of the temperature regime of vein formations by liquid inclusions: pp. 247-251 <u>in</u> Problems of Geochemistry, N.I. khitarov, Ed., Acad. Sci. U.S.S.R.; trans. by Israel Program for Sci. Translations, Jerusalem, 1969, p.247 251.

Gives homogenization temperatures for inclusions in quartz from Baja Sprie and Baja Mare ore deposits (ER).

SAWKINS, F. J., 1968, The significance of Na/K and Cl/SO_4 ratios in fluid inclusions and subsurface waters, with respect to the genesis of Mississippi Valley-type ore deposits; Economic Geology, vol. 63, pp. 935-942.

Analytical work on fluid inclusions from Mississippi Valley-type deposits has shown that the trapped fluids exhibit strong chemical similarities to the saline brines in adjacent sedimentary basins. Furthermore petroleum droplets in some inclusions attest to the presence of connate fluids during ore deposition. The Na/K ratios of inclusion fluids and connate brines indicate however that, in terms of this parameter, the groups are statistically distinct. Volcanic spring waters on the other hand have Na/K ratios that more closely approach those found in fluid inclusions.

The high Na/K ratios typical of most connate brines presumably result from silicate-pore water reactions taking place during diagenesis. The low Na/K ratios exhibited by some saline basin brines appear to be related to the presence of evaporites.

A sharp distinction between connate brines and fluid inclusions in Mississippi Valley-type ore deposits can be made on the basis of their Cl/SO_4 ratios. Volcanic waters and fluid inclusions from postmagmatic deposits exhibit Cl/SO_4 ratios that more closely approach those in Mississippi Valley fluid inclusions than those shown by connate brines.

The empirical Na/K and Cl/SO_4 data do not indicate a unique solution to the problem of the genesis of Mississippi Valley-type deposits, but they do suggest that average connate waters were not exclusively responsible for ore deposition. The data are consistent however with a genetic model involving the mixing of small amounts of relatively high potassium saline solutions containing sulfate with average connate brines. A suggested source for such solutions is the alkalic intrusive rocks that have widespread occurrence in many cratonic areas. (Author's abstract)

SCHIFFMAN, C. A., 1968, Unusual emeralds: J. Gemnology, v. 11, p.105-114.

Reports 3-phase inclusions (liquid, vapor and cubic crystal) in trapiche emeral from unknown locality. (ER)

SENGERS, J. V. and SENGERS, A. L., 1968, The critical region: Chem. Eng. News, June 10, 1968, p. 104-118. A very thorough review of the present state of studies of critical phenomena. (ER)

SHAMRAI, I.A. and TRUFANOV, V.N., 1968, Thermometric formation conditions of cinnabar ore occurrence in the northern Caucasus, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of conditions of ore formation: Moscow, "Nauka" Press, p. 223-229.

Inclusions reveal that mineral deposition was in three stages, pre-ore (250-125°C), first ore stage (150-90°C) and the second ore stage (110-60°C).(ER.)

SHUGUROVA, N.A., 1967b, Alterations in the composition of the gaseous phase of mineral inclusions, taking place in the process of formation of quartz-fluorite-bearing pegmatites: Akad. Nauk SSSR Doklady, v. 176, no.3, p. 699-702 (in Russian); translated in Acad. Sci. U.S. S.R. Doklady, Earth Sci. sec., v. 176, p. 197-200, 1968, (Author at Institute of Geology and Geophysics, Siberian Division, Academy of Sciences, USSR.

Homogenization temperatures and CO_2, CO, N_2 plus rare gases, O_2, H_2 were determined in primary inclusions in different generations of quartz and fluorspar from 3 pegmatitic bodies, Central Kazakhstan (Table 1). The CO_2 content of the gaseous phase is relatively low in the earlier (high-temperature) inclusions in quartz, is at the peak in the 500-710°C quartz, and at the minimum in the later generations. A similar relationship is shown in the inclusions of fluorite. -- V.P. Sokoloff.

SINYAKOV, V.I., 1968, Formation temperatures of magnesian skarns of a hypabyssal depth facies, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 149-151 (in Russian)

Primary gas-liquid inclusions in monticellite skarns from the Lespromkhoz deposit homogenized at 870-900°C, and even the secondary inclusions homogenized ≥480°C.(ER)

SIVORONOV, A.A., 1968, Use of liquid inclusions during study of metamorphic rocks of iron-ore deposits, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.1, Geochemistry of deep mineral-forming solutions: Moscow, "Nauka" Press, p. 181-184 (in Russian).

Homogenization temperatures for garnet and diopside from the Olingorsk deposit were mostly >530°. Secondary inclusions from various other minerals were lower, from 315° to 80°C. (ER).

SLIVKO, M.M., 1968, The inclusions of solutions in schorl crystals of Volhyn pegmatites: L'vov Gos. Univ. Mineralog. Sbornik, v.22, no. 3, p. 235-243 (in Russian).

Results of a study of primary inclusions in schorl of Archean pegmatites are given. Primary inclusions of aqueous solutions; liquid inclusions of aqueous solutions + liquid CO_2 with various contents of phases; inclusions of liquid CO_2; and inclusions containing aqueous solution + liquid CO_2 + gas + solid phases were found. Schorls of mica pegmatites are characterized by inclusions with a very high content of carbon dioxide both in a liquid phase and in a gas phase. The temperatures of homogenization (280-350°C), the homogenization types for primary inclusions, and the pressure at the moment of homogenization (1000-1500 bars) were determined. (Author's abstract)

SLIVKO, M. M., 1969a, 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.) (Translation to appear in next issue)

SLIVKO, M.M, 1969b, Thermodynamic parameters of tourminalization in pegmatites of Koretz: Akad. Nauk Ukr. RSR Dopovidi, Ser. B., v. 31, no. 3, p. 218-221 (in Ukrainian).

In schorl crystals from the Koretz pegmatites the following primary inclusions and homogenization temperatures were found: truly aqueous solutions (286-320°C); "aqueous solution + liquid CO_2" with various content of phases (260-310°C); and liquid CO_2 (16-24°C). The inclusions containing solid phases are not established. The partial and total homogenization of all the primary inclusions occurs exclusively in a liquid phase. The pressure (1000-1500 bars) in the inclusions of aqueous solution at the moment of homogenization is determined by syngenetic inclusions of aqueous solution and liquid carbon dioxide. Schorl forming solutions of mica pegmatites from various regions are characterized by high CO_2 concentration. (Author's abst.)

SMIRNOV, V. I., 1968, Pyritic deposits, Chapt. X, p. 622-647, in Genesis of endogenetic ore deposits: Moscow, "Nedra" Press, 719 pp. (in Russian): trans. in Int. Geol. Review, v. 12, no. 9., 1970, p. 1039-1058.

Homogenization and decrepitation temperatures of sulfides from various deposits, mostly from literature citations. (ER)

SOLOMON, M., 1968, (Discussion of fluid inclusions in ores) p. 11-13 in Proc. CSIRO Symp. on Iron Sulfides, North Ryde, NSW, Nov. 1968, compiled by B.H. Flinter and published by Sydney Laboratory, P.O. Box 175, Chatswood, NSW, Australia 2067.

SUKHORSKAYA ,I.M., and SUKHORSKII, R.F., 1967, Liquid and solid hydrocarbons in quartz veins and rock crystal of the Aldan shield : Geol. Geokhim. Goryuch. Iskop., no. 9, p. 55-57 (in Russian).

SUKHORUKOV, Yu.M. and FRANK, G.A., 1969, The role of decrepitation of gas-liquid inclusions in the sandstone-siltstone part of argillaceous rocks during sintering: Stroit. Mater., Detali Izdeliya, 1969, no.12, p. 29-35 (in Russian)

SUSHCHEVSKAYA, T.M., BARSUKOV, V.L., and TRUSHIKOVA, T.A., 1966. (See Translations Section)

TAKENOUCHI, S., and IMAI, H. 1969, On the salinity of liquid inclusions in quartz crystals: Jour. Geochem. Soc. Japan, v.2, (1), p. 41-42 (in Japanese). (Authors at Dept. Mineral Development Engineering, Univ. of Tokyo).

The freezing temperature of liquid inclusions in quartz from various occurrences was studied by means of the freezing microscope stage. The alcohol, cooled by dry ice, was circulated to the stage by a small pump, and the temperature in the stage was controlled by the amount of flow of chilled alcohol. It was possible to obtain the temperature as low as -50°C by this stage. The lowest freezing temperature of -6.1°C was found in inclusions from the hypothermal molybdenite-quartz veins. The freezing temperature of inclusions from the hypothermal tungsten-quartz veins was generally between -3.0° ~ -4.0°C and in these inclusions CO_2 gas hydrate or liquid CO_2 phase was recognized at temperatures lower than the room temperature. The freezing temperature of inclusions from the epithermal gold-silver or copper veins was various from almost 0°C to about -4.0°C. Quartz from chalcopyrite-bearing quartz veins in the silicifed zone of the Kurcko deposits contained inclusions, the freezing temperature of which was between -2.7° ~ -3.4°C. From these results, it is inferred that the general range of the NaCl equivalent concentration of inclusions from the above stated hydrothermal ore deposits was 5 ~ 6 weight percent(H. Imai).

THOMPSON, J.B., Jr., and Waldbaum, D.R., 1969, Analysis of the two-phase region halite-sylvite in the system NaCl-KCl: Geochem. Cosmoch. Acta v. 33, p. 671-690.

The solvus in this system (maximum about 490°C) is of possible importance in studies of inclusions containing daughter crystals of both NaCl and KCl (ER).

TILLER, W.A., 1969, Migration of a liquid zone through a solid; Journal of Crystal Growth, v.6, p. 77-85(Author at Dept. of Materials Science, Stanford University, California 94305, U.S.A.)

Recent experimental data on the migration of droplets of aqueous solutions thorugh ice under a temperature gradient driving force have been analyzed. The migration rate has been found to be limited, in part, by interface attachment kinetics. In these cases, the kinetics are layer motion limited rather than layer source limited and are affected by the adsorption of some minor constituent to the kink sites at layer edges. This latter effect modifies the usual droplet size relationship expected from simple theory (Author's abstract).

TORZA, S., and MASON, S.G., 1969, Coalescence of two immiscible liquid drops: Science, v. 163, p. 813-814.

When two immiscible liquid drops suspended in a third immiscible liquid are brought into contact, three equilibrium configurations which depend upon the spreading coefficients are possible. Experiments for a large number of systems, including three-phase emulsions, confirm the theory and indicate the mechanisms of reaching equilibrium. (Authors' abstract).
Note: I have observed some of the phenomena described here in inclusions containing a gas bubble and a globule of liquid H_2S in aqueous solutions. Editor.

TOURAY, J.C., 1968, Recherches géochimiques sur les inclusions à CO_2 liquide: Soc. française minéralogie et cristallographie Bull., v. 91, p. 367-382 (in French).

A systematic study of liquid CO_2-bearing inclusions in minerals has been carried out.

Mass spectrometric analysis of gases evolved on heating or crushing gives two results: 1) The molar ratios CO_2/H_2O are very different from one mineral to another (from 0.05 to values greater than 5). 2) Other gases are present only as traces (CH_4, N_2, H_2S).

Microscopic study has been carried out on inclusions and on families of inclusions. Homogeneity of such families and homogeneity of natural fluids rich in water and CO_2 are especially discussed. The geochemical and petrological implications of this systematic study are discussed (Author's abstract).

TOURAY, J.C., 1969a, Inclusions secondaires dans las fluorine du Jbel Tirremi: Notes Service géologique Maroc, v. 29, no. 213, p. 181-192 (in French).

Secondary inclusions are described and illustrated, containing liquid water solution, crystals of NaCl, liquid CO_2, and gaseous CO_2.(ER)

TOURAY, J. C., 1969b, Hydrocarbures liquides et gazeux en inclusions dans les minéraux: Centre de Recherches de Pau, Bull. v. 3, no. 2, p. 429-441. CH_4/CO_2 ratios are given for inclusions in autnigenic quartz and fluorite, and some decrepitation data on oil and gas inclusions. (ER)

TOURAY, Jean-Claude, and POIROT, Jean-Paul, 1968, Observations sur les inclusions fluides primaires de l'emeraud et leurs relations avec les inclusions solides: Acad. sci. [Paris] Comptes rendus, v. 266, ser D, p. 305-308.

A short review of the phases found (including several daughter minerals and CO_2), plus several excellent photographs. (ER)

TOURAY, J.C., and POIROT, J.P., 1969, Pierres naturelle, pierres artificielles: Sciences Progrès La Nature, 1969, p. 98-102 (in French) A review (no references) with photographs and discussion of inclusions in natural and synthetic gems (ER).

TRAVERIA-CROS, A. and MONTORIOL-POUS, J., 1967, Preliminary study of a new kind of hydrothermal process in two Spanish fluorite deposits (abst.): Inst. Mining and Metal. Trans., v. 76, sect. B, p. 16.

The two Spanish fluorite deposits of 'Berta' (San Cugat de Valles, Barcelona) and 'Osor' (Osor, Gerona) have been studied. The primary minerals in both deposits are fluorite, calcite, and metallic sulphides, mainly galena. The crystallization temperatures of the fluorite and galena were determined by decrepitation measurements. (Authors' abstract, shortened)

TSUTSUMI, S. and IMAI, N., 1967, Genetic interpretation of the Igashima fluorite deposit from the standpoint of fluid inclusion thermometry: Journ. Soc. Mining Geol. Japan, v. 17, p. 54- , (in Japanese). (Authors at Dept. of Mineral Resources, Waseda Univ., Japan).

The massive fluorite deposit of the Igashima mine occurs in Paleozoic limestone. The fluorite crystals have fluid inclusions composed of gas and liquid that homogenize at 80-180°C (H. Imai).

TURLYCHKIN, V.M., 1969, Two stages of mineralization in the Kandzhol ore field, Karamazar: Akad. Nauk SSSR, Izvest., Ser. Geol., v. 1969, no. 11, p. 40-52 (in Russian).

Decrepitation data on various stages of mineralization show temperatures from above 300 to 50°C. (ER)

VAN ALSTINE, R.E., 1969, Geology and mineral deposits of the Poncha Springs NE quadrangle, Chaffee County, Colorado: U.S. Geol. Survey Prof. Paper 626, 52 pp.

Homogenization and freezing temperatures are given for several of these epithermal deposits (p. 36-37), presumably from a fumarolic-hot springs environment (E.R.)

VARCEK, Cyril, 1968b, Relation between the chemistry and the formation temperature of sphalerites, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of conditions of ore formation: Moscow, "Nauka" Press, p. 285-289 (in Russian) Essentially a short review of material given in the next abstract. (E.R.)

VARČEK, C., HÁBER, M., STREŠKO, V., ŠAMAJOVA, E., 1968, Relations between chemistry, forming temperatures and physical properties in sphalerites: Acta geologica et geographica universitatis comenianae, Geologica Nr. 13. Bratislava 1968, p. 13-54. (In Slovakian with German abstract and figure captions).

The authors studied the relation between chemistry, homogenization temperature, and micro-hardness and gave data on the density and the unit cell constants of sphalerites, originating from subvolcanic, plutonic and metasomatic deposits (50 localities, mainly in CSSR but also in Romania, Hungary, Bulgaria, Poland, Eastern Germany and Russia). The content of iron substitution varies in the sphalerites from 0.44 to 12.81%. There is a visible but non-linear dependence between the Fe content and formation temperature in the sphalerites; it is not as strong as Kullerud has described. Thermometric studies were made on a Leitz heating microscope stage. The homogenization temperatures of primary fluid inclusions were measured. Temperatures in the black high iron-bearing sphalerites were measured by the decrepitation method. There was a dependence between the color and the homogenization temperature. For light sphalerites, 110°-180°C, for brown and red-brown, 180°-270°, and for dark brown 260°-290°C. For black marmatites the decrepitation temperatures generally do not exceed 300°C. Within one deposit the formation temperature of sphalerites can vary widely especially in subvolcanic deposits for example in Banska Stiavnica.

The microhardness increases first progressively with the iron content (182 kg/mm^2 - 0.44% Fe to 234 kg/mm^2 - 2.8% Fe), but when the iron content exceeds 2.8%, the microhardness goes down slowly to 206 kg/mm^2 by 13.91% Fe. It is always observed that the physical properties change strongly with an increase of the iron content up to 3 to 4 (or 6) % Fe, but further increase of iron usually has little influence. (Milan Rieder).

VERTUSHKOV, G.N., 1968a, Thermal method for discovering gas-liquid inclusions in minerals, and results of its use for describing an endogenic mineral formation: Magmat. Form., Metamorf., Metallogen. Urala, Tr. Ural. Petrogr. Soveshch., 2nd (pub. 1968), 6, 17-22 (in Russian) Edited by Dunaev, V.A. Akad. Nauk SSSR, Ural. Filial: Sverdlovsk, U.S.S.R.

Essentially the same material as in next abstract. (ER)

VERTUSHKOV, G.N., 1968b, Composition of gas-liquid inclusions in quartz as an exploration index in prospecting for vein mineral deposits. Tr. Sverdlovsk. Gorn. Inst. 1968, No. 53, 96-109 (in Russian) (Author at Sverdlovsk. Gorn. Inst. in Vakhrusheva, Sverdlovsk, USSR).

Water and CO_2 are the main components of inclusions in quartz. They make 90-5% of the total inclusion and their molar ratio of H_2O/CO_2 or V_{H_2O}/V_{CO_2} in gaseous state are controlled by the temp. and pressure. V_{H_2O}/V_{CO_2} was detd., during the last 3 years, in 2500 samples of quartz from various Ural deposits. It varied 0.5-10 with the predominant values at 1-5. The detn. of the ratio for the same quartz by closed tube method depended on the grain size of the sample: the larger the grain diam. the higher is the ratio. The scattering of the V_{H_2O}/V_{CO_2} values depended on the degree of metamorphic alteration: the higner the metamorphic grade the more heterogeneous were the gas-liq. inclusions. The V_{H_2O}/V_{CO_2} of inclusions in quartz did not depend on the chem. compn. of rocks cut by quartz veins. In the ore-free quartz veins, this ratio depends on the metamorphic grade of rocks cut by quartz veins: the V_{H_2O}/V_{CO_2} ratio in veins situated in migmatites, amphibolites, and greenstone rocks were on the av. 1.5, 2.4 and 5 resp. In ore veins, the V_{H_2O}/V_{CO_2} was somewhat lower than a general background detd. from ore-free veins. The compn. of solns. in inclusions depended only on the temp. of geochem. processes. The depths of mineralization affected only V_{H_2O}/V_{CO_2}. According to this ratio, the mineralizing solns. were similar for quartz from various areas in U.S.S.R. This indicated that after reaching a crit. value of pressure (350-400 atm.), the geochem. processes in the earth's crust are controlled by temp. and depend little on the depths of their occurrence. The compn. of gas-liq. inclusions, detd. in quartz by closed tube methods, provides sufficiently accurate information on mineralizing solns. This information can be used to outline more accurately the genesis of mineral deposits and in many cases as an exploration criterion. (C.A. 73 (4) p. 116 (Aug. 24, 1970))

VERTUSHKOV, G.N. and EMLIN, E.F., 1968, Determination of composition of gas-liquid inclusions in quartz using a "closed tube" -type apparatus: Tr. Sverdlovsk. Gorn. Inst. 1968, No. 53, 88-95 (in Russian).

The closed tube app., devised by V., was used for 3 years in detn. of compn. of gas-liq. inclusions. The main part of the app. (quartz tube) is connected hermetically with a Hg manometer and a vacuum pump. The sample is set into tube, the air is pumped out, and the tube is heated ←700-800°. The gas-liq. inclusions are opened, during heating, and the pressure, created by gases and water vapors liberated from inclusions, is detd. The tube then is cooled in a mixt. at -20 to -60°. The water vapor pressure sharply decreases and the excess water condenses on the wall of the tube. The content of water, liberated from gas-liq. inclusions, is detd. from the drop in pressure. The immersion of the tube into a cooling mixt. at an even lower temp. (-100°) decreases the pressure in the tube by condensation of CO_2. The temp.-induced compression of gases, naturally, is considered during calcns. The app. provides for detn. of total amt. of gases and vapors in inclusions. detg. the compn. of the mixt., and yields data for plotting a pressure-temp. diagram for the mineral reflecting its genetic characteristics. The detn. of mineral dissocn. temp. can be used for identification of the mineral if dissocn. is accompanied by liberation of gas. The method of calcn., possible errors, effect of errors on the results of anal. and methods for prevention of errors are described. (C.A. 73 (4) p. 116 (Aug. 24, 1970)).

VORONOI, E.E., 1967, Possibility of inorganic synthesis of methane and gaseous hydrocarbons in the earth's crust: Geol. Geokhim. Goryuch. Iskop., no. 9, p. 70-81 (in Russian).

VOVK, P.K., and VOZNYAK, D.K., 1967, Complex carbon dioxide inclusions in albite crystals: Geol. Geokhim. Goryuch. Iskop., no. 9, p. 82-87 (in Russian).

Large H_2O-CO_2 inclusions are described and water extracts were analyzed. Some methane-series hydrocarbons were detected on crushing in vacuum. (ER)

WEERTMAN, J., 1968, Bubble coalescence in ice as a tool for the study of its deformation history; Cold Regions Research and Engineering Laboratory, Research Report 251, 5 pp.

An analysis is made of the rate of bubble coalescence in a deforming ice mass. A total strain of at least 8 is required before appreciable coalescence occurs. The analysis has been applied to deforming ice shelves and ice sheets. No appreciable coalescence is expected in ice shelves but coalescence should occur in ice sheets (or glaciers) if the shear strain rate at the bottom surface is of the order of 0.075/yr or larger. Measurements of bubble concentration are capable of setting limits on paleo-strain rates of the present ice sheets. Bubble migration down temperature gradients presents complications to the study of bubble coalescence. (Author's abstract)

WHITE, D.E., 1968, Environments of generation of some base-metal ore deposits: Econ. Geology, v. 63, p. 301-335.

An extensive review of the literature on the environment of ore-deposition, based on five districts as examples. The essential data were obtained largely by analysis of fluid inclusions in ore and gangue minerals (three mining districts), and of existing thermal fluids (two active high-metal-bearing hydrothermal systems). (E.R.)

WHITE, D.E., 1969, Thermal and mineral waters of the United States-brief review of possible origins: Internat. Geol. Cong., 23rd, Reports, v. 19, Mineral and thermal waters of the world; B- oversea countries: Prague, Academia Press, p. 269-286.

This is a good review of White's ideas on the interrelationships of various types of waters, and their relation to fluid inclusion data (ER).

WILCOX, W.R., 1968, Removing inclusions from crystals by gradient techniques: Indust. Eng. Chem. v. 60, no. 3, p. 13-23.

An extensive review, with 111 references, of the host of new phenomena and the possibilities of effective industrial application of the movement of fluid inclusions in crystals, particularly by thermal gradients. (ER)

WILCOX, W. R., 1969b, Fractional solidification phenomena: Separation Science, v. 4, pt. 2, p. 95-109 (author at University of Southern California and the Aerospace Corporation, Los Angeles, California).

Zone melting of organic compounds was observed under the microscope. A host of phenomena were noted that can greatly affect the separation attained in a fractional-solidification operation. Liquid and gaseous inclusions moved toward the melt in some systems and farther into the solid in other situations. Sometimes impure melt was sucked into the frozen solid through cracks. Insoluble foreign particles were both bounced and incorporated by freezing interfaces of camphor and anthracene. Oscillations in interface position were caused by irregular free connection both inside and outside the sample cells. Bubbles in the melt sometimes caused agitation of the melt and other times selective growth of a volatile component. Bulk drainage and falling crystals from horizontal melting interfaces were observed. During melting of camphor-anthracene mixtures some anthracene platelets grew larger. (Author's abstract.) Note: The many phenomena observed are pertinent to the problems of the origin of many natural inclusions. The new zone-melting device (described) could also be useful. (ER)

WILCOX, W.R., 1969a, Anomalous gas-liquid inclusion movement: Ind. Eng. Chem., v. 61, no. 3, p. 76-77.

W presents evidence that some inclusions move away from the heat source rather than toward it during temperature gradient processes for removing gas and liquid inclusions from crystals. He concludes that surface tension effects resulting from concentration gradients set up by evaporation and condensation cause the reverse movement. Of pertinence to studies of inclusions in soluble minerals. (ER)

YAJIMA, Junkichi, 1969, Fundamental research on fluid inclusions in minerals: Kozan Chishitsu v. 19, no. 98, p. 376-388 (in Japanese), A review

YAKOVLEV, Ya.V. and LEBEDEV, P.P., 1968, Formation temperature of cassiterite-fluorite-tourmaline-quartz veins in the Deputat deposit, in Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v. 2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 162-168, (in Russian).

Homogenization (into the liquid phase) at temperatures of 145-355°C was measured on inclusions in tourmaline, quartz, cassiterite, fluorite and siderite. (ER).

YASINSKAYA, A.A., 1967, Inclusions in stony meteorities: Mineralog. Sbornik L'vov Gos. Univ. v. 21, p. 278-281 (in Russian). Author at Ivan Frank Gos. Univ., L'vov. (See Translations Section).

YODER, H.S. Jr., 1969 , Phlogopite-H_2O-CO_2: An example of the multicomponent gas problem, in Annual Rept. of the Director, Geophysical Laboratory, Carnegie Inst. of Washington Yearbook 68, p. 236-240 (plus plate following p. 356).

Several types of inclusions were found in synthetic forsterite crystals formed in the systems phlogopite-H_2O and phlogopite H_2O-CO_2 (pressure, 10kb.; temp. 1225°C). The phases present at room temperature are glass, liquid water, liquid CO_2, vapor and several crystalline phases (daughter minerals?). "It was hoped that the study of the inclusions would aid in defining the nature of the fluid in both major assemblages. However, the wide variety of inclusions, the uncertainty of conditions under which the inclusions were incorporated in the growing crystal, i.e. during run-up or under the run conditions, the heterogeneous distribution of inclusions within and between crystals, and the changing of the immediate chemical environment about the growing crystal cast doubts on interpretation. Both fosterite and phlogopite grow exceptionally fast relative to other silicates in the laboratory, and yet one commonly entraps the surrounding fluid and the other does not. These phenomena of crystal growth preclude a definitive conclusion on the character of the fluid phase at the present state of knowledge. Similar difficulties arise from the interpretation of the variety of some of the fluid inclusions found in rocks from Ascension Island (Roedder and Coombs,1967)." (p. 239). [The author does not mention, however, that although the inclusions in his products may indeed represent transient or local conditions (such as the rapid growth of crystals during the heat-up of the bomb), most natural crystals, and their inclusions, do <u>not</u> form under such extremely variable and disequilibrium conditions. (ER)

YUDIN, I.M., 1968, Temperature conditions and the formation sequence of endogenic ores of the Kounrad deposit, <u>in</u> Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of the investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 174-183 (in Russian).

Several stages in the paragenesis each give decreasing homogenization (or decrepitation) temperatures from 470° to 150°. Horizontal temperature zonging was also detected. (ER).

YUSHKIN, N.P., 1968, Mineralogy and paragenesis of native sulfur in exogenic deposits: Leningrad, "Nauka" Press 187pp. (in Russian).

Considerable discussion of the morphology and growth phenomena of sulfur crystals and 5 pages (70-74) on their inclusions. Includes 3 analyses of inclusions for (Na + K), Ca, Mg, Fe, Cl, SO_4, HCO_3, H_2S, CO_2, and pH (E.R.)

YUSHKIN, N.P. and SREBRODOL'SKII, B.I., 1965, Study of the composition of liquid inclusions in crystals of native sulfur: L'vov. Gos. Univ., Mineralog. Sbornik, v. 19, p. 229-236. (In Russian; authors at Syktyvkar. Inst. Geol., Komi Filial Akad. Nauk S.S.S.R., L'vov Gos. Univ. named for Ivan Franko). (See Translations Section).

ZATSIKHA, B.V., 1968, Formation conditions of fluorite in pegmatites of the Kamennye Mogily granite massif (Azov Sea region), <u>in</u> Mineralogical Thermometry and Barometry, N.P. Ermakov, ed., v.2, New methods and results of investigations of the conditions of ore formation: Moscow, "Nauka" Press, p. 219-223 (in Russian)

Primary fluid inclusions associated with specific growth zones show that these fluorites crystallized first as cubes at 320-340°, then formed cubooctahedrons at 125-128°, then cubes again at 145-155°C. Daughter crystals of anhydrite are reported, and pH dets. on leach solutions (5.0-6.2). (ER)

ZATSIKHA, B.V. and VOVK, P.K., 1969, On calcites from the boundary of the Donbas with the Azov area: Akad. Nauk Ukr. RSR Dopovidi, v. 31, no. 7, p. 586-588 (in Ukrainian).

A study of the crystal forms and change in habit of the calcite crystals. Homogenization of the gas-liquid inclusions occurs at 125-60°C. (E.R.)

ZATSIKHA, B.V., ZARITSKII, A.I., and STREMOVSKII, A.M., 1967, Study of the nature of hydrothermal mineralization of the connecting zone of the Donbass with the near-Azov: Geol. Geokhim. Goryuch. Iskop., no. 9, p. 127-145 (in Russian). Fluid inclusion homogenization temperatures, six analyses of water leaches for 8 constituents and 4 analyses of gases for 9 constituents.(ER).

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 LYSAK, G.I., 1968, Temperature types of fluorite deposits of the Chikoi fluorite district, western Transbaikailia (abst.): Abstracts of Reports of Third All-Union Conference on Mineralogical Thermobarometry, Moscow, Sept. 9-15, 1968, p. 172-174. Authors at L'vov University.

The Chikoi fluorite district includes the fluorite deposits of Nijnechikoi, Chikoi, Pyovrotinsky, Novopavlovsky-2, Novopavlovsky-1, Virkhevsky and Kamshevsky. They lie in a zone of Caledonian folds and are controlled by the grano-syenite stocks of the Guzirsky intrusive complex (γ) $T-T_1$ and by NE-striking deep fractures. Thermometric methods (Ermakov, 1950) were applied to the study of the conditions of formation of these deposits. These studies show that the formation of ores and the composition of mineral-forming solutions may be classified, as follows, according to the temperature: high temperature pneumatolytic to hydrothermal solutions (420°-145°C), Novopavlovsky-2 deposit; medium temperature hydrothermal solutions (310°-190°C), Nijnechikoi deposit; and low temperature hydrothermal solutions, (220°-135°C), Povorotinsky and other deposits. The geological situation and the occurrence of the deposits of different temperature types are not identical.

The high- and middle-temperature deposits lie immediately within the grano-syenite stocks of the Guzirsky complex, on their outer contacts. The ore bodies of these deposits have a N-S strike and a dip of 60°-80° toward east. On the basis of mineral composition they belong to the barite-quartz-fluorite type. Gas inclusions and polyphase inclusions with liquid CO_2 and rarely also with solid phases are characteristic of the minerals of the early stage of mineralization in the high temperature ore deposits.

Fluorite and quartz from middle temperature deposits contain fluid inclusions and rarely three-phase inclusions with liquid CO_2. On heating all the inclusions homogenize in the liquid phase.

The low temperature deposits lie between the granites and syenites of Thidinsky complex (PZ1) at a distince of 5 km from the surface outcrop of the Guzirsky complex. A NE strike of the veins and a dip of 60°-70° toward the SE is characteristic of these ore bodies. According to the mineral composition these belong to the quartz-fluorite type (Chikoi and Povorotinsky) and to the barite-quartz-fluorite type (Novopavlovsky-1). A druse texture is typical for the fluorite veins and moreover there occur very often chalcedony and also porcelain type quartz and hexagonal quartz. Mostly primary inclusions with only two phases were found in all generations of fluorite of the investigated (low temperature) deposits. At room temperature the inclusions contained about 90 % volume percent of aqueous solution and 10% gas. On heating they homogenize in the liquid phase at the following temperatures: 178°-170°C (Chikoi); 220°-135°C (Povorotinsky); 178°-145°C (Novopavlovsky-1). The age relationship between the deposits of different temperature types is not exactly determinable. But on the basis of the mineral composition and the uniform succession of deposition of minerals, it can be assumed that the high, middle, and low temperature deposits of the Chikoi fluorite district have an identical age of mineralization, even though differences in the temperature of crystallization between minerals and the differences in the distribution of ore bodies exist. Translated by Asoke Lahiry.

BALITSKII, V.S., SAMOILOVICH, M.I., NOVOZHILOV, A.I., and STUPAKOV, G.P., 1966, On the influence of temperature conditions of formation of quartz on the content of the structural aluminum impurity: Mineralog. Sbornik L'vov Gosudarst. Univ. v. 20, p. 430-434 (in Russian); authors at V.N.I.I.S.I.M.S., Ministry of Geology, U.S.S.R.

A study of formation temperatures of quartz crystals from Central Kazakhstan by the method of inclusion homogenization was carried out. The same crystals were studied by EPR (electron paramagnetic resonance) method. It has been determined that the content of structural impurity in quartz decreases with the fall of the crystallization temperature. A similar dependence is found for a structural titanium impurity in series of pegmatites ([illegible]).

Attempts to estimate the influence of temperature conditions of the crystallization of quartz on the entry of structural admixtures of aluminum were undertaken recently by Kamentsev (2). As the result of precision determinations of the unit cell parameters of quartz, Kamentsev came to the conclusion that on lowering the temperature of crystallization of quartz, the content in it of structural admixtures of aluminum is increased.

We undertook experiments to determine by another method of study the effect of temperature of formation of quartz on the entry of admixtures of aluminum and titanium. The object of the studies was crystals of quartz from the well-studied pegmatites of Central Kazakhstan (Kent, Bektauata, and Akzhailyau). The temperature conditions of crystallization of the quartz were determined by the method of homogenization of gas-liquid inclusions: the character of changes by the structural admixture of aluminum and titanium was determined by the method of electron paramagnetic resonance (E.P.R.).

A general feature of the crystals studied is their polyzonal structure, which is well emphasized by the alternation of differently colored zones of growth. Most abundant is smoky color: at Akzhailyau and Bektauata there occur relatively often crystals with zones of growth of golden-yellow color (citrine), and at Kent - a rose color with a violet tint (amethystine quartz).

In the distribution of the main zones of growth of the quartz, strict regularities were observed. The very earliest zones often consisted of the so-called "honeycomb" quartz, which at Bektauata and Akzhailyau has, as a rule, a pale- or dark-gray color with a slight smoky tint. At Kent "honeycomb" quartz of dense smoky color occurs.

"Honeycomb" quartz (sometimes with notable discontinuities) alternates with zones of crystal (Akzhailyau) or amethystine quartz

(Kent), after which there follows a zone of smoky quartz having maximum development, and further a zone of citrine. The latest zone consists of colorless or white quartz. Crystals with all the zones noted occur much more rarely than crystals in which part of the zones (especially the early ones) are omitted.

The temperature conditions of the individual zones of growth of the crystals from different pegmatite fields are rather similar and are compared in Table 1, including generalized data of L. Sh. Bazarov, A.I. Zakharchenko, V.N. Trufanov, and F.P. Mel'nikov, and our observations.

Table 1 (p. 431)

Temperature of formation of different zones of growth of quartz crystals (°C)

No. of zone of growth	Characteristics of zone	Pegmatite field		
		Kent	Bektauata	Akzhailyau
1	"Honeycomb" quartz	600-550	620-510	500-420
2	Crystals (or rose quartz)	570-520		
3	Smoky quartz	520-350	510	380-250
4	Citrine	~260-200		250-200
5	Transparent or white crust of the edge of the crystal	100-250	260-180	150-100

As seen from the table, the "honeycomb" quartz is the highest temperature; it is characterized by fracturing and twinning, which must owe their origin to the formation of paramorphs of β -quartz after α-quartz (1). Each consecutive zone is characterized by lower temperature of formation, such that differences in the temperatures of crystallization of early "honeycomb" quartz and late quartz of the edge of the crystal are 500 to 400°C. It is interesting that the pressure at the moment of crystallization in this series of zones (according to the data of Bazarov and Trufanov) falls from 700-500 to 100-35 atm.

Estimates of the content of structural admixtures of aluminum in different zones of quartz were made by comparison of the relative intensities of the lines in E.P.R. spectra. It is known that the centers of smoky coloration in quartz, originating under the action of ionizing radiation, are associated with holes, localized at "defective" tetrahedra, in which Al^{+3} ions isomorphously replace Si^{+4} ions (4,6). The E.P.R. spectra of such crystals consist of 6 groups of 6 lines and are described by g-tensors of axial symmetry.

The axes of symmetry of the g-tensors, directed along the direction Si-Si, which are six in a single cell, which explains the presence of six groups of lines (4,6). Each line is split into six by the hyperfine interaction with the nucleus of the isotope ^{27}Al (spin of nucleus I= 5/2, content 100%). Admixtures of aluminum in quartz can enter both structurally (isomorphism with silicon) and also non-structurally (in the form of injection of other phases, inclusions, etc.). The centers of the smoky coloration are formed only at structural aluminum, whereby the intensity of the signals of these lines in the E.P.R. spectrum (at slightly variable breadth of lines from sample to sample) is approximately proportional to the content of structural aluminum, isomorphously replacing silicon. Thereby, as is well known, univalent ions (Li^+, Na^+, H^+) are located in the structural canals of quartz for charge compensation.

For photography of the E.P.R. specta of different zones of crystals of quartz, samples were selected of approximately the same weight (below all magnitudes are given per unit weight). In the measurements there was set the same orientations of the crystallographic axes of the sample relative to the direction of the magnetic field. Measurements of the intensity of the E.P.R. signal of the smoky center in all samples were made twice; before and after irradiation by γ-rays (source ^{60}Co, 6×10^6r.). The results are given in Table 2 and Fig. 1(a,b). As is seen, the original smoky color of

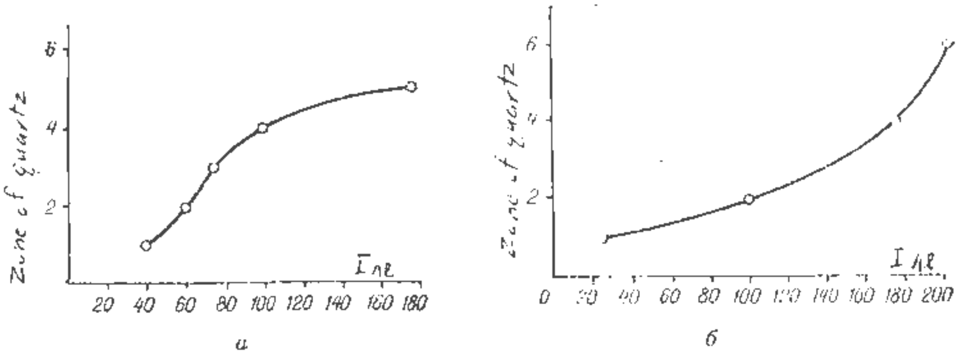


Fig. 1. Measurement of intensity of signal of EPR center in crystals of quartz, depending on the temperature of formation: (a) in pegmatites of Kent, (b) in pegmatites of Akzhailyau.

different zones and, consequently, the intensity of the E.P.R. signal from the Al-centers does not reflect the true content of structurally admixed aluminum. In the studied samples the depth of coloration of the outer zone (up to the zone of citrine quartz) after irradiation became considerably more intense than previously. In Table 2 and in Fig. 1, the zones of quartz are arranged in the order of their sequential deposition, and reflect the regular change of the temperatures of formation of the crystal. As the temperature of crystallization decreases, the content in the quartz of structural admixture of aluminum decreases considerably, although the total amount of aluminum, as judged by precision spectrographic analysis of zoned crystals of quartz (made at GIREDMET), increases from the early to the late by 2-3 fold.

In quartz from the Kent and Bektauata pegmatites, along with the centers of smoky color there are observed lines in the E.P.R.

spectrum, associated with electron Ti-centers, formed under the action of ionizing radiation. These centers are electrons, localized at "defect" tetrahedra, in which Ti^{+4} ions replaced Si^{+4}. These centers were first observed and studied by the E.P.R. method in rose quartz (7). As charge compensation here ions can serve (Na^+, Li^+, H^+), in distinction from smoky centers which are not formed if the ion compensator is hydrogen(5). A large part of such Ti-centers have alkali ions (Li^+ or Na^+) as ion compensators, so that one can assume that for most of the structural aluminum, alkali metals (Li, Na) serve as ion compensators. It is interesting that for quartz from the Bektauata pegmatite the content of structural admixture of titanium also increases with increase of the temperature of formation of the crystals. However, for quartz of the Kent pegmatite this dependence is not noted.

For more detailed characterization of the structural admixtures of aluminum and titanium in quartz, a polyzonal crystal from the Bektauata pegmatite was selected. In this crystal, in the main zones of "honeycomb" and smoky quartz there were observed many fine zones of growth, from which sixteen samples were selected (2 from the zones of "honeycomb" quartz and 14 from the zone of smoky quartz). Study of these samples by the E.P.R. method showed distinctly a general tendency towards decrease of the temperature of crystallization of the quartz (Fig. 2).

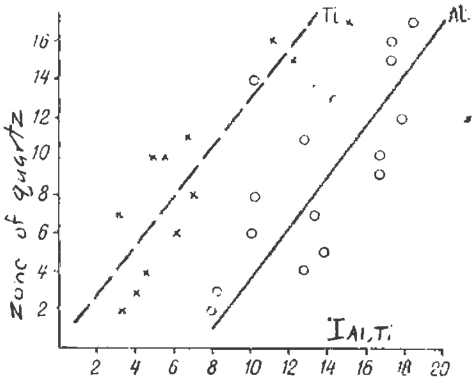


Fig. 2 (p. 433). Variation of intensity of signal of EPR-centers in polyzonal crystals of quartz from the Bektauata pegmatite. Ordinate - zone of quartz.

Thus, study by the method of homogenization of inclusions of temperature conditions of formation of crystals of quartz from crystal-bearing pegmatites of Central Kazakhstan, in connection with studies of the same samples by the E.P.R. method, permitted us to establish that with decrease of the temperatures of crystallization, the content of structural admixture of aluminum in quartz decreases substantially. The total content of aluminum in the crystal increases in this direction (probably at the expense of non-structural admixtures of inclusions of aluminosilicates). Analogous conclusions were reached by V.E. Khadzhi on the basis of optical study of Volynian quartz.

Table 2 (p. 432). Relative intensities of signal of E.P.R. of Al- and Ti-centers in quartz from pegmatites of Central Kazakhstan

No. of zones	Characteristics of zone	Relative intensities of signals of EPR (before and after irradiation)					
		Kent		Bektauata		Akzhailyau	
		I_{Al}	I_{Ti}	I_{Al}	I_{Ti}	I_{Al}	I_{Ti}
1	Colorless or white quartz	0/40	0/0	0/25	0/0	--	--
2	Citrine quartz	7/60	0/40	6/100	0.0*	10/65	0/0
3	Smoky quartz (deeply colored)	20/75	0/12	--	0/40	12/75	0/0
4	Smoky quartz (slightly colored)	10/100	3/10.5	20/175	60/175	--	--
5	Rose quartz or crystals	3/175	10.50*	4/150	15/200	--	--
6	"Honeycomb" quartz	--	--	4/200	15/200	--	--

* Sic (Ed.)

Besides the structural admixture of aluminum in the crystals from Kent and Bektauata, structural titanium has been found, the content of which in the quartz from Bektauata decreases with temperature of formation of the quartz.

Other factors also show an influence on the entry into crystals of quartz of structural admixture of aluminum (composition of mineral-forming solution, their aggregate state, the pH of the medium, etc.). Nevertheless, according to the data of V.E. Khadzhi, studying the micro-isomorphism of aluminum in synthetic crystals of quartz grown under fixed conditions, the amount of structural aluminum (at constant content of it in the system) is determined first of all by the temperature and speed of crystallization. Thereby the content of structural aluminum in the synthetic crystals increases with increase of the temperature of crystallization. Increase of the speed of growth of the crystals has a negative influence on the entry into them of structural aluminum. The formation of natural quartz from the early zone of growth to the later proceeded, as was shown above, under conditions of substantially decreasing temperature and pressure. Thereby with over-all small velocity of growth of the natural crystals (3), and also according to other considerations, the growth of the late zones was relatively less than that of the earlier zones, However, despite this, the content of structural aluminum in the late quartz is many times less than in the early quartz. This again confirms that the main factor determining the entry of aluminum into the structure of natural quartz, is the temperature of its crystallization.

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Translated by M. Fleischer

DOLGOV, Yu.A., 1968, Pressures and temperatures in the process of formation of chambered pegmatites: Doklady Akad. Nauk S.S.S.R., v. 178, p. 1171-1174 (in Russian).

Studies of the temperature of mineral formation by means of the homogenization of inclusions in minerals has become an effective method for the determination of the minimum temperature regime of mineral formation of various post-magmatic deposits, including pegmatites. Determinations of pressure are few. This is explained by the difficulties in determination of the composition of the inclusions, and mainly, the quantitative contents of salts and CO_2, which are the main components, after water, of the system. The second difficulty is the impossibility of accurate measurement of the total volume of inclusions or irregular forms and of the volume of the phases included in them. The development of new methods of study of inclusions and the finding of forms of inclusions in topaz very satisfactory for their accurate measurement permitted us to solve both these problems. To measure the temperature and pressure, we used a group of plane pseudosecondary inclusions (Fig. 1). The parallel nature of the walls of the inclusion is confirmed by the constancy of the widths of the bands of complete internal reflections (i.e., interferometry?). The pseduosecondary inclusions are located in healed fractures of the topaz crystals. In correspondence with experiments (1), the fractures in crystals of topaz are formed during sudden cooling of plates and crystals, mostly in the direction of the perfect cleavage on the pinacoid (001). Fractures obtained by sudden cooling do not, in most cases, have a healed character and encompass zones of various

Fig. 3 (p. 1171). Plane pseudosecondary inclusions in topaz. X 100.

breadth from the external faces to the center of the crystals.

A group of inclusions in one healed fracture is identical according to degree of filling, composition of solutions, and temperature of homogenization. A group of inclusions in fractures of different times of formation is characterized by different states of solutions in the cavities of the chambered pegmatite. Studies of pseudosecondary inclusions show deviations from an evolutionary course of development according to temperature, pressure, and composition of solution.

Topaz was selected for study in the form of many crystals from one pegmatite body. In any of the crystals of topaz, there are recorded in the pseudosecondary inclusions the same episodes of changes of the state of the solution, associated with the adiabatic enlargement of the cavity of the chambered pegmatite.

According to the degree of growth of the topaz crystals, any group of pseudosecondary inclusions corresponds to primary inclusions, because the healing of the fractures and the growth of the crystals occurred at the same time and under the same conditions (2). For the determination of the pressures on the curve of two-phase equilibrium corresponding to the temperature of homogenization of the inclusions, the following measurements were made: (1) temperatures of homogenization of inclusions, with accuracy 1-2%; (2) condensation of CO_2 in the inclusions at 0°; (3) determination of the temperature of freezing (thawing) of the salt solutions, with accuracy up to 0.1°; (4) determination of the concentrations of salts by NaCl-equivalents within the limits of accuracy of the available handbook experimental data; (5) three-fold planimetric measurement of the area of the phases in the inclusions, with the error, usual in such cases, of ±1%. Areal measurements were used for the volume because the thickness of the planar inclusions were constant. As the result of the measurements, we obtained source data for calculation of the pressure corresponding to the temperature of homogenization, and also data on the complete contents of CO_2 and salts (in NaCl-equivalents). The total pressure was calculated according to Dalton's Law (3):

$$P_{total} = P_{H_2O + NaCl} + P_{CO_2}.$$

The values of $P_{H_2O+NaCl}$ were taken from the data of Styrikovich and Khaibullin (4) and from the newest experimental data of Borisov and Khaibullin (5); the P_{CO_2} from the data of Kennedy (8).

Comparison of the data obtained by us for pressure with the experimental shows that the error rarely exceeds 5% of the measured value. In Table 1 are shown the temperatures of homogenization, the

Table 1 (p. 1172)

No.	Temp. hom. °C	Concentr. of salts wt%	Total wt. CO_2*	P of homogen. atm.	No.	Temp. hom. °C	Concentr. of salts wt.%	Total wt. CO_2*	P of homogen. atm.
1	260	26.2	3.20	260	16	310	26.2	3.69	295
2	400	26.2	4.03	435	17	290	26.2	2.65	255
3	260	26.3	2.82	247	18	300	26.2	2.29	287
4	300	26.2	2.93	227	19	280	26.2	4.60	328
5	300	26.2	1.64	241	20	295	26.2	4.04	248
6	380	26.2	3.09	317	21	405	26.2	1.65	354
7	290	26.2	3.65	276	22	425	26.2	1.82	430
8	280	26.2	2.71	281	23	325	26.2	6.45	331
9	280	26.3	3.18	253	24	405	26.2	4.79	388
10	305	26.2	7.99	285	25	270	26.2	6.92	285
11	280	26.2	7.01	274	26	420	26.0	2.83	432
12	300	26.3	7.53	292	27	440	26.2	4.03	460
13	320	26.0	2.57	231	28	440	26.2	1.67	533
14	310	26.2	7.47	327	29	400	26.2	1.17	300
15	270	26.2	4.16	304	30	395	26.2	4.07	345

* Editor's note - Fig. 1 shows a much higher amount of liquid CO_2.

total content of CO_2, the concentration of salts in NaCl-equivalents, and the calculated pressures, corresponding to temperature of homogenization.

The data given permit one to assert:

1. The temperatures of healing of fractures in topaz and trapping pseudosecondary inclusions in them had a minimum interval of temperature on the curve of two-phase equilibrium of 260 to 440°.

2. All inclusions homogenized in the gas phase. In this case the correction of temperatures for pressure is large, even for small changes of pressure. The capture of inclusions can be accomplished at relatively large superheat under isochoric conditions; however, the pressures for inclusions with low density were changed slightly.

3. The ranges of minimum pressure on the curve of two-phase equilibrium, corresponding to the temperature of homogenization, is 230-530 atm.

As shown on the graph (Fig. 2), the temperatures and pressures of homogenization show that they are all, without exception, located

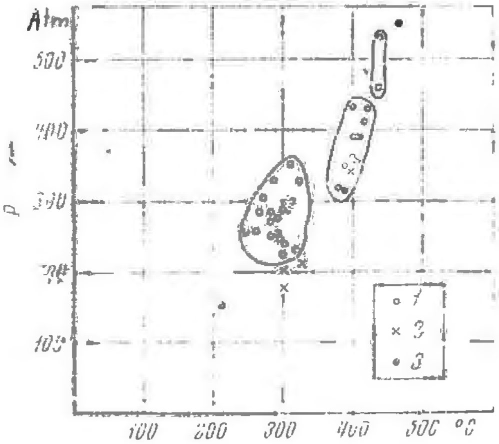

Fig. 2 (p. 1173). Pressures and temperatures in the course of the formation of chambered pegmatite (Volyn); (1) -topaz, (2)-beryl, (3)-quartz.

left of the line* of two-phase equilibrium of pure water. It is clear that the line of two-phase equilibrium is displaced into the region of lower temperatures, because of the effect of CO_2. For each inclusion or group of inclusions there exists its curve of two-phase equilibrium, the position of which is determined by the content of CO_2. The content of CO_2, according to the data obtained, changed repeatedly, and some groups of points lie on one curve of equilibrium of the system H_2O-CO_2, within the limits of accuracy of the measurements. The magnitude of the salt concentration, as has been shown experimentally up to now, scarcely changes the position of the line of two-phase equilibrium of pure water (7).

In the inclusions studied, the salt concentration (in NaCl-equivalents) has a constant magnitude (about 26%). The greatest deviation from the line of two-phase equilibrium was obtained in the field of relatively low temperature and low pressure. This indicates that for field 3, the relative contents of CO_2 were highest, as confirmed by measurements. The data obtained show that the significant causes that carried the system to an episodic regime was decrease of pressure (density) and temperature. At the time of this sharp episodic change, the evolutionary course of the development of the system was disrupted. Such a cause can only be the adiabatic expansion of the system, associated with instantaneous increase of volume (8). Geological observations have shown that a chambered pegmatite constitutes a material and strucural discontinuity in the mass of quasi-isotropic country rock (granite). Such a discontinuity acts as a concentrator of stresses and a cause of their resolution in the form of the contractional or tectonic fractures associated with chambered pegmatites. Instantaneous increase of the volume of the chamber is also a necessary and sufficient condition, which leads to sharp drops in the temperature, pressure, and density of the solutions. There are a large number of observations showing the association of fractures with chambered pegmatites. Analogous observations on the concentration of stress around a discontinuity and its resolution in the form of fractures are widely known and have been the subject of studies in metallurgy, petrology, ceramics, and brick manufacture.

In the P-T diagram (Fig. 2) are shown three regions of adiabatic expansion, which correspond to large increase of volume and a substan-

* Not shown on Fig. 2. Ed.

tial change of the state of the system. The greatest change is registered for the inclusions of field 3. The low temperatures are united with low pressures and density of the solution. Together with this, there are observed relatively high contents of CO_2. This feature is explained by the sharp difference in volatility of CO_2 and water. From the pore space of the rocks surrounding the pegmatite, the solutions will be transported into the region of lower pressure (chamber) until there arises an equilibrium pressure between rocks and the chamber. The process of transfer of the water-CO_2 mixture is accomplished in accord with the volatility of the components of the mixture. The volatilities will characterize the tendency of the component to escape from the given phase.

For the temperature 400° the volatility of water equals 200 atmospheres, that of CO_2 600 atm. With large drops in pressure equilibrium will be established at the expense of the predominating entry into the region of low pressures of the more volatile component--CO_2. Predominance of CO_2 is observed for inclusions of region 3. For fields 2 and 1 the content of CO_2 is less; the temperatures, pressures, and densities of solutions are higher than correspond to the smaller magnitude of the adiabatic expansion. The close position of the inclusions of fields 1 and 2 to the curve of two-phase equilibrium of pure water also is confirmed by the low content of CO_2 and the small deviation from the evolutionary state. Surveys of temperature, pressure, and contents of the main components in the system were made in a pegmatite field, from which about two tons of crystals of topaz were found (Volynia, Ukr. S.S.R.). The high speed of crystallization is explained by the episodic drops of temperature, the cause of which is the adiabatic expansion. The sharp acceleration of recrystallization under natural conditions, as well as in laboratory and industrial experiments, is attained as the result of the effect of temperature decrease. The decreases of pressure found also undoubtedly promote mass transfer and increase the speed of growth of the crystals (9). The adiabatic expansion of any developing cavity space in the Earth's crust, in distinction from isochoric conditions of growth, lead to sharp disturbance of the evolutionary heat transfer and mass transfer, and also assists the acceleration of recrystallization and localization of mineral matter.

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IKORSKII, S.V., 1966, Inlusions of villiaumite and their connection with organic matter in rock-forming minerals of the Khibina massif: Geokhimiya 1966, No. 8, p. 1002-1003 (in Russian). (Auther at Geol. Inst., Kola Filial, Acad. Sci. USSR, Apatite.) Abstract pub. in Geochem. Internat., v.3, no. 4, p. 791.

Villiaumite (NaF) is a characteristic typomorphic fluorine-containing mineral of agpaitic alkalic rocks (1). In the opinion of Kogarko (1), who studied the conditions of formation of villiaumite in nepheline syenites, the crystallization of this mineral occurred from residual solutions enriched in fluorine, at the post-magmatic stage, transitional towards the hydrothermal (2,3).

During the study of inclusions of hydrocarbons in rock-forming minerals of Khibina, it was found that some of the minerals contain inclusions of NaF. Observations were made under the microscope in thick polished sections (tenths of a millimeter) in transmitted and reflected light at magnifications of 160-900 fold. Study of the contained inclusions in the light of their luminescence, excited by blue- and ultra-violet light, was carried out on the luminescence microscope ML-2 and on the microscope MIN-8 with luminescent arrangement OI-17. To observe the inclusions in the process of being heated to 600°, there was used a microthermochamber with contact warming of the sample and water-cooling of the frame. Before study in blue- and ultra-violet light and in the microthermochamber the polished plates of the minerals were removed with chloroform from the objective stage and carefully washed with alcohol.

The inclusions of villiaumite were first found in eudialyte and nepheline of a pegmatite, occurring in trachyte-like khibinites. Previously, in the minerals of these pegmatites, there were studied inclusions of hydrocarbon gases and bitumens (4). On further observation, inclusions of NaF were found in nepheline of urtites, selected at different parts of the massif (Kukisvumchorr Mt., Suoluaiv Mt., Kuel'por Mt., Pasvumchorr Mt.). From the results of study of aqueous extracts, the presence of villiaumite was established in nepheline of khibinite, foyaite, and rischorrite.

In eudialyte villiaumite occurs in the form of independent deposits or as daughter crystal-villiaumite in the cavities of multiphase inclusions (gas+bitumen+daughter crystal). In the crystal "host" the inclusions are located in zones, going in various directions, or are associated with the cleavage direction in eudialyte. In the same zones intergrowths of crystallites of aegirine and gas inclusions are usually present. The form of the independent deposits of villiaumite is rounded, sometimes bounded by irregular or smooth outlines, of size up to 0.1 mm. (Fig. 1). Often on the surface of the inclusions

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Fig. 1 (p. 1002a). Inclusions of villiaumite in eudialyte of pegmatite.
(a) - group of small inclusions of villiaumite (B) and gas (x260);
(b) - cubic crystallites of villiaumite, adhering to inclusions of aegirine (x 55). ([illegible] included here)

there are found small gas bubbles. In the multi-phase inclusions, villiaumite sometimes occupies up to 50% of the volume of the cavity, taking its form (Fig. 2a, a'). Small daughter crystals of villiaumite usually have rectangular outlines, and nearly always, as in the

Fig. 2 (p. 1000a). Multiphase inclusions in eudialyte of pegmatite a, a' --inclusions in which villiaumite (B) occupies about half the volume of the cavity. At the end of the cavity, occupied by a gas phase, there is developed a rim of bitumen (x 760).

daughter crystals of aegirine, have rounded rims of bituminous matter, the luminescence of which is seen well in blue- and ultraviolet-light (Fig. 2, b, b'). The size of the multi-phase inclusions attains

Fig. 2 (p. 1000b). Multi-phase inclusions in eudialyte of pegmatite. b,b' --inclusions of daughter crystals of villiaumite. The bitumen forms rims around the villiaumite and "capillaries" at the surface of the walls of the cavity. X 1300. a,b in normal transmitted light; a',b' --luminescing bitumen in blue-violet light with illumination of the sample above the microscope objective.

0.2-0.3 mm., form is irregular or, in small inclusions, partly rounded. Heating the inclusions in the microthermochamber up to 600° caused no distinct changes in the daughter crystals, except for disappearance of the rose color of the villiaumite at 310-340°. Changes of the bituminous matter in the large multi-phase inclusions were observed at heating to temperatures of [illegible] (4); at [illegible] the bitumen went into the gaseous state, yielding when cooled below 150-200° a transparent condensate of luminescent liquid. Aqueous solutions were not observed in the cavities of multi-phase inclusions. In this case, apparently, the conclusion of Semenov on the predominant role of hydrothermal processes in the formation of villiaumite (7) does not apply.*

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*Regrettably, this conclusion was not supported by the author by study of the content of water in the studied nephelines. One must call attention to the presence of water in some nephelines from rocks of the Khibina massif. (T.N. Ivanov, Apatite deposits of the Khibina tundra, Gosgeoltekhizdat, Moscow, 1963.)

In nepheline or urtite villiaumite forms rounded or partially bounded inclusions of size up to 0.06 mm. These inclusions, as a rule, adhere to prismatic crystals of aegirine, which impregnate nepheline, located mainly along the cleavage directions in the crystal-"host" (Fig. 3a). Previously there were noted nepheline analogous cases of adherence of similar crystallites of aegirine to gas inclusions (6). Sometimes there is observed the adherence of villiaumite to deposits of an optically biaxial mineral (feldspar?), which does not dissolve in HCl, has lower indices of refraction than nepheline, and lower birefringence (Fig. 3b).

(Not included here)
Fig. 3 (p. 1002a). Inclusions of villiaumite (B) in nepheline of urtite. X 350.
(a) Inclusions adhering to crystallite of aegirine;
(b) Inclusions adhering to deposits of feldspar(?).

The index of refraction of villiaumite is somewhat lower than that of methyl alcohol (1.329). On introducing water under the cover glass, villiaumite in opened inclusions is dissolved in 2-3 seconds. Under the microscope, deposits of villiaumite, because of its very low index of refraction, are very similar to gaseous inclusions, but differ from them in the rose color. In reflected light, reflections are not observed at the surface of inclusions of villiaumite, unlike gaseous inclusions.

With the purpose of approximately estimating the number of inclusions of villiaumite in different minerals F was determined in aqueous estracts from monomineralic fractions of different samples of rock. The determination of fluorine was made as follows: A weighed sample of mineral (10g) was pulverized in a porcelain mortar for 30-40 minutes, treated in a porcelain dish with several portions of hot distilled water of total volume 50-70ml. After obtaining on the centrifuge a solution free from mineral suspension, half of it (25-30 ml.) was diluted with water to a volume of 90 ml., in which F was determined colormetrically (E.I. Uspenskaya, analyst) by the use of acid zirconium-alizarin lake) (7). The analyses were completed directly after centrifuging. The content of F^- in such diluted volumes of extracts was usually in the range 0.03-0.99 mg*. The computed contents of F (in %) from the weight of sample taken were: for nepheline (13 samples) 0.0074-0.0232, feldspar (8 samples) 0.0006-0.0053, aegirine (5 samples) 0.0036-0.0077. In two samples of nepheline (from urtite and ijolite), fluorine was not found.
In eudialyte, where the above-described inclusions of villiaumite were observed, the content of F^- equalled 0.008%. On comparison of the amounts of fluorine and hydrocarbon gases given off by grinding in a hermetic ball mill of the same samples of nepheline, a specific association was found between these two components. As a rule, high contents of fluorine (0.01-0.02%) are characteristic of samples of nepheline in which the amount of hydrocarbon gases is close to 100 cu.

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*For control, the determination of F^- in the extract of one sample of nepheline (sample 2005a) was made both by direct analysis and also with preliminary distillation of the solution. The contents of F obtained were 0.84 and 0.80 mg., respectively.

cm./kg. mineral. This relation is shown in Fig. 4, where the contents

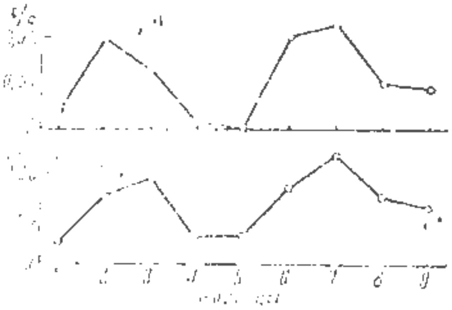

Fig. 4 (p.1003). Content of fluorine (NaF) and methane (in cu. cm./kg. mineral) in samples of nepheline. 1,2,3--nepheline from khibinite (samples 2004, 2000, 2001); 4,5,6--nepheline from urtite (samples [illegible], [illegible], 470); 7-8--from pegmatite (samples 2005, 2010); 9--nepheline from rischorrite (sample 2031).

of fluorine (NaF) and methane are given for the same samples of nepheline (methane is more than 90% by volume of the hydrocarbon gases of the nepheline).

The results given indicate that inclusions of villiaumite are probably as widely distributed in the rock-forming minerals of the Khibina massif as inclusions of organic matter and aegirine. During the chemical analysis of the minerals, the inclusions of NaF will apparently affect the results, although to a small degree, giving excess amounts of F and Na. The joint occurrence of villiaumite and organic matter within closed cavities in eudialyte and also the relation between the number of inclusions and the content of hydrocarbon gases in nepheline may be considered as indication of their closeness in time and conditions of formation.

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Translated by Michael Fleischer.

KOPLUS, A.V., KORYTOV, F. Ya., & PUZANOV, L.S., 1968, New data on the vertical temperature zoning of fluorite deposits (abst): Abstracts of Report of Third All-Union Conference on Mineralogical Thermobarometry, Moscow, Sept. 9-15, 1968, p. 198-200. The quartz-fluorite type and the sulphide-fluorite type deposits have a great economic importance within the fluorite formation of the fluorite deposits. These deposits are very widely distributed in Transbaikal and the central Asiatic region. In past years they have been discovered in the Altai mountains also. A detailed study of the important fluorite deposits of these areas shows that there exists a similarity in regard to the geological structure and mineralogical-geochemical conditions of formation. Besides it is typical that the process of mineral formation took place in several stages and that the distribution in space of the paragenetically associated minerals of similar composition shows a regularity. Earlier it was believed that a direct pulsation zoning had developed during the mineralization in the deposits of the quartz-fluorite type and the sulphide-fluorite type. The new investigations of the deposits in Transbaikal, central Asia, and the Altai mountains, however, indicate a reverse zoning in most. Such is the case in the following deposits:

Transbaikal - Kalanguisky, Usuglinsky, Khuraisky, Abagaituisky, Solonechny, etc.
Altai mountains - Kayanchinsky, Busyginsky, Tayezny, etc.
Central Asia - Agata-Chibargatinsky, Takobsky, Naugarjansky, Kanimansursky, etc.

In these the minerals of earlier stage of mineralization were deposited predominantly in the upper parts of the ore bodies, whereas the late stage mineral associations, which consist mainly of porcelain quartz, sulphides, light colored fluorite and barite, are found in the deeper(lower) parts of the ore bodies. Similar regularities in the distribution of mineral associations deposited in different periods of time confirm the existence of a reverse temperature zoning. According to the results of homogenization temperature measurements, the process of formation of ores took place between 300° C and 60°C. The major part of the vein mineralization in the upper parts of the ore bodies occurred between 300°C-180°C. With increasing depth a decrease in temperature of formation of about 10-15°C, rarely 20°C and in individual cases even about 50°C (Usuglinsky deposit, Transbaikal) per 100 meter is recorded. This reverse vertical temperature zoning is to be expected in newly opened up deposits of the quartz-fluorite type and the sulphide-fluorite type in Transbaikal, Altai and central Asia also. From these facts it is to be expected that only those fluorite deposits which show a mineral paragenesis of the earlier stage, deposited relatively at higher temperatures, at the present surface of erosion are to be considered as good prospects. Translated by Asoke Lahiry.

KOVALISHIN, Z.I., 1966, Characteristics of gaseous components of some pegmatites of Volynia, Akad. Nauk SSR, Issled. prirod. tekh mineral. L'vov, 1964, p. 49-53 (pub. 1966).

Study of the genesis of the pegmatites of Volynia is to a considerable degree made difficult by the processes of intensive kaolinization of both the country rocks and also the pegmatites themselves. The pegmatite body we studied occurs amidst fresh dark-green biotite-amphibole granites with structures which outline the pegmatite body. In this pegmatite there is punched a vertical hole of diameter 6 m. and depth 7-8m. In the walls of this hole (Fig. 1) there are traced the following zones of the pegmatites: (a) the graphic zone of

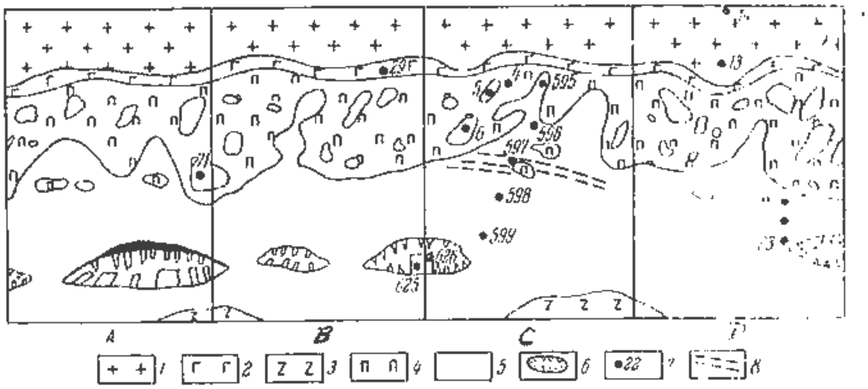

Fig. 1 (p. 50). Schematic drawing of the walls of the hole in the pegmatite body; (1) biotite-amphibole granite; (2) graphic zone; (3) pegmatite zone; (4) block microcline; (5) blocky quartz; (6) nests with crystals of morion; (7) place of selection of sample and their numbers; (8) region of crushing; (A) - northern wall; (B) eastern wall; (C) southern wall; (D) western wall.

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thickness from 5-10 cm. to 0.5 m.; (b) pegmatite zone (developed in the lower part); (c) zone of blocky feldspar of thickness from 1 to 3 3m.; (d) quartz core of size 6 x 4 m.

Of major interest is the clarification of the role played by the volatile components in the process of formation of pegmatites of this type. All investigators, even though differing on the method and source of the formation of pegmatites, assume an important role of gases in pegmatite formation (Fersman , 1940; Zavaritskii, 1947; Korzhinskii, 1953). Several papers have been devoted in recent years to clarifying the composition of the gases of pegmatitic processes (Elinson and Polykovskii, 1961a, 1961b).

To study the composition of the gases taking part in the formation of a completely differentiated pegmatite, the method was used of extracting them in a spherical vacuum grinder, followed by collection in a special apparatus (Kovalishin, 1962) and analysis in the gas analyzer V.T.I.-2. During the grinding the gases were liberated from the inclusions, which are relicts of the mineral-forming solution (Ermakov, 1950; Kalyuzhnyi, 1960). With the aim of establishing specific regularities in the change if composition of the gases, samples were taken from different-age zones of the pegmatites. The gas was studied as to its contents of acid gases (CO_2 +H_2S +

other), CmHn, O_2, H_2, CO_2, CnH_2n+2, N_2, and total rare gases (He, Al (sic, Ar?), and other). Water vapor was first condensed in a trap at -78°C and did not hinder the analysis.

The results of the analyses of the gases extracted from samples selected by the zones of the pegmatites are given in Table 1. The samples were collected in the walls of the hole downward in the section. In the table the results of the analyses are given in correspondence with this section, which gives the possibility of tracing the change of composition of the gases with depth. As seen from the first section (samples 595, 596, 597, 598, 599, 626, 625), the total amount of the gaseous mixture (see Table) gradually decreases, and in the period of crystallization of large crystals of morion equals 26-28 ml/kg. The content of acid gases (CO_2, H_2S, and others) gradually increases and attains 92 volume %. The content of CO_2 predominates over those of other acid gases. In general, the tendency of increase of the content of acid gases has some deviations for the region of crushing in the quartz zone (sample 597). With this same region is associated the largest amount of extracted gas (232.9 ml/kg). The content of saturated hydrocarbons (CnH_{2n+2}) likewise increases with depth. It is characteristic that for quartz from the feldspar zone it is approximately 1.5 volume %, and for quartz of various types of the quartz zone 3-3.5 volume %.

In distinction to the acid gases and the saturated hydrocarbons, the role of the remaining components decreases with depth. They change within the following limits (in volume %): hydrogen from 5.67 to 1.68; oxygen from 1.03 to 0.37; nitrogen + rare gases from 33.03 to 2.63.

The second section (samples 29, 4, 5, 6-63) were taken from the graphic and feldspar zones (see Fig. 1). Despite the large differences in type of formation (graphic zone, quartz, feldspar), here also was observed increase of the content of acid gases with depth. They increased from 17.18 through 21.30-37.30 to 59.95 volume %. The remaining gases obeyed the same rules with depth as in the previous section (contents of N + rare gases, H, and others decrease). The last section (samples 22, 24, 23-63) was collected in the quartz zone. Here are noted some reversed regularities. The content of acid gases is small, but is less towards the center zone (60-58-56 volume %). The contents of H, saturated hydrocarbons, and O decrease, whereas the content of N + rare gases increases from 34 to 40 volume %. One analysis was made from the pegmatite zone, located below the quartz core, near the granite. In contents of the most important constituents it is similar to the results of the analyses of gases extracted from the upper peripheral part of the pegmatite.

With the aim of establishing the effect of the volatile components taking part in the process of formation of the pegmatite on the enclosing granite, we give analyses of gaseous extracts from the core at different depths of some drill cores in the region of the studied pegmatite. The results of these analyses are given in the table. The places where samples were taken are plotted in Fig. 2, from which it follows that the studied granite is below and above, in the center and at the edges of the pegmatite body. This section of samples according to the cross-section made it possible to establish some very interesting regularities.

As seen from the table (samples 686, 688, 690, 692, 694), the content of acid gases in the granites increases with approach to the pegmatite (8.33-30.14 volume %), is highest in the pegmatite itself

Table 1 (p. 51-52). Results of analyses of gas extracts.

No. of sample	Place sample collected	Composition of gas, volume%							Volume of gas, mg per kg sample
		CO_2+H_2S	C_mH_n	O_2	H_2	CO	C_nH_{2n+2}	N_2+rare gases	
		A. From minerals of the pegmatite zone							
595	Gray, smoky quartz at the contact with feldspar	64.69	0.00	1.03	5.67	0.00	1.54	27.07	159.0
596	Light-gray quartz, upper quartz zone	76.65	0.00	0.92	4.11	0.00	1.72	16.60	176.6
597	Gray mottled quartz of area of crushing in quartz zone	64.0	0.00	0.50	0.99	0.00	1.48	33.03	232.9
598	Smoky, platy quartz of quartz zone	84.28	0.00	0.32	5.38	0.00	3.01	7.01	215.6
599	Platy morion of quartz zone	89.51	0.00	0.75	3.00	0.00	3.00	3.74	66.8
626	Milky-ice quartz, center of giant crystal from cavity	91.97	0.00	0.37	1.68	0.00	3.35	2.63	25.7
625	Morion of outer zone of crystal-giant from cavity	87.19	0.00	1.01	3.25	0.00	3.45	5.10	28.6
71	Gray topaz from feldspar zone	89.42	0.00	0.76	2.11	0.00	1.92	5.79	40.3

Table (p. 51-52) - continued

29-63	Pegmatite of graphic structure	17.18	0.00	3.78	1.37	0.00	0.34	77.33	126.9
4-63	Microline from blocky feldspar zone	21.30	0.00	9.02	2.34	0.00	0.00	67.34	78.6
5-63	Gray quartz from quartz segregations of feldspar zone	37.30	0.00	3.17	0.59	0.00	0.00	58.94	258.5
6-63	Gray quartz from quartz segregations of feldspar zone, 1.5 m. depth	59.95	0.00	0.83	0.00	0.00	0.00	39.22	236.0
22-63	Milky-white quartz of quartz zone, 0.5 m. from feldspar zone	60.51	0.00	0.86	1.50	0.00	2.78	34.35	147.8
24-63	Smoky quartz of quartz zone, 1.2 m. from feldspar zone	58.92	0.00	0.51	0.76	0.00	1.78	38.03	218.4
23-63	Dark smoky morion of quartz zone, 2.0 m. from feldspar zone	56.94	0.00	0.52	0.69	0.00	1.73	40.12	156.3
72-63	Pegmatite, pegmatite zone below quartz zone, depth 7 m.	19.25	0.00	10.81	1.01	0.00	2.02	66.91	137.4

Table (p. 51-52) - continued.

		B. From granite, enclosing pegmatite							
701	Core 1883, depth 27.6 m., granite wiht rosy K feldspar 1 m. from pegmatite	55.44	0.00	1.48	8.91	0.00	1.98	32.19	30.8
702	Core 1883, depth 9.0 m., kaolinized granite 5 m. below pegmatite	10.00	0.00	5.00	12.50	0.00	6.66	65.84	15.7
703	Core 1883, depth 8.0 m., fresh dark-green granite at contact with rosy granite	16.21	0.00	4.05	9.46	0.00	10.81	59.47	7.13
686	Core 1882, depth 28.5 m., granite pale-green	6.66	0.00	4.44	13.33	0.00	15.55	60.02	7.12
688	Core 1882, depth 21.5 m., granite pale-green	61.97	0.00	2.11	3.52	0.00	4.93	27.47	9.17
690	Core 1882, depth 17.5-20.0 m., pegmatite of graphic structure	77.50	0.00	1.46	5.13	0.00	2.44	13.47	48.70
692	Core 1882, depth 14.0 m., granite dark-green	30.14	0.00	2.20	3.67	0.00	0.00	63.99	10.17
694	Core 1882, depth 8.8 m., granite dark-green	8.33	0.00	2.08	14.58	0.00	0.00	75.01	7.46

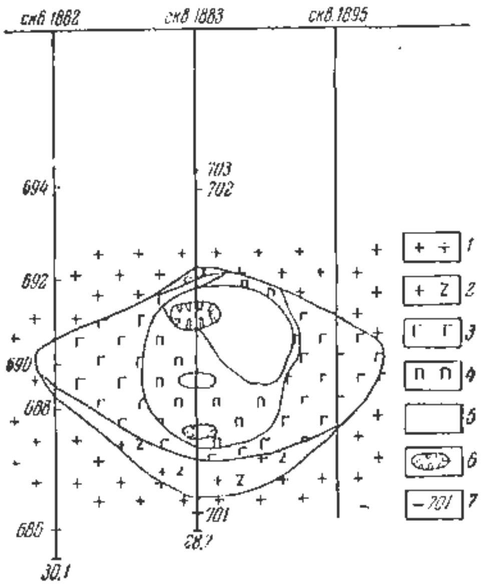

Fig. 2 (p. 50). Schematic section of pegmatite body from drilling data; (1) granite; (2) pegmatitic granite; (3) graphic zone; (4) blocky microcline, (5) blocky quartz; (6) cavities; (7) place core was selected.

(77.50 volume %), and then diminishes with distance from the pegmatite (61.97-6.66 volume %). Very distinctly is traced the regularity of the diminishing role of oxygen with approach to the pegmatite (4.44 - 2.11 - 1.46 - 2.20 - 2.08 volume %). There is a decrease of the content of hydrogen, saturated hydrocarbons, and nitrogen in total rare gases. Thus, only the contents of acid gases increase. Quantitatively the gas predominates in the pegmatite; it is less in the granite, and the amount of gas decreases sharply with distance of the point of collection of the sample from the pegmatite. Other sections in the granites repeat in the principal features (samples 701, 702, 703) the regularities found in the sections discussed above.

Conclusions

1. Study of the gases leached from different minerals and zones of a pegmatite permitted us to determine in them acid gases, hydrogen, saturated hydrocarbons, oxygen, nitrogen and total rare gases. CO_2 was not determined and CO was not found anywhere.

2. In different stages of the formation of the pegmatite, the roles of the separate components of the gas mixture change. Thus, the acid gases (especially CO_2) have the highest concentrations in the last stages of the process. It must be stated that these are the dominant gases, because they are noted in all stages in contents more than 50 volume %. The role of saturated hydrocarbons also increases. Their contents increase, as compared to the starting stages, and then change slightly. The roles of hydrogen, nitrogen, and total rare gases, and oxygen diminish with the progress of the process.

3. The quantitative content of volatile components is considerably decreased in the late stages.

4. Study of the gases from the enclosing granites showed that the gaseous components of the pegmatitic fluids were diffused into the country rocks, causing some changes in them. Thus, around the pegmatite there is formed an aureole, which is easily found by studying the content of gases in the enclosing granites.

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Translated by Michael Fleischer.

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(Ed. note: Unfortunately only a translation of the Table of Contents is available at this time. It does help the reader to judge the scope of the work, however, and to find specific sections of interest.)

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LYAKHOV, YU. V., and MYAZ', N. I., 1966, Temperature regime of formation of quartz of the Baleisk deposit, eastern Transbaikal, in Tsvetkov, A. I., ed., Studies of natural and synthetic mineral formation (Material Soveshchanie, 7th, L'vov 1964): Moscow, Nauka press, p. 43-48 (in Russian).

The Baleisk gold-ore deposits are located in the rim part of a small tectonic depression of graben type, filled predominantly by conglomerates of Lower Cretaceous age (Petrovskaya and others, 1961; Bernshtein, 1963). The base and edge of the depression consist mainly of granodiorites of Hercynian age. The ore body is located in conglomerates, granodiorites, and also Upper Jurassic sandstones. Within the deposits are distinguished ore zones, including a series of connecting veins, veinlets, and stockworks of mineralization, the latter constituting an unusual mineralization of carbonate-quarz composition with admixtures of kaolinite and adularia. Of the ore minerals, there are known pyrite, marcasite, arsenopyrite, galena, sphalerite, chalcopyrite, stibnite; rare are hessite, calaverite, pyrargyrite, and tetrahedrite; the latter is an unusual indicator of commercially valuable ore and accompanies accumulations of gold. In general, the ores are characterized by extremely small content of sulfides and are classified as lean-sulfide ore. According to the data of Petrovskaya and others, (1961), the ore deposits in the Baleisk deposit were formed in five steps, connected by the following stages: I - pre-productive stage (1) early chalcedonic quartz; II - first productive stage (2) adularia-carbonate-quartz stage; III - interproductive stage (3) carbonate-quartz stage; IV - second productive stage (4) in quartz-polymetallic sulfide stage; (5) gold-pyrargyrite stage; (6) comb-like quartz and redeposited gold; V - post-productive stage; (7) "porcelain-like" quartz; (8) quartz-pyrite; (9) quartz-stibnite; (10) horizontally banded chalcedony.

The wide development in the ores of the Baleisk type of the fine-grained variety of quartz, the presence of carbonate, kaolinite, and adularia, the only occurrence of hessite and calaverite, the high silver content of the gold, and also the abundance of banded, collomorphic, and skeletal texture permitted the same authors (petrovskaya and others, 1961; Petrovskaya, 1963) to find features relating the Baleisk deposit with the group of epithermal formations, produced under near-surface conditions.

In contrast with the fine-grained chalcedony-like accumulations of quartz, its medium- and coarsely-crystalline aggregates are not typical for the deposit as a whole. In connection with this, the Baleisk gold-ore deposits up to now have not been studied by the method of mineral thermometry. In 1963 we began the mineral-thermometric study of Baleisk ores. To accomplish this, columnar, somewhat comb-shaped and platy varieties of quartz, and also separate varieties of carbonates were used. The most favorable object for study were the veins of the northern flank of the deposit; a steeply-dipping body of thickness from

5 to 30 cm. in a north-northwest direction, located in granodiorites. The structure of the veins is symmetrical, rarely asymmetrical. In near-selvage areas are concentrated deposits of milky-white platy or festoon-like quartz (I) of the adularia-carbonate stage, which is cut or cemented by aggregates of coarsely-columnar quartz (II) of the carbonate-quartz stage (Fig. 1). The central area of the vein is usually filled by calcite of platy (II) and rhombohedral (III) habit; the former contains a small amount of the magnesium component. Often the platy crystals of cream-colored carbonate II forms skeletal structures, which is sometimes partly or completely replaced by the later quartz III. The latter usually contains disseminated inclusions of arsenopyrite. In the case of the absence of the skeletal carbonate II, the quartz III is deposited in the form of fine-grained accumulations also containing arsenopyrite, or it forms small brushes of small (1-5 mm) crystallites, overgrown on crystals of quartz II and carbonate III.

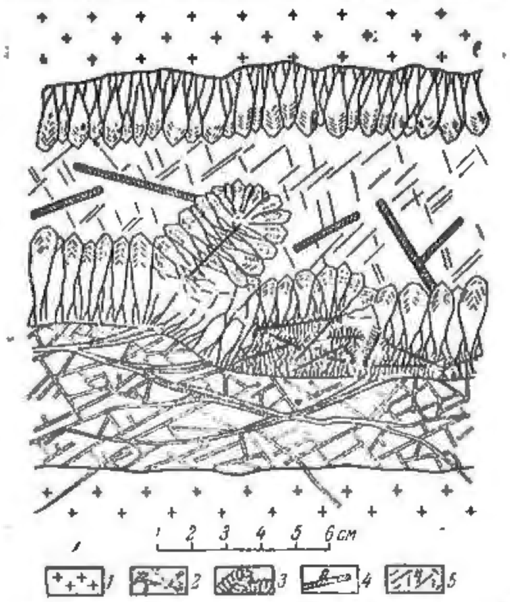


Fig. 1 (p. 44). Schematic structure of one of the veins of the Baleisk deposit. (1) granodiorite; (2) platy quartz with relicts of calcite; (3) coarsely columnar crystals of quartz; (4) tabular crystals of creamy carbonate; (5) calcite of rhombohedral habit.

On microscopic study of the platy quartz I in the central parts of most plates there are observed relicts of carbonate I replaced by it (Petrovskaya and others, 1961), having polysynthetic trilling intergrowths. X-ray structural analysis showed them to be calcite. In contrast to the quartz I, the relict carbonate I abounds in pseudo-secondary (Ermakov, 1950) gas-liquid inclusions (L = 85-82%) of regular form (Fig. 2), homogenizing according to the first type (Ermakov, 1950), i.e. in the liquid phase, at a temperature of 240-230°C. Rarely there occur primary inclusions of sizes from 0.001 to 0.03 mm., with temperatures of homogenization 245-240°, according to the first type. Quartz I contains only rare chains of secondary inclusions, homogenized in the interval 270-250°C. At this temperature, there began the formation of the following carbonate-quartz association, marked by the crystallization of quartz II.

Fig. 2 (p. 45). Pseudo-secondary gas-liquid inclusions (235°)C in relicts of platy carbonate I. Magnification 870. (Omitted).

In the base of the columnar aggregates of quartz II there are often observed medium-grained dense areas formed of relict platy structure (see Fig. 1). It is evident that it originated as the result of complete replacement by quartz II of a previously deposited platy mineral (carbonate?). The crystals of quartz II, crown-shaped frameworks of fine-grained structure, gradually are enlarged and pass into parallel-columnar formations. Along these plates are usually observed micro-cavities, which appear to be the result of geometric separation of micro-crystals of quartz II. In some micro-cavities there are preserved relicts of quartz-forming solution that caused the decomposition of the platy mineral (Fig. 3). Homogenization of such inclusions begins as 270-265° according to Type I.

Fig. 3 (p. 46). Primary gas-liquid inclusions (270°C) in the base of a crystal of quartz II). (Omitted.)

In the course of the crystallization of quartz II, the habit of its crystal varies from short prismatic to obelisk-like. Crystals of quartz II have complex zoned structure; they are registered by gas-liquid inclusions (0.001-0.01 mm.) of quartz-forming solution (Fig. 4). The form of the inclusions is irregular or approximately rectangular; they are oriented perpendicular to the rhombohedral faces and are arranged as if following the transition. Such inclusions can be referred according to mechanism of formation to inclusions of skeletal growth, originating as the result of rapid crystallization of the individual (Ermakov, 1950).

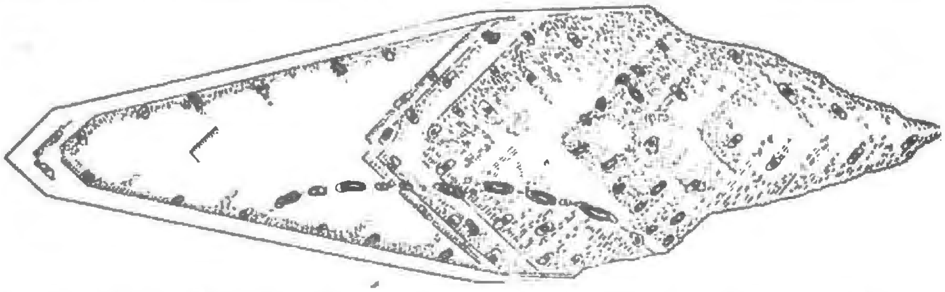


Fig. 4 (p. 47). Scheme of arrangement of primary and pseudo-secondary inclusions in coarsely columnar crystals of quartz II.

In composition most of the inclusions are gas-liquid with filling of the liquid phase up to 80-85%. As the result of thermometric analysis of the inclusions, taken from different zones of crystals, it was established that they are homogenized in the liquid phase in the temperature range of 265-225°C. Thereby the inclusions from the root part of the crystal is homogenized at 265-250°C, from the central part at 250-240°C, and from the outer part at 240-225°C. Among the gas-liquid inclusions there are also often observed substantially gaseous inclusions (L=5-0%). Sometimes there occur separate zones of entirely gaseous inclusions. In the central zones one can observe that the gas-liquid inclusions are concentrated in the lower part of the zone and in the direction towards its periphery gradually changes to gaseous, predominant in the upper part of the zone.

In crystals of quartz II, a fairly large role belongs to pseudo-secondary inclusions, which are located along healed fractures, not emerging from the limits of the outer zone. In composition, they, like the primary ones, are gas-liquid and rarely essentially gaseous inclusions. Rarely these groups of inclusions are observed together in a single fissure and are homogenized in the corresponding phases (liquid and gaseous) in the narrow temperature interval 250-230°C. The syngenesis of primary, equal-temperature, essentially liquid and essentially gaseous inclusions permit one to consider them as relicts of liquid and gas phases of a single mineral-forming system existing in dynamic equilibrium under definite thermodynamic conditions (Ermakov, 1950, Kalyuzhnyi, 1961). It is evident that the crystallization of the coarsely-crystalline quartz II took place from periodically boiling aqueous solutions. The total concentration of salts in the liquid phase of the inclusions, determined from the degree of filling and the temperature of their homogenization, is 5-10%. Using the laws of heterogeneous equilibrium for the system vapor-water and vapor-30% aqueous solution of NaCl (Lemmlein and Klevtsov, 1956), one can calculate that the pressure in the process of quartz formation was of the magnitude 30-40 atm. So low a pressure excludes the necessity of introducing corrections for pressure into the temperature of homogenization of the inclusions, and permits one to consider them as true temperatures of mineral paragenesis (Ermakov, 1950; Kalyuzhnyi, 1961).

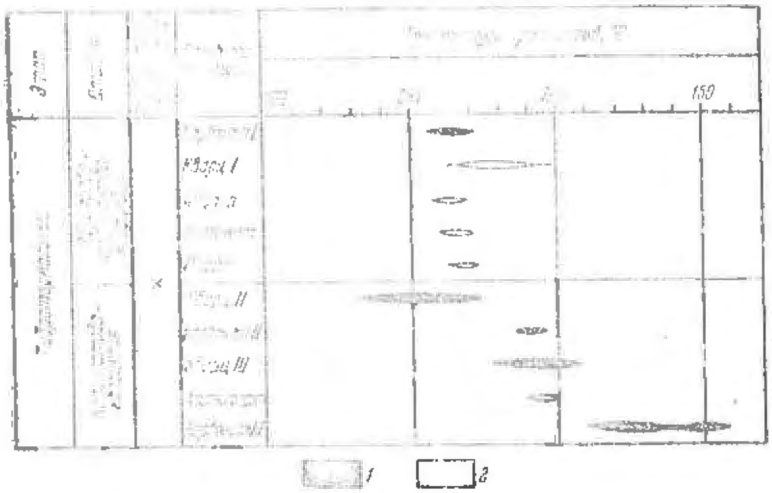
By microscopic study, the platy crystals of the cream-colored carbonate of the formation II are shown to be saturated by gas-liquid inclusions (0.001-0.01 mm.), analogous to those in the carbonate I. They are characterized by maintained filling (L=85-87%) and are homogenized in the liquid phase in the temperature interval 210-105°C. The occurrence of these inclusions is strictly limited to the platy crystals of carbonate II. The carbonate III surrounding it is entirely free of similar inclusions. It is probably that with respect to carbonate II, such inclusions are pseudo-secondary and characterize the temperature conditions of its crystallization.

With complete replacement of carbonate II by quartz III there originated a quartz skeleton, which differs from the structure of quartz I only in the interaction with quartz II and a somewhat larger size. The gas-liquid inclusions, located in the coarse-platy quartz III, are homogenized in the liquid phase in the temperature interval 225-190°C.

It is curious that the process of development of pseudomorphs of quartz after early "paper spar" from one of the polymetallic deposits of the Far East, according to the data of Ermakov (1950), also proceeded slowly in a considerable interval of decrease of temperature from 250 to 150°C.

In the completion of the carbonate-quartz stage of mineral paragenesis of the Baleisk deposits, there occurred abundant deposition of carbonate III in the form of large crystals of rhombohedral habit, tinted in white and greenish zones. Among the gas-liquid inclusions found in carbonate III, one can distinguish two temperature groups: 180-170° and 150-140°C, which apparently also correspond to the period of most active crystallization of the mineral. Among the clearly secondary inclusions are found two-phase gas-liquid inclusions with temperature of homogenization 90-70°C, and single-phase liquid inclusions, corresponding to warm aqueous solutions having temperatures below 50°C.

Study of the inclusions of mineral-forming solutions in minerals of the Baleisk ores gives the basis for affirming that the formation of these ores in different stages of mineral genesis (Fig. 5) occurred from ionic-molecular solutions, having temperatures of 270-250°C. In the process of ore formation the temperature of the solution dropped without special drops. Notable temperature discontinuity marked the ore deposition in the carbonate-quartz stage of the process. To the same period belongs frequent boiling of the solution, caused apparently by the



Column captions, from left to right and top to bottom, in sequence:
1. Stage; Hydrothermal
2. Substage; Adularia-carbonate-quartz; Carbonate quartz
3. Intra-mineral adjustments (fracturing? Ed.)
4. Main minerals; Carbonate I; Quartz I; Adularia; Kaolinite; Pyrite. Quartz II; Carbonate II; Quartz III; Arsenopyrite; Carbonate III.
5. Temperature of solution, °C

Fig. 5 (p. 48). Sequence and temperature regime of the formation of minerals in the two main stages of mineralization of the Baleisk deposits (northern boundary). 1-temperature interval according to inclusions; 2 - assumed temperature interval.

regime of decrease of pressure (to 30-40 at.) with periodic opening of ore-enclosing fractures. This conclusion confirms the idea of Tatarinov (1963) on the boiling of solutions, formed in near-surface deposits. At the same time, the data of mineral thermometric study given permit one to reconsider the conclusion that the Baleisk deposit is epithermal and that its ores were predominantly colloidal solutions (Petrovskaya and others, 1961). On the basis of the study given of the Baleisk deposit, it can be referred to the type of medium-temperature formations at small depth (epimesothermal, according to Ingerson, 1964). It is interesting that there has recently appeared an analogous indication for certain gold-silver deposits of Northern Dobrudja (Manilichi and Bordok, 1964).

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MIRONOVA, O.F. and NAUMOV, G.B., 1967, Method of determining the concentration of CO_2 in gas-liquid inclusions; Geokhimiya 1967, No. 10, p. 1121-1123 (in Russian) (Authors at Vernadskii Inst. of Geochemistry and Analytical Chemistry, Acad. Sci. USSR, Moscow).

The determination of the concentration of CO_2 in gas-liquid inclusions of minerals permits one to obtain very useful information on the behavior of one of the main components of ore-forming hydrothermal solutions. However, in the existing methods up to the present, the determination of water and CO_2 has been made on separate samples, which entails a series of additional errors.

CO_2 is usually determined by the conductometric method proposed in 1947 by B. Bruns and others (1). The nature of the method is essentially the recording of the change of electrical conductivity of a solution of $Ba(OH)_2$ as CO_2 is absorbed. This principle was used by Kryukov and Rengarten for the microdetermination of C in metals (2). In application to gas-liquid inclusions, the method has been described in detail by Khitarov and Rengarten (3). The method is not laborious and is sufficiently accurate, but for the occurrences of CO_2, its content in gas-liquid inclusions is comparable to that of water in them.

Water is determined mostly by the method of Brush-Penfield, which consists essentially in heating a weighed sample strongly in a sealed tube, after which its middle part in which the water has condensed is cut off, and weighed, either directly or by a tube of absorbent (4). The first method is distinguished by its speed, but is less accurate than the second, and requires a large number of parallel determinations for satisfactory results. With a small number of gas-liquid inclusions, where especially there are irregularities in their distribution, there are given in the literature average data of 20-30 determinations of the water content (5).

No data are given in the literature on the accuracy and sensitivity of this method, but because of the completion by weighing, one can say that the accuracy does not exceed the accuracy of weighing, and the sensitivity that of the analytical weights. To determine water, small weights of sample, of the order of 1 g., are usually taken. The absolute amount of water is thereby often tenths of milligrams, which is at the limit of sensitivity of the weighing method.

The obtained contents of the components are calculated to 100 g. of mineral, and for concentrations of CO_2 and H_2O, one takes the ratio of these magnitudes. Thereby the calculation has, besides the errors associated with the determination of small contents, also the inhomogeneity of the distribution of the inclusions, the incompleteness of their opening at varying temperature and time of opening, size of fraction, etc. It is not accidental that in such a method parallel determinations commonly diverge greatly from one another and it is necessary to make a large number of repeat determinations to obtain satisfactory results (5).

Often the determination of water and CO_2 are generally made on different fractions with different temperatures of decrepitation. Thereby, the percent of inclusions opened in the same weight of mineral will differ, which necessitates the appearance of an additional systematic error.

Many of these errors can be excluded if one analyzes the gas-liquid inclusions for different components on a single weight of sample. We undertook experiments to find methods of determination of water and CO_2 from a single weight of sample by means of the separation of the CO_2 and H_2O set free by decrepitation, and their further independent determination.

As concerns water, we used the usual method, proposed by A.G. Elitsur for the determination of water in aquo-complex compounds (6). The method essentially consists of the reaction of water with calcium hydride; the amount of water is judged from the volume of hydrogen given off, assuming that the reaction proceeds stoichiometrically according to the equation: $CaH_2 + 2H_2O = Ca(OH)_2 + 2H_2\uparrow$.

The method is rather simple, and the slight solubility of hydrogen and the large specific volume imparts to it high sensitivity.

In the paper by Goldinov et al. (7) it was shown by calculation that according to the thermodynamic stability of the products of reaction given above, they should be CaO, not the hydroxide. In order to insure the formation of the stoichiometric amount of CaO, it was proposed to carry out the reaction at a temperature of 550-600° (8). However, the determination of water in standard samples gives the basis of assuming that at room temperature because of the low speed of reaction the product is practically calcium hydroxide.

Because the opening of the gas-liquid inclusions is carried out by heating in a current of nitrogen, we were obliged to modify the original method. In the process of decrepitation of the sample, the water vapor given off is carried off by the current of nitrogen and is caught in the calcium hydride unit.

To check the method, determinations of water were made in artificially prepared mixtures (potassium ferrocyanide with potassium chloride and $MgSO_4 \cdot 7H_2O$ with Na_2SO_4) in a current of nitrogen or by heating copper oxide in a current of hydrogen. In the first case, the crystal hydrates were picked under the binoculars and carefully mixed with the fillers. In all cases, the error of the determination did not exceed 10% relative. The sensitivity of the method was of the order of a few gammas.

Experimental Part

The preparation of the sample was made as for the determination of CO_2 (2). A current of nitrogen, purified from CO_2 and water vapor, was passed through the system for 30 minutes. The weighed sample in a quartz boat was placed in a combustion tube (without stopping the current of nitrogen) and nitrogen was passed through the system for 30 minutes more. Then under the cell with calcium hydride was placed a vessel with cooling mixture (ethyl alcohol and "dry ice") of temperature -65°; the furnace was closed and the sample was kept at the temperature of decrepitation (temperature of furnace controled by thermocouple). When the electrical conductivity of the $Ba(OH)_2$ solution ceased to change*, the heating is completed, and the current of nitrogen is passed through about 40 minutes more. All this time the temperature of the cooling mixture is kept at -65° by adding "dry ice." At the conclusion of the experiment, the cell with calcium hydride is changed over to a burette with a levelling bottle, the level of the water in the burette is determined at zero, and thawing of the cell is begun. After the volume of water in the burette ceases to change, the volume of evolved gas is read off. The number obtained is corrected for the change in volume of the gas in the cell during the thawing. This correction can be calculated in a "blank experiment" or its magnitude can be excluded, bringing the temperature of the cell, after thawing, again to -65°, and reading off at this temperature. Along with the burette with leveling bottle, one can use the simplest or an automatic graduated gas burette with a drop of mercury (see the figure). The content of water is calculated according to the formula:

$$m = \frac{V \times 18\ P}{(227 + t_K^{\circ}) \times 62351},$$

where m is the amount of water in g., V the volume of hydrogen given off in ml., 18 is the equivalent (weight) of water, P is atmospheric pressure in mm Hg st. (standard? MF), 62351 is the gas constant. tK is room temperature in °C.

Calculation of the contents of CO_2 is given in the paper by Kryukov and Rengarten (2).

The method was tested on some samples of quartz. The results are given in the table.

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*If the change of conductivity of the $Ba(OH)_2$ solution is very large, it is possible, not waiting for the opening of all the gas-liquid inclusions, to discontinue the experiment, because to us the ratio H_2O to CO_2 is important. From these considerations one cannot obtain an exact weight of sample.

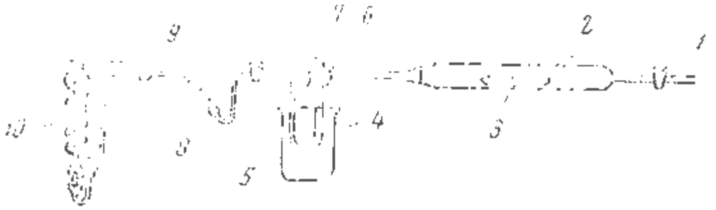

Figure (p. 1122). Apparatus for the determination of the concentration of CO_2 in gas-liquid inclusions.
1 - tube bringing in dry gas, freed from CO_2; 2 - quartz tube for opening the inclusions; 3 - boat with weighed sample; 4 - cell with calcium hydride; 5 - vessel for freezing mixture; 6 - three-way stopcock; 7 - outlet to burette with levelling bottle; 8 - bulb tube with 0.01 N solution of iodine; 9 - tube with solid KI to collect iodine vapor; 10 - small spiral absorber with solution of $Ba(OH)_2$.

Table (p. 1123)

Percent content of CO_2 in the water

No.	Sample	Content in sample, ppm		CO_2 in H_2O, %	Deviation from mean, %
		H_2O	CO_2		
1	Single crystal of quartz, Urals	7.46	1.31	14.93	0.30
		4.60	0.78	14.58	0.05
		4.67	0.78	14.38	0.25
	Average			14.63	0.20
2	Quartz, massive compact, Transbaikal	0.82	0.57	41.12	1.11
		2.15	1.62	42.97	0.74
		3.26	2.49	43.35	1.12
		3.34	2.37	41.47	0.76
	Average			42.23	0.93
3	Small, transparent, well-rounded crystals, Kazakhstan	2.22	0.06	2.63	0.59
		1.63	0.02	1.43	0.59
	Average			2.04	0.59

From the table it is seen that in the sample of quartz No. 3 there is observed a considerable divergence of results. This is explained by the fact that at low concentrations of CO_2, the more so when the number of inclusions is not large and the amount of material is limited, the content of CO_2 in the weighed sample is a few gammas, which is within the limit of sensitivity of the conductometric method. In these cases a more sensitive method of determining CO_2 is necessary.

The obtained percent content of CO_2 is the total content, including dissolved CO_2, CO_2 from independent phases, if they are present, and half the HCO_3^- ion from bicarbonate present in the solution.

In the analysis of carbonate minerals, it is necessary to consider the possibility of dissociation of the mineral itself. During the analysis of calcite and dolomite, we have found that up to 400° their dissociation can practically be disregarded. In the analysis of minerals intergrown with calcite, this necessitates precautionary measures.

Conclusions

A method is proposed for determination of water and CO_2 in gas-liquid inclusions in a single weighed sample. The water is determined by a modification of the Elitsur method.

Inclusion of a cell with calcium hydride for the determination of water in the system of conductometric determination of CO_2 permits one to determine water also on the same weighed sample without using additional time, with the same accuracy and degree of sensitivity.

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MOROZOV, S.A., 1966, The chemical composition of quartz-forming solutions of Western Pamir (from study of gas-liquid inclusions in quartz): Doklady Akad. Nauk Tadzhik S.S.R. v. 9, p. 28-31 (in Russian). (Presented by R.B. Baratov, Corresponding Member of the Academy of Sciences, Tadzhik S.S.R., 2-17-1965)

Inclusions of residual solutions can be used with calculations in certain circumstances to clarify the composition of mineral-forming solutions. For this purpose several methods have been worked out, which we have used to clarify the chemical composition of quartz-forming solutions, which formed the hydrothermal crystal-bearing veins of Western Pamir. Below are given only the data obtained as the result of determinations of the chemical composition of aqueous extracts from quartz and the study of the salt content in inclusions according to the "daughter" minerals. Similar studies were previously made by A.I. Zakharchenko (1,2); our observations supplement and refine the conclusions of this investigator.

The method of preparation of aqueous extracts adopted by us is similar to that described (3). Colloidal solutions of quartz, obtained by grinding samples, were removed by centrifugation. In the treatment of the results, we took into account that far from all the mineral matter trapped in the inclusions went into solution, and that the samples themselves were not equivalent on the score of amounts and volumes of inclusions. In this connection, in order to avoid large errors in the interpretation of the results of the analyses, we worked only with approximate quantitative ratios.

The data obtained of chemical study of aqueous extracts of quartz (see Table) show the solutions preserved in the inclusions are mainly chloride, but with a very significant content of bicarbonate. In the overwhelming majority of the samples, Cl^{-1} predominates over HCO_3^{-1}. The ion SO_4^{-2} always occurs in subordinate amounts with respect to Cl^{-1} and in most cases to HCO_3^{-1}. In only a few samples does sulfate predominate over bicarbonate.

Of the cations present in the aqueous extracts, Mg, Na, and K are constantly present. Ca is noted in some samples. The results of the analyses permit one to draw the conclusion that in most samples the cations occur in the relations: $Na+K > Mg$, and only in some samples was the reverse relation noted. Ca^{+2} in the overwhelming majority of cases occurs in subordinate amounts, and only in a single case predominated over Mg^{+2} or $Na^{+1} + K^{+1}$. The separate determination of Na and K on aqueous extracts from quartz veins of this region, made previously (2), show that in most cases Na predominates over K.

Besides the components listed, there was constantly recorded in the aqueous extracts SiO_2 in amounts from tenths to 53 mg per 100 g sample. Fluorine was also found in the aqueous extracts (1).

Spectrographic analysis shows that in dry residues from the aqueous extracts of quartz there were present constantly and in significant amounts, Si, Na, Ca, K, Mg, Fe, Al, and Mn, Also present constantly, but in somewhat smaller amounts were found Ba, Sr, B, Cu, Ti, and traces of Cr. Rather often Ni and Zn were present, and in a single sample were found small amounts of Pb, V, Ag, and Cd, and traces of Mo.

The analyses were made in the chemical laboratory of the Institute of Geology (Dushanbe), analyst Z.A. Shakhalieva. Fe^{+2} and Fe^{+3} were not found, therefore are not listed in the table. The difference between the sum of the anions and of the cations was taken as the content of $Na^{+1} + K^{+1}$.

The spectrographic analyses confirm qualitatively the above-given characteristics of the compositions of the solutions in the inclusions, and in some cases supplement them. Thus, the chemical analyses did not show many elements, whereas the spectographic analyses show their presence in significant amounts (for example. Fe, Al, Mn, Ba, B, etc.).

On examination of quartz plates under the microscope, there were found in inclusions of residual solutions, in addition to the usual liquid and gas phases, a series of "daughter" minerals, the identification of which is known to be difficult.

We determined reliably halite, sylvite, carbonate, hematite, and hydromica. Halite is a very common "daughter" mineral and is found in inclusions, both in vein quartz and in rock crystal, in high-temperature and in low-temperature primary inclusions. It is absent only in some low-temperature primary and in secondary inclusions of residual solutions. Sylvite occurs much more rarely than halite and always with the latter. Its crystallites also yield in size to those of halite. Occurrences in the inclusions of residual solutions of carbonate, hematite, and hydromica, are rather rare, so that on this basis one can only assume the presence of their components in the mineral-forming solutions. In many inclusions of some deposits there was noted an independent phase liquid CO_2, sometimes in rather considerable amounts -- up to 50-80 volume percent of the vacuole. In some sections of vein quartz we found inclusions very similar to bitumen in outward appearance,

The presence of H_2S was noted in some, especially low-temperature inclusions (1,2).

Thus, generalizing the data obtained, one may draw the following conclusions: In the solutions in the inclusions chlorides of Na, K, and Mg predominate; bicarbonates and carbonates have somewhat less abundance, but in some samples predominate over chlorides. Sulfates of Ca, Mg, and Na occur always in subordinate amounts, and in many samples are generally absent. It was noted that the role of chloride decreases with increase of the bicarbonate content. In the solutions SiO_2 is always recorded (probably all in the form of easily soluble salts -- R_2SiO_3 or $R_2Si_2O_5$). Rather often free CO_2 is present in the inclusions.

Comparing the analyses of aqueous extracts from vein quartz and rock crystal, one can note that these solutions have, in the main, similar compositions. However, there are sometimes observed rather sharp differences. Thus, for example, in some aqueous extracts from vein quartz the Cl^{-1} ion predominates whereas in extracts from rock crystal its role decreases. Simultaneously there is an increase of the ratio of Mg^{+2} to $Na^{+1}+K^{+1}$, i.e. apparently there is noted a certain change in the composition of the solution.

Chemical analyses of aqueous extracts from quartz of crystal-bearing veins of Western Pamir*

No. of sample	Dry residue, mg.	SO_4^{-2}	Cl^{-1}	HCO_3^{-1}	Ca^{+2}	Mg^{+2}	Na^{+1} $+K^{+1}$ by difference	SiO_2	Total mg/equiv.	
		In mg. per 100 g. sample							Anions	Cations
		Vein quartz								
878	34	not found	9	19	not found	3	7	0.4	0.564	0.247
908	37	8	26	8	" "	2	20	0.4	1.031	0.164
827	38	not found	9	28	" "	2	12	53	0.711	0.164
838	34	2	8	13	" "	1	9	46	0.479	0.082
740	36	13	11	1	" "	4	6	not detd.	0.597	0.329
790	26	2	16	1	4	3	1	" "	0.509	0.445
165	44	not found	11	22	not found	4	4	50	0.669	0.493
160	50	2	22	14	" "	3	15	49	0.891	0.247
238	49	1	22	16	" "	[illegible]	15	46	0.902	0.247
793	32	3	17	not found	" "	3	9	not detd.	0.[illegible]54	0.246
796	30	6	15	" "	2	3	5	" "	0.548	0.345
797	22	not found	15	" "	not found	5	0.2	" "	0.423	0.431
802	81	3	39	" "	" "	2	23	" "	1.162	0.1[illegible]4
442	98	not found	58	17	3	7	27	0.2	1.913	0.726
666	82	" "	34	26	3	1	26	not found	1.384	0.232
510	103	" "	45	33	3	7	25	3	1.808	0.726
889	24	" "	9	9	not found	3	3	8	0.401	0.247
912	7	4	2	1	" "	1	2	4	0.155	0.082
831	46	2	25	10	" "	3	15	30	0.910	0.247
572	30	not found	4	11	" "	3	1	50	0.292	0.247
451	39	" "	12	18	2	1	10	38	0.632	0.181
982	16	" "	8	7	not found	3	2	not found	0.339	0.247
12	38	10	8	12	1	4	6	46	0.629	0.379
44	41	8	11	18	not found	6	6	53	0.771	0.493

*The analyses were made in the chemical laboratory of the Institute of Geology (Dushanbe), analyst Z.A. Shakhalieva. Fe^{+2} and Fe^{+3} were not found, therefore are not listed in the table. The difference between the sum of the anions and of the cations was taken as the content of Na^{+1} + K^{+1}.

By comparison of spectrographic analyses of dry residues of aqueous extracts from vein quartz and rock crystal, one can sometimes note only a greater variety of elements in the vein quartz. In other cases such differences are not detected.

Comparing the results obtained with the data on other crystal-bearing provinces of the Soviet Union (4,5,6), one must admit that the chemical features of quartz-forming solutions are apparently very similar.

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PANINA, L.I., 1966, On the genesis of nepheline syenites of Borgoi: Akad. Nauk SSSR Sibirskoye Otdeleleniye, Geologii i Geofizikii, Trudy, 1966, no. 8, p. 114-115 (in Russian).

During 1958-1960 in the territory of the Buryat A.S.S.R. in the lower course of the Dzhidy River a series of massifs of nepheline syenite was found, among which the Borgoi has the largest size (area 3.5 sq. km.) . Most geologists (1) state that the Borgoi nepheline syenites were formed under hypabyssal conditions during intensive tectonic activity as the result of differentiation of a basic nepheline magma with some assimilation of the rocks of its roof.

G.V. Smirnov (3,4) suggests the formation of these nepheline syenites from"magma of a one-phase complex." The injected magma of syenitic composition subjected to endogenic autometasomatism an early alkalic stage. At the high temperatures the "through-magmatic" solutions existed in equilibrium with the minerals of the rocks and produced only their recrystallization. Later on the cooling of the massif progressed non-uniformly: decreasing temperatures quickly were attained in the near-contact areas. With a sufficiently long process, the course of the "through-magmatic" solutions across this endocontact zone raised the activity of the alkali metals so high that the formation of a magma of high alkalinity became possible. As the reult of this process there were formed nepheline and biotite after aegirine.

In connection with such contradictory ideas on the genesis of the Borgoi nepheline syenites, the specific temperatures of formation, are of great interest, of unaltered minerals of these syenites. For this purpose we have carried out mineralothermometric analyses. The objects of study were predominantly fresh gray-green or green nepheline, both from pegmatitic and from medium-fine-grained varieties. To heat the inclusions up to their homogenization we used the method, developed in 1961 in the laboratory of mineral-forming solutions of the Institute of Geol. Geophys., Siberian branch, Academy of Sciences, U.S.S.R., by means of a high-temperature microthermo-chamber, permitting us to heat the sample to 1200°C. The hermeticy of the inclusions was verified by repeated homogenization.

In a survey of plates of nepheline syenites the presence was established of both solid, liquid, and gaseous inclusions (according to the terminology of Lesnyak (2)). Only the liquid and gaseous inclusions were studied, which differed from one another only in the degree of filling.

Morphologically the inclusions are very diverse, but more often negative crystals were noted, repeating the form of the mineral-"host." Their size in most cases was thousandths of a millimeter. Because of the small size, the accuracy of measurement of the results of homogenization is ±10°. Often at high temperatures of homogenization there was observed a general darkening of the inclusion, because of which the phase boundaries became difficult to determine, and naturally the accuracy of the measurement was also altered.

149 measurements were made of the most characteristic temperatures of homogenization (see Table), of liquid and gaseous inclusions, of which liquid two-phase constituted 90-92%, liquid three-phase 5%, and essentially gaseous, 3-5%.

The essentially gaseous (liquid-gas) inclusions consist of gas and liquid solutions, such that the gaseous phase occupies 60-75% of the volume of the vacuole. Homogenization occurs in the gas at high temperatures (750° in sample 24a and 700° in sample 20b). The liquid two-phase inclusions (gas + solution) have degrees of filling from 0.7 to 0.95 and are homogenized in a very broad interval (from 730° to 60°).

The three-phase inclusions, composed of "aqueous solution + gas bubbles + mineral-host*," are homogenized in the liquid phase in the interval of 200° to 230°. On heating the inclusions, the mineral-hosts*, as a rule, are dissolved somewhat before the gas bubbles disappear. Dark-brown, and sometimes transparent, mineral-hosts* have either disk-like or nearly rounded forms, are of very small size, so that the determination of their composition and properties is nearly impossible.

Because it is not possible to determine the primary nature of the inclusions nor can the inclusions studied be referred to secondary ones, consequently the temperature of crystallization of the nepheline ought to be not lower than the maximum temperatures of homogenization of inclusions, i.e. 750°.

The data given by us are of preliminary character and are not entirely sufficient to generalize conclusions; however, with some

* Presumably daughter crystals (Ed.)

assurance one can say that the Borgoi nepheline crystallized from a magmatic melt.

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Table (p. 114)

Occurrence of highest temperature of homogenization		Region of low-temperature homogenization	
No. of sample	Temperature of homogenization, °C	No. of sample	Temperature of homogenization, °C
24a	750	[illegible]	[illegible]
20b	730	[illegible]	[illegible]
20b	700	[illegible]	[illegible]
20b	570	46	250
51	550	51	200
24a	530(?)	20b	170
51	500	24a	130
7g	500(?)	24a	80
7g	480	24a	60
24a	460		
29b	440		
46	420		
51	420		
20b	420(3)		

PETERSIL'E, I. A., ANDREEVA, E. D., and SVESHNIKOVA, E. V., 1965, The organic matter in the rocks of some alkaline massifs of Siberia: Izv. Ak. Nauk S.S.S.R., The Geology Series 1965, No. 6, pp. 26-37 (in Russian), translated by Aelita Demin, Geol. Survey of Greenland, Copenhagen.

The presence of hydrocarbon gases and reduced high-molecular weight organic compounds sealed in rocks or in cavities in the minerals from alkaline intrusive massifs are of theoretical as well as practical interest. At first hydrocarbon gases and reduced bitumen, close in composition to that of bitumens of the petroleum series, were studied from the largest alkaline massifs in the world, Khibina and Lovozero, situated in the central part of the Kola peninsula (1).

The amount and composition of the gases differ in the various rocks of the different intrusive complexes of these massifs. Also, the gas phase of the intrusive rocks differs considerably from that of the metasomatic rocks subjected to secondary processes.

The rock-forming minerals of the alkaline rocks are also different in respect to the gas phase. For instance, the highest hydrocarbon gas content has been determined in nepheline. The non-albitised potassium-sodium feldspars are also characterised by high contents, while the feldspars subjected to even the slightest albitization contain almost no hydrocarbon gases. Such gases are practically absent from albite. The minerals contain the gases as primary gas- or gas-liquid inclusions under high pressure.

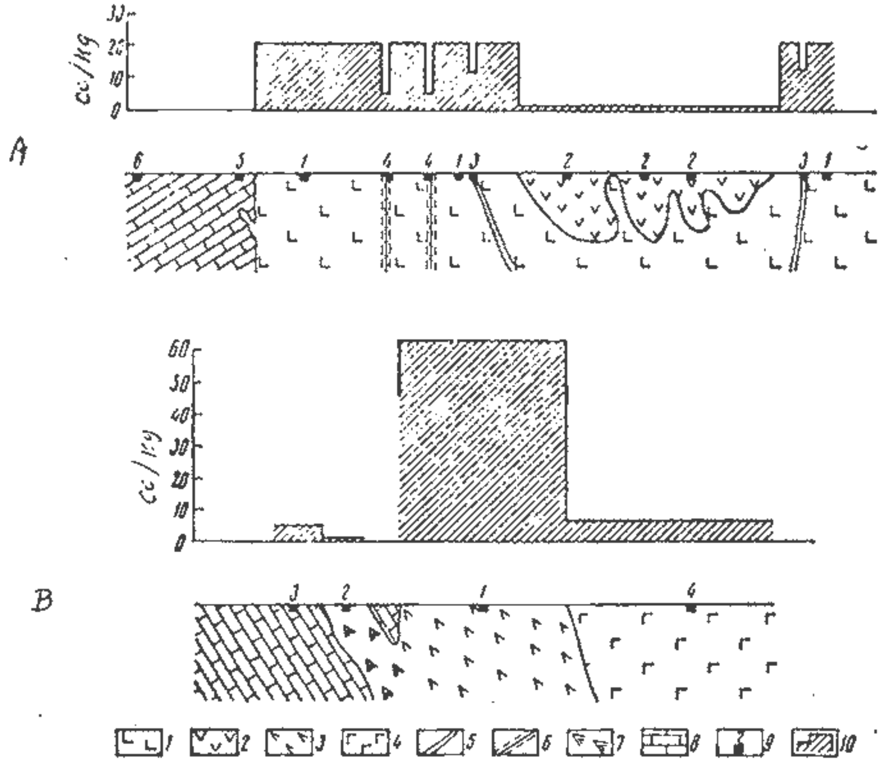
Besides, closed pores of the alkaline rocks and mineral cavities contain bitumen, the composition of which varies in different intrusive and metasomatic alkaline formations and in the host-rocks.

The study of the gas phase in the alkaline rocks may help to reconstruct the environments during their formation. In this connection the authors of the present article undertook a study of the organic substances in the rocks of certain intrusive massifs of the Siberian Platform. The gases and bitumens from the Sredne-Tatarkov and Kiya-Shaltyr massifs, and the gas phase from five rock specimens from the Goryachegory massif were examined. The gas was extracted by mechanical crushing of the rocks to 0.01 mm in a sealed ball-mill. The gas was analysed on a gas chromatograph with the following sensitivities: H_2 - 0.005%; CO - 0.01%; CH_4 - 0.03%; hydrocarbons C_2 - C_3 - 0.005%. The accuracy of the determination is ±5%. The noble gases were not analysed. The bitumen analysis was carried out in order to study the elementary composition of a chloroform extract of bitumen ("A") and the composition of the disseminated carbon ($C_{disp.}$) in the rocks.

The Middle-Tatar alkaline massif is situated on the Yenisei Ridge in the western-most fold ranges of the Siberian Platform. A leucocratic aegirine-nepheline syenite intrusion breaks through the Sinian limestones and schists. The absolute age of the intrusion was determined with K/Ar method as 662 m.y. The structure of the massif is simple, the nepheline syenite forming the main bulk of its volume. Only in the apical part this rock is replaced by rocks of ijolitic composition which, according to geologic and petrographic data, were possibly formed as the result of replacement of the schists and limestones of the roof during the magmatic stage of the intrusion. The marginal contacts of the intrusion are somewhat enriched in aegirine and accessory minerals compared to the nepheline syenites. Veins of alkaline syenite are widely developed. The chemical composition of the Middle-Tatar nepheline syenite is similar to that of the Lovozero foyaite.

As a result of the contact action of the intrusion on the enclosing limestones and schists the latter were recrystallized to form augite, tremolite, phlogopite, sphene and other minerals. The thickness of the outer contact zone is about 300 m. During the postmagmatic stage the nepheline syenites near faults were albitized and microclinized by alkaline solutions.

A schematic geological section of the massif, the sampling localities and the average content of the hydrocarbon gases in the rocks are presented in figure A, and the composition of the gases is given in Table 1.



Average content of hydrocarbon gases in sealed pores of igneous rocks of Middle Tateria (A) and Kiya - Shaltyrsk (B) alkalic massifs
1 - nepheline syenites; 2 - rocks of ijolite composition;
3 - urtites; 4 - olivine-titanaugite gabbro; 5 - alkalic pegmatites;
6 - albitized nepheline syenites; 7 - albitized and zeolitized urtites; 8 - country rock limestone; 9 - place of collection of sample; 10 - average content of hydrocarbon gas.

The natural gas mixture in the closed pores and in the cavities of the nepheline syenite minerals is characterised by a strong prevalence of CH_4 (94.38%) over other components; the amount of H_2, CO, C_2 - C_3 hydrocarbons and CO_2 is insignificant. The maximum gas content in the nepheline syenites is 34.69 cm^3/kg of the rock; the average content (according to the analyses of four samples) is 22.12 cm^3/kg.

Compared to the nepheline syenite, the ijolite of the apical part of the massif contains only one twentieth as much gas (0.94 cm^3/kg of rock). The gas phase of the ijolite contains a considerable amount of CO_2, H_2 (37.26%) and CO (13.82%); the CO_2 content is higher (9.57%) while the hydrocarbon gas has decreased markedly. The amount of hydrocarbon gases in the ijolite (0.37 cm^3/kg) is 57 times lower than that in nepheline syenite. It is of interest to note that a specimen of nepheline syenite from the contact zone with ijolite is also characterised by an insignificant gas content - 1.42 cm^3/kg; methane here makes only 0.79 cm^3.

The great quantity of hydrocarbon gas in the nepheline syenite indicates the reducing character of the medium during the crystallization of the alkaline magma. The ijolites were presumably formed under somewhat different conditions, i.e. the magma reacted with the rocks of the roof; in this case the magma was oxidized and the chemistry of the process was also different. The alkaline pegmatites genetically connected with the nepheline-syenite intrusion have the same gas phase as the latter, though in a smaller amount (14.25 cm^3/kg of rock).

Later albitization greatly affects the content and composition of the gas phase of the nepheline syenite. For instance, in albitized nepheline syenite the average gas content is 3.77 cm^3/kg of rock, that is one seventh of that in the non-albitized rock (Table 1). The change in the amount of methane in the natural gas mixture in the albitized rocks is particularly abrupt; the hydrogen and carbon monoxide contents are less than half as much.

The effect of the intrusion on the gas phase of the host rocks can be traced only in the zone of the marginal contacts. The limestones at a distance of 1-10 m from the contact contain a fair amount of gas (3.47 cm^3/kg). In comparison with the nepheline syenite this limestone contains more H_2, CO and CO_2 and much less methane (0.35 cm^3/kg) and is free of C_3 - C_2 hydrocarbons. In the limestones 300-400 m from the contact the gas content is considerably lower (0.69 cm^3), the H_2 amount is insignigicant and much less than CO (from 0.06 to 0.13 cm^3), and the amounts of CH_4 (0.25 cm^3) and CO_2 (0.16 cm^3) have also decreased.

<u>The Kiya-Shaltyr massif</u> is situated in the northeastern part of the Kuznets-Alatau, which forms a part of the Altar-Sayan folded province. The massif occurs in Lower Cambrian effusive-sedimentary series and was apparently formed in three phases: first an intrusion of gabbro, then a horse-shoe-like body of urtite, and finally nepheline syenite veins. Urtite was intruded at the contact between the gabbro and the limestone; its absolute age according to the K/Ar method is 371 ± 17 m.y.

The contact action of urtite on the gabbro has resulted in the formation of a contact-reaction zone of nephelinized gabbro and ijolite, averaging 30-40 m thick. The limestone in the narrow contact zone with urtite contains scapolite and other metamorphic minerals. During the postmagmatic stage the urtite was albitized and zeolitized. These processes are mainly developed in the marginal parts and in the apophyses of the intrusion; they are rarely observed in fracture zones.

Figure B presents a schematic section of the urtite body, the points of sampling, and the hydrocarbon gas contents in the rocks (the diagram above the section). Table 2 presents the amount and constitution of the gases in the closed pores of the rocks and in the cavities of the minerals for the Kiya-Shaltyr alkaline massif as a whole.

The highest gas content (up to 105 cm^3/kg) is observed in the urtite. A predominant component of the natural gas mixture in this rock is methane (97.7%) the average content of which is 64.42 cm^3/kg (62.94 in table 2). Besides methane the mixture also contains its homologues - ethane and propane. The amounts of H_2 (0.69 cm^3/kg), CO (0.29 cm^3/kg) and CO_2

Table 1. The content (cm^3/kg of the rock) and composition (vol. %) of the gases in the rocks of the Middle-Tatar alkaline massif.

No. of the points (localities) presented on fig. A	No. of specimens	Rock Name	Average total gas content	Hydrocarbon gas content		Composition[1/]					
				min.	max.	H_2	CH_4	C_2H_6	C_3H_8	CO	CO_2
1	4	Nepheline syenites	22.12	7.57	33.08	$\frac{0.87}{1.72}$	$\frac{20.86}{94.38}$	$\frac{0.27}{1.22}$	$\frac{0.01}{0.04}$	$\frac{0.56}{2.50}$	$\frac{0.04}{0.15}$
2	7	Metasomatic rocks of ijolite composition	0.94	0.01	1.04	$\frac{0.35}{37.26}$	$\frac{0.36}{38.29}$	$\frac{0.01}{1.06}$	$\frac{0.00}{0.00}$	$\frac{0.13}{13.82}$	$\frac{0.09}{9.57}$
3	1	Alkaline pegmatite	14.25			$\frac{0.72}{5.04}$	$\frac{12.07}{84.70}$	$\frac{0.53}{3.71}$	$\frac{0.02}{0.28}$	$\frac{0.85}{5.96}$	$\frac{0.06}{0.42}$
4	3	Albitized nephiline syenites	3.77	0.60	4.42	$\frac{0.15}{3.98}$	$\frac{3.35}{88.85}$	$\frac{0.00}{0.00}$	$\frac{0.00}{0.00}$	$\frac{0.19}{5.04}$	$\frac{0.08}{2.13}$
5	3	The limestones 1-10 m from the intrusion	3.47	0.23	0.45	$\frac{1.04}{30.00}$	$\frac{0.35}{10.08}$	$\frac{0.00}{0.00}$	$\frac{0.00}{0.00}$	$\frac{1.84}{53.02}$	$\frac{0.24}{6.90}$
6	2	The limestones 300-400 m from the intrusion	0.69	0.14	0.42	$\frac{0.09}{13.05}$	$\frac{0.24}{37.68}$	$\frac{0.01}{1.45}$	$\frac{0.00}{0.00}$	$\frac{0.17}{24.63}$	$\frac{0.16}{23.19}$

[1/] In this table, as well as in Table 2, the numerator presents the average content of the gas and the denominator presents the amount of the gas related to the total amount of gases, 100%.

Table 2. The gas content (cm^3/kg) and composition (vol. %) in the rocks of the Kiya-Shaltyr alkaline massif.

No. of the localities presented on fig. B.	No. of speci-mens	Rock name	Average total gas content	Hydrocarbon gas content		Composition 1/					
				min.	max.	H_2	CH_4	C_2H_6	C_3H_8	CO	CO_2
1	6	Urtite	64.42	35.42	103.31	$\frac{0.69}{1.07}$	$\frac{62.94}{97.70}$	$\frac{0.40}{0.63}$	$\frac{0.01}{0.01}$	$\frac{0.29}{0.45}$	$\frac{0.08}{0.14}$
2	3	Albitized and zeolitized urtites	1.54	0.31	0.67	$\frac{0.64}{41.55}$	$\frac{0.54}{35.07}$	$\frac{0.00}{0.00}$	$\frac{0.00}{0.00}$	$\frac{0.15}{9.74}$	$\frac{0.21}{13.64}$
3	2	Metamorphosed limestone with scapolite	6.03	4.45	4.86	$\frac{0.86}{14.40}$	$\frac{4.61}{76.55}$	$\frac{0.04}{0.66}$	$\frac{0.00}{0.00}$	$\frac{0.29}{4.83}$	$\frac{0.23}{3.66}$
4	4	Olivine-titanaugite gabbro	7.51	2.32	10.35	$\frac{1.16}{15.45}$	$\frac{6.02}{80.16}$	$\frac{0.01}{0.13}$	$\frac{0.00}{0.00}$	$\frac{0.22}{2.92}$	$\frac{0.10}{1.34}$
	2	Nepheline syenite from veins	3.16	1.55	3.00	$\frac{0.52}{16.67}$	$\frac{2.26}{71.42}$	$\frac{0.01}{0.31}$	$\frac{0.00}{0.00}$	$\frac{0.24}{7.49}$	$\frac{0.13}{4.11}$

1/ See note on Table 1.

(0.08 cm^3/kg) are insignificant. Thus, the gas phase of the urtite consists almost entirely of hydrocarbon gases (98.34%).

Albitization and zeolitization of the urtite led to the loss of the gas phase. Thus the average gas content of the rock has decreased to 1.54 cm^3, the CH_4 content has decreased 12 times (0.54 cm^3). The amounts of H_2 and CO are also lower, but the amount of CO_2 has increased up to 0.21 cm^3/kg.

In the olivine-titanaugite gabbro the average gas content is 7.5 cm^3/kg, and there is rather much methane (6.02 cm^3), but the C_2 - C_3 gases are practically absent. The H_2 content in the gabbro (1.16 cm^3) is higher than that of the urtite, and the amounts of CO and CO_2 are insignificant. The metamorphosed limestones with scapolite are distinguished by a relatively high content of CO_2 (0.23 cm^3), comparatively low contents of methane (4.61 cm^3) and H_2 (0.86 cm^3) and by an insignificant amount of ethane (0.04 cm^3/kg).

The Goryachegorsk alkaline massif is situated in the Southern part of the Krasnoyarsk region within the Chulymo-Yenisei basin. The nepheline-bearing rocks form a large stock-like rounded body composed mainly of equigranular theralite-syenite. Porphyritic varieties are found only in the northeastern part of the massif. The equigranular rocks are composed mainly of nepheline, plagioclase, and augite which in places grades into titanaugite or aegirine-augite. The secondary minerals cancrinite, hydromicas, zeolites, calcite, etc. are characteristic. The porphyritic rocks are characterised by a high nepheline content (70-80%), soda-orthoclase instead of plagioclase, and by the predominance of olivine among the mafic minerals. According to I. V. Luchitskii (8) the nepheline crystals are in many places altered and in some cases are wholly replaced by cancrinite, hydromicas and zeolites.

The authors have studied the gas phases in five rock specimens from the Goryachegorsk massif (from A. S. Sakharov's collection) with the following results:

Table 3. The average gas composition (cm^3/kg rock).

Rock names	H_2	CH_4	C_2H_6	C_3H_8	CO	CO_2
Theralite	2.28	0.016	0.00	0.00	2.02	0.04
Pink nepheline syenite	2.40	0.26	0.00	0.00	1.22	0.07
Nepheline syenite-porphyry	0.61	0.03	0.00	0.00	0.44	0.11
Nepheline syenite	5.97	0.00	0.00	0.00	2.93	0.12
Feldspatic urtite (plagiojuvite?)	3.04	0.00	0.00	0.00	1.52	0.07

The composition of the gas phase of the rocks of the Goyrachegorsk massif differs widely from that of the alkaline rocks of the Middle-Tatarka and Kiya-Shaltyr massifs. The former rocks contain considerably less gases (1.19-8.02 cm^3/kg) and are almost free of hydrocarbon gases. Only in one of five samples was methane found (0.26 cm^3), while the rest are either free of methane or contain it in a very small amount. The C_2 - C_3 hydrocarbons were not found in any of these five specimens.

A dispersed bituminous substance ("A") has been extracted from the rocks of the Middle-Tatarka and Kiya-Shaltyr alkaline massif. It is a dense greasy mass of a light brown to dark brown color and with a pleasant odor. It is free of humic acids and contains little sulphur. The composition of a chloroform extract of bitumen ("A") varies from 0.0017 to 0.0085 weight % of the rock.

Table 4. The average composition of the chloroform extract from the bitumen "A" and of the dispersed carbon (C disp.) in the rocks of the Middle-Tatarka and Kiya-Shaltyr alkaline massifs (in weight %)

No. of samples	Rock Names	Bitumen content, % of rock	C disp.	Elementary composition of bitumen, "A", % C	H	N+O+S	C/H
	The Middle-Tatarka massif						
4	Nepheline syenite	0.0041	0.065	75.23	11.74	13.03	6.4
5	Metasomatic rocks of ijolitic composition	0.0043	0.071	60.65	8.81	30.54	6.9
1	Nepheline syenite at contact with ijolite	0.0032	0.118	63.66	8.95	27.39	7.1
4	Pegmatites	0.0043	0.054	62.84	8.76	28.40	7.2
3	Albitized nepheline syenite	0.0026	0.054	54.05	7.94	38.01	6.8
2	Limestones 1-10 m from the contact	0.0050	0.560	69.85	10.45	19.70	6.6
2	Limestones 300-400 m from the intrusion	0.0052	0.890	61.39	8.67	29.94	7.0
	The Kiya-Shaltyr massif						
7	Urtite	0.0046	0.120	73.00	10.54	16.45	6.9
3	Albitized and zeolitized urtite	0.0051	0.090	63.44	8.64	27.29	7.3
2	Limestone with scapolite	0.0033	0.167	-	-	-	-
3	Gabbro	0.0035	0.030	67.95	10.44	21.61	6.5

The bituminous substance from the nepheline syenites of the Middle-Tatarka massif contains considerable amounts of carbon (up to 80.50%) and hydrogen (up to 13.77%). The bitumen from the metasomatic ijolitic rocks is more acidic and contains much less carbon (up to 65.95%) and hydrogen (up to 9.46%); sulphur, oxygen and nitrogen make up 40.73%. The bitumen of the albitized nepheline syenite contains the lowest amount of carbon and hydrogen. It is of interest to note that the bituminous substance of the limestones at the contact with the intrusive body, which were affected by the alkaline melt, is of a more reducing nature and contains up to 75.04% of carbon and up to 11.59% of hydrogen. In the limestone specimens taken at a distance of 300-400 m from the intrusion the maximum carbon content in the bitumen does not exceed 63.67%, and hydrogen - 8.95%. The average content of the dispersed carbon (C disp.), the bitumen and the elementary composition of the organic matter of the rocks of the Middle-Tatarka are presented in Table 4.

Among the rocks of the Kiya-Shaltyr massif the highest amounts of carbon and hydrogen in bitumens are found in urtite (up to 76.90% and 13.05%) and in gabbro (up to 72.23% and 11.19% respectively). The albitized urtite is characterized by low contents of carbon (up to 65.81%) and hydrogen (up to 8.83%).

The examination of the organic substances from the rocks of the Middle Tatarka and Kiya-Shaltyr massifs revealed that the highest C and H contents in bitumens is characteristic of the unaltered intrusive rocks - nepheline syenite, urtite, and gabbro - in the closed pores of which there is a considerable quantity of hydrocarbon gases. The bitumens from the metasomatic, especially the albitized rocks, are more acidic and contain considerably less C and H.

It should be remembered that in these alkaline massifs of Siberia the main component of the gas phase of the unaltered (or slightly altered) rocks is methane, which makes up 80-90% of the natural gas mixture. The methane homologous (ethane and propane) are also present. The amount of other components of the gas phase (exclusive of the inert gases) is limited to 1.5 - 4%. The unaltered intrusive rocks differ from the alkaline metasomatic rocks and from the rocks enclosing the massif by the amount of gas. For example, in nepheline syenite (the Middle-Tatarka massif) and urtite (the Kiya-Shaltyr massif) the gas content is 7-20 times higher than in the other rocks of these massifs.

Table 5. The average content of gases, cm^3/kg.

Names of rock and massif	H_2	CH_4	C_2H_6	C_3H_8	CO	CO_2
Nepheline syenite of the Middle-Tatarka massif	0.38	20.86	0.27	0.01	0.56	0.04
Foyaite from the upper part of the differentiated complex of the Lovozero massif	1.50	22.02	1.01	0.84	0.17	0.04
Foyaite from the lower part of the differentiated complex of the Lovozero massif	1.32	32.66	0.88	0.35	1.01	0.04

It is of interest to compare the gas composition of the alkaline rocks of the Siberian massifs with that of previously studied alkaline intrusions of the Kola peninsula. As mentioned above, the chemical composition of the nepheline syenites of the Tatarka is close to that of the Lovozero foyaite, which is also substantiated by a comparison of the compositions of the natural gases presented below. A certain similarity between the gas compounds of the Kiya-Shaltyr urtite and the Khibina urtite can be observed. The highest content of the hydrocarbon gases in the Kiya-Shaltyr urtite reaches 103.31 cm^3, and in the Khibina urtite - 139.99 cm^3.

Table 6. The average content of gases, cm^3/kg.

Names of rock and massif	H_2	CH_4	C_2H_6	C_3H_8	CO	CO_2
Urtite from the Kiya-Shaltyr massif	0.69	62.94	0.40	0.01	0.29	0.08
Urtite from the Khibina massif (Kuel'por Mounain)	0.75	72.88	1.04	0.03	0.95	0.008
Urtite from the Khibina massif (N'orpakhk Mountain)	0.71	46.58	0.60	0.05	0.86	0.04

Thus, the nepheline syenite of Tatarka and the urtite of Kiya-Shaltyr are close to the foyaite and urtite of the Lovozero and Khibina massifs on the Kola peninsula by the character of the gas components: the predominance of methane and the presence of a small amount of ethane and propane. The difference is only in a somewhat lower content of the hydrocarbons C_2 - C_3.

With respect to composition of the gas phase, the rocks of the Goryachegorsk massif and the metasomatic alkaline rocks of Middle-Tatarka are close to the alkaline rocks of the ultrabasic-alkaline massifs of the Kola peninsula: Afrikanda, Kovdor and Gremyakha-Vyrmes. These rocks from Siberia and Kola contain an insignificant amount of methane and are practically free of the C_2 - C_3 hydrocarbons. Therefore the intrusive and presumably metasomatic alkaline rocks can be clearly distinguished by their gas components.

The metamorphosed carbonate host rocks of the Middle-Tatarka massif contain small volumes of gases (0.69 cm^3/kg): up to 0.1 cm^3/kg of hydrocarbons and up to 0.01 cm^3/kg of hydrogen and are free of the C_2 - C_3 hydrocarbon gases. The limestones and dolomites of the Imandra-Varzuga suite, which encloses the Khibina massif, are characterised by a small content of methane (0.05 - 0.85 cm^3) and hydrogen (0.09 - 0.45 cm^3).

Table 7. The average content of gases, cm^3/kg.

(Name of rock and massif)	H_2	CH_4	C_2H_6	C_3H_8	CO	CO_2
The metasomatic ijolitic rocks of the Middle-Tatarka massif	0.35	0.36	0.01	0.00	0.13	0.09
The nepheline syenite-porphyry of the Goryachegorsk massif	0.61	0.03	0.00	0.00	0.44	0.11
The alkaline rocks of the Bol'shoi Kovdor massif	0.61	0.07	0.00	0.00	-	0.02
The alkaline rocks of the Malyi Kovdor massif	0.33	0.14	0.00	0.00	-	0.01
The alkaline rocks of the Afrikanda massif	2.93	0.33	0.00	0.00	-	0.00
The nepheline syenite of the Gremyakha-Vyrmes massif	1.47	0.34	0.00	0.00	-	0.00

The total gas volume in limestones around each of these two massifs does not exceed 1.0 cm^3/kg (exclusive of the inert gases). Therefore the metamorphosed limestones enclosing the Middle-Tatarka and Khibina massifs are characterised by similar gas contents.

The characteristic feature of the intrusive alkaline rocks of Siberia and Kola is the presence of hydrocarbon gases and bituminous substances. However, the amount of carbon in these rocks is low, which is shown on the Table 8 below:

Table 8

Name of massif and rock	Content, weight %			
	gas	bitumen	Dispersed carbon	total
The Middle-Tatarka nepheline syenite	0.0015	0.0038	0.065	0.070
The Lovozero foyaite	0.0017	0.0016	0.060	0.063
The Kiya-Shaltyr urtite	0.0034	0.0033	0.120	0.127
The Khibina Urtite	0.0040	0.0017	0.070	0.076

When calculating the content of carbon in a gas only the carbon of the gases captured in the closed pores of the rocks and in the cavities of the minerals was taken into account. The carbon of gases of the free phase was not included. Regardless of the small percentage of carbon in the alkaline igneous rocks its total content in the large massifs is fairly great. Thus if the thickness of the Khibina massif is taken to be a depth of seven kilometers, the carbon mass in the massif will be $1.52 \cdot 10^{10}$ tons.

The study of the gas phase and dispersed bitumens in the alkaline rocks in certain Siberian massifs, and comparison of the results with those previously obtained for the alkaline massifs of the Kola peninsula make it possible to form an idea about the regularity of the character of the organic substances in these intrusive formations of the two largest alkaline provinces, which are of different ages.

At present there are two hypotheses to explain the presence of organic substances in igneous rocks. N.A. Eremenko and N.B. Vassoevich, M.F. Dvali (3;1959), and E.M. Lyutkevich (9;1960) consider that the metamorphosed sedimentary host rocks are the source of the organic substances in the alkaline rocks. This idea has been disproved by one of the authors of the present article on the basis of the results of a study of the alkaline massifs of Kola. The present results of the examination of organic substances from the alkaline massifs of Siberia provide additional evidence against this hypothesis.

The host-rocks of the Middle-Tatarka and Kiya-Shaltyr massifs are limestones. In order to be able to enrich the alkaline melt with organic substances these limestones ought to contain these substances in sufficient amounts. The organic substances should have been accumulated mainly in the apical and marginal parts of an intrusion.

The study of the limestones enclosing the Middle-Tatarka massif showed that these rocks are practically free of hydrocarbon gases and the amount of bituminous substances is only 0.005%. The bitumens extracted from the limestones are more acid than the bitumens from the nepheline syenite and contain less carbon and hydrogen. To remind, the gas phase of the limestones 300-400 m from the massif (table 1) contains a very small amount of hydrogen (0.09 cm^3/kg) and carbon monoxide (0.17 cm^3), and an insignificant amount of methane (0.25 cm^3), but relatively large amounts of carbon dioxide (0.16 cm^3). The average total gas content in the limestones is 0.69 cm^3/kg.

The limestones from the contact zone are recrystallized and have been heated by the alkaline solutions. The content of H_2 ([illegible].64 cm^3) and CO (1.84 cm^3) has been abruptly increased in these rocks while the amount of methane (0.35 cm^3/kg) is extremely low. The total average content of the gases in the limestones at 1-10 m from the massif is 3.47 cm^3/kg. The amount of bituminous substances in the limestones of the outer contact zone of the massif and in the limestones situated far from the intrusion is the same, but the bitumen contains higher amounts of carbon and hydrogen and lower amount of organic carbon (sic.) It should be emphasized that in the outer contact zone the H_2, CO, and to a lesser extent the CO_2 contents have been increased, which is probably reflected in the composition of the bitumen.

In the apical part of the Middle-Tatarka massif there are places where the schists and limestones of the roof are fully assimilated, resulting in the formation of alkaline rocks of ijolitic composition. At the same time hydrocarbon gases and reduced bituminous substances were not observed in the closed pores of the rocks or in the cavities of the minerals. The highest content of hydrocarbon gases in these rocks does not exceed 1.04 cm^3/kg. The amount of bitumen in these rocks and in nepheline syenite far from the contact is the same, but in the former rocks the bitumen is considerably oxidised (C - 60.65%, H - 8.81%). Within the Middle-Tatarka massif the highest content of hydrocarbon gases (up to 33.1 cm^3) has been observed in the intrusive rocks proper (nepheline syenite) far from the contact with the sedimentary rocks and without traces of assimilation of the latter.

Thus, the contact zone of the Middle-Tatarka massif, where the alkaline solution activity was most effective on the host rocks, is practically free of hydrocarbon gases and the content of dispersed bitumen in this zone does not exceed the amount of that in the igneous rocks. The apical part of the massif, where the limestones and the schists of the roof were fully assimilated, does not contain any significant amount of the hydrocarbon gases, and the bituminous substances are oxidised there.

In the Kiya-Shaltyr massif high contents of hydrocarbon gases are observed also only in the intrusive alkaline rock (urtite). In the limestones of the outer contact zone the content of gases is lower than in urtite. Thus, the sedimentary rocks enclosing the alkaline massifs and the localities of their distinct assimilation are free of hydrocarbon gases. At the same time the amount of gas is highest in the igneous alkaline rocks where the interaction of the alkaline melt and the sedimentary rocks has not been observed. All this indicates that the gases in nepheline syenite do not come from the sedimentary rocks.

At the same time a question arises: could the organic substances exist as methane series hydrocarbons and high molecular weight bituminous compounds at the high temperature conditions of an alkaline melt? During thermal breakdown of paraffinic hydrocarbons, methane is the most stable, but according to experimental data it also breaks down to C and H at a temperature above 500°. The heavier C_2-C_3 hydrocarbons break down at lower temperatures.

For the determination of the temperature limit for bituminous substances extracted from the alkaline rocks, the bitumens were heated in a nitrogen atmosphere at a pressure of 1 atm (1). At 220-240° the bitumen boiled up and after evaporation of the easily boiling fraction it changed into a dense dark brown mass. At 600° the bitumen vaporized.

S.V. Ikorskii (5) heated the bitumen from a gas inclusion in eudialyte without opening the inclusion. Because the gas in this inclusion was under a high pressure this experiment can be likened to the processes in a natural autoclave. Here the pressure corresponded to that at which this alkaline rock crystallized. The examination of the bitumen was under the luminescence microscope. At about 350° the bitumen in the inclusion liquified and moved around; over 400° the bitumen began to decay and ceased to be luminescent.

The numerous experimental studies here and abroad show that at the temperature of beginning of crystallization of alkaline melts, organic substances occur as hydrocarbon gases. Bitumens, which are formed only at lower temperatures, could not exist. Therefore,if the organic compounds were adopted from the sedimentary rocks during assimilation in the high temperature alkaline melt they ought to have been broken down into carbon and hydrogen. The synthesis of hydrocarbon compounds was possible only at lower temperatures.

Most supporters of the hypothesis of a non-organic origin of oil admit the impossibility of formation of hydrocarbons in a magmatic melt at high temperatures. They suggest as most probable that the hydrocarbons were formed in the hydrothermal solutions. This was suggested by V.N. Florovskaya and V.G. Melkov (11), L.N. Kapchenko (6), A.N. Dubrovin (4), K.K. Volosovich (2) and others. According to L.N. Kapchenko: "as the magma cooled, the high temperature front moved towards the chamber, and hydrothermal processes and the processes of synthesis of the hydrocarbons took place in fractures of the upper part of the already crystallized magmatic massif." (6, p. 52). The temperature of crystallization of the hydrothermal minerals (from 50 to 500°), according to this group of scientists, coincided with the temperature of synthesis of the hydrocarbons.

The study of the hydrocarbon gases and bitumens from the rocks of the alkaline massifs of Kola and Siberia reveals that their formation is not connected with hydrothermal processes. The upper and outer contact parts of the massifs, where the hydrothermal solutions usually are concentrated, are free of hydrocarbon gases and the bituminous substances here have a more oxidized character than in the intrusive rocks. Moreover, the hydrothermal formations developed within the massifs do not contain hydrocarbon gases.

Hydrocarbon gases and reduced bitumens occur in the closed pores of all intrusive rocks of the examined alkaline massifs and in the inclusions of all magmatic high-temperature minerals. At the same time the hydrocarbon gases are found in a free phase within the system of primary fractures in the rocks of the massifs, except in the fractures formed after the complete consolidation of an intrusion. The total content of hydrocarbon gases in the volume of the rocks of the massifs is rather significant. But the intrusive alkaline rocks affected by secondary processes (including hydrothermal processes) have lost their hydrocarbon gases. As mentioned above, the hydrothermal vein formations within the intrusive alkaline rocks are free of hydrocarbon gases (10).

There is no doubt that the alkaline intrusive rocks and minerals contain a great amount of hydrocarbon gases and a bituminous substance of the petroleum family which could not, as such compounds, exist in the high-temperature magmatic melt itself. The optimum temperature range for the synthesis of hydrocarbons is 500-150°. It is natural to suggest that this process took a long (geological) time during the slow coolong of the intrusive body and the presence of natural catalysts. The entire mass of data accumulated during the studies of the alkaline massifs substantiates this point of view.

The synthesis of hydrocarbons from CO and H_2 or CO and H_2O is widely used in industry. The parameters and conditions of this process have been determined. The synthesis of hydrocarbons from C and H_2 or C and H_2O is also easy enough. Hydrogen and carbon monoxide and also carbon are very common in the magmatic rocks and could serve a source material for the synthesis of the hydrocarbons.

The duration of the process of natural catalysts is of a great importance. By studying the gases from the rock-forming minerals of the Khibina and Lovozero alkaline massifs it was revealed that nepheline contains a greater amount of the hydrocarbon gases than aegirine (10). A.N. Bashkirov and his co-authors (1) tested the catalytic effects during the synthesis of hydrocarbons from CO and H_2 in a matrix of natural silicate minerals. They found out that nepheline is a stronger catalyst than aegirine. During the synthesis at a pressure of 30 atm and a temperature of 450°, nepheline being a catalyst, the degree of transformation of CO was 90% and the yield of total hydrocarbons reached 50 g/m^3. When aegirine was used as a catalyst at the same conditions the degree of transformation of CO was only 26% and the total yield of hydrocarbons was 34 g/m^3.

The new data obtained during the study of the isotopic composition of carbon from the hydrocarbon gases and dispersed bitumens of the rocks of the Kola peninsula substantiates the hypothesis that the hydrocarbons were synthesized during the slow cooling of the alkaline massifs (7). The isotopic composition of carbon of the bitumens extracted from the alkaline rocks is close to that of petroleum carbon. The hydrocarbon gases of the alkaline rocks differ considerably in carbon isotopic composition from the gases of the oil and gas deposits.

The carbon of the latter deposits is heavier than that of the bitumen of the alkaline rocks. This might indicate that the hydrocarbon gases of the alkaline rocks were formed at higher temperatures than the biutmens, and that the carbon of the former is closer to primary carbon. In the bitumens, as in the lower temperature formations, the processes of the isotopic fractionation are more effective. This fact conforms to our idea that during the gradual cooling of an alkaline massif at first methane was formed, then its homologs at a lower temperature, and finally the high molecular weight bituminous substance were formed (10).

Conclusions

1. The study of the organic substances from the Middle Tatarka and Kiya-Shaltyr alkaline massifs of Siberia revealed a considerable content of hydrocarbon gases and reduced bituminous substances in the alkaline intrusive rocks. The amounts and compositions of the gases in these rocks are close to those of the chemically similar rocks of the Khibina and Lovozero alkaline massifs in the Kola peninsula.

2. The metasomatic nepheline-bearing ijolitic rocks from the near roof part of the Middle-Tatarka massif and the alkaline rocks of the

Goryachegorsk massif are almost free of hydrocarbon gases and contain a bituminous substance of an acidic nature. By the composition of the gases contained in these rocks they are similar to the alkaline formations of the Kovdor, Afrikanda and Gremyakha-Vyrmes massifs in the Kola peninsula.

3. The study of organic substances, along with the geologic and petrographic criteria, may substantially help to reveal the magmatic or metasomatic nature of the alkaline rocks.

4. The postmagmatic processes modifying the intrusive alkaline rocks also alter their gas-phase; this phenomenon can be used to find out the character and intensity of the superposed processes.

5. The regularity in behavior of the organic substances in the alkaline intrusive rocks of Siberia and the Kola peninsula and the experimental data make possible a suggestion that the hydrocarbon gases and bitumens in these rocks were formed as a result of the non-organic synthesis which took place during the gradual cooling of the intrusive bodies.

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Weskly mineralized alkaline hydrothermal solutions are typical of tin-ore deposits of the Far East (Myao-Chan, Lifudzin, Khrustalnoye, Primorskoye). Two solution groups, chloride-carbonate sodic potassic and chloride-sodic solutions have been singled out according to the chemical composition. In the studied solutions fluorine plays an important role its concentration varying from 0.2 to 1.5 g/l. It has been found that lithium concentration in the solutions is 0.002-0.009 g/l. (Authors' abstract).

The tin-ore deposits of the Komsomolsk region, belonging to cassiterite-silicate formations (1), occur in sandstone-shale strata of the Jurassic and effusive-sedimentary rocks of the Cretaceous.

The process of ore formation began with the formation of metasomatic quartz-tourmaline rock (Stage I). At the same time or somewhat earlier, metasomatic quartz-sericite rocks were developed, the appearance of which can be considered as alteration around the ore of the quartz-tourmaline stage. The temperature interval of this stage, according to the determinations of A.P. Kokokina and P.G. Korosteleva and our data, is 300-360°. Then (sometimes with crushing) begins the productive quartz-cassiterite stage (quartz for the ore-free zone). Together with quartz are deposited cassiterite, wolframite, arsenopyrite, and chalcopyrite. For this stage is not characteristic wall rock alteration. There is noted only slight silicification of the contact and fragments of early formed rock fallen into the zone, and also the recrystallization of tourmaline with the formation of a rim of acicular, usually green, tourmaline. The temperature interval of stage II lies in the range 270-350°; the maximum number of determinations are in the interval from 270 to 320°.

The appearance of the following stages -- quartz-sulfide, quartz-sulfide-carbonate, sericite-carbonate--is not always observed, and they are characteristic of the completely formed zone of mineralization with the development of tin mineralization.

In view of the difficulty of separating the quartz-sulfide and the quartz-sulfide-carbonate stages, very similar in time, conditions of deposition, and temperature, it seems permissable to unite them into a single stage III of mineralization. In stage III the deposition proceeds of chalcopyrite, pyrrhotite, pyrite, quartz, sphalerite, galena, fluorite, and carbonates. For this stage of ore formation, alteration around the veins is expressed by propylitization of the country rock, but the intensity of this phenomenon depends on the composition of the country rock. The mineral complex of stage IV--sericite-kaolin with chalcedony and stibnite, sometimes with cinnabar--occupies a very small place of the total volume of the zone, but the stage represents a substantially different state and is therefore considered as an independent one.

In the Myao-Chan region there is developed a normal temperature vertical zoning. The zoning is expressed in changes of types of ores and metasomatites of differing mineralogical composition. Thus, in the Pereval'nyii deposits, with gradual withdrawal from the intrusive (from south to north), wolframite-cassiterite-quartz ores (southern zone) change into cassiterite-arsenopyrite-quartz ores (Maisk zone), then to cassiterite-arsenopyrite-quartz ores with sphalerite and chalcopyrite (central zone) and further pass into sulfide-wolframite-cassiterite-quartz ores in the northern ore zone.

The zoning of metasomatic wall rocks is expressed in the change vertically from the bottom upward of quartz-tourmaline rocks to the lower-temperature complex--the propylites.

The thickness of the quartz-tourmaline rock from below is reduced up to complete disappearance in the rocks of the Amutsk strata of the Upper Cretaeous (for example, the surfaces of the upper zone of Snezhinka in the Levo-Khumulinsk field.) In layers of various, mainly intermediate effusives of this formation, constituting the Upper Mesozoic section of the region, there occurs intensive development of propylite around the ore. In these same effusive layers the appearance of regional early propylitization is independent of the ore. The formation of propylite around the ore apparently is aided by the combination of two factors: favorable composition of country rock (for example, intermediate effusive and intrusive rocks) and the deposition of essentially sulfidic ores. When only one of these factors appears, there is usually observed slight development of propylite, while in the zone of quartz-sericite rocks chloritization is developed in places.

Summarizing, one can represent schematically the sequence of development of mineralization in these deposits as given in Table 1.

Table 1 (p. 950)

No. of stage	Stage	Alteration of country rock	Temp. Range °C
I	Quartz-tourmaline*	Formation of quartz-sericite rock	300-360
II	Quartz-cassiterite	Silicification Propylitization	270-320
III	Sulfide-quartz-carbonate	"	100-260
IV	Sericite-kaolinite	---	50-100

*Provisionally separated.

Thereby it must be added that the separation of the quartz-tourmaline stage as the first stage of the process is somewhat provisional, because it is inseparably associated with the following quartz-cassiterite stage, but for discussion of the data obtained on the composition of gas-liquid inclusions it is convenient to consider it separately.

Study of the composition of inclusions in the minerals of the Myao-Chan tin-ore zone (2) showed that deposition of the minerals occurred from chloride-bicarbonate sodium-potassium solutions. With the transition to the later stages at lower temperatures in the solutions, the concentration of bicarbonate ion increased and that of chloride decreased. It has been established that the solutions were slightly mineralized, the average magnitude of mineralization being about 2.2%. So low a magnitude of the concentration of ions in solution did not permit at first by means of usual analysis to find a series of ions and to determine the changes of their concentrations in the process or ore formation. This referred especially to fluorine and calcium, and to some degree to other ions.

During continued work there was additionally specially selected and analyzed material such that it gave the possibility of more complete and exact characterization of the composition of the hydrothermal solutions of individual deposits. Most of the analyses were made for the deposits Solnech, Festival, and Pereval; data were also obtained for the poorer and barren mineralized zones. For comparison, material was analyzed of the sulfide-cassiterite deposits of the Maritime Region -- Khrustal, Lifudzin, Primorsk, Silin.

The most useful mineral for analysis of the composition of inclusions is quartz, which is deposited in the course of all the processes of ore formation. But only in the quartz-cassiterite stage does it form coarsely-crystalline and compact masses suitable for selection of material . In Stage I, poorly crystalline quartz is closely associated with sericite and tourmaline; in stage III with sulfides. Therefore most of our determinations refer to stage II, the quartz-cassiterite stage.

Of the early pre-ore samples, we were able to separate quartz of the Chalbin granite (no. 554), quartz from quartz-feldspar separates in the Chalby granite and in the granite-porphyry of the Kholdamin area (nos. 313 and 36), quartz from essentially quartzitic areas of the quartz-tourmaline rocks (no. 1107, stage I, Krasivaya zone), drusy pre-ore quartz with mica (no. 57) from the Primorsk deposit.

For stage III samples nos. 47, 401, and 1387 were analyzed, of sugary quartz of the Yagodnaya zone and no. 342 of the main zone from the Solnech deposit (quarry).

The remaining determinations refer to stage II for various ore zones and deposits. Samples nos. 12, 469, 100, V, 30, 65, 202, 66, 228, 262, and 229 are from the main zone, central area, Solnech deposit. Samples 71 and 200--southern zone, Solnech. Samples no. 1541, 625,186, 177, and 145--northern zone, Pereval. Samples nos. 97, 105, 106, 107, 351, 385, 397, 413, 417, 431, 458, and 1388--Yagodnaya zone, Festival. Samples nos. 1107 and 1408--Krasivaya zone, Festival. Samples nos. 573 and 574--Preryvistyi area, Festival. Samples nos. 91 and 92--Ozernoe. Samples nos. 77 and 925--Levosilin zone. Samples nos. 595 and 600--Avral'naya zone. Sample no. 529--Zverinaya zone. Sample no. 264--Lifudzin. Sample no. 47--Primorsk. Samples nos. 8129, 8041, and A--Khrustal. Sample no. 8207--Silin.

Inclusions in quartz and in cassiterite were analyzed from samples 65, 197, 204, and 469, but only in quartz from the remaining samples.

Reliability of determinations was attained by two methods: (1) the large number of analyses, (2) high analytical accuracy of determinations by concentrating the aqueous extracts.

More than 50 complete analyses of the composition of aqueous extracts of inclusions were made. We were successful in determining accurately for concentrated solutions the concentrations of calcium, fluorine, and lithium. Regrettably, magnesium was not determined. As already noted (3), the character of the curves of temperature of decrepitation shows the ratio of primary and secondary inclusions. Plotting decrepitation curves for our samples shows that the percentage of secondary inclusions, formed at a later time, is small, not exceeding 10%. Some of these curves are given in Fig. 1.

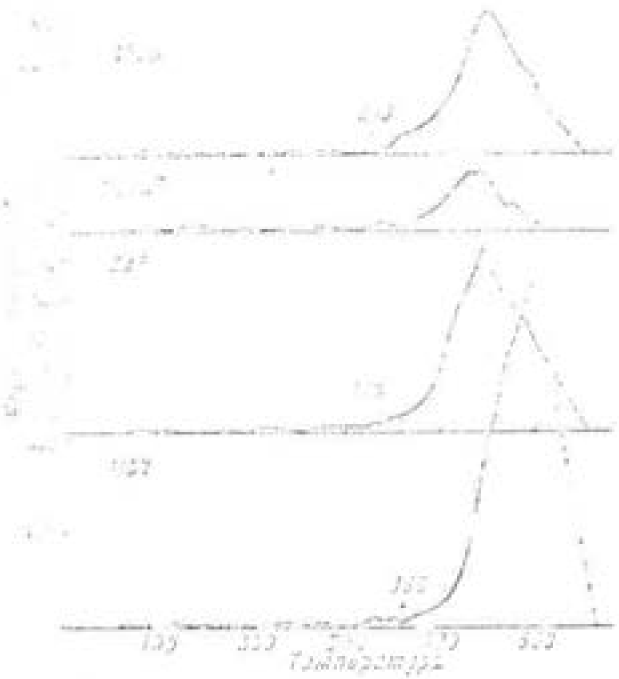

Fig. 1 (p. 951). Decrepitation curves of some samples from the Kyuo-Chan tin-bearing zone. No. of impulses (ordinate) vs. temperature (abcissa).

In Table 2 are given the results of the analyses of the combined samples by separate horizons of the ore zone, selected by drifts. The remaining data are plotted on the triangular diagrams of composition Na-K-Ca and Cl-HCO_3-F (Fig. 2), and the ratios of the components are shown in Tables 3-5. For the greatest clarity in considering the data further, we shall work with the ratios of the ions, which practically do not depend on the concentration of the solution and closely express the changes of the ratios of the ions in the solution in the process of ore formation.

Table 2 (p. 952). Composition of solution from analysis of inclusions

No. of sample	Brief characteristics	H_2O wt.%	Na		K		Ca		Li	
			g-equiv/1	g/1.	g-equiv/1.	g/1.	g-equiv/1	g/1.	g-equiv/1.	g/1.
554	Quartz from granite, Chalb area	0.30	1.19	27.37	0.33	12.87	0.49	9.8	not detd.	--
1107	Quartz, stage I, from quartz-tourmaline rock, Krasivaya zone, Festival	0.22	0.46	10.64	0.08	3.22	0.11	2.10	" "	--
1388	Quartz, stage II, Yagodnaya zone, cuts 3-5, 7-9-11-15-17, Festival	0.47	0.73	16.59	0.05	2.15	0.03	0.64	0.003	0.04
1387	Quartz, stage III, Yagodnaya zone, cut 1-3, Festival	0.54	0.52	12.05	0.05	1.9	0.06	1.0	not detd.	--
458	Quartz, stage II. Yagodnaya zone, cut 35, Festival	0.28	0.33	7.41	0.04	1.74	0.07	1.31	0.02	0.13
1541	Quartz, stage II, North zone, Pereval	0.15	1.34	30.50	0.28	11.43	0.20	3.74	0.061	0.04
472	Quartz, stage III, Main zone, cut 15, Solnech	0.23	0.29	6.71	0.03	1.14	0.13	2.52	not detd.	--

Table 2 (cont'd)

Cl		HCO_3^-		F		Total cations g-eq/1	Total anions g-eq/1	Atomic ratios				Total g/1
g-equiv/1.	g/1.	g-equiv/1	g/1.	g-equiv/1	g/1.			Na/K	Na/Ca	Cl/F	Cl/HCO_3	
2.10	74.55	tr.	--	0.10	1.84	2.01	2.20	3.60	2.43	21.0	--	126.43
0.61	21.98	0.01	0.68	0.11	2.18	0.65	0.73	5.75	4.18	5.55	61.0	40.80
0.78	27.72	0.03	1.95	0.01	0.32	0.81	0.82	14.60	24.33	78.0	26.0	49.38
0.58	20.78	0.08	0.45	0.05	0.79	0.73	0.71	10.4	8.66	7.25	1.16	36.97
0.44	9.87	tr.	--	0.13	0.26	0.46	0.57	8.25	4.74	3.38	--	20.72
1.75	61.93	0.81	3.66	0.12	2.56	1.90	2.68	4.78	6.70	14.58	21.6	86.41
0.34	12.33	0.11	6.13	not det.	--	0.45	0.45	9.67	2.23	--	3.09	28.83

Results and their discussion

Comparison of the analyses of the water-soluble part of the inclusions (Fig. 2) shows that of the three principal cations of the solution -- Na, K, and Ca --, Na is the main one. Maximum predominance of Na over K is observed for horizon 2 adit of the Yagodnaya zone (Festival deposit), for the Levosilin zone, and the zone of the Avral'nyi spring, where this ratio increases to 10. The minimum magnitude of Na/K found is 1-2.

Potassium is not always second in concentration of the cations. For the solutions from inclusions in quartz of granite and quartz-feldspar deposits, calcium is more characteristic. In some ore zones, for example the Ozernyi (Lake) zone, the concentration of Ca is also high and equal to that of K. The ratio Na/Ca varies in approximately the same limits as Na/K, from 2 to 10.

Among the anions in the hydrothermal solutions of Myao-Chan, chloride predominates. For the mineralized zones of the Festival and Pereval deposits, chloride predominates significantly over bicarbonate ion.

In some samples bicarbonate ion is not found or is present in traces. The same picture is characteristic for inclusions in the quartz of granite and of quartz-feldspar deposits. On the diagram of anionic composition, the compositions of the points are grouped in the chloride zone. On the other hand, in samples from Solnech, Lunn, and Tikhii, the concentrations of bicarbonate ion in the solutions is considerable; sometimes a predominance of HCO_3^{-1} over Cl is observed. The ratio Cl/HCO_3 varies in the ranges 0.2-4, averaging 2.2. For many samples, characterized by high concentration of bicarbonate ion, a diminished role of sodium is observed -- the ratios Na/K and Na/Ca diminish to 2-3. It is interesting to compare the data on this group of ore zones with those for tin-ore deposits of the Kavalerov region, Maritime Province (Far East) (Lifudzin, Khrustal, Silinskii). For these deposits a constant predominance of bicarbonate ion in the mineral-forming solutions is characteristic. Chloride is found in traces or not at all. The ratios Na/K and Na/Ca in these solutions are low -- from 0.5 to 3; solutions predominate in which the concentrations of Na and K are similar.

A very important ion of hydrothermal solutions is fluoride, able to form stable complex compounds with many metal ions. For sulfide-cassiterite deposits, fluoride is not as characteristic as it is for quartz-cassiterite ones, where a whole series of minerals enriched in fluoride is present. In the Myao-Chan deposits, fluoride minerals occur very rarely and in small amounts (fluorite in the Yagodnyi and Vodorazdel'nyi zones).

At the same time, determinations of the composition of inclusions (Tables 3,4) showed that the concentrations of fluoride in hydrothermal solutions of sulfide-cassiterite deposits are considerable, in the range 0.1-1.5 g/l. The maximum magnitudes (3.43 and 1.90 g/l.) were found in the Yagodnyi zone in a sample from drill hole 110 and in sample 397 on the horizon of adit 2. A high content of F was noted in sample no. 1107 -- the quartz, quartz-tourmaline stage of the Krasiva zone. In samples of early pre-ore material (samples

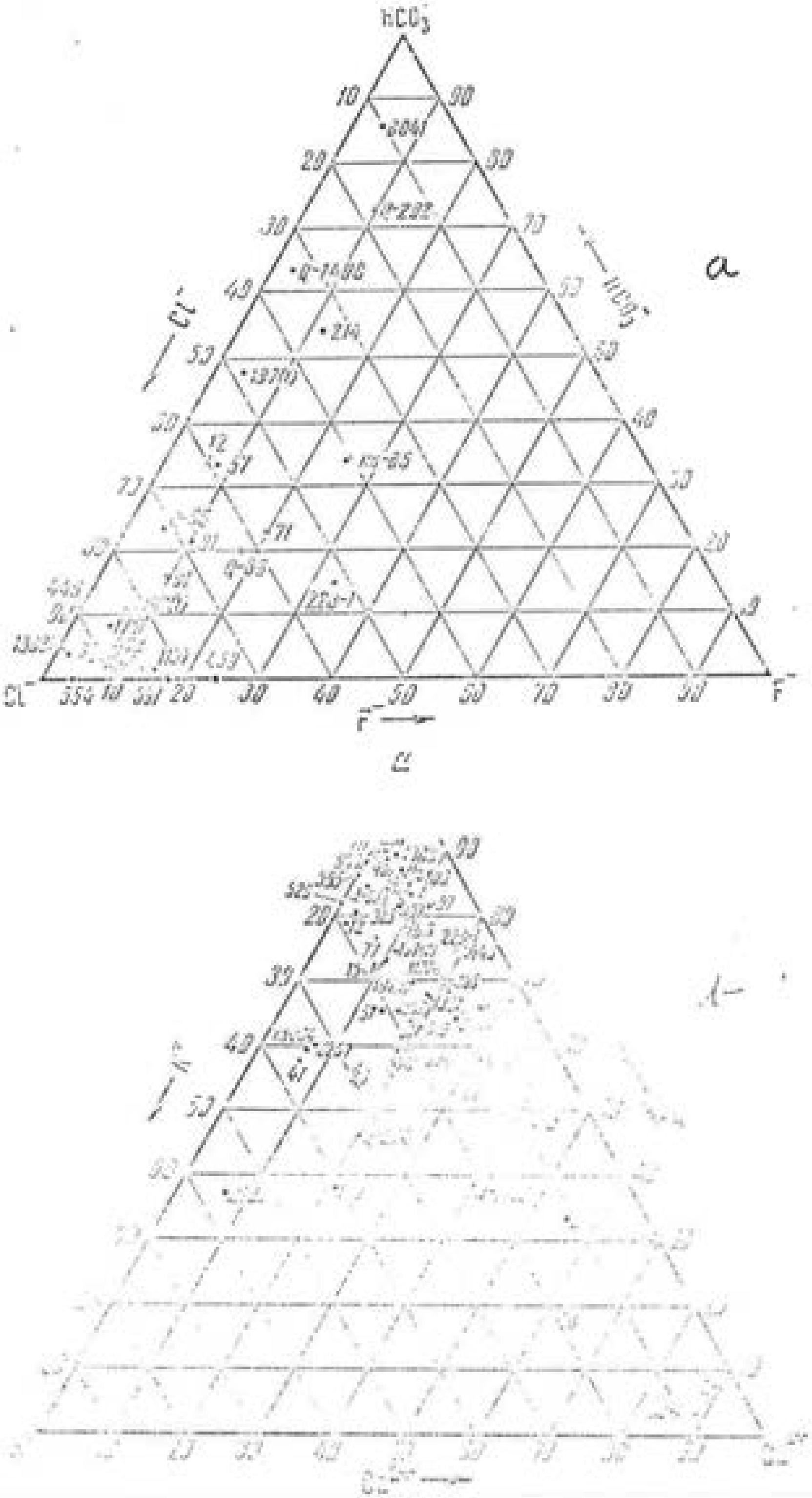

Fig. 2 (p. 953). Diagrams of the ratio of anions (a) and cations (b) in the composition of aqueous extracts from minerals of tin-bearing deposits of the Far East.

Table 3 (p. 955). Composition of mineral-forming solutions of tin-ore deposits*

Deposit, ore zone	Type of mineralization	Country rock	No. of anal.	Relation of		Na/K		Na/Ca		Cl^-/HCO_3^-		Cl^-/F^-	
				Cations	Anions	Range	Av.	Range	Av.	Range	Av.	Range	Av.
Quartz from granite, Chalba area	Barren	--	1	Na>Ca>K	Cl≫ F>HCO_3	3.5	--	2.2	--	**	--	21.7	
Quartz from quartz-feldspar deposits, Khaldeni	"	Granitic	2	Na>Ca>K	Cl≫ F>HCO_3	4-5.5	4.7	1.5-3	2.2	5-30	17.5	15.4	15.4
Solnech, main zone, central area	Very rich	Sandstone-shale and granitic	14	Na>K>Ca	Cl>HCO_3>F	1-10	5.3	0.3-23	5.9	0.2-4	2.2	1.6-12.7	5.1
Solnech, main zone, southern area	Poor	Sandstone-shale strata	2	Na>Ca>K	Cl≫ F>HCO_3	3-5	4	1.2	--	36.6	--	13.6	--
Lunnaya zone	Rich	"	1	Na>K≫ Ca	HCO_3>Cl>F	12		15	--	0.6	--	3.0	--
Pridorozhnaya zone	"	Granitic	2	Na>Ca≈K	HCO_3≫ Cl	5	5	4.5-6.5	5.5	0.8-1	0.9	11.4	--
Festival, Yagodnyi zone	"	Sandstone-shale and effusive-sedimentary rocks	14	Na>K>Ca	Cl>F>HCO_3	6.5-16	10.4	3-40	16.1	5	***	4-46	--

Table 3 (p. 955). Composition of mineral-forming solutions of tin-ore deposits--Continued.

						Na/K		Na/Ca		Cl/HCO3		Cl/F	
Festival, Krasivaya zone	Average	Sandstone-shale	1	Ca>Na>K	$HCO_3 > Cl > F$	1.5	--	0.8	--	0.5	--	9.67	--
Festival, Preryvisty zone		Effusive sedimentary rocks	2	Na>Ca=K	$Cl \gg F = HCO_3$	2.5-4	3.2	3	3	20	--	16	--
Pereval'nyi, north zone	Rich	Intermediate, basic effusives	5	Na>K=Ca	$Cl \gg HCO_3 = F$	5-8	6.3	4.5-7	6.2	7-100	--	11.6-15.6	13.6
Ozernaya zone	Average	Ditto	2	Na>Ca=K	$Cl \gg HCO_3 > F$	3-4	3.5	1.8-4	2.9	0.25-3	--	8.0	--
Tikhii area, Levosilinsk zone	Lean	Sandstone-shale	2	Na>K>Ca	$Cl > HCO_3$	5-8	--	10-15	12.5	1.1-2	1.5	--	--
Tikhii area, Avralnaya zone	Barren	Ditto	2	Na>K>Ca	$Cl > HCO_3$	7-8	7.5	--	--	4	--	--	--
Zone of Everin spring	"	"	1	Na>K>Ca	$Cl > HCO_3$	5	--	--	--	6.5	--	--	--
Khrustal Lifudzin Silinsk Maritime	Very rich	"	7	Na>K>Ca	$HCO_3 \gg F \approx HCO_3$	0.5-3	1.2	0.6-8.0	4.0	--	--	2.0-7.5	--

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* In all the columns besides the first two, data for the quartz-cassiterite stage are considered.

** Analyses in which the ion was either not determined, or not found, are not calculated. The average magnitudes are for the most reliable cases.

*** Of 14 analyses, HCO_3^- was not found in six.

Table 4 (p. 956). Content of fluoride in ore-forming solutions*

No. of sample	Place collected and mineral analyzed	Conc. of F		Cl/F
		mg-equiv/100g	g/l.	
	Solnech deposit			
66	Quartz, main zone	0.008	0.25	3.1
202	" " "	0.008	0.25	7.3
469	" " "	0.018	0.56	3.1
12	" " "	0.016	0.50	5.6
204	" " "	0.008	0.25	---
376	" " "	0.015	0.47	---
65	" " "	0.020	0.62	12.7
65	Cassiterite, main zone	0.019	0.60	1.7
228	Quartz " "	0.021	0.66	8.2
228	Cassiterite " "	0.035	1.10	1.6
31	Quartz, south zone	0.027	0.86	13.6
	Festival deposit			
385-A	Quartz, Yagodnaya zone	0.012	0.37	--
385-B	" " "	0.015	0.47	---
458	" " "	0.004	0.12	30.0
487	" " "	0.110	3.43	---
397	" " "	0.062	1.90	4.5
1387	" " "	0.024	0.75	13.0
1388	" " "	0.008	0.25	46.2
1107	" , Krasivaya zone	0.051	1.59	5.4
1408	" " "	0.006	0.19	9.7

Table 4 (p. 956). Content of fluoride in ore-forming solutions--Continued.

666	Quartz, Luchistaya zone	0.009	0.28	--
667	" " "	0.008	0.25	--
573	" , Proryvistaya "	0.019	0.60	16.0
	Parovalnyi deposit			
177	Quartz, north zone	0.017	0.53	15.6
625	" " "	0.020	0.62	11.6
	Priborezhnyi deposit			
197	Quartz	0.009	0.28	11.4
197	Cassiterite	0.029	0.86	--
214	[illegible] deposit	0.014	0.44	3.0
8041	Khrustal "	0.025	0.78	2.0
57	[illegible] "	0.022	0.69	7.5
554	Quartz, from Chalbinsk granite	0.029	1.72	21.7
36	" , Kholdominsk granite	0.022	1.32	15.4

*See footnote on Table 5

nos. 554 and 36), the concentrations of fluorine are also high (1.7 and 1.32 g/1.).

Lower levels. F:0.5-0.8 g/1., are characteristic of the Maritime quartz-cassiterite ores. Analysis of the ratio Cl/F shows that with a considerable scatter of the data, they can be separated into groups of samples with low magnitudes. They are characteristic of samples from areas very rich in (early) cassiterite (Main, Solnech, and Lunnaya zones). The composition of the inclusions in the cassiterite itself also reflects the enrichment of the solution in fluoride during the deposition of cassiterite. Thus, for sample no. 65, the ratio Cl/F equals 1.7, whereas for quartz no. 65 it is increased to 12.7. Sample no. 228-1 of gray early quartz with abundant cassiterite I - 1.6, and for no. 228-2, a white, later quartz with cassiterite II, this ratio equals 8.2. In cassiterite from the Lifudzin deposit (no. 264), chloride is not found and HCO_3 and F predominate among the anions with HCO_3/F 1.5, whereas in the quartz associated with the cassiterite, sharp predominance of bicarbonate was established.

Table 5 (p. 957). Concentration of lithium in mineral-forming solutions.*

No. of sample	Name of zones and the analyzed mineral	Concentration of Li	
		mg-equiv/100 g.	g/1.
71	Solnechnoe, southern Asia, quartz, stage I	0.0028	0.0084
197	Pridorozhnaya, quartz, stage II	0.0025	0.0029
264	Lifudzin, cassiterite II, quartz, stage II	0.0047	--
1541	North zone, Pereval, quartz, stage II	0.0043	0.0049
625	" " " " " "	0.0036	0.0041
397	Yagodnaya zone, Festival, quartz, stage II	0.0081	0.0093
397	" " " " " "	0.0084	0.0096
458	" " " " " "	0.0051	0.0058
1388	" " " " " "	0.0021	0.0024

* Correction, printed in Geokhimiya, 1966, no 12, p. 1520:
Footnote to tables 4 and 5: Weight concentrations of F and Li in the mineral-forming solutions were calculated from the mean value of the concentration of water in the inclusions: 0.61% in Stage II, and 0.3% in pre-ore samples.

From the paper of Barsukov and Kuril'chikova (4) on the transport of tin under hydrothermal conditions, it follows that tin can form rather stable fluor-hydroxyl complex compounds. Study of systems of various compositions permitted the authors to draw the conclusion that under natural conditions the transported tin is realized in the form of hydroxy-fluor-stannates.

The solubility of tin hydroxide was determined at 300° for solutions containing fluorine, from 1.7 to 10 g/1. In all cases fluor-hydroxyl complexes were formed and increased solubility of tin (up to 0.4 g/1.) was observed. The lower limit of the concentration of F in the experiments was similar to the content of F found by us in the solutions - 1.5 g/1. This permits one to assume that the enrichment in fluorine of the gas-liquid inclusions in cassiterite and in the quartz associated with its deposition is associated with the hydrolysis of the transported tin compound, accompanying the escape into the solution of free fluoride ions.

It has already been mentioned that in concentrated aqueous extracts we were able to determine lithium. Its concentration is

1.5-2 orders lower than the content of the main cation - sodium (Table 5). Approximately the same ratio Na/Li was first found by Roedder (5), but for lead-zinc deposits of Mississippi (sic).

The problem of acidity-alkalinity regime of hydrothermal solutions is important for the interpretation of processes of mineral formation and is not simple to solve. Often on the basis of mineralogical and petrographic observations, establishing the carrying out of alkalies from the country rock, one speaks of the appearance of acid solutions where one must speak only of a comparitively small decrease of the magnitude of the pH, rarely attaining the pH of a neutral medium. It is evident that in Nature the most abundant deep hydrotherms are nearly neutral, slightly alkaline, and slightly acid.

Direct measurement of the pH of solutions of aqueous extracts from inclusions does not give reliable data. It seems to us that a more reliable method of estimating pH, starting from carbonate equilibria, was proposed by Ryzhenko (6). Calculation of data previously obtained by us on the contents in the solutions of CO2 and HCO_3, given in ref. (2), show that the solutions were slightly alkaline with a range of pH from 6.5 to 9.5*. With decrease of temperature, with transition from quartz-cassiterite stage to quartz-sulfide and carbonate-sulfide, the alkalinity of the solutions increases.

Analysis of the data presented leads to the following conclusions:

1. For sulfide-cassiterite deposits of the Far East there have been established two types of chemical composition of hydrothermal solutions (in each of which there exists variation of composition). The first is the chloride-carbonate, sodium-potassium solutions. The ratios of the components on the average are Na/K 4.4, Na/Ca 6.2, Cl/HCO_3 2, Cl/F 6. This type is characteristic for the zones of Pridorozhnyi, Ozernaya, Levosilinsk, Avral'nyi, and the main Solnech, and for the Maritime deposits.

The second type is the sodium-chloride solutions, in which the average magnitudes of ratios are approximately Na/K 5.8, Na/Ca 6.6; for Cl/HCO_3 the lower limit of the ratio is 5, the upper limit is very high, because the concentration of HCO_3^- falls below the limit of sensitivity of the method. For the ratio Cl/F there is a large scatter of magnitudes -- from 4 to 46 with an average of about 10-11.

2. The concentration of fluorine in the hydrothermal solutions that formed the sulfide-cassiterite deposits is significant, of the order of 1.5 g/l., which may provide for the transport of tin in the form of complex compounds of the type $[Sn(OH)_xF_{6-x}]^{-2}$. The transport of tin in the form of such complex ions is confirmed by the data on the decrease of the ratio Cl/F in solutions of inclusions in areas of enriched tin mineralization and in cassiterite.

3. The concentrations of lithium in the mineral-forming solutions ranged from 2.4 to 9.6 mg/l.

4. The hydrothermal solutions forming sulfide-cassiterite deposits were alkaline.

In conclusion the authors express thanks to V.I. Lebedev who made the flame-photometric determinations of Na, K, and Ca.

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*The neutral point at 300° corresponds to a pH 5.8, so that all the studied solutions are practically alkaline.

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YASINSKAYA, A.A., 1967, Inclusions in stony meteorites: Mineralog. Sbornik L'vov Gos. Univ. v. 21, p. 278-281 (in Russian). (Author at Ivan Franko Gos. Univ., L'vov.)

Minute inclusions of highly compressed, mostly liquidified CO_2 and the inclusions of another composition were found in olivine, pyroxene and plagioclase by microscopic examination of thin doubly polished plates of chondrites and achondrites. The description of different kinds of inclusions is given in the article. Some comparisons and conclusions are given. (Author's abstract).

During the microscopic study of thin (0.1-0.3mm.) sections, polished on both sides, of the chondrites "Saratov", "Okhansk," and "Belopol," and transparent sections of the achondrites "Chervonyi Kut" and "Yurtuk,"* inclusions of different composition were found, and among them inclusions of dense, mostly compressed carbon dioxide. These inclusions occur in fine cystallites and grains of olivine, constituting chondrules of microphyritic and completely crystalline structure, and also in grains of plagioclase and pyroxene of achondrites. The inclusions are easily seen in immersion preparations obtained from grains, for example olivine, selected from the chondrule under the binocular lens, crushed between two microscope slides, and placed in an immersion liquid with n close to the n_β of the mineral. In the usual microscopic survey of a sample, the CO_2 inclusions appear as small (less than 3-5 μm) non-transparent dark

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*Material for study was from samples from the personal collction of Prof. P.N. Chirvinskii, located in the Mineralogical Museum of L'vov Univ.

spots (Fig. 1,6), and only rarely do larger inclusions occur. In the main, the inclusions are close in size to the resolving power of the microscope. Thereby it is necessary for their study to use strong magnification and bright illumination, obtained by means of a condenser.

The inclusions of CO_2 differ from the non-transparent small inclusions of nickel-iron and troilite in that in them there is usually a light point in the center amidst a dark part around it. The inclusions are distributed irregularly in the entire volume of the grain and their contents are not the same in different grains.

In individual grains of olivine and plagioclase there are observed densely located small and very very small inclusions, oriented approximately along crystallographic directions or located along curved surfaces within the grain, traced by small elevation or lowering of the microscope tube.

Most of the inclusions are secondary, trapped at the time of the healing of fractures in the grains of olivine, plagioclase, and pyroxene, but some of them are apparently primary and pseudo-secondary (inclusions of CO_2 and melt, which filled fissures which originated in the process of the growth of the crystal (fig. 1,3). Often the healed fracture pinches out within a single grain, which is confirmed by the gradual decrease of size and number of inclusions in the direction of pinching out. It is possible that part of the secondary inclusions of CO_2 originated during the decrepitation of larger primary inclusions in the period of healing of very fine fissures in the parts of the grain adjacent to the vacuole.

Single-phase and two-phase inclusions occur. In phase composition and ratio of phases, the inclusions are subdivided into gaseous, essentially gaseous, gas-liquid, liquid, congealed, and solid ones. Thereby there are distinguished among the essentially gaseous and gas-liquid ones, in their turn, inclusions with CO_2 and other compositions.

According to the morphological features one can separate the following varieties of inclusions: irregular and oval plane (Fig. 1,1); having the form of isometric negative crystals (fig. 1, 2a; fig. 1, 2b); tubular (fig. 1,2b); vermiform (fig.1,3); oval and spherical (fig. 1, 4a,b); indefinite forms (fig. 1, 4v,5).

The filling of two-phase gas-liquid inclusions varies within wide limits -- from 50-90% liquid CO_2 to 20-10% (tubular inclusions). For those where gas bubbles are small and separated from the wall of the vacuole, one can observe Brownian movement. Inclusions with a high percent of filling by liquid CO_2 homogenized in the liquid phase on heating in the temperature interval from +29° to +31°C. Thereby the bubbles disappeared instantaneously, did not appear during cooling to room temperature, but on freezing to -5°C in some single-phase inclusions, small gas bubbles were formed.

The gas-liquid inclusions of indefinite composition behave otherwise. Individual small oval inclusions of similar type with filling 30-40% homogenized on heating in the gas phase, so that bubbles do not change for a long time in volume, but at 80-90°C gradually expanded to the disappearance of the meniscus. Spherical, dark, larger inclusions did not change when heated up to temperatures of the order of 250-300°C.

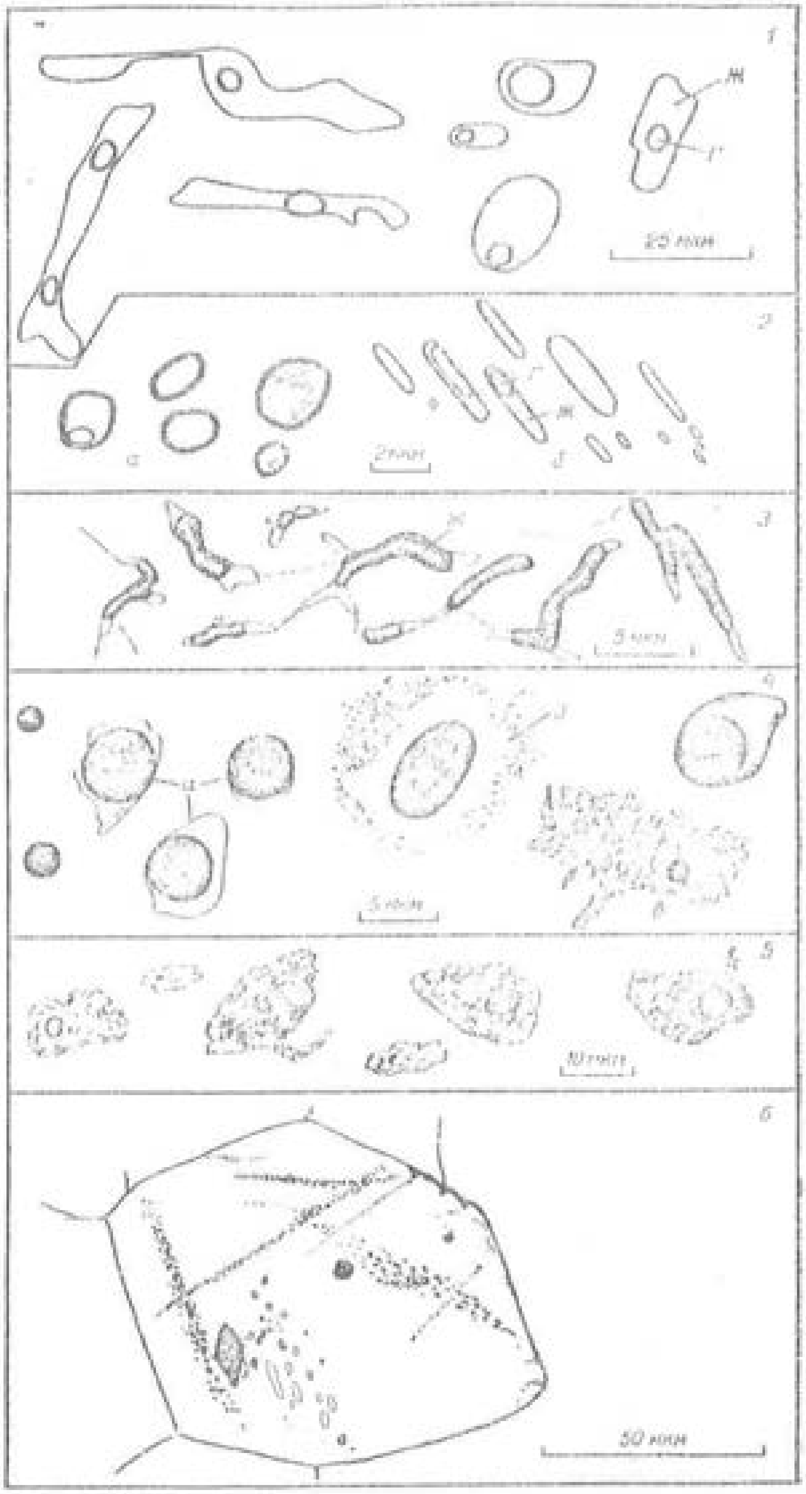

Fig. 1. Types of inclusions in olivine, plagioclase, and pyroxene from stony meteorites. (1st Figs 1-6)

6 - distribution of inclusions within a single grain of olivine. Zarisovka under the binocular microscope. [illegible]

As noted above, besides the gas-liquid and liquid inclusions of CO_2, there are also found congealed (Fig. 1, 4v, 5, and fig. 2v) and solid inclusions. Especially abundant are such inclusions in plagioclase and pyroxene from the achondrites "Chervonyi Kut" and "Yurtuk."

Among the congealed inclusions, apparently melts of primordial material, one can separate glassy, combined (glassy and recrystallized), and recrystallized. Glassy inclusions have predominantly oval form, and for them is characteristic the presence of small, immobile ("fastened") gas bubbles, probably originating as a result of contraction. The volume of bubbles is usually constant with respect to the volume of the glass (3-5%). There also occur small glassy inclusions without bubbles, apparently originating during rapid cooling of the melt. The recrystallized inclusions have a brownish tint and contain gas bubbles; the ratio of the volumes of gas and glass, converted into a granular mass, is generally inconstant in them. As a rule, the gas bubbles of this variety of inclusions are larger than the bubbles in glassy inclusions. The combined inclusions contain small immobile bubbles in the glassy part. Inclusions also occur that consist of glass, crystalline phases, and gas bubbles. Besides, one must note congealing of inclusions of glass in the form of very fine veinlets in crystals and grains, which apparently originated as the result of partial melting of minerals of the meteorite in cosmic space (1).

The results of preliminary observations on inclusions in olivine constituting chondrules of meteorite, and also in plagioclase and pyroxene entering into the composition of achondrites, permits one to draw some comparisons and conclusions. The described inclusions in meteorites are very similar to inclusions in phenocrysts of olivine, pyroxene, and plagioclase from dunite, peridotite, pyroxenite, gabbro, basalt, from various areas of the Earth, described by Roedder (2).

Carbon dioxide is one of the constituents of the parental matter, from which the minerals occurring in meteorites originated. If one assumes (by analogy with terrestrial ultrabasic rocks) that CO_2 can form in the original silicate melt as a separate, immiscible phase (2), one does not exclude the possibility that in the period of capture (trapping), both primary and secondary inclusions of melt are growing or healing crystals with a silicate fluid containing microscopic globules of another immiscible fluid, consisting of dense supercritical CO_2.

Comparison of the ratios of liquid and gas phase CO_2 in the inclusions in olivine of meteorites with the analogous data for terrestrial olivine rocks (for systems at high temperatures and pressures) permit one to judge as a first approximation the pressures at the period of trapping the primary or the predominantly secondary inclusions. These magnitudes are of the order 2500-5000 bars, corresponding to depths of deposition of about 8 to 16 km. If one takes into account that even in the parental body, or in consequence of collision and impact of the parental body in cosmic space, there can occur decrepitation of the inclusions occurring under higher pressures, then the mentioned limits of magnitude of pressure and depth of deposition can be considered minima. Not excluded also is the possibility of partial loss of CO_2 and the decrepitation of larger inclusions during the travel of the meteorite in the Earth's atmosphere and its fall to the earth. This probably explains the presence in minerals of the meteorite of only very small inclusions, the size of which is often at the limit of the resolution of the microscope. One must also consider the mechanical stability and resistance to cracking of olivine at high temperatures.

We have carried out only the first observations on inclusions in stony meteorites and have stated some considerations relative to the origin of CO_2 and the thermodynamic conditions in the period of trapping inclusions by crystals of olivine, plagioclase, and pyroxene. It is possible that further studies will show new facts and other interpretations, yet there remains the undoubted fact of the unity of matter in the universe.

Thanks are expressed to Docents L.I. Koltun and A.V. Piznyur for scientific consultations while this work was being done.

Fig. 2 (opp. p. 275). Inclusions of CO_2 in olivine from chondrules of "Saratov" meteorite. (omitted)

(a) two-phase gas-liquid inclusions

(b) isometric and oval inclusions, predominently one-phase

(c) recrystallized inclusions of glass. Thin section, X 500

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Translated by Michael Fleischer.

YUSHKIN, N.P. and SREBRODOL'SKII, B.I., 1965, Study of the composition of liquid inclusions in crystals of native sulfur: Mineralog. Sbornik, L'vov. Gos. Univ., v. 19, p. 229-236. (in Russian; authors at Syktyvkar. Inst. Geol., Komi Filial Akad. Nauk S.S.S.R., L'vov Gos. Univ. named for Ivan Franko).

Summary - "The liquid inclusions in the crystals of native sulphur from the Rozdol and Shorshuisk deposits have been determined. A short characteristic of sulphur-precipitating solutions is given." (Authors' abstract).

The problems of the genesis of deposits of native sulphur, occurring in sulphate-carbonate rocks, have not yet been solved. Light can be shed on them only by direct or indirect determination of the sulphur-depositing solutions, from which the crystallization of native sulphur occurred. Knowledge of the composition of relict mineral-forming medium is of importance also for other problems of mineral formation.

Until recently the composition and character of sulphur-depositing solutions has been determined on the basis of indirect methods. Thus, as the result of studies of the mineralogical paragenetic complex of native sulphur minerals and the physico-chemical features of contemporary sulphur deposition (1,8), most investigators have come to the conclusion that the primary forms of native sulfur are deposited from hydrogen sulfide, chloride, alkali-earth-sodium waters of high salinity during their mixing with oxygen-containing sulfate calcium-magnesium infiltration waters. Study of the ground waters of the Shorsui deposit (Uzbek S.S.R.) by one of us (8) permitted a rather detailed characterization of contemporary sulfur-depositing solutions and the geochemistry of the processes proceeding in the system of these waters, and by means of the ontogeny of the mineral aggregates (9) to state that the geochemical features of this deposit from the beginning of its formation to the present had not changed essentially, and the data on contemporary sulfur deposition (with known reservations) can be extrapolated to all periods of the formation of the deposit.

Nevertheless, as mentioned above, all these judgments on the character of the sulfur-depositing solutions are based in indirect determinations, and only the study of primary liquid inclusions in the crystals of sulfur, which are the residue of the mineral-forming medium, can give the key to knowledge of the physico-chemical character of the sulfur-depositing solutions.

Inclusions of liquids are noted in the crystals of sulfur and their paragenetic minerals from many deposits, but limited knowledge of their composition is contained only, to our knowledge, in papers by Silvestri (11) and Sjögren (10), who made analyses of liquid inclusions in crystals of Sicilian sulfur. Recently one of us (5), studying crystals of sulfur from the near-Carpathian deposits, described in them inclusions of liquid, some primary, some secondary. We have studied the morphology of liquid inclusions in Shorsui and Rozdol crystals, and in the former we have also studied the composition of the solutions contained in the crystals.

In the Shorsui crystals of sulfur, inclusions are found very often. In individual samples they occupy 10-15% of the volume of the crystals. Most often the crystals of sulfur contain many small inclusions of liquid, of volume 0.001-0.01 mm^3 and individual large inclusions 1.25-1.50 mm^3. The average content of the inclusions is 1-2%

All the inclusions are single phase liquid. Sometimes the surfaces of the vacuoles are covered by fine brown films of entrained bitumen, which indicates a connection of the sulfur-depositing solutions with oil. Such films are noted in the body of the crystals, and outside the inclusions, where they cover the buried faces marking zones of growth. The form of the inclusions is elongated, spindle-shaped, and capillary, rarely complex, with branches directed toward the center of origin of the crystal (Fig. 1).

Rather often the inclusions have faces of the form of rhombic negative crystals.

The distribution of the inclusions in the obdy of the crystal-host, as a rule, is regular--they are elongated with the long side parallel to specific crystallographic directions, corresponding to faces of a crystal, and recorded, although very crudely, by zones of growth. Some inclusions are curved, but individual straight-line parts are in this case always parallel to faces. All this indicates

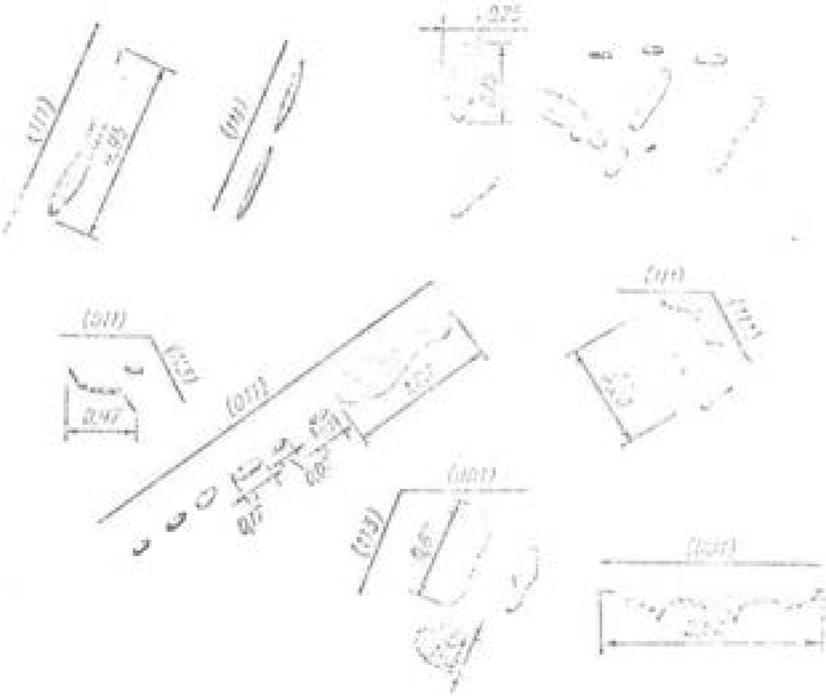

Fig. 1 (p.231). Liquid inclusions in crystals of sulfur from the Shorsui deposit.

that the liquid inclusions are primary and were formed during the selective growth of the crystal, alternating with normal growth.

In the Rozdol crystals of sulfur, the liquid inclusions are more diverse than those from Shorsui.

Primary inclusions (Fig. 2, 1-5), thanks to their size(5x8 mm.) are noted even by the naked eye and are easily diagnosed under the binoculars. In outward apppearance one can separate among them the irregular and the spindle-shaped.

The irregular inclusions (see Fig. 2, nos. 1,4) are attracted

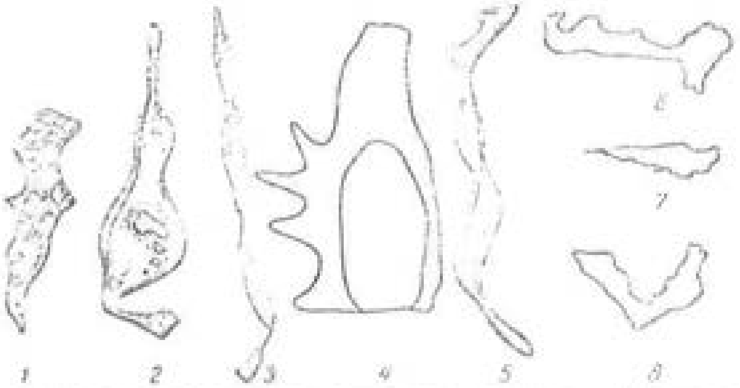

Fig. 2 (p. 231). Liquid inclusions in crystals of sulfur from the Rozdol deposit.

to the zone of growth of the peripheral part of the crystal. They have irregular, winding contours, sometimes with sharp, spine-like off-shoots, which are located close to the thicker part of the inclusions. In one of these a gas bubble was found, of anomalous origin, which occupied two-thirds of the cavity of the inclusion (Fig.3). It is difficult to determine the volume of the gas bubble more accurately, because of the irregular form of the inclusions. If one assumes that the contained inclusions have not changed since the time of capture by the crystal of the relict mineral-forming medium, one can assume that SO_3 or CO_2 enter into the composition of the gas phase. Inclusions with very large gas bubbles, apparently containing SO_3 gas, were found by Lazarenko and Slivko (3) in crystals of celestite in paragenesis with sulfur.

Fig. 3 (opp. p. 232). Irregular liquid inclusions in crystals of sulfur. Rozdol. X13. (omitted)

The spindle-shaped inclusions (see Fig. 2, nos. 2,3,5) are located close to the central part of the crystal. Their outlines are smooth, with gradual transition from the thickened part (bulge) to the narrower(constricted) (Fig. 4). In the very narrow places a tendency is observed towards the separation of the inclusion into independent parts. This is well shown in Fig. 5, where three inclusions, previously constituting a single one, later split and are joined only by a fine connector.

Fig. 4 (opp. p. 232). Spindle-shaped liquid inclusions in crystals of sulfur. Rozdol. X12. (omitted)

Fig. 5 (opp. p. 232). Splitting of band of spindle-shaped inclusions into compound, more balanced parts. Rozdol. X13. (omitted)

Under crossed Nicols the inclusions are dark, and in transmitted light are clear only in the central part. In two of these (see Fig. 2, nos. 1,2) there are observed clearly well-defined areas that do not extinguish in crossed Nicols.

The <u>secondary inclusions</u> (see Fig. 2, 6-8) are most abundant in crystals of sulfur from Rozdol. They are located in the near-surface part of the crystal, sometimes equally distributed on all planes of the faces (most often (001)). Rarely they are arranged on curved surfaces, devoid of definite crystallographic indexes and approximately parallel to one another, To the secondary inclusions also are referred the small inclusions of volume up to 0.01 mm^3., arranged in chains of 10-15 in one series.

According to the classification of Kalyuzhnyi (2), the studied inclusions are early secondary. Although they have zonal growth, it is not in direct contact with them.

Thanks to the fact that in the Shorsui sulfur there were excellently preserved primary vacuoles and secondary inclusions are absent, crystals from this deposit were chosen for study of the composition of the mineral-forming solutions.

To analyze the liquid inclusions, opened by crushing the mineral, their contents were extracted.

For microchemical analysis were selected, well-faceted crystals of native sulfur of all morphological types in the proportions in which they occur in the deposit. All crystals were inspected under the binoculars, and only those were chosen for study in which there were no solid inclusions. Small pieces of the crystals after being freed from liquid inclusions by crushing and washing in alcohol were tested for purity by semiquantitative spectrographic analysis. In most of the crystals, there were small contents--thousandths, or rarely hundredths of a percent of Al, Mg, Ca, Si, and ten-thousandths of a percent of Ba.

All these elements apparently occur as submicroscopic solid inclusions, invisible even under the microscope. According to the chemical analyses, made of the extracts of liquid inclusions, they contained less than 0.01% of solid admixtures.

Thus the material for the experiments was selected very pure and the effect of soluble solid particles on the composition of the extracts was reduced a minimum.

Weights of sulfur up to 200g. were extracted as a powder with grain size 0.01-0.001 mm., which made sure that practically all the liquid inclusions in the crystal were opened. The extraction of the soluble salts in the inclusions was made with distilled water. The sample was wetted with 500ml. of distillate at a temperature of 18° and was intensely shaken for 20 minutes, let stand for an hour, and then filtered on a Buchner funnel and washed. The total amount of leach water was 700ml. Chemical analysis of the aqueous extract was made in the laboratory of the geological institute of the Komi Filial, Academy of Sciences, USSR, by T.V. Andreeva. Parallel control blank analyses were made of bidistillate to determine the corrections for the water, reagents, and dishware.

The content of liquid inclusions in the sample were determined by drying a quartered sample of 2.780 g. in a drying cabinet at a temperature of 62-72°C. In the first minutes of heating, there was a loss of weight of 1.08% and then for four hours heating, constant weight was maintained. At the end of the experiment the sample was fused at 110°C and then cooled, its weight not changing thereby. According the measurements of the volume of the inclusions, their content in the sample was determined as 1%, which hardly differs from the content determined by drying. These data permit one to establish that in extraction of the 200 g. of powder used in washing by 700ml. H_2O there was dissolved salts from 2.16 ml. of solvent.

In the table are given the results of analysis of aqueous extracts from crystals of sulfur and their calculation to the composition of the liquid inclusions. Besides the components given in the table, traces of Sr and Ba were found in the samples, and during grinding of the crystals there was apparent a sharp smell of H_2S. The concentration of H^+ion, determined by a colorimetric method--by the introduction with a needle into large inclusions  of indicators (bromthymol blue, bromcresol purple, and cresol red)--was 7-7-5.

As seen from the table, the solutions of the inclusions, and consequently the sulfur-depositing solutions, in chemical composition belong to the type of H_2S-bearing chloride alkali-earth sodium brines with total mineralization of more than 60g/l., as determined by indirect methods. Their reaction is neutral or slightly alkaline and the presence of H_2S indicates their reducing properties.*

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* The salt composition of inclusions of crystals of sulfur from Shorsui is rather similar to the composition of inclusions of

Sicilian gypsum in paragenesis with sulfur (10), but the latter is poor in calcium ion.

According to the magnitude of pH, the liquid inclusions in **Shorsui** sulfur are not different from those in the sulfur of the Rozdol deposit. (The magnitude of pH of the solution of inclusions for Rozdol sulfur, measured at our request by V.A. Kalyuzhnyi, was 7 ± 0.2).

We have plotted on the rectangular graph of N.I. Tolstikhin (Fig. 6) data on the composition of the waters of the Shorsui sulfur deposits, participating in contemporary sulfur deposition. Field I is occupied

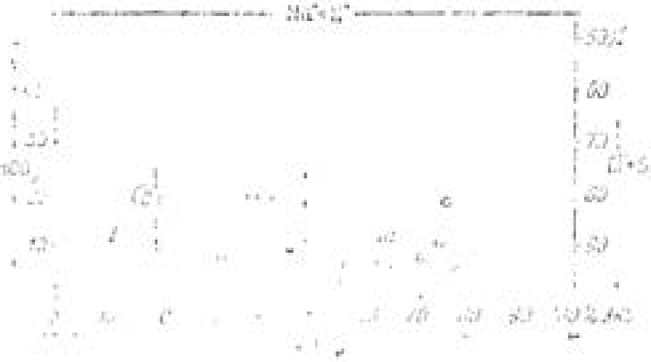

Fig. 6 (p. 234). Chemical composition of subsurface water, participating in contemporary sulfur deposition, and the composition of liquid inclusions (diameter of circles on the scale of 1 mm: 10 g characterizes the magnitude of total mineralization of the waters).

1 -- liquid inclusions in crystals of natural sulfur;
2 -- infiltration water;
3 -- water from which native S is depositing;
4 -- water from which native S and calcite are depositing;
5 -- H_2S-bearing chloride sodium brines, associated with oil-bearing deposits;
6 -- vein inclusions in gypsum from Sicily (10).

by chloride-sodium brines, highly mineralized, associated with oil deposits also producing H_2S. Field III is the slightly saline infiltration water of calcium-magnesium-sulfate type. Lying between them is the field II occupied by waters transitional from the infiltration to the "oily" type, which were formed as a result of mixing I and III. According to the chemical composition they differ from the Ca-Na chloride-sulfate waters by their increased salinity and are transitional to brines of chloride sodium--alkali-earth type. The solutions of the liquid inclusions also lie in this field and differ from the contemporary sulfur-depositing solutions only by somewhat higher content of bicarbonate ion, which in the subsurface water, permeating the mining works, is able to escape because of the sharp decrease in partial pressure of CO_2.

Thus, the presence of single-phase liquid inclusions in crystals of native sulfur from the studied deposits confirm the low temperature of the mineral-forming solutions. The crystallization of sulfur from H_2S-bearing chloride sodium--alkali-earth waters during their mixing with Ca-Mg infiltration waters in the Shorsui deposit, and the separa-

Table (p. 233). Analysis of aqueous extracts of crystals of sulfur and the composition of subsurface

	Form of calcn.	Content, per liter							
		Cations				Anions			
		K·+Na·	Ca··	Mg··	Fe··+Fe···	Cl'	SO_4''	HCO_3'	
Aqueous extract from crystals of sulfur	mg.	31.00	12 62	1.70	0.06	45.73	15.85	24.41	See next page
	mg-equi.	1.24	0.64	0.14	--	1.29	0.33	0.40	
	% mg-equiv.	61.43	31.65	6.92	--	63.87	16.33	19.80	
The same recalculated to the composition of the inclusions	mg.	14,688.90	5,935.18	784.04	37.04	27,171.29	7,337.96	11,300.96	
	mg-equiv.	638.91	296.16	64.73	1.32	597.09	152.77	185.21	
	% mg-equiv.	61.39	31.56	6.91	0.14	63.87	16.33	19.80	
Subsurface water in one of the workings	mg.	8,639.26	1,926.60	1,350.23		17,004.00	3,393.40	5,886.50	
	mg-equiv.	375.62	96.33	110.67	--	479.0	71.65	96.9	
	% mg-equiv.	64.56	16.50	18.94	--	71.40	12.30	16.30	

(continued from previous page)

water of the Shorsui deposit

Mineralization	H_2S	CO_2	pH	Notes
131.51	++	+		In 700 ml. of distilled water, 2.16 ml. dissolved of the solution of liquid inclusions
60,921.31	++	+	7-7.5	Qualitative analysis showed traces of Sr and Ba
38,199.99	155.7	155.0	7.4	

tion of multi-faceted sulfur as the result of the recrystallization of crytocrystalline sulfur in the Rozdol deposit occurred in solutions near neutrality.

In conclusion, the authors express deep thanks to V.A. Kalyuzhnyi for reviewing the manuscript and making several suggestions.

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Translated by Michael Fleischer

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